9TH INTERNATIONAL CONFERENCE ON HIGH TEMPERATURE CERAMIC MATRIX COMPOSITES - HTCMC 9

Toronto Marriott Downtown Eaton Centre Hotel | Toronto, Ontario Canada

GLOBAL FORUM ON ADVANCED MATERIALS AND TECHNOLOGIES FOR SUSTAINABLE DEVELOPMENT - GFMAT 2016

JUNE 26 – JULY 1, 2016

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The American Ceramic Society
www.ceramics.org

Welcome

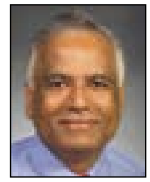
The American Ceramic Society welcomes you to the 9th International Conference on High Temperature Ceramic Matrix Composites (HTCMC-9), including the Global Forum on Advanced Materials and Technologies for Sustainable Development (GFMAT 2016). HTCMC-9 will continue the tradition of successful previous conferences held in Bordeaux (France, 1993), Santa Barbara (USA, 1995), Osaka (Japan, 1998), Munich (Germany, 2001), Seattle (USA, 2004), New Delhi (India, 2007), Bayreuth (Germany, 2010), and Xi'An (China, 2013). We invite you take advantage of all the opportunities to network and learn. Several special activities are planned in addition to the technical program:

- Renew acquaintances and get to know new ones during the Welcome Reception on Sunday from 5:00-7:00 p.m.
- The opening plenary session will take place on Monday, June 27 from 8:30 a.m. – noon and features four outstanding leaders. See the details of this exciting session on page iii.
- A networking lunch will follow the opening plenary session from noon – 1:00 p.m.
- Students and Young Professionals are invited to grow their professional network and with a lunchtime seminar on Tuesday, June 28 "Survival Skills for Scientists". Sponsored by ACerS Global Graduate Researcher Network and Saint-Gobain.
- Continue your learning experience and opportunity to network at the Poster Session on Tuesday, June 28, 6:30-8:30 p.m. In addition to the Best Poster Awards, ACerS Global Graduate Researcher Network (GGRN) is sponsoring the GGRN Student Poster Awards
- Take time to explore Toronto during the free time Wednesday afternoon. Meet up with your colleagues and enjoy all Toronto has to offer. ACerS staff and the local concierge will be available in the lobby to help you with suggestions.
- HTCMC-9 attendees are invited to be our guests and continue networking during the conference dinner on Thursday, June 30 from 7:00-9:30 p.m. A surprise program is planned.
- When the program ends on Friday, be sure to get out and celebrate Canada Day, a national holiday, frequently referred to as Canada's Birthday!

Our special thanks to conference sponsors, Tianniao High Technology Co. Ltd., TOTO Ltd., Saint-Gobain, TR Ltd., The Society of Powder Technology, and Materials Today.

The American Ceramic Society thanks you for participating in HTCMC-9 and hope you benefit from your time in Toronto.

Organizing chairs


Singh

Mrityunjay Singh
General chair
OAI, USA


Ohji

Tatsuki Ohji
HTCMC-9 Lead chair
AIST, Japan


Morscher

Gregory N. Morscher
HTCMC-9 Cochair
Univ. Akron, USA


Dong

Shaoming Dong
HTCMC-9 Cochair
SICCAS, China


Mathur

Sanjay Mathur
GFMAT 2016 Lead chair
Univ. Cologne, Germany


Shimamura

Kiyoshi Shimamura
GFMAT 2016 Cochair
NIMS, Japan


Siaj

Mohamed Siaj
GFMAT 2016 Cochair
UQÀM, Canada

Table of Contents

Final Program

Sponsored by SAINT-GOBAIN and ACerS Global Graduate Researcher Network

STUDENT AND YOUNG PROFESSIONALS LUNCH SEMINAR

Tuesday, June 28 | Noon – 1:00 P.M. | York A

Survival Skills for Scientists

Prof. Federico Rosei, INRS – EMT, Canada

Lunch provided to seminar attendees on first come first served basis.

Global Graduate Researcher Network—Tuesday, June 28 | 6:30 – 8:30 P.M.

STUDENT POSTER AWARDS

The Global Graduate Researcher Network (GGRN) is sponsoring Student Poster Awards. Current graduate and undergraduate students presenting a poster are eligible for consideration for the GGRN Student Poster Award. Student posters will be reviewed by technical reviewers from the ACerS community.

Five GGRN Student Poster Awards of $200 each will be given to the top five poster presenters. All awards will be announced at the conference dinner on Thursday, June 30, 7 to 9:30 p.m.

Best Poster Awards—Tuesday, June 28 | 6:30 – 8:30 P.M.

The Best Poster Awards will be selected from posters that are displayed during the specified poster presentation period when the poster evaluation is performed. Consideration for the award will be given to all poster presenters.

The posters will be evaluated by the Best Poster Award selection committee consisting of technical reviewers from the ACerS community.

The Best Poster Award will consist of first, second and third prizes for each contest. The cash awards for the first, second and third place prizes will be $500, $300 and $200, respectively. All awards will be announced at the conference dinner on Thursday, June 30, 7 to 9:30 p.m.

Schedule at a Glance

SUNDAY, JUNE 26, 2016

Registration	4:00 p.m. – 7:00 p.m.	Ballroom Foyer
Welcome reception	5:00 p.m. – 7:00 p.m.	

MONDAY, JUNE 27, 2016

Registration	7:30 a.m. – 6:00 p.m.	Ballroom Foyer
Plenary Session	8:30 a.m. – 12:00 p.m.	Salon A&B
Networking Lunch	12:00 p.m. – 1:30 p.m.	Salon A&B
*Concurrent Sessions	1:30 p.m. – 6:00 p.m.	

TUESDAY, JUNE 28, 2016

Registration	7:30 a.m. – 6:00 p.m.	Ballroom Foyer
*Concurrent Sessions	8:30 a.m. – 6:00 p.m.	
Young Professionals Seminar: 'Survival Skills for Scientists'	12:00 p.m. – 1:15 p.m.	York A
Lunch on own	12:00 p.m. – 1:30 p.m.	
Poster Session	6:30 p.m. – 8:30 p.m.	Salon A&B

WEDNESDAY, JUNE 29, 2016

Registration	8:00 a.m. – 12:00 p.m.	Ballroom Foyer
*Concurrent Sessions	8:30 a.m. – 12:00 p.m.	
Free afternoon and Evening	12:00 p.m. +	

THURSDAY, JUNE 30, 2016

Registration	8:00 a.m. – 5:30 p.m.	Ballroom Foyer
*Concurrent Sessions	8:30 a.m. – 5:30 p.m.	
Lunch on own	12:00 p.m. – 1:30 p.m.	
Conference Banquet	7:00 p.m. – 9:30 p.m.	Salon A&B

FRIDAY, JULY 1, 2016

Registration	8:00 a.m. – 12:00 p.m.	Ballroom Foyer
*Concurrent Sessions	8:30 a.m. – 12:00 p.m.	

*Concurrent Sessions are in Salon C, Salon D, Trinity I – V, York A, York B and Bay

MONDAY | JUNE 27, 2016

Session starts at 8:30 a.m. with opening remarks

9 – 9:40 a.m.

Shunpei Yamazaki

Founder and president, Semiconductor Energy Laboratory Co., Ltd.

Title: ***Discovery of Indium Gallium Zinc Oxide (CAAC-IGZO) and Its Applications in Next Generation Information Display Devices***

9:40 – 10:20 a.m.

A.N. Sreeram

Sr. Vice President Research & Development and Chief Technology Officer, Dow Chemical Company

Title: ***The Science of Materials: Impactful Solutions to Big Global Challenges***

10:40 – 11:20 a.m.

Katherine A. Stevens

General manager, materials and process engineering, GE Aviation

Title: ***SiC/SiC Ceramic Matrix Composites for Jet Engines***

11:20 a.m. – Noon

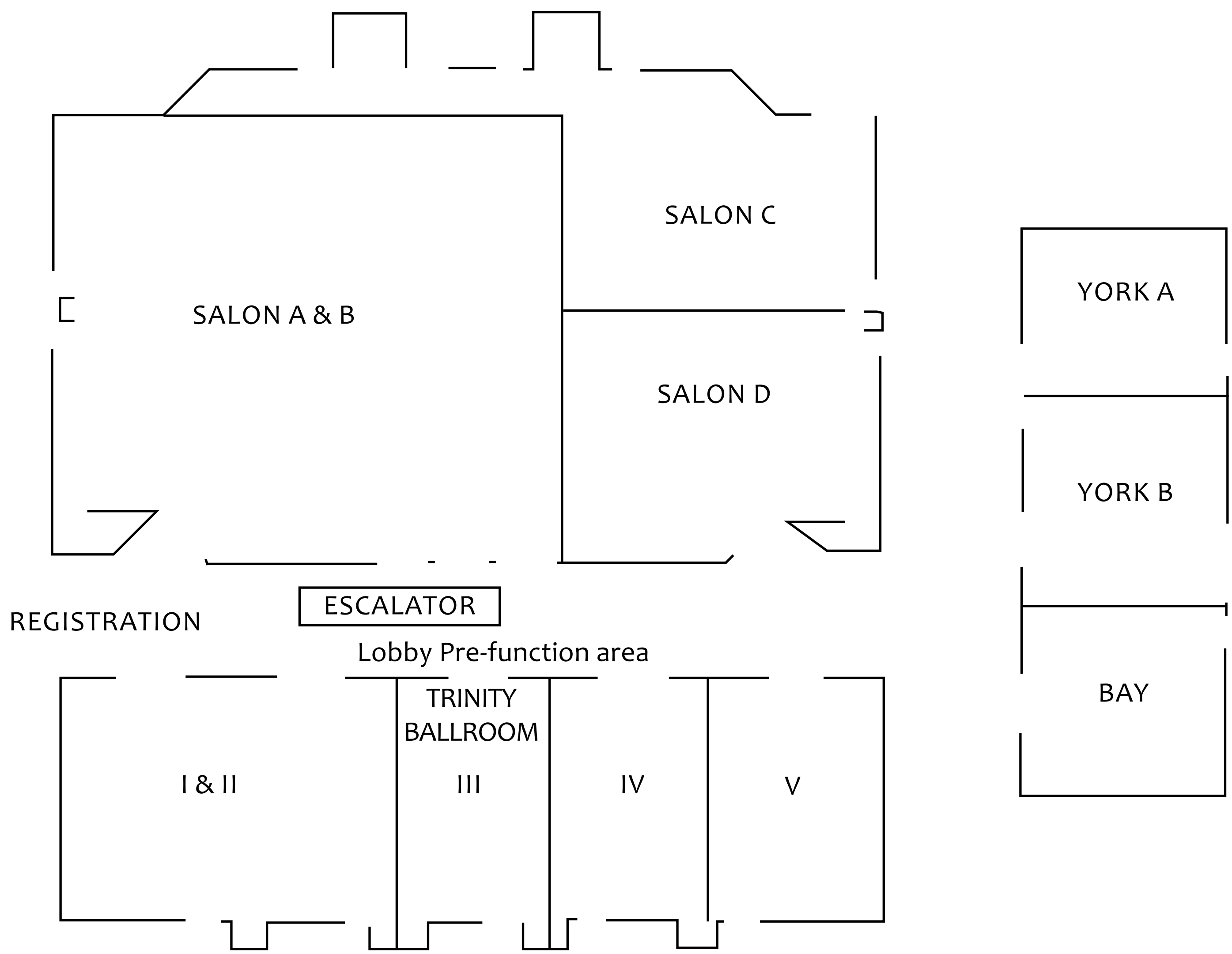
Jörg Esslinger

Director Materials Engineering, MTU Aero Engines, AG

Title: ***Ceramic Matrix Composites (CMCs): Enabling Materials for Competitive Aero-Engines***

Hotel Floor Plan

Lower Convention Center



Technical Program at a Glance

Session Title	Date	Time	Location
H1. Computational Modelling and Design of New Materials and Processes			
Atom-scale Modeling I	Thursday, June 30, 2016	1:50 - 3:20 PM	Bay
Atom-scale modeling II	Thursday, June 30, 2016	3:20 - 4:50 PM	Bay
Large-scale Modeling I	Friday, July 1, 2016	8:30 - 10:20 AM	Bay
Large-scale Modeling II	Friday, July 1, 2016	10:20 - 11:20 AM	Bay
H2: Design and Development of Advanced Ceramic Fibers, Interfaces, and Interphases in Composites- A Symposium in Honor of Professor Roger Naslain			
Introduction to Ceramic Matrix Composites/ Novel SiC Fibers and Properties of SiC Fibers	Tuesday, June 28, 2016	8:30 AM - Noon	Salon D
SiC/SiC and C/C Composite Material /Interfaces and Interphases in CMCs	Tuesday, June 28, 2016	1:30 - 5:20 PM	Salon D
Oxide Fibers for Ceramic Matrix Composites	Wednesday, June 29, 2016	8:30 - 10:00 AM	Salon D
H3. Innovative Design, Advanced Processing, and Manufacturing Technologies			
Innovative Design I	Monday, June 27, 2016	1:30 - 5:30 PM	Bay
Innovative Design II	Tuesday, June 28, 2016	8:30 AM - Noon	Bay
Innovative Design III	Tuesday, June 28, 2016	1:30 - 5:30 PM	Bay
Innovative Design IV	Wednesday, June 29, 2016	8:30 AM - 12:20 PM	Bay
Innovative Design V	Thursday, June 30, 2016	8:30 AM - Noon	Bay
H4. Materials for Extreme Environments: Ultrahigh Temperature Ceramics (UHTCs) and Nano-laminated Ternary Carbides and Nitrides (MAX Phases)			
New Precursors for Powders, Coatings, and Matrix or Fibers of Composites	Thursday, June 30, 2016	8:30 - 10:20 AM	Salon C
Methods for Improving Damage Tolerance, Oxidation and Thermal Shock Resistance	Thursday, June 30, 2016	10:20 AM - Noon	Salon C
Novel Processing Methods (Bulk, Coatings and Thin Films)	Thursday, June 30, 2016	1:30 - 3:20 PM	Salon C
Structure-property Relationships of Existing Systems	Thursday, June 30, 2016	3:20 - 5:30 PM	Salon C
Novel Characterization Methods and Lifetime Assessment; Other High Temperature Material and Properties	Friday, July 1, 2016	8:30 - 10:10 AM	Salon C
H5. Polymer Derived Ceramics and Composites			
PDC Composites I	Monday, June 27, 2016	1:30 - 3:30 PM	Trinity IV
PDC Composites II	Monday, June 27, 2016	3:30 - 6:10 PM	Trinity IV
PDC Fibers	Tuesday, June 28, 2016	8:20 - 10:20 AM	Trinity IV
Applications of PDCs	Tuesday, June 28, 2016	10:20 - 11:50 AM	Trinity IV
PDC Precursors and Microstructure	Tuesday, June 28, 2016	1:20 - 3:20 PM	Trinity IV
Microstructure and Properties of PDCs	Tuesday, June 28, 2016	3:20 - 6:00 PM	Trinity IV
H6. Advanced Thermal and Environmental Barrier Coatings: Processing, Properties, and Applications			
Environmental Barrier Coating Processing and Development	Thursday, June 30, 2016	8:30 AM - Noon	Trinity IV
Environmental Barrier Coating Processing, Characterizaton and Modeling	Thursday, June 30, 2016	1:30 - 5:30 PM	Trinity IV
Advanced Thermal and Environmental Barrier Coatings	Friday, July 1, 2016	8:40 AM - 12:20 PM	Trinity IV
H7. Thermomechanical Behavior and Performance of Composites			
Creep, Rupture, and Fatigue of CMCs	Thursday, June 30, 2016	8:30 - 10:30 AM	Salon D
Environmental Effects at Elevated Temperatures	Thursday, June 30, 2016	10:30 - 11:10 AM	Salon D
Modeling Thermo/mechanical/environmental Behavior of CMCs	Thursday, June 30, 2016	1:30 - 3:20 PM	Salon D
Elevated Temperature Test Techniques	Thursday, June 30, 2016	3:20 - 4:40 PM	Salon D

Technical Program at a Glance

Session Title	Date	Time	Location
H8: Ceramic Integration and Additive Manufacturing Technologies			
Ceramic Integration and Additive Manufacturing Technologies	Monday, June 27, 2016	1:30 - 5:00 PM	Salon D
H9. Component Testing and Evaluation of Composites			
Characterization of Ceramic Matrix Composites	Thursday, June 30, 2016	8:30 AM - Noon	Trinity I/II
CMC Properties under Severe Conditions	Thursday, June 30, 2016	1:30 - 5:10 PM	Trinity I/II
H11. CMC Applications in Transportation and Industrial Systems (includes H10)			
High Performance Friction Materials	Monday, June 27, 2016	1:30 - 4:40 PM	Salon C
Materials and Manufacturing Processes for Serial Production	Tuesday, June 28, 2016	8:30 - 10:20 AM	Salon C
Oxidation and Corrosion of Hot Structures in Realistic Environments	Tuesday, June 28, 2016	10:20 AM - Noon	Salon C
Novel Application areas and Technology Transfer	Tuesday, June 28, 2016	1:30 - 4:40 PM	Salon C
Young Professionals Forum - Next Generation Materials for Multifunctional Applications and Sustainable Development, and Concurrent Societal Challenges in the New Millennium			
Young Professional Forum I: Funding, Academia, Industry, and Beyond	Monday, June 27, 2016	1:30 - 3:20 PM	York A
Young Professional Forum II: Health and Materials	Monday, June 27, 2016	3:20 - 5:20 PM	York A
Young Professional Forum III: Multifunctional Materials, Porous, and Catalytic Materials	Tuesday, June 28, 2016	8:30 - 10:20 AM	York A
Young Professional Forum IV: Health, Energy, and Emerging Technologies	Tuesday, June 28, 2016	10:20 AM - Noon	York A
Young Professional Forum V: Seminar	Tuesday, June 28, 2016	Noon - 1:15 PM	York A
G1. Powder Processing Innovation and Technologies for Advanced Materials and Sustainable Development			
Energy-saving Processing, Smart Recycling of Materials, and Particle Design	Monday, June 27, 2016	1:30 - 5:30 PM	Trinity III
Advanced Characterization and Composite Particles	Tuesday, June 28, 2016	8:30 AM - 12:20 PM	Trinity III
Composite and Porous Structure Control	Tuesday, June 28, 2016	1:30 - 5:30 PM	Trinity III
Novel Shaping, Forming, Sintering Technology and Nano/microstructure Control	Wednesday, June 29, 2016	8:30 - 11:40 AM	Trinity III
G2. Functional Nanomaterials for Sustainable Energy Technologies			
Functional Nanomaterials for Sustainable Energy Technologies I	Monday, June 27, 2016	2:00 - 4:30 PM	York B
Functional Nanomaterials for Sustainable Energy Technologies II	Tuesday, June 28, 2016	2:00 - 5:20 PM	York A
Functional Nanomaterials for Sustainable Energy Technologies III	Wednesday, June 29, 2016	9:00 - 11:50 AM	York A
Functional Nanomaterials for Sustainable Energy Technologies IV	Thursday, June 30, 2016	8:30 AM - Noon	York A
G3: Novel, Green, and Strategic Processing and Manufacturing Technologies			
Novel, Green, and Strategic Processing I	Thursday, June 30, 2016	8:30 AM - Noon	York B
Novel, Green, and Strategic Processing II	Thursday, June 30, 2016	1:30 - 4:40 PM	York B
Novel, Green, and Strategic Processing III	Friday, July 1, 2016	8:30 - 11:40 AM	York B

Session Title	Date	Time	Location
G4. Ceramics for Sustainable Infrastructure: Geopolymers and Sustainable Composites			
Green Building Materials	Wednesday, June 29, 2016	8:30 - 11:30 AM	Trinity IV
G5. Advanced Materials, Technologies, and Devices for Electro-optical and Medical Applications			
Semiconductor I	Monday, June 27, 2016	1:30 - 5:10 PM	Trinity V
Optical Material I	Tuesday, June 28, 2016	8:30 - 11:50 AM	Trinity V
Semiconductor II	Tuesday, June 28, 2016	1:30 - 5:10 PM	Trinity V
Optical Material II	Wednesday, June 29, 2016	8:30 - 11:40 AM	Trinity V
Optical Material III	Thursday, June 30, 2016	8:30 - 11:50 AM	Trinity V
Optical Material IV	Thursday, June 30, 2016	1:30 - 3:20 PM	Trinity V
Ferro/Piezo I	Thursday, June 30, 2016	3:20 - 5:20 PM	Trinity V
Ferro/Piezo II	Friday, July 1, 2016	8:30 - 11:50 AM	Trinity V
G6: Porous Ceramics for Advanced Applications Through Innovative Processing			
Innovative Characterizations, Modeling and Mechanical Responses of Porous Ceramics	Monday, June 27, 2016	1:30 - 3:20 PM	Trinity I/II
Advanced Processing Methods and Characterization Technologies of Ceramic Foams I	Monday, June 27, 2016	3:20 - 5:40 PM	Trinity I/II
Novel Sintering Technologies for Porous Ceramics	Tuesday, June 28, 2016	9:00 - 10:20 AM	Trinity I/II
Recent Innovations in Freeze Casting	Tuesday, June 28, 2016	10:20 AM - Noon	Trinity I/II
Advanced Processing Methods and Characterization Technologies of Ceramic Foams II	Tuesday, June 28, 2016	1:30 - 3:20 PM	Trinity I/II
Novel Developments and Engineering Applications of Porous Ceramics	Tuesday, June 28, 2016	3:20 - 5:30 PM	Trinity I/II
Membranes and High SSA Ceramics	Wednesday, June 29, 2016	8:30 - 10:20 AM	Trinity I/II
Innovations in Processing Methods of Porous Ceramics	Wednesday, June 29, 2016	10:20 AM - Noon	Trinity I/II
G7: Advanced Functional Materials, Devices, and Systems for Environmental Conservation and Pollution Control			
Advanced Functional Materials, Devices, and Systems for Environmental Conservation and Pollution Control I	Thursday, June 30, 2016	9:00 AM - Noon	Trinity III
Advanced Functional Materials, Devices, and Systems for Environmental Conservation and Pollution Control II	Thursday, June 30, 2016	1:40 - 5:10 PM	Trinity III
Advanced Functional Materials, Devices, and Systems for Environmental Conservation and Pollution Control III	Friday, July 1, 2016	8:40 - 11:30 AM	Trinity III
G8. Multifunctional Coatings for Sustainable Energy and Environmental Applications			
Coatings for Engineering Applications	Tuesday, June 28, 2016	8:30 AM - Noon	York B
Coatings for Energy and Environmental Applications	Tuesday, June 28, 2016	1:30 - 5:40 PM	York B
Functional Coatings and Thin Films	Wednesday, June 29, 2016	8:30 AM - Noon	York B

Symposia listing with organizers

H1: Computational modeling and design of new materials and processes

Organizers: Gerard L. Vignoles, University of Bordeaux, Laboratory for Thermostructural Composites, France; Jing-Yang Wang, Institute of Metal Research, China; Emmanuel Baranger, ENS Cachan, France; Hans J. Seifert, Karlsruhe Institute of Technology, Germany; Qingfeng Zeng, Northwestern Polytechnical University, China; Yong Du, Central South University, China

H2: Design and development of advanced ceramic fibers, interfaces, and interphases in composites: A symposium in honor of professor Roger Naslain

Organizers: Bernd Clauss, Institute of Textile Chemistry and Chemical Fibers, Germany; René Pailler, French National Centre for Scientific Research, Laboratory for Thermostructural Composites, France; Toshihiro Ishikawa, Tokyo University of Science, Japan; Greg N. Morscher, University of Akron, USA; Ron Kerans, US Air Force Research Laboratory, USA; Lalit M. Manocha, Defence Materials Stores, Research & Development Establishment, India; Akira Kohyama, Muroran Institute of Technology, Japan; Natalya I. Baklanova, Institute of Solid State Chemistry and Mechanochemistry, Russia; Sylvain Jacques, French National Centre for Scientific Research, Laboratory for Thermostructural Composites, France; Ji Yeon Park, Korea Atomic Energy Research Institute, Korea; Shaoming Dong, Shanghai Institute of Ceramics, Chinese Academy of Sciences, China

H3: Innovative design, advanced processing, and manufacturing technologies

Organizers: Shaoming Dong, Shanghai Institute of Ceramics, Chinese Academy of Sciences, China; Walter Krenkel, University of Bayreuth, Germany; Hai-Doo Kim, Korea Institute of Materials Science, Korea; Dileep Singh, Argonne National Laboratory, USA; David B. Marshall, Teledyne Scientific Co., USA; Michael Cinibulk, US Air Force Research Laboratory, USA; Jacques Lamon, French National Centre for Scientific Research, University of Bordeaux, France; Andrea Lazzeri, University of Piza, Italy; Ji Yeon Park, Korea Atomic Energy Research Institute, Korea; Laifei Cheng, Northwestern Polytechnical University, China; Katsumi Yoshida, Tokyo Institute of Technology, Japan; Sergei T. Mileiko, Institute for Solid State Physics, Russian Academy of Sciences, Russia; Yutaka Kagawa, University of Tokyo, Japan; Christian Wilhelmi, EADS Innovation Works, Airbus Group Innovations, Germany; Dechang Jia, Harbin Institute of Technology, China

H4: Materials for extreme environments: Ultrahightemperature ceramics and nano-laminated ternary carbides and nitrides (MAX phases)

Organizers: Yanchun Zhou, Aerospace Research Institute of Material and Processing Technology, China; Jon Binner, University of Birmingham, UK; Erica L. Corral, University of Arizona, USA; Sea-Hoon Lee, Korea Institute of Materials Science, Korea; Per Eklund, Linköping University, Sweden; William G. Fahrenholtz, Missouri University of Science and Technology, USA; Greg Hilmas, Missouri University of Science and Technology, USA; Peter McBreen, Laval University, Canada; Frederic Monteverde, Institute of Science and Technology for Ceramic Materials, National Research Institute, Italy; Miladin Radovic, Texas A&M University, USA; Jochen Schneider, Rhine-Westphalia Institute of Technology Aachen, Germany; Luc J. Vandeperre, Imperial College London, UK; Guo-Jun Zhang, Shanghai Institute of Ceramics, Chinese Academy of Sciences, China

H5: Polymer-derived ceramics and composites

Organizers: Paolo Colombo, Università di Padova, Italy; Ralf Riedel, Technical University Darmstadt, Germany; Philippe Miele, University of Montpellier 2, France; Guenter Motz, University of Bayreuth, Germany; Gian Domenico Sorarù, University of Trento, Italy; Peter Kroll, University of Texas, USA; Gurpreet Singh, Kansas State University, USA; Yuichi Ikuhara, University of Tokyo, Japan; Yuji Iwamoto, Nagoya Institute of Technology, Japan; Zhaoju Yu, Xiamen University, China; Yiguang Wang, Northwestern Polytechnical University, China; Yingde Wang, National University of Defense Technology, China

H6: Advanced thermal and environmental barrier coatings: Processing, properties, and applications

Organizers: Dongming Zhu, NASA Glenn Research Center, USA; Satoshi Kitaoka, Japan Fine Ceramics Center, Japan; Hagen Klemm, Fraunhofer Institute for Ceramic Technologies and Systems IKTS, Germany; Peter Mechnich, German Aerospace Center, Germany; Soumendra N. Basu, Boston University, USA; Robert Vaßen, Jülich Research Centre GmbH, Germany; Yutaka Kagawa, University of Tokyo, Japan; Daniel R. Mumm, University of California, Irvine, USA; Rogerio S. Lima, National Research Council, Canada; Molly Gentleman, Stony Brook University, USA; Ping Xiao, University of Manchester, UK; Jacques Lamon, National Centre of Scientific Research, France; Yan-Chun Zhou, Aerospace Research Institute of Material and Processing Technology, China; Valerie Wiesner, NASA Glenn Research Center, USA

H7: Thermomechanical behavior and performance of composites

Organizers: Gregory N. Morscher, University of Akron, USA; Triplicane Parthasarathy, UE S Inc., USA; Hejun Li, Northwestern Polytechnical University, China; Jacques Lamon, National Centre of Scientific Research, France; Craig Przybyla, US Air Force Materiel Command, US Air Force Research Laboratory, USA; Frank Zok, University of California Santa Barbara, USA; Marina Ruggles-Wrenn, Air Force Institute of Technology, USA; James D. Kiser, NASA Glenn Research Center, USA

H8: Ceramic integration and additive manufacturing Technologies

Organizers: Monica Ferraris, Politecnico di Torino, Italy; Michael C. Halbig, NASA Glenn Research Center, USA; Soshu Kirihara, Osaka University, Japan; Johannes Homa, Lithos GmbH, Austria; Miranda Fateri, FH Aachen, Germany; Cynthia Gomes, BAM Federal Institute for Materials Research and Testing, Germany; Tatsuya Hinoki, Kyoto University, Japan; Michael J. Reece, Queen Mary University of London, UK; Cesar R. Foschini, Sao Paulo State University, Brazil; Thomas Weißgärber, Fraunhofer Institute for Manufacturing Technology and Advanced Materials, Dresden, Germany

H9: Component testing and evaluation ofComposites
Organizers: Dietmar Koch, German Aerospace Center, Germany; Greg N. Morscher, University of Akron, USA; Tatsuya Hinoki, Kyoto University, Japan; Laifei Cheng, Northwestern Polytechnical University, China

H10: Energy and aerospace applications: Challenges and opportunities (combined with H11)
Organizers: Hua-Tay Lin, Guangdong University of Technology, China; Yutaka Kagawa, University of Tokyo, Japan; Yutai Katoh, Oak Ridge National Lab, USA; Laifei Cheng, Northwestern Polytechnic University, China; Walter Krenkel, University of Bayreuth, Germany; Ji-Jung Kai, City University of Hong Kong, Hong Kong; John Holowczak, United Technologies Research Center, USA; Jay Lane, Rolls-Royce Corp., USA; Shaoming Dong, Shanghai Institute of Ceramics, Chinese Academy of Sciences, China; David Marshall, Teledyne Scientific Company, USA; Jacques Lamon, National Centre for Scientific Research, France

H11: Ground-based applications: Transportation and industrial systems
Organizers: Bernhard Heidenreich, German Aerospace Center, Germany; Shaoming Dong, Shanghai Institute of Ceramics, Chinese Academy of Sciences, China; Peter Filip, Southern Illinois University, USA; Yutaka Kagawa, University of Tokyo, Japan; Tomaž Kosmač, Jozef Stefan Institute, Slovenia; Walter Krenkel, University of Bayreuth, Germany; Victor I. Kulik, Baltic State Technical University, Russia; Matthias Kunz, WPX Faserkeramik GmbH, Germany; Alex Luan, Northwestern Polytechnical University, China; Lalit M. Manocha, Defence Materials Stores, Research & Development Establishment, India; Marco Orlandi, Brembo SGL Carbon Ceramic Brakes, Italy; Gerard L. Vignoles, University of Bordeaux, Laboratory for Thermostructural Composites, France; Roland Weiss, Schunk Kohlenstofftechnik, Germany

G1: Powder processing innovation and technologies for advanced materials and sustainable development
Co-organized with the Society of Powder Technology, Japan, and Society for the Promotion of Science 124th Committee, Japan
Organizers: Makio Naito, Joining and Welding Research Institute Osaka University, Japan; Junichi Tatami, Yokohama National University, Japan; Masayoshi Fuji, Nagoya Institute of Technology, Japan; Yuji Hotta, National Institute of Advanced Industrial Science and Technology, Japan; Ewsuk Kevin, Sandia National Laboratories, USA; Sanjay Mathur, University of Cologne, Germany; Yoshio Sakka, National Institute for Materials Science, Japan; Koichi Yasuda, Tokyo Institute of Technology, Japan; Di Zhang, Shanghai Jiao Tong University, China

G2: Functional nanomaterials for sustainable energy technologies
Organizers: Sanjay Mathur, University of Cologne, Germany; Lionel Vayssieres, Xi'an Jiaotong University, China; Yoon-Bong Hahn, Chonbuk National University, Korea; Silke Christiansen, Helmholtz Energy Zentrum, Berlin; Heli Wang, National Renewable Energy Laboratory, Colorado, USA; Juan-Ramon Morante, Catalonia Institute for Energy Research, Spain; Gunnar Westin, Uppsala University, Sweden; Daniel Chua, National University Singapore, Singapore; Taejin Hwang, Korea Institute of Industrial Technology, Korea; Thomas Fischer, University of Cologne, Germany

G3: Novel, green, and strategic processing and manufacturing technologies
Organizers: Tatsuki Ohji, National Institute of Advanced Industrial Science and Technology, Japan; Surojit Gupta, University of North Dakota, USA; Manish Mehta, National Center for Manufacturing Sciences, USA; Richard D. Sisson Jr., Worcester Polytechnic Institute, USA; Tohru S. Suzuki, National Institute for Materials Science, Japan; Yiquan Wu, Alfred University, USA; Jerzy Lis, AGH University of Technology, Poland

G4: Ceramics for sustainable infrastructure: Geopolymers and sustainable composites
Organizers: Waltraud M. Kriven, University of Illinois at Urbana-Champaign, USA; Henry A. Colorado, University of Antioquia, Colombia

G5: Advanced materials, technologies, and devices for electro-optical and medical applications
Organizers: Kiyoshi Shimamura, National Institute for Materials Science, Japan; Noboru Ichinose, Waseda University, Japan; Didier Chaussende, National Centre for Scientific Research, Grenoble, France; Christophe Dujardin, Claude Bernard University Lyon 1, France; Qiang Li, Tsinghua University, China; Alain Largeteau, Institute for Solid State Chemistry Bordeaux, France; Mikio Higuchi, Hokkaido University, Japan; Toru Ujihara, Nagoya University, Japan; Yuji Noguchi, Tokyo University, Japan; Hiroshi Maiwa, Shonan Institute of Technology, Japan

G6: Porous ceramics for advanced applications through innovative processing
Organizers: Manabu Fukushima, National Institute of Advanced Industrial Science and Technology, Japan; Young-Wook Kim, University of Seoul, Korea; Paolo Colombo, University of Padua, Italy; Samuel Bernard, European Institute of Membranes, France; Tobias Fey, University of Erlangen-Nuremberg, Germany; Tim Van Gestel, Jülich Research Centre, Germany; Yuji Iwamoto, Nagoya Institute of Technology, Japan; Yasuo Kogo, Tokyo University of Science, Japan; Alberto Ortona, University of Applied Sciences and Arts of Southern Switzerland, Switzerland; Aleksander Pyzik, Dow Chemical Company, USA; Yuping Zeng, Shanghai Institute of Ceramics, Chinese Academy of Sciences, China

Symposia Listing with Organizers

G7: Advanced functional materials, devices, and systems for environmental conservation and pollution control
Organizers: Nobuhito Imanaka, Osaka University, Japan; Taek-Soo Kim, Korea Institute of Industrial Technology, Korea; Shinobu Fujiwara, Keio University, Japan; Yasuhiro Shimizu, Nagasaki University, Japan

G8: Multifunctional coatings for sustainable energy and environmental applications
Organizers: Jun Akedo, National Institute of Advanced Industrial Science and Technology, Japan; Masakatsu Kiyohara, TOTO Ltd., Japan; Seiji Kuroda, National Institute for Materials Science, Japan; Hiroaki Nishikawa, Kinki University, Japan; Sanjay Sampath, Stony Brook University, USA; Tom Coyle, University of Toronto, Canada; Dong-Soo Park, Korea Institute of Materials Science, Korea; Tatsuki Ohji, National Institute for Materials Science, Japan; Tetsuo Tsuchiya, National Institute for Materials Science, Japan

Young Professionals Forum: Next-generation materials for multifunctional applications and sustainable development, and concurrent societal challenges in the new millennium
Organizers: Surojit Gupta, University of North Dakota, USA; Eva Hemmer, National Institute of Scientific Research –Center for Energy, Materials and Telecommunications, Canada; Rafik Naccache, National Institute of Scientific Research –Center for Energy, Materials and Telecommunications, Canada; Peter Wich, Johannes Gutenberg University Mainz, Germany; Partha P. Mukherjee, Texas A&M University, USA; Aiguo Zhou, Henan Polytechnic University, China; Dongsheng Wen, University of Leeds, UK; P. Ramasamy, Anna University, India; Thomas Fischer, University of Cologne, Germany

Oral Presenters

Name	Date	Time	Room	Page Number
		A		
Akedo, J.	28-Jun	2:00PM	York B	14
Akedo, J.	30-Jun	1:30PM	York B	23
Allemand, A.	1-Jul	9:10AM	Salon C	30
Allix, M.	29-Jun	10:40AM	Trinity V	20
Almansour, A.S.	30-Jun	9:10AM	Salon D	27
Almeida, R.S.	29-Jun	9:20AM	Salon D	21
Andi, U.	28-Jun	2:40PM	Salon C	17
Aoki, T.	28-Jun	2:00PM	Bay	15
Apostolov, Z.D.	28-Jun	10:50AM	Salon D	11
Arnal, S.	30-Jun	5:10PM	Trinity IV	27
Ashizawa, H.	28-Jun	2:20PM	York B	14
Asthana, R.	27-Jun	2:20PM	Salon D	6
		B		
Backman, L.	30-Jun	11:20AM	Salon C	25
Backov, R.	29-Jun	10:20AM	Trinity I/II	20
Banerjee, S.	28-Jun	10:20AM	York A	12
Basha, M.	28-Jun	4:20PM	Salon C	17
Bausa, L.E.	30-Jun	8:30AM	Trinity V	23
Becker, T.	1-Jul	9:20AM	Bay	30
Bernard, S.	28-Jun	10:20AM	Trinity IV	11
Bernard, S.	29-Jun	9:40AM	Trinity I/II	20
Bernardo, E.	28-Jun	1:30PM	Trinity I/II	14
Bernardo, E.	28-Jun	11:10AM	Trinity IV	11
Bessho, M.	28-Jun	8:30AM	Trinity V	9
Bhatt, R.	30-Jun	8:30AM	Salon D	27
Boakye, E.E.	28-Jun	4:20PM	Salon D	15
Bordia, R.	27-Jun	1:30PM	Trinity I/II	8
Bordia, R.	30-Jun	8:30AM	Trinity IV	26
Bouillon, E.	28-Jun	11:20AM	Salon C	12
Bourret, E.	29-Jun	8:30AM	Trinity V	20
Braulio, M.	30-Jun	2:40PM	Trinity I/II	28
Buekenhoudt, A.	29-Jun	8:30AM	Trinity I/II	20
Bureau, B.	30-Jun	10:20AM	Trinity V	23
		C		
Caccia, M.R.	28-Jun	2:00PM	Trinity I/II	14
Caccia, M.R.	28-Jun	9:30AM	Salon C	12
Carney, C.	30-Jun	3:50PM	Salon C	26
Chandio, A.D.	1-Jul	11:40AM	Trinity IV	31
Chaussende, D.	28-Jun	4:10PM	Trinity V	14
Chen, M.Y.	30-Jun	3:50PM	Trinity I/II	28
Chen, X.	1-Jul	10:20AM	York B	29
Chen, Y.	28-Jun	3:50PM	York A	13
Cheng, L.	28-Jun	3:20PM	Bay	16
Cherepy, N.	29-Jun	9:00AM	Trinity V	20
Cho, T.	30-Jun	11:20AM	York B	22
Chuankrerkkul, N.	28-Jun	11:20AM	Bay	11
Clauss, B.	28-Jun	8:30AM	Trinity IV	11
Clerici, M.	28-Jun	10:50AM	York A	12
Colling, T.	28-Jun	9:50AM	York A	12
Colombo, P.	28-Jun	10:50AM	Trinity IV	11
Colorado, H.	29-Jun	10:20AM	Trinity IV	20
Cook, R.D.	27-Jun	5:30PM	Trinity IV	6
Coyle, T.	28-Jun	4:10PM	York B	15
		D		
Dabkowska, H.A.	28-Jun	11:20AM	Trinity V	9
Dai, J.	30-Jun	9:40AM	Bay	25
Dairiki, K.	30-Jun	10:40AM	York B	22
Dittert, C.	28-Jun	4:10PM	Trinity I/II	14
Dong, C.	28-Jun	3:20PM	York A	13
Dong, S.	28-Jun	10:20AM	Salon C	12
Dong, S.	28-Jun	2:30PM	Bay	16
Duan, X.	30-Jun	5:10PM	Salon C	26
Durif, C.	27-Jun	4:40PM	Trinity I/II	8
Dutto, M.	27-Jun	2:00PM	Trinity III	7
		E		
Eng, R.	27-Jun	4:50PM	Trinity IV	6
Esslinger, J.	27-Jun	11:20AM	Salon A/B	5
Estili, M.	27-Jun	3:20PM	Trinity III	7
Ewsuk, K.	28-Jun	2:30PM	Trinity III	13
		F		
Fellah, C.	28-Jun	2:00PM	Salon D	15
Feller, J.	30-Jun	10:50AM	York A	22
Feng, L.	30-Jun	4:30PM	Salon C	26
Fey, T.	28-Jun	4:30PM	Trinity I/II	14
Fonblanc, D.	28-Jun	1:40PM	Trinity IV	16
Fu, Z.	1-Jul	8:50AM	Salon C	30
Fu, Z.	30-Jun	9:00AM	York B	22
Fu, Z.	30-Jun	9:20AM	Salon C	25
Fujihara, S.	30-Jun	4:40PM	Trinity III	24
Fujii, Y.	27-Jun	3:20PM	Trinity V	8
Fukushima, M.	1-Jul	11:20AM	York B	29
Fukushima, M.	28-Jun	11:00AM	Trinity I/II	10
Fukushima, M.	28-Jun	9:30AM	Trinity IV	11
		G		
Gadow, R.	27-Jun	4:20PM	Trinity IV	6
Gansert, R.V.	1-Jul	10:20AM	Trinity IV	31
Gaume, R.M.	29-Jun	9:30AM	Trinity V	20
Go, T.	29-Jun	9:40AM	Salon D	21
Gogia, B.	30-Jun	9:00AM	Trinity IV	26
Golden, R.A.	28-Jun	4:40PM	Bay	16
Gopinathan Nair, A.M.	1-Jul	10:50AM	Trinity V	29
Gu, H.	30-Jun	4:10PM	Salon C	26
Guan, X.	28-Jun	4:40PM	York A	13
Guo, C.	27-Jun	5:10PM	Trinity III	7
Gupta, M.	1-Jul	11:00AM	Trinity IV	31
Gupta, S.	1-Jul	10:40AM	York B	29
Gupta, S.	28-Jun	11:40AM	York A	12
Gupta, S.	30-Jun	10:20AM	York B	22
		H		
Ha, J.	29-Jun	9:00AM	Trinity I/II	20
Hackemann, S.	30-Jun	9:00AM	Trinity I/II	28
Hagiwara, M.	1-Jul	10:50AM	Trinity III	29
Halbig, M.C.	27-Jun	2:00PM	Salon D	6
Hara, K.	28-Jun	1:30PM	Trinity V	13
Hasegawa, M.	1-Jul	9:00AM	Trinity IV	30
Haug, S.J.	27-Jun	4:00PM	Trinity IV	6
Hay, R.	28-Jun	9:20AM	Salon D	11
Heidenreich, B.	28-Jun	2:20PM	Salon C	16
Hemmer, E.	27-Jun	4:50PM	York A	9
Hemmer, E.	29-Jun	9:30AM	York A	19
Herrmann, M.	27-Jun	3:20PM	Salon D	6
Hodaj, F.	27-Jun	4:20PM	Salon D	6
Hojo, J.	30-Jun	3:40PM	Trinity III	24
Hosono, E.	30-Jun	10:40AM	Trinity III	24
Hotta, Y.	28-Jun	4:50PM	Trinity III	13
Hu, C.	27-Jun	3:50PM	Bay	5
Hu, D.	30-Jun	2:00PM	Salon C	26
Hu, J.	28-Jun	2:20PM	Salon D	15
Hu, J.	30-Jun	9:30AM	Trinity V	23
Hu, K.	28-Jun	9:30AM	York A	12
Huang, Z.	30-Jun	4:50PM	Salon C	26
Humbs, W.	28-Jun	1:30PM	Salon C	16
		I		
Iijima, M.	28-Jun	11:40AM	Trinity III	9
Imanaka, N.	30-Jun	2:30PM	Trinity III	24
Imanaka, Y.	30-Jun	3:50PM	Trinity V	23
Inada, M.	28-Jun	3:50PM	Trinity I/II	14
Inoue, R.	28-Jun	2:20PM	Trinity I/II	14
Ionescu, E.	28-Jun	2:00PM	Trinity IV	16
Ionescu, E.	28-Jun	2:20PM	Trinity IV	16
Ionescu, E.	30-Jun	8:30AM	Salon C	25
Iqbal, A.	29-Jun	11:30AM	York A	20
Ishihara, S.	28-Jun	12:00PM	Trinity III	9
Ishikawa, R.	28-Jun	2:00PM	Trinity V	14
Ishikawa, R.	28-Jun	3:40PM	Trinity IV	16

Oral Presenters

Name	Date	Time	Room	Page Number
Ishikawa, T.	30-Jun	9:30AM	York B	22
Isu, N.	28-Jun	4:20PM	Trinity III	13
Ito, A.	30-Jun	10:30AM	Trinity IV	26
		J		
Jackson, B.	27-Jun	5:10PM	Bay	5
Jacques, S.	28-Jun	3:40PM	Salon D	15
Jang, B.	30-Jun	4:30PM	Trinity IV	27
Jeon, J.	30-Jun	4:20PM	Trinity V	23
Jia, D.	29-Jun	8:30AM	Bay	21
Jiang, W.	1-Jul	11:10AM	Trinity III	30
Jones, J.P.	30-Jun	3:20PM	Salon D	28
		K		
Kaban, I.	1-Jul	9:30AM	Salon C	30
Kagawa, Y.	27-Jun	4:10PM	Salon C	6
Kagawa, Y.	28-Jun	8:30AM	York B	10
Kageyama, H.	30-Jun	1:40PM	Trinity III	24
Kakisawa, H.	30-Jun	4:10PM	Trinity IV	27
Kamimura, M.	27-Jun	4:20PM	York A	9
Kamitani, M.	28-Jun	8:30AM	Trinity III	9
Kamiya, T.	27-Jun	4:40PM	Trinity V	8
Kanechika, Y.	27-Jun	2:30PM	Trinity V	7
Kanechika, Y.	27-Jun	4:10PM	Trinity III	7
Kang, J.	28-Jun	2:00PM	Trinity III	13
Kaplan, W.D.	30-Jun	8:30AM	York B	22
Kawaharamura, T.	28-Jun	4:30PM	York B	15
Kawanishi, K.	30-Jun	4:50PM	Trinity I/II	28
Kelso, J.F.	28-Jun	9:30AM	Trinity V	9
Kerans, R.J.	28-Jun	3:20PM	Salon D	15
Khanna, A.S.	28-Jun	4:10PM	Bay	16
Kherani, N.P.	27-Jun	2:00PM	York B	7
Kim, D.	29-Jun	10:50AM	Trinity I/II	20
Kim, D.	30-Jun	4:10PM	Trinity I/II	28
Kim, K.	27-Jun	3:20PM	Salon C	6
Kim, Y.	29-Jun	9:20AM	Trinity I/II	20
Kim, Y.	30-Jun	2:30PM	York B	23
Kirihara, S.	1-Jul	9:00AM	York B	29
Kirihara, S.	27-Jun	2:40PM	Salon D	6
Kiser, J.D.	27-Jun	4:50PM	Bay	5
Kiser, J.D.	30-Jun	4:30PM	Trinity I/II	28
Kishi, H.	30-Jun	3:20PM	Trinity V	23
Kita, K.	28-Jun	5:10PM	Trinity I/II	14
Kitaoka, S.	30-Jun	9:50AM	Trinity IV	26
Kleebe, H.	28-Jun	3:20PM	Trinity IV	16
Klemm, H.	27-Jun	1:30PM	Bay	5
Klemm, H.	30-Jun	3:20PM	Trinity I/II	28
Kobayashi, K.	27-Jun	4:50PM	Trinity III	7
Koch, D.	27-Jun	1:30PM	Trinity IV	5
Kodama, N.	30-Jun	1:30PM	Trinity V	23
Koel, B.E.	28-Jun	2:00PM	York A	13
Konegger, T.	28-Jun	10:50AM	Bay	11
Kothanda Ramachandran, D.	30-Jun	10:20AM	Salon C	25
Kothanda Ramachandran, D.	30-Jun	11:40AM	Salon C	26
Krenkel, W.	27-Jun	1:30PM	Salon C	6
Krenkel, W.	29-Jun	10:20AM	Bay	22
Kriven, W.M.	29-Jun	8:30AM	Trinity IV	20
Kulik, A.	1-Jul	10:40AM	Bay	30
Kulik, A.	30-Jun	10:20AM	Bay	25
Kulik, V.	27-Jun	2:00PM	Salon C	6
Kumar, R.S.	30-Jun	2:40PM	Salon D	27
Kunz, W.	30-Jun	9:30AM	Trinity IV	26
		L		
Lange, F.	1-Jul	9:00AM	Bay	30
Langhof, N.	27-Jun	2:30PM	Salon C	6
Largeteau, A.	30-Jun	4:50PM	Trinity V	24
Larson, N.M.	29-Jun	9:00AM	Bay	21
Lazzeri, A.	27-Jun	4:30PM	Bay	5
Lee, H.	28-Jun	8:30AM	Bay	11
Legin, B.	30-Jun	10:20AM	Trinity I/II	28
Leisner, V.	30-Jun	2:00PM	Trinity IV	27

Name	Date	Time	Room	Page Number
Lewis, A.	27-Jun	1:30PM	York A	8
Li, J.	28-Jun	5:00PM	Salon D	15
Li, L.	30-Jun	2:20PM	Salon D	27
Li, M.	30-Jun	8:30AM	York A	22
Li, Q.	1-Jul	9:30AM	Trinity V	29
Li, S.	30-Jun	3:20PM	Salon C	26
Li, Y.	29-Jun	11:00AM	Trinity III	19
Li, Z.	28-Jun	3:50PM	Trinity III	13
Lilova, K.	1-Jul	11:20AM	Trinity IV	31
Liu, M.	27-Jun	3:50PM	York B	7
Liu, Y.	27-Jun	2:00PM	Bay	5
Liu, Y.	27-Jun	4:40PM	Salon D	6
Liu, Y.	30-Jun	10:50AM	Bay	25
Liu, Y.	30-Jun	4:00PM	York B	23
Loison, S.	28-Jun	9:00AM	Salon D	11
Lu, G.	28-Jun	4:20PM	York A	13
Luan, X.	28-Jun	10:50AM	Salon C	12
		M		
Ma, D.	27-Jun	2:30PM	York B	7
Magdaluyo, E.D.	28-Jun	5:00PM	York A	13
Mahshid, S.	30-Jun	2:00PM	Trinity V	23
Mahshid, S.S.	30-Jun	11:20AM	York A	22
Maillé, L.	29-Jun	9:20AM	Bay	21
Maiwa, H.	1-Jul	10:20AM	Trinity V	29
Manghnani, M.	28-Jun	11:10AM	Salon D	11
Manghnani, M.	30-Jun	2:20PM	Salon C	26
Manocha, L.M.	28-Jun	3:20PM	Salon C	17
Manocha, S.	28-Jun	3:50PM	Salon C	17
Mansour, R.	30-Jun	11:00AM	Trinity I/II	28
Manulyk, A.	1-Jul	8:30AM	Salon C	30
Markel, I.J.	30-Jun	4:30PM	Bay	25
Mathur, S.	28-Jun	10:20AM	Trinity III	9
Matsuda, M.	30-Jun	9:00AM	Trinity III	24
Matsunaga, C.	28-Jun	11:20AM	Trinity I/II	10
Matsuoka, M.	28-Jun	10:50AM	Trinity III	9
Mechnich, P.	30-Jun	4:50PM	Trinity IV	27
Medri, V.	27-Jun	3:20PM	Trinity I/II	8
Mileiko, S.T.	29-Jun	8:30AM	Salon D	21
Millstone, J.	27-Jun	3:20PM	York B	7
Millstone, J.	28-Jun	9:00AM	York A	12
Miura, A.	28-Jun	2:20PM	Trinity V	14
Miyayama, M.	30-Jun	11:30AM	Trinity III	24
Mogilevsky, P.	28-Jun	4:00PM	Salon D	15
Moreau, C.	28-Jun	10:50AM	York B	10
Morscher, G.N.	30-Jun	8:30AM	Trinity I/II	28
Mostaghimi, J.	28-Jun	9:30AM	York B	10
Muto, H.	27-Jun	2:40PM	Trinity I/II	8
		N		
Naccache, R.	27-Jun	3:50PM	York A	9
Naito, M.	29-Jun	9:40AM	Trinity III	19
Nakamura, J.	27-Jun	2:40PM	Trinity III	7
Nakamura, T.	28-Jun	3:40PM	Trinity V	14
Nakamura, T.	29-Jun	9:30AM	York B	21
Nakanishi, T.	30-Jun	11:20AM	Trinity V	23
Nakao, W.	28-Jun	11:40AM	Salon C	12
Namura, K.	29-Jun	10:40AM	York B	21
Narciso, J.	28-Jun	3:50PM	Bay	16
Narciso, J.	28-Jun	4:50PM	Trinity I/II	14
Naslain, R.R.	28-Jun	8:30AM	Salon D	10
Natali Murri, A.	29-Jun	9:00AM	Trinity IV	20
Newton, C.D.	30-Jun	9:40AM	Trinity I/II	28
Nier, N.	27-Jun	4:10PM	Bay	5
Nikonam Mofrad, R.	28-Jun	9:40AM	Trinity I/II	10
Nishikawa, H.	28-Jun	5:20PM	York B	15
Nishikawa, H.	29-Jun	11:40AM	York B	21
Noeth, A.	28-Jun	10:20AM	Salon D	11
		O		
Oda, H.	28-Jun	9:40AM	Salon D	11
Ogasawara, K.	1-Jul	9:00AM	Trinity III	29

Oral Presenters

Name	Date	Time	Room	Page Number
Ogawa, K.	28-Jun	9:00AM	York B	10
Ogawa, T.	1-Jul	8:30AM	Trinity V	29
Ogawa, T.	1-Jul	9:00AM	Trinity V	29
Ogawa, T.	1-Jul	9:20AM	Trinity IV	30
Ohashi, N.	27-Jun	3:50PM	Trinity V	8
Ohji, T.	27-Jun	1:30PM	Salon D	6
Olufsen, F.	28-Jun	2:00PM	Salon C	16
Opila, E.J.	28-Jun	5:10PM	Trinity IV	16
Orlandi, M.	28-Jun	9:00AM	Salon C	12
Ortona, A.	27-Jun	2:00PM	Trinity IV	5
Ortona, A.	27-Jun	5:00PM	Trinity I/II	8
Ortona, A.	30-Jun	8:30AM	Bay	25
Osada, M.	29-Jun	11:10AM	York B	21
Osei-Agyemang, E.	30-Jun	4:10PM	Bay	25
Ostrouchov, C.N.	30-Jun	2:20PM	Bay	24
		P		
Panigrahi, M.	29-Jun	9:30AM	Trinity IV	20
Park, J.	28-Jun	1:30PM	York B	14
Parker, C.G.	30-Jun	2:40PM	Trinity IV	27
Parthasarathy, T.A.	30-Jun	2:00PM	Salon D	27
Persson, C.	30-Jun	9:30AM	York A	22
Pfeifer, S.	29-Jun	9:00AM	Salon D	21
Pierce, J.	30-Jun	9:30AM	Salon D	27
Pimputkar, S.	27-Jun	1:30PM	Trinity V	7
Prakasam, M.	29-Jun	11:10AM	Trinity V	20
Presby, M.J.	30-Jun	2:20PM	Trinity I/II	28
Przybyla, C.P.	30-Jun	1:30PM	Salon D	27
		Q		
Quenneville, F.	30-Jun	11:40AM	York A	22
		R		
Razavi-Khosroshahi, H.	29-Jun	9:20AM	Trinity III	19
Reitz, R.B.	28-Jun	9:00AM	Bay	11
Riman, R.	27-Jun	2:30PM	York A	8
Roduner, E.	29-Jun	10:50AM	York A	19
Rosei, F.	28-Jun	12:00PM	York A	17
Rosei, F.	29-Jun	9:00AM	York A	19
Rösiger, A.	27-Jun	3:20PM	Bay	5
Rousseau, B.	28-Jun	2:40PM	Trinity I/II	14
Ruggles-Wrenn, M.	30-Jun	11:00AM	Salon C	25
Ruggles-Wrenn, M.	30-Jun	8:50AM	Salon D	27
		S		
Saito, M.	27-Jun	2:00PM	Trinity V	7
Sakamoto, W.	28-Jun	3:50PM	York B	15
Sakka, Y.	29-Jun	10:20AM	Trinity III	19
Santato, C.	30-Jun	10:20AM	York A	22
Sarigiannidou, E.	27-Jun	4:20PM	Trinity V	8
Sarigiannidou, E.	28-Jun	4:40PM	Trinity V	14
Sawada, H.	29-Jun	10:20AM	York B	21
Scheffler, M.	27-Jun	4:10PM	Trinity I/II	8
Schmidt-Wimmer, S.	29-Jun	10:50AM	Bay	22
Schmidt, M.	28-Jun	1:20PM	Trinity IV	16
Seeley, Z.M.	29-Jun	10:20AM	Trinity V	20
Sekino, T.	30-Jun	4:10PM	Trinity III	24
Sevener, K.M.	30-Jun	9:20AM	Trinity I/II	28
Sha, J.	27-Jun	2:30PM	Bay	5
Shahien, M.	28-Jun	11:20AM	York B	10
Shaw, J.H.	30-Jun	11:40AM	Trinity IV	26
Shi, Y.	1-Jul	9:40AM	Bay	30
Shimamura, K.	1-Jul	11:20AM	Trinity V	29
Shinoda, K.	28-Jun	10:20AM	York B	10
Singh Sandhu, K.	30-Jun	11:40AM	York B	22
Singh, G.	28-Jun	5:40PM	Trinity IV	16
Singh, I.B.	30-Jun	2:10PM	Trinity III	24
Singh, I.B.	30-Jun	4:20PM	York B	23
Smith, C.	30-Jun	3:40PM	Salon D	28
Song, Q.	28-Jun	2:40PM	Salon D	15
Spatz, C.	29-Jun	9:40AM	Bay	21
Sreeram, A.N.	27-Jun	9:40AM	Salon A/B	5

Name	Date	Time	Room	Page Number
Stevens, K.A.	27-Jun	10:40AM	Salon A/B	5
Stevenson, A.	28-Jun	8:30AM	York A	12
Stiglich, J.	27-Jun	5:20PM	Trinity I/II	8
Stiglich, J.	28-Jun	4:40PM	Salon D	15
Stiglich, J.	30-Jun	10:40AM	Salon C	25
Stoker, A.	30-Jun	11:00AM	York B	22
Sudre, O.	30-Jun	2:00PM	Trinity I/II	28
Sugimura, W.	28-Jun	3:10PM	Trinity V	14
Suzuki, M.	28-Jun	11:40AM	York B	10
Suzuki, M.	28-Jun	3:30PM	York B	15
Suzuki, T.S.	30-Jun	3:20PM	York B	23
		T		
Tafu, M.	1-Jul	9:30AM	Trinity III	29
Takahashi, T.	29-Jun	9:00AM	Trinity III	19
Takahashi, Y.	30-Jun	10:50AM	Trinity V	23
Takai, C.	27-Jun	4:30PM	Trinity III	7
Takeda, T.	28-Jun	10:20AM	Trinity V	9
Tamayo, A.	28-Jun	4:50PM	Trinity IV	16
Tamayo, A.	29-Jun	11:20AM	Trinity I/II	21
Tanaka, H.	29-Jun	9:00AM	York B	21
Tanaka, K.	1-Jul	10:20AM	Trinity III	29
Tanaka, M.	1-Jul	8:40AM	Trinity IV	30
Tanaka, S.	27-Jun	2:20PM	Trinity I/II	8
Tanaka, S.	28-Jun	9:00AM	Trinity III	9
Tao, X.	30-Jun	9:00AM	Trinity V	23
Tatami, J.	29-Jun	11:20AM	Trinity III	19
Tatami, J.	30-Jun	3:40PM	York B	23
Tatarko, P.	27-Jun	3:40PM	Salon D	6
Tavakoli, A.	28-Jun	4:00PM	Trinity IV	16
Thomann, I.	30-Jun	9:00AM	York A	22
Toda, K.	1-Jul	8:40AM	Trinity III	29
Toda, K.	27-Jun	2:20PM	Trinity III	7
Toda, K.	28-Jun	10:50AM	Trinity V	9
Todt, A.	28-Jun	9:20AM	Bay	11
Tokairin, T.	30-Jun	2:20PM	Trinity V	23
Tokoro, C.	27-Jun	1:30PM	Trinity III	7
Tominaga, Y.	27-Jun	3:50PM	Trinity III	7
Toury, B.	28-Jun	2:40PM	Trinity IV	16
Travitzky, N.	1-Jul	8:30AM	York B	29
Tsuchiya, T.	28-Jun	5:00PM	York B	15
Tsunoura, T.	28-Jun	9:40AM	Bay	11
Tuan, W.	28-Jun	1:30PM	Trinity III	13
		U		
Uchikoshi, T.	28-Jun	11:10AM	Trinity III	9
Ueno, S.	28-Jun	10:40AM	Trinity I/II	10
Ueno, S.	30-Jun	3:20PM	Trinity III	24
Usubaliyev, T.B.	1-Jul	12:00PM	Trinity IV	31
		V		
Vanka, S.	29-Jun	11:10AM	York A	19
Vassen, R.	30-Jun	1:30PM	Trinity IV	26
Vayssieres, L.	28-Jun	2:30PM	York A	13
Verma, V.	1-Jul	9:50AM	Salon C	30
Vetrone, F.	27-Jun	3:20PM	York A	9
Vignoles, G.L.	1-Jul	10:20AM	Bay	30
Vignoles, G.L.	1-Jul	11:00AM	Bay	30
Vignoles, G.L.	1-Jul	8:30AM	Bay	30
Vignoles, G.L.	27-Jun	3:50PM	Salon C	6
Vignoles, G.L.	30-Jun	2:40PM	Bay	24
Vogt, U.F.	28-Jun	3:20PM	Trinity I/II	14
		W		
Wada, S.	30-Jun	2:00PM	York B	23
Wakiya, N.	30-Jun	11:00AM	Trinity III	24
Wamser, T.	30-Jun	11:20AM	Bay	25
Wang, H.	27-Jun	4:10PM	York B	7
Wang, J.	28-Jun	9:00AM	Trinity I/II	10
Wang, J.	30-Jun	3:20PM	Bay	25
Wang, P.	30-Jun	10:20AM	Trinity III	24
Wang, X.	27-Jun	4:00PM	Salon D	6

Presenting Author List

Oral Presenters

Name	Date	Time	Room	Page Number
Wang, Y.	1-Jul	10:40AM	Trinity IV	31
Wang, Y.	28-Jun	9:00AM	Trinity IV	11
Wang, Z.	30-Jun	9:00AM	Bay	25
Weber, W.J.	30-Jun	1:50PM	Bay	24
Weichand, P.	27-Jun	2:30PM	Trinity IV	5
Weiss, R.	28-Jun	8:30AM	Salon C	12
Westin, G.	29-Jun	10:20AM	York A	19
White, M.	28-Jun	10:20AM	Trinity I/II	10
Wich, P.R.	27-Jun	2:00PM	York A	8
Wiesner, V.L.	30-Jun	11:20AM	Trinity IV	26
Wilhelm, M.	27-Jun	3:50PM	Trinity I/II	8
Wilhelmi, C.	30-Jun	1:30PM	Trinity I/II	28
Wilson, M.	30-Jun	10:30AM	Salon D	27
Wu, Y.	1-Jul	11:00AM	York B	29
		X		
Xiong, D.	28-Jun	3:20PM	Trinity III	13
Xu, C.	28-Jun	1:30PM	Bay	15
		Y		
Yamaguchi, N.	30-Jun	2:20PM	Trinity IV	27
Yamamoto, T.	29-Jun	8:30AM	York B	21
Yamashita, S.	28-Jun	5:10PM	Trinity III	13
Yamazaki, S.	27-Jun	9:00AM	Salon A/B	5
Yashima, M.	28-Jun	9:30AM	Trinity III	9
Yashima, M.	30-Jun	9:30AM	Trinity III	24
Yasuda, K.	27-Jun	2:00PM	Trinity I/II	8
Yasuda, K.	29-Jun	10:40AM	Trinity III	19
Ye, F.	29-Jun	11:10AM	Bay	22
Yin, X.	28-Jun	4:20PM	Trinity IV	16
Yoo, Y.	1-Jul	9:40AM	Trinity IV	31
Yoon, B.	27-Jun	5:10PM	Trinity IV	6
Yoon, D.	28-Jun	9:00AM	Trinity V	9
Yoshida, K.	28-Jun	10:20AM	Bay	11
Yoshida, K.	28-Jun	2:40PM	York B	15
Yoshioka, S.	30-Jun	10:50AM	Salon D	27
Yoshiya, M.	30-Jun	3:20PM	Trinity IV	27
		Z		
Zeng, Q.	30-Jun	3:50PM	Bay	25
Zeng, Y.	28-Jun	9:20AM	Trinity I/II	10
Zhang, D.	29-Jun	8:30AM	Trinity III	19
Zhang, G.	1-Jul	9:30AM	York B	29
Zhang, G.	30-Jun	1:30PM	Salon C	26
Zhang, H.	28-Jun	11:40AM	Trinity I/II	10
Zhang, W.	28-Jun	1:30PM	Salon D	15
Zhang, X.	29-Jun	11:30AM	Bay	22
Zhao, Z.	29-Jun	12:00PM	Bay	22
Zhou, A.	28-Jun	11:20AM	York A	12
Zhou, H.	30-Jun	9:20AM	Bay	25
Zhou, Y.	30-Jun	3:50PM	Trinity IV	27
Zhou, Y.	30-Jun	9:00AM	Salon C	25
Zhu, D.	30-Jun	11:00AM	Trinity IV	26
Zok, F.W.	27-Jun	3:30PM	Trinity IV	6
Zunjarrao, S.C.	30-Jun	10:40AM	Trinity I/II	28

Poster Presenters

Name	Date	Time	Room	Page Number
Arioka, Y.	28-Jun	6:30PM	Salon A/B	17
Ashoori, A.	28-Jun	6:30PM	Salon A/B	17, 18
Asumani, O.	28-Jun	6:30PM	Salon A/B	17
Bahmer, M.	28-Jun	6:30PM	Salon A/B	17
Caccia, M.R.	28-Jun	6:30PM	Salon A/B	18, 19
Chen, P.	28-Jun	6:30PM	Salon A/B	18
Chen, X.B.	28-Jun	6:30PM	Salon A/B	18
Colorado, H.	28-Jun	6:30PM	Salon A/B	17
Du, H.	28-Jun	6:30PM	Salon A/B	17
Fukushima, A.	28-Jun	6:30PM	Salon A/B	17
Gao, L.	28-Jun	6:30PM	Salon A/B	18
Guo, A.	28-Jun	6:30PM	Salon A/B	18
Inada, M.	28-Jun	6:30PM	Salon A/B	17
Inoue, R.	28-Jun	6:30PM	Salon A/B	18
Jian, K.	28-Jun	6:30PM	Salon A/B	19
Jiang, Y.	28-Jun	6:30PM	Salon A/B	17
Jiao, J.	28-Jun	6:30PM	Salon A/B	18
Kameda, Y.	28-Jun	6:30PM	Salon A/B	17
Kim, S.	28-Jun	6:30PM	Salon A/B	18
Konegger, T.	28-Jun	6:30PM	Salon A/B	18
Kothanda Ramachandran, D.	28-Jun	6:30PM	Salon A/B	18
Kusano, D.	28-Jun	6:30PM	Salon A/B	17
Laszkiewicz- Lukasik, J.	28-Jun	6:30PM	Salon A/B	18
Lee, J.	28-Jun	6:30PM	Salon A/B	18
Lee, K.	28-Jun	6:30PM	Salon A/B	18
Lin, H.	28-Jun	6:30PM	Salon A/B	18
Liu, X.	28-Jun	6:30PM	Salon A/B	18
Lu, Y.	28-Jun	6:30PM	Salon A/B	18
Ma, Y.	28-Jun	6:30PM	Salon A/B	19
Maillé, L.	28-Jun	6:30PM	Salon A/B	18
Malyi, O.I.	28-Jun	6:30PM	Salon A/B	17
Mansour, R.	28-Jun	6:30PM	Salon A/B	19
Matsunaga, C.	28-Jun	6:30PM	Salon A/B	17
Muroyama, S.	28-Jun	6:30PM	Salon A/B	18
Muto, H.	28-Jun	6:30PM	Salon A/B	17
Nakauchi, Y.	28-Jun	6:30PM	Salon A/B	19
Narciso, J.	28-Jun	6:30PM	Salon A/B	19
Park, K.	28-Jun	6:30PM	Salon A/B	17
Paskaramoorthy, R.	28-Jun	6:30PM	Salon A/B	18
Pi, H.L.	28-Jun	6:30PM	Salon A/B	18
Regiani, I.	28-Jun	6:30PM	Salon A/B	18
Seong, Y.	28-Jun	6:30PM	Salon A/B	18
Shahien, M.	28-Jun	6:30PM	Salon A/B	18
Takasu, T.	28-Jun	6:30PM	Salon A/B	17
Tamagawa, Y.	28-Jun	6:30PM	Salon A/B	18
Tanaka, I.	28-Jun	6:30PM	Salon A/B	17
Tang, L.S.	28-Jun	6:30PM	Salon A/B	18
Tao, X.	28-Jun	6:30PM	Salon A/B	19
Tavakoli, A.	28-Jun	6:30PM	Salon A/B	18
Ueno, S.	28-Jun	6:30PM	Salon A/B	17, 19
Wang, J.	28-Jun	6:30PM	Salon A/B	18
Wang, K.	28-Jun	6:30PM	Salon A/B	17
Woo, S.	28-Jun	6:30PM	Salon A/B	18
Wu, Y.	28-Jun	6:30PM	Salon A/B	17
Xiang, Y.	28-Jun	6:30PM	Salon A/B	18
Yoshida, K.	28-Jun	6:30PM	Salon A/B	17
Yoshiya, M.	28-Jun	6:30PM	Salon A/B	18
Zhang, H.	28-Jun	6:30PM	Salon A/B	17
Zhu, D.	28-Jun	6:30PM	Salon A/B	19
Zhu, Y.	28-Jun	6:30PM	Salon A/B	18

Monday, June 27, 2016

Plenary Session

Room: Salon A/B

Session Chair: Mrityunjay Singh, Ohio Aerospace Institute

8:30 AM

Introduction and Overview

Tatsuki Ohji, HTCMC-9 lead chair; Sanjay Mathur, GFMAT 2016 lead chair

8:45 AM

Welcome Remarks

Mrityunjay Singh, HTCMC-9 & GFMAT 2016 general chair

9:00 AM

(PL-001-2016) Discovery of Indium Gallium Zinc Oxide (CAAC-IGZO) and Its Applications in Next Generation Information Display Devices

S. Yamazaki*[1]; 1. Semiconductor Energy Laboratory Co., Ltd., Japan

9:40 AM

(PL-002-2016) The Science of Materials: Impactful Solutions to Big Global Challenges

A. N. Sreeram*[1]; 1. The Dow Chemical Company, USA

10:20 AM

Break

10:40 AM

(PL-003-2016) SiC/SiC Ceramic Matrix Composites for Jet Engines

K. A. Stevens*[1]; 1. GE Aviation, USA

11:20 AM

(PL-004-2016) Ceramic Matrix Composites (CMCs): Enabling Materials for Competitive Aero-Engines

J. Esslinger*[1]; 1. MTU Aero Engines AG, Germany

H3. Innovative Design, Advanced Processing, and Manufacturing Technologies

Innovative Design I

Room: Bay

Session Chairs: Shaoming Dong, Shanghai Institute of Ceramics, Chinese Academy of Sciences; Christian Wilhelmi, Airbus Group Innovations

1:30 PM

(H3-001-2016) Non-oxide ceramic matrix composites for application in hot gas atmospheres – requirements and potential (Invited)

H. Klemm*[1]; K. Schönfeld[1]; W. Kunz[2]; C. Steinborn[1]; 1. FhG IKTS Dresden, Germany; 2. Fraunhofer IKTS, Germany

2:00 PM

(H3-002-2016) Chemical Vapor Deposition on Multi-element Ceramics in Si-B-C-N Systems (Invited)

Y. Liu*[1]; L. Cheng[1]; L. Zhang[1]; 1. Northwestern Polytechical University, China

2:30 PM

(H3-003-2016) Co-toughened C-SiC-based composites by SiC nanofibers and carbon fibers (Invited)

J. Sha*[1]; J. Dai[1]; Z. Zhang[1]; J. Li[1]; W. Krenkel[2]; 1. Dalian University of Technology, China; 2. University of Bayreuth, Germany

3:00 PM

Break

3:20 PM

(H3-004-2016) Comparison of Machining Technologies for CMC Materials using Advanced 3D Surface Analysis (Invited)

R. Goller[1]; A. Rösiger*[1]; 1. University of Applied Sciences, Germany

3:50 PM

(H3-005-2016) Design, fabrication and properties of multifunctional ultra-high temperature ceramic matrix composites

C. Hu*[1]; S. Tang[1]; H. Cheng[1]; 1. Institute of Metal Research, CAS, China

4:10 PM

(H3-006-2016) Influence of the annealing process parameters in the production of new short fibre-reinforced C/C-SiC composites

N. Nier*[1]; D. Nestler[1]; K. Roder[1]; E. Paessler[1]; J. Weisshuhn[1]; A. Todt[1]; H. Gurk[1]; L. Kroll[1]; S. Spange[1]; G. Wagner[1]; 1. TU Chemnitz, Germany

4:30 PM

(H3-007-2016) Manufacturing of non oxide Ceramic Matrix Composites by microwave heating applied to Chemical Vapor Infiltration

A. Lazzeri*[1]; G. Annino[2]; M. Coltelli[1]; L. Aliotta[1]; V. Gigante[1]; 1. National Interuniversity Consortium of Materials Science and Technology (INSTM) c/o University of Pisa, Italy; 2. National Research Council of Italy, Italy

4:50 PM

(H3-008-2016) Updating Composite Materials Handbook-17 Volume 5—Ceramic Matrix Composites

J. D. Kiser*[1]; K. David[2]; C. Davies[3]; R. Andrulonis[4]; C. Ashforth[5]; 1. NASA Glenn Research Center, USA; 2. The Boeing Company, USA; 3. Federal Aviation Administration/Materials & Structures, USA; 4. Wichita State University, USA; 5. Federal Aviation Administration, USA

5:10 PM

(H3-009-2016) Oxide-Oxide CMCs: Enabling Widespread Industry Adoption

B. Jackson*[1]; L. Visser[2]; A. Beaber[2]; A. Barnes[2]; J. Lincoln[3]; 1. Composite Horizons, USA; 2. 3M, USA; 3. Axiom Materials, Inc., USA

H5. Polymer Derived Ceramics and Composites

PDC Composites I

Room: Trinity IV

Session Chair: Paolo Colombo, University of Padova

1:30 PM

(H5-001-2016) Polymer derived ceramic matrix composites – potential and limits (Invited)

D. Koch*[1]; 1. Institute of Structures and Design, Germany

2:00 PM

(H5-002-2016) Sandwich structured composites from polymer derived matrices (Invited)

A. Ortona*[1]; 1. SUPSI, Switzerland

2:30 PM

(H5-003-2016) Investigation on Interlaminar Strength of 3D-Basalt Fiber Reinforced SiOC-Hybrid-Composites

P. Weichand*[1]; R. Gadow[1]; 1. Institute for Manufacturing Technologies of Ceramic Components and Composites, University of Stuttgart, Germany

2:50 PM

Break

PDC Composites II

Room: Trinity IV

Session Chair: Dietmar Koch, Institute of Structures and Design

3:30 PM

(H5-004-2016) Matrix Concepts and Processing Protocols for Robust SiC-Based CMCs (Invited)

F. W. Zok*[1]; N. M. Larson[1]; R. B. Reitz[1]; C. G. Levi[1]; 1. University of California, Santa Barbara, USA

4:00 PM

(H5-005-2016) Fiber-Matrix adhesion in CFRC greenbodies and its influence on microcrack formation during carbonization process

S. J. Haug*[1]; W. M. Mueller[1]; M. G. Sause[1]; S. Horn[1]; 1. University of Augsburg, Germany

4:20 PM

(H5-006-2016) SiOC based fiber reinforced composites, their manufacturing, processing and special applications (Invited)

R. Gadow*[1]; P. Weichand[1]; 1. Institute for Manufacturing Technologies of Ceramic Components and Composites, University of Stuttgart, Germany

4:50 PM

(H5-007-2016) Lightweight telescope mirrors and structural components development with polymer derived ceramics for future space telescopes

R. Eng*[1]; 1. NASA Marshall Space Flight Center, USA

5:10 PM

(H5-008-2016) Effects of SiC filler materials on the properties of SiC_f/SiC composites made by precursor impregnation and pyrolysis process

B. Yoon*[1]; S. Lee[1]; S. Singh[1]; J. Yin[1]; 1. Korea Institute of Materials Science, Republic of Korea

5:30 PM

(H5-009-2016) Refractory Adhesives for Bonding of Polymer Derived Ceramics

R. D. Cook*[1]; 1. Lancer Systems, USA

H8: Ceramic Integration and Additive Manufacturing Technologies

Ceramic Integration and Additive Manufacturing Technologies

Room: Salon D

Session Chairs: Michael Halbig, NASA Glenn Research Center; Soshu Kirihara, Osaka University

1:30 PM

(H8-001-2016) High-Value Added Ceramic Products Manufacturing Technologies – R&Ds on Additive Manufacturing (Invited)

T. Ohji*[1]; 1. National Institute of Advanced Industrial Science and Technology (AIST), Japan

2:00 PM

(H8-002-2016) Additive Manufacturing Development for NASA Aerospace Applications

M. C. Halbig*[1]; M. Singh[2]; 1. NASA Glenn Research Center, USA; 2. Ohio Aerospace Institute, USA

2:20 PM

(H8-003-2016) Active Metal Brazing and Diffusion Bonding of Ceramics to Metals for Structural and Thermal Applications

M. Singh[2]; M. C. Halbig[1]; R. Asthana*[3]; 1. NASA Glenn Research Center, USA; 2. Ohio Aerospace Institute, USA; 3. University of Wisconsin-Stout, USA

2:40 PM

(H8-004-2016) Stereolithographic Additive Manufacturing of Biological Scaffolds with Structural Fluctuation

S. Kirihara*[1]; 1. Osaka University, Japan

3:00 PM

Break

3:20 PM

(H8-005-2016) Joining of Silicon Carbide by Laser-Supported Heating – Chances and Limits

M. Herrmann*[1]; S. Ahmad[2]; W. Lippmann[1]; H. J. Seifert[2]; A. Hurtado[1]; 1. Technische Universität Dresden, Germany; 2. Karlsruhe Institute of Technology, Germany

3:40 PM

(H8-006-2016) Joining of CVD-SiC and Ceramic Matrix Composites with Ti_3SiC_2 using Spark Plasma Sintering

P. Tatarko*[2]; V. Casalegno[1]; M. Salvo[1]; M. Ferraris[1]; M. Reece[2]; 1. Politecnico di Torino, Italy; 2. Queen Mary University of London, Nanoforce Technology Ltd., United Kingdom

4:00 PM

(H8-007-2016) Preparation and bonding properties of high-temperature organic adhesives prepared by precursor (V-PMS) and fillers

X. Wang*[1]; J. Wang[1]; H. Wang[1]; 1. National University of Defense Technology, China

4:20 PM

(H8-008-2016) Role of interfacial interactions in joining of ceramics by brazing alloys

F. Hodaj*[1]; 1. Grenoble Institute of Technology, France

4:40 PM

(H8-009-2016) The preparation of (SiC, B_4C and TiC)/Cusil hybrid tape and its application in the joining of Silicon carbide ceramics

Y. Liu*[1]; 1. Shanghai Institute of Ceramics, Chinese Academy of Sciences, China

H11. CMC Applications in Transportation and Industrial Systems

High Performance Friction Materials

Room: Salon C

Session Chair: Bernhard Heidenreich, German Aerospace Center

1:30 PM

(H11-001-2016) Successful Spin-off from Space to Terrestrial Applications: Development, Status and Perspectives of Carbon/Ceramic Brakes (Invited)

W. Krenkel*[1]; 1. University of Bayreuth, Germany

2:00 PM

(H11-002-2016) Analysis of Friction Materials for Brake Pads of Heavy Loaded Brake Systems with Discs Made of SiC-Matrix Composites (Invited)

V. Kulik*[1]; A. Nilov[1]; A. Garshin[2]; 1. Baltic State Technical University "VOENMEH", Russian Federation; 2. State Polytechnical University, Russian Federation

2:30 PM

(H11-003-2016) The study of C/C-SiC based friction materials on a dynamometer at high braking pressures and speeds (Invited)

W. Krenkel[1]; N. Langhof*[1]; 1. University of Bayreuth, Germany

3:00 PM

Break

3:20 PM

(H11-004-2016) Development of Carbon Fiber Reinforced CMC for aircraft and automobile application (Invited)

K. Kim*[1]; D. Im[1]; Y. Choi[1]; J. Lee[1]; Y. Kang[1]; N. Lee[1]; 1. DACC Carbon Co., Ltd, Republic of Korea

3:50 PM

(H11-005-2016) Carbon-based friction materials: Fabrication, characterization and modeling towards new concepts

G. L. Vignoles*[1]; 1. University of Bordeaux 1, France

4:10 PM

(H11-006-2016) Damage Evolution Mechanism and Reliability of Short Carbon Fiber Dispersed SiC Matrix Composite (Invited)

Y. Kagawa*[1]; 1. The University of Tokyo, Japan

G1. Powder Processing Innovation and Technologies for Advanced Materials and Sustainable Development

Energy-saving Processing, Smart Recycling of Materials, and Particle Design

Room: Trinity III

Session Chairs: Makio Naito, JWRI, Osaka University; Yoshio Sakka, National Institute for Materials Science (NIMS)

1:30 PM

(G1-001-2016) A smart recycling process for tantalum recovery from WEEEs by selective grinding (Invited)

C. Tokoro*[1]; Y. Tsunazawa[1]; S. Owada[1]; 1. Waseda University, Japan

2:00 PM

(G1-002-2016) Infiltration of molten silicon in a porous body of B_4C under microwave heating

M. Dutto*[1]; S. Marinel[2]; D. Goeuriot[1]; S. Saunier[1]; 1. Mines Saint-etienne, France; 2. CRISMAT Laboratory UMR 6508 CNRS-ENSICaen-UCBN, France

2:20 PM

(G1-003-2016) Development of Novel Soft Chemistry

K. Toda*[1]; S. Kim[1]; K. Uematsu[1]; M. Sato[1]; 1. Niigata University, Japan

2:40 PM

(G1-004-2016) Preparation of carbamate-containing calcium carbonate for radioactive waste water treatment

J. Nakamura*[1]; Y. Sakka[1]; T. Kasuga[2]; 1. National Institute for Materials Science (NIMS), Japan; 2. Nagoya Institute of Technology, Japan

3:00 PM

Break

3:20 PM

(G1-005-2016) Carbon Nanotube – Ceramic Matrix Composites: Processing and Characterizations (Invited)

M. Estili*[1]; Y. Sakka[1]; 1. National Institute for Materials Science (NIMS), Japan

3:50 PM

(G1-006-2016) Study on preparation of exfoliated mica nanosheets for mica-resin composite as insulation materials

Y. Tominaga*[1]; Y. Hotta[1]; K. Fukushima[2]; Y. Takezawa[2]; 1. National Institute of Advanced Industrial Science and Technology, Japan; 2. Hitachi Chemical Co., Ltd., Japan

4:10 PM

(G1-007-2016) Synthesis and alalysis of novel AlN filler for high thermal conductivity resin composite

Y. Kanechika*[1]; Y. Fukunaga[1]; M. Wan[1]; S. Fujii[1]; K. Sugawara[1]; T. Kawamura[1]; J. Tatami[2]; 1. TOKUYAMA Corp., Japan; 2. Yokohama National University, Japan

4:30 PM

(G1-008-2016) Synthesis of hollow silica nanoparticles using poly (acrylic acid) with aliphatic amines

C. Takai*[1]; H. Imabeppu[1]; H. Razavi Khosroshahi[1]; M. Fuji[1]; 1. Nagoya Institute of Technology, Japan

4:50 PM

(G1-009-2016) Research and development of wet-chemical process for lanthanum germanate oxyapatite

K. Kobayashi*[1]; Y. Igarashi[2]; T. Higuchi[2]; Y. Sakka[1]; 1. National Institute for Materials Science (NIMS), Japan; 2. Tokyo Univeristy of Science, Japan

5:10 PM

(G1-010-2016) $BaTiO_3$/Silicone Composites for Mechanical Sensor

C. Guo*[1]; C. Takai[1]; H. Razavi Khosroshahi[1]; M. Fuji[1]; 1. Nagoya Institute of Technology, Japan

G2. Functional Nanomaterials for Sustainable Energy Technologies

Functional Nanomaterials for Sustainable Energy Technologies I

Room: York B

Session Chair: Lionel Vayssieres, Xi'an Jiaotong University

2:00 PM

(G2-001-2016) Nano-Structured Materials in High-Performance Solar Devices (Invited)

N. P. Kherani*[1]; 1. University of Toronto, Canada

2:30 PM

(G2-002-2016) Near-infrared Photon Harvesting in Solar Cells and Photocatalysis by using Semiconductor and/or Plasmonic Nanostructures (Invited)

Z. Xu[1]; D. Ma*[1]; 1. INRS, Uni. Quebec, Canada

3:00 PM

Break

3:20 PM

(G2-003-2016) Solution Phase Strategies for VLS-like growth on Colloidal Plasmonic Substrates (Invited)

J. Millstone*[1]; 1. University of Pittsburgh, USA

3:50 PM

(G2-004-2016) Shape-Controlled Metal/Semiconductor Nanocrystals in a Well-Controlled Kinetic Process and Their Application for Electrocatalysis or Photocatalysis

M. Liu*[1]; X. Wang[1]; L. Zhao[1]; 1. Xi'an Jiaotong University, China

4:10 PM

(G2-005-2016) Growth control of molybdenum disulfide nanostructure on carbon paper by thermal chemical vapor deposition for highly efficient hydrogen evolution

H. Wang*[1]; D. Chua[2]; 1. National University of Singapore, Singapore; 2. Nagaoka University of Technology, Singapore

G5. Advanced Materials, Technologies, and Devices for Electro-optical and Medical Applications

Semiconductor I

Room: Trinity V

Session Chairs: Naoki Ohashi, National Institute for Materials Science (NIMS); Didier Chaussende, CNRS

1:30 PM

(G5-001-2016) Advances in Basic Ammonothermal Growth of Bulk Gallium Nitride Crystals (Invited)

S. Pimputkar*[1]; S. Griffiths[1]; T. Malkowski[1]; S. Suihkonen[2]; J. S. Speck[1]; S. Nakamura[1]; 1. University of California, Santa Barbara, USA; 2. Aalto University, Finland

2:00 PM

(G5-002-2016) High Quality Bulk GaN Crystal Grown by Acidic Ammonothermal Method (Invited)

M. Saito*[1]; Q. Bao[1]; K. Kurimoto[2]; D. Tomida[1]; K. Kojima[1]; Y. Kagamitani[3]; R. Kayano[2]; T. Ishiguro[1]; S. Chichibu[1]; 1. Tohoku University, Japan; 2. The Japan Steel Works, Japan; 3. Mitsubishi Chemical Corp., Japan

2:30 PM

(G5-003-2016) Effects of lattice defects on thermal and optical properties of aluminum nitride ceramics (Invited)

Y. Kanechika*[1]; S. Fujii[1]; K. Sugawara[1]; 1. TOKUYAMA Corp., Japan

3:00 PM

Break

3:20 PM

(G5-004-2016) Development of Liquid Crystal Display with RGB Laser Backlight (Invited)

Y. Fujii*[1]; 1. Mitsubishi Electric Corporation Advanced Technology R&D Center, Japan

3:50 PM

(G5-005-2016) Investigation of defects and impurity in oxides for optoelectronic applications (Invited)

N. Ohashi*[1]; 1. National Institute for Materials Science (NIMS), Japan

4:20 PM

(G5-006-2016) Polarity control of well-ordered epitaxial ZnO nanowire arrays by selective area growth

E. Sarigiannidou*[1]; E. Appert[1]; S. Guillemin[1]; A. Bocheux[1]; F. Donatini[2]; G. Bremond[3]; I. Robin[4]; V. Consonni[1]; 1. Univ. Grenoble Alpes, CNRS, LMGP, France; 2. Univ. Grenoble Alpes, CNRS, Inst NEEL, France; 3. Institut des Nanotechnologies de Lyon, France; 4. CEA, LETI, France

4:40 PM

(G5-007-2016) Amorphous Oxide Semiconductors: Present technology status, materials science, and new materials (Invited)

T. Kamiya*[1]; H. Kumomi[1]; H. Hosono[1]; 1. Tokyo Institute of Technology, Japan

G6: Porous Ceramics for Advanced Applications Through Innovative Processing

Innovative Characterizations, Modeling and Mechanical Responses of Porous Ceramics

Room: Trinity I/II

Session Chair: Manabu Fukushima, National Institute of Advanced Industrial Science and Technology (AIST)

1:30 PM

(G6-001-2016) Integrated Experimental and Computational Investigation of the Processing and Properties of Hierarchical Porous Ceramics (Invited)

R. Bordia*[1]; C. Martin[2]; 1. Clemson University, USA; 2. Université de Grenoble - Alpes, France

2:00 PM

(G6-002-2016) Application of 3-parameter Weibull Distribution to Porous Ceramics

K. Yasuda*[1]; H. Kita[2]; M. Takahashi[3]; Y. Takahashi[4]; S. Tanaka[5]; S. Honda[6]; T. Mitsuoka[7]; H. Muto[8]; S. Yamamoto[9]; Y. Yoshizawa[10]; 1. Tokyo Institute of Technology, Japan; 2. Nagoya Univ., Japan; 3. Ehime Univ., Japan; 4. Noritake Company Limited, Japan; 5. Nagaoka Univ. Tech., Japan; 6. Nagoya Tech., Japan; 7. NGK Spark Plug Co., Ltd., Japan; 8. Toyohashi Univ. Tech., Japan; 9. Asuzac, Japan; 10. AIST, Japan

2:20 PM

(G6-003-2016) Internal pore structure in porous ceramics evaluated by micro x-ray CT

S. Tanaka*[1]; K. Yasuda[2]; H. Kita[4]; M. Takahashi[5]; Y. Takahashi[6]; S. Honda[7]; T. Mitsuoka[8]; H. Muto[3]; S. Yamamoto[9]; Y. Yoshizawa[10]; 1. Nagaoka University of Technology, Japan; 2. Tokyo Institute of Technology, Japan; 3. Toyohashi University of Technology, Japan; 4. Nagoya University, Japan; 5. Ehime University, Japan; 6. Noritake Co. Ltd., Japan; 7. Nagoya Institute of Technology, Japan; 8. NGK Spark Plug Co., Ltd, Japan; 9. Asuzac, Japan; 10. AIST, Japan

2:40 PM

(G6-004-2016) Elastplastic Indentation on Porous Ceramic Materials (Invited)

H. Muto*[1]; 1. Toyohashi University of Technology, Japan

3:00 PM

Break

Advanced Processing Methods and Characterization Technologies of Ceramic Foams I

Room: Trinity I/II

Session Chairs: Tobias Fey, Friedrich-Alexander University Erlangen-Nürnberg; Enrico Bernardo, University of Padova

3:20 PM

(G6-005-2016) Insight into geopolymers porosity (Invited)

V. Medri*[1]; E. Papa[1]; A. Natali Murri[1]; E. Landi[1]; P. Benito[2]; A. Vaccari[2]; 1. National Research Council of Italy, Italy; 2. University of Bologna, Italy

3:50 PM

(G6-006-2016) Monolithic Hybrid Ceramics prepared by Emulsion based Process (Invited)

M. Wilhelm*[1]; F. Schlüter[1]; K. Rezwan[1]; 1. University of Bremen, Germany

4:10 PM

(G6-007-2016) Electrical and thermal conductivity of ceramic foam (Invited)

M. Scheffler*[1]; S. Rannabauer[1]; U. Betke[1]; 1. University of Magdeburg, Germany

4:40 PM

(G6-008-2016) Microcellular Silicon Carbide Foams from boron-modified polycarbosilanes

C. Durif*[1]; P. Miele[1]; S. Bernard[1]; F. Grasset[3]; O. Lacroix[3]; P. Colombo[2]; 1. European Membrane Institute, France; 2. University of Padova, Italy; 3. AREVA Technical Center, France

5:00 PM

(G6-009-2016) High temperatures oxidation behavior of SiC based periodic and random cellular architectures in calm and flowing air

E. Rezaei[2]; A. Ortona*[1]; 1. SUPSI, Switzerland; 2. EPFL, Switzerland

5:20 PM

(G6-010-2016) Foam-reinforced Thermal Insulation for High Temperature and Cryogenic Temperature Applications

J. Stiglich*[1]; B. Williams[1]; V. Arrieta[1]; 1. Ultramet, USA

Young Professionals Forum - Next Generation Materials for Multifunctional Applications and Sustainable Development, and Concurrent Societal Challenges in the New Millennium

Young Professional Forum I: Funding, Academia, Industry, and Beyond

Room: York A

Session Chairs: Surojit Gupta, University of North Dakota; Eva Hemmer, University of Ottawa; Adam Stevenson, Saint-Gobain

1:30 PM

(YPF-001-2016) Funding Opportunities in Materials Engineering at the National Science Foundation (Invited)

A. Lewis*[1]; 1. National Science Foundation, USA

2:00 PM

(YPF-002-2016) Biopolymer-based Nanoparticles: Dynamic Materials for Drug Delivery (Invited)

P. R. Wich*[1]; D. Bamberger[1]; M. Fach[1]; L. Radi[1]; 1. Johannes Gutenberg-University Mainz, Germany

2:30 PM

(YPF-003-2016) Zero-Waste Sustainable Infrastructure Materials (Invited)

R. Riman*[1]; 1. Rutgers University, USA

3:00 PM

Break

Young Professional Forum II: Health and Materials

Room: York A

Session Chairs: Sankha Banerjee, California State University, Fresno; Peter Wich, Johannes Gutenberg-University Mainz

3:20 PM

(YPF-004-2016) Nanoparticles Excited With Near Infrared Light: Shining the Light on Multi-Modality (Invited)

F. Vetrone*[1]; 1. Institut National de la Recherche Scientifique (INRS), Université du Québec, Canada

3:50 PM

(YPF-005-2016) Nanoparticles as "Contrast Agents" in Imaging Applications (Invited)

R. Naccache*[1]; A. Mazhorova[3]; M. Clerici[2]; H. Breitenborn[3]; L. Razzari[3]; F. Vetrone[3]; R. Morandotti[3]; 1. Concordia University, Canada; 2. University of Glasgow, United Kingdom; 3. University du Quebec, Institut National de la Recherche Scientifique, Canada

4:20 PM

(YPF-006-2016) Biocompatible Polymer-conjugated Inorganic Nanophosphors for Near-infrared in vivo Imaging in the Second Biological Window (Invited)

M. Kamimura*[1]; K. Soga[1]; 1. Tokyo University of Science, Japan

4:50 PM

(YPF-007-2016) Exploiting the Near-Infrared Biological Window for Lanthanide-based Temperature Measurements (Invited)

E. Hemmer*[1]; A. Skripka[1]; F. Légaré[1]; F. Vetrone[1]; 1. INRS-EMT, Canada

Tuesday, June 28, 2016

G1. Powder Processing Innovation and Technologies for Advanced Materials and Sustainable Development

Advanced Characterization and Composite Particles

Room: Trinity III

Session Chairs: Sanjay Mathur, University of Cologne; Masayoshi Fuji, Nagoya Institute of Technology

8:30 AM

(G1-011-2016) "Mechanochemical" is one of the most important phenomena in the future of milling technology (Invited)

M. Kamitani*[1]; 1. Makino Corporation, Japan

9:00 AM

(G1-012-2016) Control of mesoscale structure evolution in alumina ceramics (Invited)

S. Tanaka*[1]; T. Hondo[1]; K. Yasuda[2]; F. Wakai[2]; 1. Nagaoka University of Technology, Japan; 2. Tokyo Institute of Technology, Japan

9:30 AM

(G1-013-2016) Precise Structure Analysis of Advanced Ceramic Materials through Powder Diffraction (Invited)

M. Yashima*[1]; K. Fujii[1]; E. Niwa[1]; 1. Tokyo Institute of Technology, Japan

10:00 AM

Break

10:20 AM

(G1-014-2016) Metal Oxide Nanosurfaces and Hetero-interfaces for Solar Harvesting Applications (Invited)

S. Mathur*[1]; Y. Gönüllü[1]; T. Fischer[1]; 1. University of Cologne, Germany

10:50 AM

(G1-015-2016) Microstructure control of Al_2O_3/ZrO_2 ceramics using nanocomposite particles prepared by mechanical treatment

M. Matsuoka*[1]; T. Uoji[3]; J. Tatami[3]; M. Naito[1]; C. Tokoro[2]; 1. JWRI, Osaka University, Japan; 2. Waseda University, Japan; 3. Yokohama National University, Japan

11:10 AM

(G1-016-2016) Fabrication of Oriented β-SiAlON:Eu^{2+} Phosphor Layer by Magnetic Field-Assisted Electrophoretic Deposition (Invited)

T. Uchikoshi*[1]; 1. National Institute for Materials Science, Japan

11:40 AM

(G1-017-2016) Forming composites of silica nanoparticles deposited on silica porous particles through mechanical treatment and their drying properties

M. Iijima*[1]; M. Hayakawa[1]; J. Tatami[1]; M. Sato[2]; Y. Kakizawa[2]; S. Hiroshima[2]; M. Koide[2]; 1. Yokohama National University, Japan; 2. Lion Corporation, Japan

12:00 PM

(G1-018-2016) Simulation of elastic-plastic materials breakage using ADEM

S. Ishihara*[1]; J. Kano[1]; 1. Tohoku University, Japan

G5. Advanced Materials, Technologies, and Devices for Electro-optical and Medical Applications

Optical Material I

Room: Trinity V

Session Chairs: Luisa Bausa, Universidad Autonoma de Madrid; Bruno Bureau, University of Rennes 1

8:30 AM

(G5-008-2016) Consideration of Silver Plate Corrosion Process on the Surface of CoB type of LED Package (Invited)

M. Bessho*[1]; 1. Toshiba Lighting, Japan

9:00 AM

(G5-009-2016) Blue laser-driven phosphor ceramic plate for white light generation (Invited)

D. Yoon*[1]; 1. SungKyunKwan University, Republic of Korea

9:30 AM

(G5-010-2016) Ceramic phosphor properties and microstructures of solid state light sources (Invited)

J. F. Kelso*[1]; A. Lenef[1]; M. Raukas[1]; 1. Osram Sylvania, USA

10:00 AM

Break

10:20 AM

(G5-011-2016) Discovery of New Phosphors by Analysis of Fine Crystals (Single Particle Diagnosis Approach) (Invited)

T. Takeda*[1]; N. Hirosaki[1]; S. Funahashi[1]; R. Xie[1]; 1. National Institute for Materials Science (NIMS), Japan

10:50 AM

(G5-012-2016) Synthesis of New Phosphors using Melt-Quenching Method (Invited)

K. Toda*[1]; S. Kim[1]; K. Uematsu[1]; M. Sato[1]; 1. Niigata University, Japan

11:20 AM

(G5-013-2016) From Ceramics to Single Crystals: A Glimpse into the Optical Floating Zone (Invited)

H. A. Dabkowska*[1]; 1. McMaster University, Canada

G6: Porous Ceramics for Advanced Applications Through Innovative Processing

Novel Sintering Technologies for Porous Ceramics

Room: Trinity I/II

Session Chairs: Mary Anne White, Dalhousie University; Shunkichi Ueno, Nihon University

9:00 AM

(G6-011-2016) Porous Nano-SiC as Thermal Insulator: Wisdom on Balancing Thermal Stability and Low Thermal Conductivity (Invited)

J. Wang*[1]; 1. Institute of Metal Research, China

9:20 AM

(G6-012-2016) Porous Si_3N_4 ceramics prepared via nitridation of Si powder

Y. Zeng*[1]; 1. Shanghai Institute of Ceramics, Chinese Academy of Sciences, China

9:40 AM

(G6-013-2016) Highly porous interpenetrating network reaction-bonded silicon nitride

R. Nikonam Mofrad*[1]; R. Drew[1]; M. Pugh[1]; 1. Concordia University, Canada

10:00 AM

Break

Recent Innovations in Freeze Casting

Room: Trinity I/II

Session Chairs: Yu-Ping Zeng, Shanghai Institute of Ceramics, Chinese Academy of Sciences; Jingyang Wang, Institute of Metal Research

10:20 AM

(G6-014-2016) Freeze-Cast Methods to Make Porous Ceramics: Principles and Examples (Invited)

M. White*[1]; J. Conrad[1]; S. Ellis[1]; C. Romao[1]; 1. Dalhousie University, Canada

10:40 AM

(G6-015-2016) Formation mechanism of lotus type porous ceramics with high porosity through solidification process (Invited)

S. Ueno*[1]; 1. Nihon University, Japan

11:00 AM

(G6-016-2016) Thermal conductivity, strength and energy-saving effect of mullite thermal insulators prepared by gelation freezing route

M. Fukushima*[1]; T. Ohji[1]; Y. Yoshizawa[1]; 1. National Institute of Advanced Industrial Science and Technology (AIST), Japan

11:20 AM

(G6-017-2016) Fabrication and thermal insulation properties of highly porous silica based ceramics via gelation-freezing of diatomite based slurry

C. Matsunaga*[1]; M. Fukushima[1]; H. Hyuga[1]; Y. Yoshizawa[1]; 1. National Institute of Advanced Industrial Science and Technology (AIST), Japan

11:40 AM

(G6-018-2016) Macroprous SiOC ceramics made by freeze casting for cryogenic applications

H. Zhang*[1]; C. L. Fedelis[1]; M. Wilhelm[1]; K. Rezwan[1]; 1. University of Bremen, Germany

G8. Multifunctional Coatings for Sustainable Energy and Environmental Applications

Coatings for Engineering Applications

Room: York B

Session Chairs: Jun Akedo, AIST; Motofumi Suzuki, Kyoto University

8:30 AM

(G8-001-2016) High Temperature Functional Ceramic Coatings for Energy Saving Applications (Invited)

Y. Kagawa*[1]; 1. The University of Tokyo, Japan

9:00 AM

(G8-002-2016) High Temperature Oxidation Behavior and Improvement of Interface Strength of Thermal Barrier Coatings Using Oxide Ceramics-Containing Bond Coatings (Invited)

K. Ogawa*[1]; 1. Tohoku University, Japan

9:30 AM

(G8-003-2016) Suspension plasma spray of yttria stabilized zirconia thermal barrier coatings (Invited)

J. Mostaghimi*[1]; L. Pershin[1]; T. Coyle[1]; P. Xu[1]; 1. University of Toronto, Canada

10:00 AM

Break

10:20 AM

(G8-004-2016) Hybrid aerosol deposition (HAD): A new challenge to fill a gap between aerosol deposition and thermal spray (Invited)

K. Shinoda*[1]; T. Saeki[1]; M. Mori[2]; J. Akedo[1]; 1. National Institute of Advanced Industrial Science and Technology (AIST), Japan; 2. Ryukoku University, Japan

10:50 AM

(G8-005-2016) Suspension Thermal Spray Coatings for Sustainability and Environmental Applications (Invited)

C. Moreau*[1]; 1. Concordia University, Canada

11:20 AM

(G8-006-2016) Using an Axial Feeding DC-Plasma Spray Gun for Fabrication of Ceramic Coatings

M. Shahien*[1]; M. Shahien[2]; M. Suzuki[1]; 1. National Institute of Advanced Industrial Science and Technology (AIST), Japan; 2. Central Metallurgical Research and Development Institute (CMRDI), Egypt

11:40 AM

(G8-007-2016) Microstructure Control of Ceramic Coatings by Axial Feeding DC-Plasma Spray System

M. Suzuki*[1]; M. Shahien[1]; 1. National Institute of Advanced Industrial Science and Technology (AIST), Japan

H2: Design and Development of Advanced Ceramic Fibers, Interfaces, and Interphases in Composites- A Symposium in Honor of Professor Roger Naslain

Introduction to Ceramic Matrix Composites / Novel SiC Fibers and Properties of SiC Fibers

Room: Salon D

Session Chairs: Sergei Mileiko, Institute of Solid Physics; Randall Hay, Air Force Research Laboratory

8:30 AM

(H2-001-2016) A Journey in the Field of Ceramic Matrix Composites (Invited)

R. R. Naslain*[1]; 1. University Bordeaux, France

9:00 AM

(H2-002-2016) Physical and chemical properties of silicon carbide fibers

S. Loison*[1]; C. Huguet[1]; 1. HERAKLES, France

9:20 AM

(H2-003-2016) Oxidation Rates, Microstructure, and Mechanical Properties of SiC Fibers Heat-Treated in $Si(OH)_4$ Saturated Steam

R. Hay*[1]; 1. Air Force Research Laboratory, USA

9:40 AM

(H2-004-2016) Effects of the microstructure, and degradation reaction under heat-treatment on mechanical properties of SiC polycrystalline fiber

H. Oda*[2]; T. Ishikawa[1]; 1. Tokyo University of Science, Yamaguchi, Japan; 2. UBE Industries, Ltd., Japan

10:00 AM

Break

10:20 AM

(H2-005-2016) Development of non-oxide ceramic fibers and their coatings (Invited)

A. Noeth*[1]; A. Rüdinger[1]; M. Rothmann[3]; W. Humbs[3]; B. Heidenreich[2]; 1. Fraunhofer ISC, Germany; 2. German Aerospace Center, Germany; 3. BJS Ceramics GmbH, Germany

10:50 AM

(H2-006-2016) StarFire SMP-10 as a Potential SiC Fiber Precursor

Z. D. Apostolov*[1]; S. Potticary[1]; M. Cinibulk[1]; 1. Air Force Research Lab, USA

11:10 AM

(H2-007-2016) Characterization of the Microstructure, Interfacial Composition, Phases and Elastic Properties in CFCCs Using Interdisciplinary NDE Techniques

M. Manghnani*[1]; R. M. Lemor[3]; M. Prasad[2]; 1. University of Hawaii, USA; 2. Colorado School of Mines, USA; 3. kibero GmbH, Germany

H3. Innovative Design, Advanced Processing, and Manufacturing Technologies

Innovative Design II

Room: Bay

Session Chairs: Walter Krenkel, University of Bayreuth; Xiaoming Duan, Harbin Institute of Technology

8:30 AM

(H3-010-2016) Characterization of SiC_f/SiC composite tube prepared by CVI (Invited)

J. Park[1]; S. Jeong[1]; S. Kim[1]; D. Kim[1]; H. Lee*[1]; W. Kim[1]; 1. Korea Atomic Energy Research Institute, Republic of Korea

9:00 AM

(H3-011-2016) Fundamentals of Reactive Alloy Melt Infiltration for SiC/SiC composites

R. B. Reitz*[1]; F. W. Zok[1]; C. G. Levi[1]; 1. University of California, Santa Barbara, USA

9:20 AM

(H3-012-2016) Influencing the mechanical properties of weak matrix C/C composites by means of microstructural design

A. Todt*[1]; D. Nestler[1]; K. Roder[1]; N. Nier[1]; G. Wagner[1]; 1. TU Chemnitz, Germany

9:40 AM

(H3-013-2016) High temperature wet oxidation behavior of SiC fiber-reinforced SiC-based composites fabricated by melt infiltration using Si binary alloys

T. Tsunoura*[1]; K. Yoshida[1]; T. Yano[1]; T. Aoki[2]; T. Ogasawara[3]; 1. Tokyo Institute of Technology, Japan; 2. Japan Aerospace Exploration Agency, Japan; 3. Tokyo University of Agriculture and Technology, Japan

10:00 AM

Break

10:20 AM

(H3-014-2016) Application of Electrophoretic Deposition for Interphase Formation on Polycrystalline and Amorphous SiC Fibers in SiC_f/SiC Composites (Invited)

K. Yoshida*[1]; T. Kikuhara[1]; N. Mizuta[1]; T. Ajito[1]; T. Yano[1]; M. Kotani[2]; T. Aoki[2]; T. Ogasawara[3]; 1. Tokyo Institute of Technology, Japan; 2. Japan Aerospace Exploration Agency (JAXA), Japan; 3. Tokyo University of Agriculture and Technology, Japan

10:50 AM

(H3-015-2016) Polymer-precursor-based processing approaches towards layered and bulk ceramic composites (Invited)

T. Konegger*[1]; C. Drechsel[1]; 1. TU Wien - Vienna University of Technology, Austria

11:20 AM

(H3-016-2016) Powder injection moulding of zirconia-alumina ceramic matrix composite using water-soluble binder system

N. Chuankrerkkul*[1]; 1. Chulalongkorn University, Thailand

H5. Polymer Derived Ceramics and Composites

PDC Fibers

Room: Trinity IV

Session Chair: Samuel Bernard, CNRS

8:30 AM

(H5-010-2016) State of the Art and New Developments of Polymer Derived Ceramic Fibers (Invited)

B. Clauss*[1]; 1. DITF, Germany

9:00 AM

(H5-011-2016) Synthesis, Properties and Applications of SiC Ultrathin Fibers via Electrospining Combined with Polymer-derived Ceramics Route (Invited)

Y. Wang*[1]; 1. National University of Defence Technology, China

9:30 AM

(H5-012-2016) Preceramic polymer derived porous ceramics, nanowires and ceramic fibers (Invited)

M. Fukushima*[1]; K. Kita[1]; P. Colombo[2]; H. Hyuga[1]; Y. Yoshizawa[1]; N. Kondo[1]; 1. National Institute of Advanced Industrial Science and Technology (AIST), Japan; 2. University of Padova, Italy

10:00 AM

Break

Applications of PDCs

Room: Trinity IV

Session Chair: Gabriela Mera, Technical University Darmstadt

10:20 AM

(H5-013-2016) Polymer-Derived Ceramics: From Single Phase to Nanocomposite Structures with Tailored Porosity for Hydrogen Production (Invited)

S. Bernard*[1]; 1. CNRS, France

10:50 AM

(H5-014-2016) Additive Manufacturing with Preceramic Polymers

P. Colombo*[1]; 1. University of Padova, Italy

11:10 AM

(H5-015-2016) Polymer-derived Bioactive Wollastonite-Diopside Glass-ceramics: from Foams to Direct Ink Writing

E. Bernardo*[1]; 1. University of Padova, Italy

H11. CMC Applications in Transportation and Industrial Systems

Materials and Manufacturing Processes for Serial Production

Room: Salon C

Session Chair: Roland Weiss, Schunk Kohlenstofftechnik GmbH

8:30 AM

(H11-007-2016) Production and Development of Composites for Industrial High Temperature Applications (Invited)

R. Weiss*[1]; 1. Schunk Kohlenstofftechnik GmbH, Germany

9:00 AM

(H11-008-2016) Continuous siliconization process for a mass production of CMC brake discs (Invited)

M. Orlandi*[1]; M. Valle[2]; D. Coslovi[1]; M. Marschall[3]; 1. BSCCB, Italy; 2. Petroceramics SpA, Italy; 3. BSCCB GmbH, Germany

9:30 AM

(H11-009-2016) Effects of hot-spot formation during MW-assisted synthesis via reactive infiltration of C_f/SiC composite materials

M. R. Caccia*[2]; A. Camarano[2]; J. Narciso[1]; 1. Alicante University, Spain; 2. University of Alicante, Spain

9:50 AM

Break

Oxidation and Corrosion of Hot Structures in Realistic Environments

Room: Salon C

Session Chair: Shaoming Dong, Shanghai Institute of Ceramics, Chinese Academy of Sciences

10:20 AM

(H11-010-2016) Corrosion Behavior of SiC_f/SiC Composites in Molten Fluoride Salts (Invited)

S. Dong*[1]; H. Wang[1]; Y. Kan[1]; H. Zhou[1]; 1. Shanghai Institute of Ceramics, Chinese Academy of Sciences, China

10:50 AM

(H11-011-2016) Hydrothermal oxidation of carbon fiber reinforced ceramic matrix composite (Invited)

X. Luan*[1]; J. Yuan[2]; X. Hai[1]; Y. Zou[1]; R. Riedel[2]; E. Ionescu[2]; 1. Northwestern Polytechical University, China; 2. Technische Universität Darmstadt, Germany

11:20 AM

(H11-012-2016) Ceramic Matrix Composite Design and Behavior for Aero Engines Gas Turbines Components

E. Bouillon*[1]; D. Marsal[1]; A. Mouret[1]; 1. Safran Herakles, France

11:40 AM

(H11-013-2016) Mechniacal properties and original features of fiber-reinforced self-healing ceramics

W. Nakao*[1]; 1. Yokohama National University, Japan

Young Professionals Forum - Next Generation Materials for Multifunctional Applications and Sustainable Development, and Concurrent Societal Challenges in the New Millennium

Young Professional Forum III: Multifunctional Materials, Porous, and Catalytic Materials

Room: York A

Session Chairs: Alexis Lewis, National Science Foundation; Richard Riman, Rutgers University; Matteo Clerici, University of Glasgow

8:30 AM

(YPF-008-2016) Structure Property Relations in Anisotropically Porous Ceramics (Invited)

A. Stevenson*[1]; J. Seuba[1]; S. Deville[2]; 1. Saint-Gobain, France; 2. CNRS, France

9:00 AM

(YPF-009-2016) NMR techniques to study the formation, structure, and use of small nanoparticle alloys (Invited)

J. Millstone*[1]; 1. University of Pittsburgh, USA

9:30 AM

(YPF-010-2016) Tuning the hydrothermal gelation of graphene oxide (Invited)

K. Hu*[1]; X. Xie[2]; T. Szkopek[1]; M. Cerruti[1]; 1. McGill University, Canada; 2. Sichuan University, China

9:50 AM

(YPF-011-2016) Embedded chip-scale supercapacitors with novel functionalized architecture and tailored ionic liquid-based electrolyte

T. Colling*[1]; V. Scott[2]; J. Ready[3]; 1. Georgia Institute of Technology, USA; 2. NASA Jet Propulsion Laboratory, USA; 3. Georgia Tech Research Institute, USA

10:10 AM

Break

Young Professional Forum IV: Health, Energy, and Emerging Technologies

Room: York A

Session Chairs: Jill Millstone, University of Pittsburgh; Rafik Naccache, Institut National de la Recherche Scientifique

10:20 AM

(YPF-012-2016) Polymer Matrix Based Multiphasic Piezoelectric Composites: Fabrication and Characterization (Invited)

S. Banerjee*[1]; 1. California State University, Fresno, USA

10:50 AM

(YPF-013-2016) Novel nonlinear effects and detection schemes at THz frequencies (Invited)

M. Clerici*[1]; M. Peccianti[2]; A. Mazhorova[3]; S. Ho[6]; B. Schmidt[3]; L. Caspani[4]; A. Pasquazi[2]; A. Couairon[5]; F. Vidal[3]; L. Razzari[3]; J. Ali[6]; F. Légaré[3]; T. Ozaki[3]; D. Faccio[4]; R. Morandotti[3]; 1. University of Glasgow, United Kingdom; 2. University of Sussex, United Kingdom; 3. INRS, Canada; 4. Heriot-Watt University, United Kingdom; 5. École Polytechnique, France; 6. Universiti Teknologi Malaysia, Malaysia

11:20 AM

(YPF-014-2016) Preparation and Methane Adsorption of Two-dimensional Carbide Ti_2C

A. Zhou*[1]; F. Liu[1]; 1. Henan Polytechnic University, China

11:40 AM

(YPF-015-2016) 3D Printing of MAX Reinforced Composites

R. Dunnigan[1]; S. Ghosh[1]; F. AlAnazi[1]; S. Gupta*[1]; 1. University of North Dakota, USA

G1. Powder Processing Innovation and Technologies for Advanced Materials and Sustainable Development

Composite and Porous Structure Control

Room: Trinity III

Session Chairs: Kevin Ewsuk, Sandia National Laboratories; Yuji Hotta, National Institute of Advanced Industrial Science and Technology (AIST)

1:30 PM

(G1-019-2016) From Biomimetic Concept to Engineering Reality – Design of Ceramic Reinforcement (Invited)

W. Tuan*[1]; Y. Yu[1]; 1. National Taiwan University, Taiwan

2:00 PM

(G1-020-2016) Nanoporous Composites as Advanced Electrodes for Supercapacitors (Invited)

J. Kang*[1]; 1. Tianjin Polytechnic University, China

2:30 PM

(G1-021-2016) Characterization and Modeling to Design and Develop Particle-Filled-Glass Composites (Invited)

K. Ewsuk*[1]; 1. Sandia National Laboratories, USA

3:00 PM

Break

3:20 PM

(G1-022-2016) Bioinspired Graphene-Copper Matrix Nanocomposites (Invited)

D. Xiong*[1]; M. Cao[1]; Q. Guo[1]; Z. Tan[1]; G. Fan[1]; Z. Li[1]; D. Zhang[1]; 1. Shanghai Jiao Tong University, China

3:50 PM

(G1-023-2016) Bioinspired Fabrication, Properties and Applications of Nanocarbon Reinforced Aluminum Composites (Invited)

Z. Li*[1]; G. Fan[1]; Z. Tan[1]; D. Xiong[1]; Q. Guo[1]; Y. Su[1]; D. Zhang[1]; 1. Shanghai Jiao Tong University, China

4:20 PM

(G1-024-2016) Energy-saving Housing Materials using Nano Porous Ceramics Structure (Invited)

N. Isu*[1]; 1. LIXIL Corp., Japan

4:50 PM

(G1-025-2016) Development of Ceramic Mold for Rapid Forming of CFRP Composite Using Microwave

Y. Hotta*[1]; D. Shimamoto[1]; Y. Tominaga[1]; 1. National Institute of Advanced Industrial Science and Technology, Japan

5:10 PM

(G1-026-2016) Particle size blending effect on the heat transfer property of BN particle packed bed

S. Yamashita*[1]; H. Kita[1]; 1. Nagoya University, Japan

G2. Functional Nanomaterials for Sustainable Energy Technologies

Functional Nanomaterials for Sustainable Energy Technologies II

Room: York A

Session Chair: Sanjay Mathur, University of Cologne

2:00 PM

(G2-007-2016) Insights from Surface Science into Surface and Interface Properties of Photoelectrocatalysts for Solar Fuels (Invited)

B. E. Koel*[1]; C. X. Kronawitter[1]; P. Zhao[1]; Z. Chen[1]; 1. Princeton University, USA

2:30 PM

(G2-008-2016) New Design Strategy for Advanced Photocatalysts (Invited)

L. Vayssieres*[1]; 1. Xi'an Jiaotong University, China

3:00 PM

Break

3:20 PM

(G2-009-2016) Local Atomic and Electronic Structures of Energy Materials Characterized by Synchrotron X-ray Spectroscopy (Invited)

C. Dong*[1]; 1. Tamkang University, Taiwan

3:50 PM

(G2-010-2016) One-pot synthesis of heterostructured photocatalysts for improved solar-to-hydrogen conversion (Invited)

Y. Chen*[1]; Z. Qin[1]; X. Guan[1]; M. Liu[1]; 1. Xi'an Jiaotong University, China

4:20 PM

(G2-011-2016) Fabrication of Low Adsorption Energy Ni-Mo Clusters Co-catalyst in Metal-Organic Frameworks for Visible Photocatalytic Hydrogen Evolution

G. Lu*[1]; 1. Lanzhou Institute of Chemical Physics, China

4:40 PM

(G2-012-2016) Photocatalytic Seawater Splitting on Metal-Nitride Nanowires

X. Guan*[1]; F. Chowdhury[2]; L. Vayssieres[1]; L. Guo[1]; Z. Mi[2]; 1. Xi'an Jiaotong University, China; 2. McGill University, Canada

5:00 PM

(G2-013-2016) Synthesis of Ca-Al Hydrotalcite with Li^+, K^+, and Ti^{4+} Promoter as Heterogeneous Solid Base Catalyst

E. D. Magdaluyo*[1]; 1. University of the Philippines, Philippines

G5. Advanced Materials, Technologies, and Devices for Electro-optical and Medical Applications

Semiconductor II

Room: Trinity V

Session Chairs: Toshio Kamiya, Tokyo Institute of Technology; Eirini Sarigiannidou, Grenoble INP

1:30 PM

(G5-014-2016) Growth of hexagonal boron nitride films on sapphire substrates by the chemical vapor deposition using BCl_3 and NH_3 as sources (Invited)

K. Hara*[1]; N. Umehara[1]; A. Masuda[1]; T. Shimizu[1]; T. Kouno[1]; H. Kominami[1]; 1. Shizuoka University, Japan

2:00 PM

(G5-015-2016) Luminous complex point defect structure in Ce doped cubic boron nitride

R. Ishikawa*[1]; N. Shibata[1]; F. Oba[2]; T. Taniguchi[5]; S. Findlay[3]; I. Tanaka[4]; Y. Ikuhara[1]; 1. University of Tokyo, Japan; 2. Tokyo Institute of Technology, Japan; 3. Monash University, Australia; 4. Kyoto University, Japan; 5. National Institute for Materials Science (NIMS), Japan

2:20 PM

(G5-016-2016) Synthesis of nitride nanoparticles using $NaNH_2$ melt (Invited)

A. Miura*[1]; M. Higuchi[1]; K. Tadanaga[1]; 1. Hokkaido University, Japan

2:50 PM

Break

3:10 PM

(G5-017-2016) Impact of hydrogen doping for defect formation behavior in CZ-Si crystal growth (Invited)

W. Sugimura*[1]; T. Ono[1]; M. Hourai[1]; K. Higashida[2]; 1. SUMCO Corporation, Japan; 2. Kyushu University, Japan

3:40 PM

(G5-018-2016) Advanced SiC power devices with trench structures and the high temperature operations of these devices (Invited)

T. Nakamura*[1]; 1. ROHM Co., Ltd., Japan

4:10 PM

(G5-019-2016) Solution growth of Silicon Carbide: State of the art and perspectives (Invited)

D. Chaussende*[1]; Y. Shin[1]; K. Ariyawong[1]; J. Dedulle[1]; T. Ouisse[1]; E. Sarigiannidou[1]; O. Chaix-Pluchery[1]; 1. CNRS, Univ. Grenoble Alpes, France

4:40 PM

(G5-020-2016) Al-Si-C ternary alloys: A “new” family of wide band gap semiconductors (Invited)

E. Sarigiannidou*[1]; O. Chaix-Pluchery[1]; H. Le Tran[1]; M. Modreanu[2]; L. Pedesseau[3]; D. Chaussende[1]; 1. Univ. Grenoble Alps, CNRS, LMGP, France; 2. Tyndall National Institute, University College Cork, Ireland; 3. UMR FOTON, CNRS, INSA Rennes, France

G6: Porous Ceramics for Advanced Applications Through Innovative Processing

Advanced Processing Methods and Characterization Technologies of Ceramic Foams II

Room: Trinity I/II

Session Chair: Miki Inada, Kyushu University

1:30 PM

(G6-019-2016) Novel gel casting process for the manufacturing of glass foams (Invited)

E. Bernardo*[1]; A. Rincon Romero[1]; 1. University of Padova, Italy

2:00 PM

(G6-020-2016) Synthesis of porous carbon materials with hierarchical structure

M. R. Caccia*[2]; D. Zabiegaj[3]; F. Ravera[3]; J. Narciso[1]; 1. Alicante University, Spain; 2. University of Alicante, Spain; 3. National Research Council of Italy, Italy

2:20 PM

(G6-021-2016) Fracture behavior of Three-dimensionally Networked Porous Carbon Material under Stress Concentration

R. Inoue*[1]; E. Kojyo[1]; Y. Kogo[1]; 1. Tokyo University of Science, Japan

2:40 PM

(G6-022-2016) Radiative properties of silicon carbide open-cell foams up to 1300 K: A multi length-scale modelling approach

B. Rousseau*[1]; S. Guevelou[1]; A. Mekeze-Monthe[1]; G. Domingues[1]; J. Vicente[2]; A. Fussel[3]; D. Haase[3]; J. Adler[3]; L. Del Campo[4]; D. De Sousa Meneses[4]; 1. LTN UMR CNRS 6607, France; 2. IUSTI UMR CNRS 7343, France; 3. Fraunhofer IKTS, Germany; 4. CEMHTI UPR CNRS 3079, France

3:00 PM

Break

Novel Developments and Engineering Applications of Porous Ceramics

Room: Trinity I/II

Session Chairs: Alberto Ortona, SUPSI; Ulrich Vogt, Empa, Swiss Federal Laboratories for Materials Science and Technology

3:20 PM

(G6-023-2016) Solar-Thermal Redox Reaction for Syngas Production on CeO_2 Foam Ceramics (Invited)

U. F. Vogt*[1]; A. Bonk[1]; M. V. Schlupp[1]; C. Battaglia[1]; A. Steinfeld[2]; 1. Empa, Swiss Federal Laboratories for Materials Science and Technology, Switzerland; 2. ETH Zürich, Switzerland

3:50 PM

(G6-024-2016) Kinetic approach for the adsorption-photodecomposition properties of mesoporous silica-titania (Invited)

M. Inada*[1]; K. Hayashi[1]; J. Hojo[1]; 1. Kyushu University, Japan

4:10 PM

(G6-025-2016) Optimized Ceramic for Hypersonic Applications with Transpiration Cooling - OCTRA (Invited)

C. Dittert*[1]; M. Kütemeyer[1]; 1. DLR - German Aerospace Center, Germany

4:30 PM

(G6-026-2016) Loop heat pipe wicks of biomorphous SiC ceramic

B. Weisenseel[1]; B. Zierath[1]; P. Greil[1]; T. Fey*[1]; 1. Friedrich-Alexander University Erlangen-Nürnberg, Germany

4:50 PM

(G6-027-2016) Reactivity of SiC single crystal with Ir at high temperature

A. Camarano[3]; D. Giuranno[2]; E. Ricci[2]; J. Narciso*[1]; 1. Alicante University, Spain; 2. CNR-IENI, Italy; 3. University of Alicante, Spain

5:10 PM

(G6-028-2016) Porous alumina derived from the mixed powder including aluminum and alumina

K. Kita*[1]; M. Fukushima[1]; N. Kondo[1]; 1. National Institute of Advanced Industrial Science and Technology (AIST), Japan

G8. Multifunctional Coatings for Sustainable Energy and Environmental Applications

Coatings for Energy and Environmental Applications

Room: York B

Session Chairs: Kentaro Shinoda, National Institute of Advanced Industrial Science and Technology (AIST); Tetsuya Yamamoto, Kochi University of Technology; Minoru Osada, National Institute for Materials Science

1:30 PM

(G8-008-2016) Highly Transparent Scratch-resistant Coating using Aerosol Deposition Process (Invited)

J. Park*[1]; D. Kim[1]; M. Lee[1]; J. Lim[1]; S. Oh[1]; 1. IONES, Republic of Korea

2:00 PM

(G8-009-2016) Insulating Ceramic layers Prepared by Aerosol Deposition for Heat Dissipation Circuit Boards of High Power Devices

J. Akedo*[1]; H. Tsuda[1]; 1. AIST, Japan

2:20 PM

(G8-010-2016) Erosion Behavior of Yttrium Oxide film prepared by Aerosol Deposition Method in the Plasma Process

H. Ashizawa*[1]; M. Kiyohara[1]; 1. TOTO Ltd., Japan

2:40 PM

(G8-011-2016) Sintering of YOF Ceramics and Their Properties (Invited)

K. Yoshida*[1]; T. Tsunoura[1]; T. Yano[1]; 1. Tokyo Institute of Technology, Japan

3:10 PM

Break

3:30 PM

(G8-012-2016) Enhanced Li ion conductivity of sulfide solid electrolyte films by aerosol deposition method and its application to all-solid-state Li ion batteries

M. Suzuki*[1]; T. Takemoto[2]; Y. Ishiguro[2]; J. Akedo[1]; 1. National Institute of Advanced Industrial Science and Technology, Japan; 2. Toyota Motor Corp., Japan

3:50 PM

(G8-013-2016) Photocurrent and Photovoltaic Properties of $BiFeO_3$ Thin Films on ITO/Glass Substrates Prepared by Chemical Solution Deposition

W. Sakamoto*[1]; T. Katayama[1]; K. Hayashi[1]; T. Yogo[1]; 1. Nagoya University, Japan

4:10 PM

(G8-014-2016) Functional Ceramic Coatings by Solution Precursor Plasma Spray Deposition

T. Coyle*[1]; Y. Gazman[1]; Y. Cai[1]; P. Xu[1]; J. Mostaghimi[1]; 1. University of Toronto, Canada

4:30 PM

(G8-015-2016) Development of Innovative Atmospheric-Pressure Epitaxial Growth Technique “Mist Chemical Vapor Deposition” based on Leidenfrost state droplets (Invited)

T. Kawaharamura*[1]; 1. Kochi University of Technology, Japan

5:00 PM

(G8-016-2016) Advanced Phosphor Thin Films fabricated by Photoinduced Chemical Solution Deposition

T. Tsuchiya*[1]; T. Nakajima[1]; Y. Uzawa[1]; 1. National Institute of Advanced Industrial Science and Technology (AIST), Japan

5:20 PM

(G8-017-2016) Transfer process of epitaxially grown piezoelectric $BaTiO_3$ thin films to flexible polymer sheets

H. Nishikawa*[1]; M. Yokura[2]; S. Kaneko[3]; T. Endo[4]; 1. B.O.S.T., Kinki Univ., Japan; 2. Grad. School Eng., Mie Univ., Japan; 3. Kanagawa Ind. Technol. Center, Japan; 4. Fac. Eng., Gifu Univ., Japan

H2: Design and Development of Advanced Ceramic Fibers, Interfaces, and Interphases in Composites- A Symposium in Honor of Professor Roger Naslain

SiC/SiC and C/C Composite Materials / Interfaces and Interphases in CMCs

Room: Salon D

Session Chairs: Bernd Clauss, DITF; Andreas Noeth, Fraunhofer ISC; Weigang Zhang, Institute of Process Engineering/CAS

1:30 PM

(H2-008-2016) From Hybrid Polymers to Composite Ceramics: Metallocenes Catalytic Insertion Polymerization of Silenes (Invited)

W. Zhang*[1]; M. Ge[1]; X. Lv[2]; Y. Tian[2]; S. Yu[1]; 1. Institute of Process Engineering/CAS, China; 2. University of Chinese Academy of Sciences, China

2:00 PM

(H2-009-2016) HRTEM investigation of local damage mechanisms at fiber/matrix interface of SiC/SiC composites

C. Fellah*[1]; J. Braun[1]; S. Poissonnet[1]; M. Berger[2]; C. Sauder[1]; 1. CEA, France; 2. MINES ParisTech, France

2:20 PM

(H2-010-2016) The micro-scale and macro-scale crack propagation behaviors of SiC nanowires reinforced SiC_f/SiC composites

J. Hu*[1]; S. Dong[1]; 1. Shanghai Institute of Ceramics, Chinese Academy of Sciences, China

2:40 PM

(H2-011-2016) Mechanical properties of three-dimensional carbon/carbon composites with vertically-aligned carbon nanotubes

Q. Song*[1]; L. Feng[1]; H. Li[1]; 1. Northwestern Polytechnical University, China

3:00 PM

Break

3:20 PM

(H2-012-2016) The Role of Interfaces and Interphases in Life Limiting Behavior of Ceramic Composites

R. J. Kerans*[1]; 1. Air Force Research Lab, USA

3:40 PM

(H2-013-2016) BN interphases processed by LPCVD with different microstructures and characterized using SiC/SiC minicomposites

C. Chanson[2]; S. Jouannigot[1]; E. Martin[3]; S. Jacques*[1]; 1. CNRS, France; 2. LCTS - CNRS, France; 3. University of Bordeaux, France

4:00 PM

(H2-014-2016) Rare earth disilicate fiber coatings for SiC/SiC CMCs: Coating process design and evaluation

P. Mogilevsky*[2]; E. E. Boakye[2]; T. Key[2]; M. Cinibulk[1]; R. Hay[1]; S. Opeka[2]; 1. Air Force Research Laboratory, USA; 2. UES, Inc., USA

4:20 PM

(H2-015-2016) Processing of $RE_2Si_2O_7$ Fiber–Matrix Interphases for SiC–SiC Composites

E. E. Boakye*[2]; P. Mogilevsky[2]; T. A. Parthasarathy[2]; K. Keller[2]; T. Key[2]; S. Opeka[2]; R. Hay[1]; M. Cinibulk[1]; 1. Air Force Research Laboratory, USA; 2. UES Inc., USA

4:40 PM

(H2-016-2016) Fiber Interface Coatings via UVCVD for High Temperature Fiber-reinforced Ceramic Matrix Composites

J. Stiglich*[1]; B. Williams[1]; J. Brockmeyer[1]; V. Arrieta[1]; 1. Ultramet, USA

5:00 PM

(H2-017-2016) Preparation of CVD-SiBCN coatings and its effects on the oxidation resistance of SiC_f/SiC composites

J. Li*[1]; 1. National University of Sciences and Technology, China

H3. Innovative Design, Advanced Processing, and Manufacturing Technologies

Innovative Design III

Room: Bay

Session Chairs: Alexey Kulik, STR Group, Inc.; Dileep Singh, Argonne National Lab

1:30 PM

(H3-017-2016) Three-Dimensional Multi-Reinforced Ceramic Composites with Enhanced Through-Thickness Thermal Conductivity (Invited)

C. Xu*[1]; 1. Florida State University, USA

2:00 PM

(H3-018-2016) Processing of Tyranno ZMI fiber/$TiSi_2$–Si matrix composites for high-temperature structural application (Invited)

T. Aoki*[1]; T. Ogasawara[3]; T. Tsunoura[2]; K. Yoshida[2]; T. Yano[2]; 1. Japan Aerospace Exploration Agency, Japan; 2. Tokyo Institute of Technology, Japan; 3. Tokyo University of Agriculture and Technology, Japan

2:30 PM

(H3-019-2016) Ultra-high Temperature Ceramic Matrix Composites Fabricated by an improved RMI Method (Invited)

S. Dong*[1]; D. Jiang[1]; 1. Shanghai Institute of Ceramics, Chinese Academy of Sciences, China

3:00 PM

Break

3:20 PM

(H3-020-2016) Fabrication and dynamic compressive properties laminated ceramics by reactive hot pressing and reactive jointing method (Invited)

L. Cheng*[1]; L. Li[1]; L. Zhang[1]; 1. Northwestern Polytechnical University, China

3:50 PM

(H3-021-2016) Manufacture of SiC /$ZrSi_2$ composite materials

O. Coloma[2]; A. Camarano[2]; M. R. Caccia[2]; J. Narciso*[1]; 1. Alicante University, Spain; 2. University of Alicante, Spain

4:10 PM

(H3-022-2016) Development of superfine nano-composites anti-fouling coatings for Ship Hulls (Invited)

A. S. Khanna*[1]; 1. IIT Bombay, India

4:40 PM

(H3-023-2016) High Temperature Oxidation of Yttrium Silicides

R. A. Golden*[1]; E. J. Opila[1]; 1. University of Virginia, USA

H5. Polymer Derived Ceramics and Composites

PDC Precursors and Microstructure

Room: Trinity IV

Session Chair: Hans-Joachim Kleebe, Technical University of Darmstadt

1:20 PM

(H5-016-2016) From Chemistry to Processing of Boron-Modified Silicon Carbide Matrix Composite Precursors

M. Schmidt*[1]; S. Bernard[1]; G. Chollon[2]; 1. European Membrane Institute, France; 2. Laboratoire des Composites Thermostructuraux, France

1:40 PM

(H5-017-2016) From Chemistry to Processing of Boron-Modified Polycarbosilazanes: Toward the Preparation of Bulk SilicoBoron (Carbo)Nitride Ceramic

D. Fonblanc*[1]; F. Rossignol[2]; S. Bernard[1]; 1. European Membrane Institute, France; 2. Science des Procédés Céramiques et de Traitements de Surface, France

2:00 PM

(H5-018-2016) Effect of Boron Incorporation on the Phase Composition and High-Temperature Behavior of Polymer-Derived Silicon Carbide

E. Ionescu*[1]; 1. Technical University Darmstadt, Germany

2:20 PM

(H5-019-2016) Nanocarbon containing C/SiO(C)-based ceramics: Synthesis approaches and functional properties

G. Mera[2]; R. Riedel[1]; E. Ionescu*[2]; 1. TU Darmstadt, Germany; 2. Technical University Darmstadt, Germany

2:40 PM

(H5-020-2016) PDCs route as an alternative method to get self-standing highly crystallized h-BN

B. Toury*[1]; F. Gombault[1]; S. Yuan[2]; C. Journet[1]; A. Brioude[1]; 1. University of Lyon, France; 2. INSA Lyon, France

3:00 PM

Break

Microstructure and Properties of PDCs

Room: Trinity IV

Session Chair: Emanuel Ionescu, Technical University Darmstadt

3:20 PM

(H5-021-2016) Correlation Between Microstructure Evolution and High-Temperature Behavior of SiOC-based Polymer Derived Ceramics

H. Kleebe*[1]; E. Ionescu[1]; R. Riedel[1]; 1. Technical University Darmstadt, Germany

3:40 PM

(H5-022-2016) Single Si atoms and silicon nitride nano-clusters in SiCN polymer-derived ceramics

R. Ishikawa*[2]; G. Mera[1]; E. Ionescu[1]; R. Riedel[1]; Y. Ikuhara[2]; 1. TU Darmstadt, Germany; 2. University of Tokyo, Japan

4:00 PM

(H5-023-2016) Effect of the Free-Carbon Phase on the Structure of Polymer Derived Silicon Carbide Ceramics

A. Tavakoli*[1]; C. Gervais[2]; F. Babonneau[2]; R. Bordia[1]; 1. Clemson University, USA; 2. Collège de France, France

4:20 PM

(H5-024-2016) Electromagnetic absorption properties of silicon-based polymer derived ceramics (Invited)

X. Yin*[1]; 1. Northwestern Polytechical University, China

4:50 PM

(H5-025-2016) Evaluation of the thermal behavior of silicon oxycarbide receivers against concentrated solar radiation

A. Tamayo*[1]; A. Mazo[1]; A. Lopez-Delgado[2]; I. Padilla[2]; F. Rubio[1]; J. Rubio[1]; 1. Institute of Ceramics and Glass, CSIC, Spain; 2. Spanish National Research Center for Metallurgy, Spain

5:10 PM

(H5-026-2016) Oxygen Transport in Sol-Gel Derived and Thermally Grown Borosilicate Glasses (Invited)

B. McFarland[1]; E. J. Opila*[1]; 1. University of Virginia, USA

5:40 PM

(H5-027-2016) Precursor-Derived Ceramic Nanowire and Nanosheet Composites for High Power Laser Radiometry

G. Singh*[1]; 1. Kansas State University, USA

H11. CMC Applications in Transportation and Industrial Systems

Novel Application areas and Technology Transfer

Room: Salon C

Session Chairs: Lalit Manocha, SICART; Bernhard Heidenreich, German Aerospace Center

1:30 PM

(H11-014-2016) Non-oxide ceramic matrix composites for industrial and aerospace applications (Invited)

W. Humbs*[2]; M. Rothmann[2]; R. McKown[2]; J. Schull[1]; 1. BJS Composites GmbH, Germany; 2. BJS Ceramics GmbH, Germany

2:00 PM

(H11-015-2016) Application of CMC Materials in Rocket Propulsion

F. Olufsen*[1]; E. Orbekk[1]; 1. Nammo Raufoss AS, Norway

2:20 PM

(H11-016-2016) C/C-SiC Sandwich Structures for Lightweight and Thermally Stable Components in Satellites and Industrial Applications

B. Heidenreich*[1]; N. Gottschalk[2]; Y. Klett[2]; D. Koch[1]; 1. German Aerospace Center, Germany; 2. University of Stuttgart, Germany

2:40 PM

(H11-017-2016) 3D C_f/SiC-C Composites with SiC/PyC Multilayer Matrix Produced by ICVI

U. Andi*[1]; M. Basha[1]; D. K. David[2]; S. Vidyavathy[2]; S. Singh[3]; V. Prasad[3]; 1. CSIR-National Aerospace Laboratories, India; 2. Anna University, India; 3. Defence Metallurgical Research Laboratory, India

3:00 PM

Break

3:20 PM

(H11-018-2016) Carbons as reinforcements for Carbon and ceramic matrix Composites (Invited)

L. M. Manocha*[1]; 1. SICART, India

3:50 PM

(H11-019-2016) Meso/Macrostructure Porous Ceramics as such and in composites form for valued applications (Invited)

S. Manocha*[1]; 1. GGS IP UNIVERSITY, India

4:20 PM

(H11-020-2016) Synthesis of C_f/SiC composites with $(PyC/SiC)_{n=4}$ multilayer interface via CVI and their characterization

M. Basha*[1]; S. Murugan[1]; S. Singh[2]; S. Sankaranarayanan[3]; U. Andi[1]; V. Prasad[2]; 1. CSIR-National Aerospace Laboratories, India; 2. Defence Metallurgical Research Laboratory, India; 3. National Institute of Technology Tiruchirappalli, India

Young Professionals Forum - Next Generation Materials for Multifunctional Applications and Sustainable Development, and Concurrent Societal Challenges in the New Millennium

Young Professional Forum V: Seminar

Room: York A

Session Chairs: Eva Hemmer, University of Ottawa; Surojit Gupta, University of North Dakota

12:00 PM

(YPF-016-2016) Survival Skills for Scientists (Invited)

F. Rosei*[1]; 1. INRS, Canada

Poster Session

Room: Salon A/B

6:30 PM

(P001-2016) Improvement workability of recycled gypsum powder from waste plasterboard by using dry/aqueous process

Y. Kameda*[1]; M. Matsubara[1]; M. Tafu[1]; S. Takamatsu[1]; T. Toshima[1]; T. Ohshima[2]; 1. National Institute of Technology, Toyama College, Japan; 2. Hokusei Kigyou Co. Ltd, Japan

(P002-2016) Synthesis and characteristics of thermoelectric $Ca_{3-x}Ce_xCo_4O_{9+\delta}$ powders prepared by sol–gel method

K. Park*[1]; J. S. Cha[1]; D. Hakeem[1]; 1. Sejong University, Republic of Korea

(P003-2016) Fabrication of porous metal/carbon composites and their extinction characteristic as smoke interfering materials

Y. Wu*[1]; Y. Mu[1]; Q. Liu[2]; P. Bi[1]; 1. State Key Laboratory of NBC Protection for Civilian, China; 2. Shanghai Jiao Tong University, China

(P004-2016) Synthesis and photochemical properties of silicon doped TiO_2 nanotubes by hydrothermal method

P. Dao[1]; K. Du[1]; G. Liu[1]; M. Tayyib[1]; K. Wang*[1]; 1. University College of Southeast Norway, Norway

(P005-2016) Dielectric properties of amorphous SiO_2 and their link with those of other SiO_2 polymorphs

O. I. Malyi*[1]; M. Boström[1]; V. V. Kulish[2]; P. Thiyam[3]; D. F. Parsons[4]; C. Persson[1]; 1. University of Oslo, Norway; 2. National University of Singapore, Singapore; 3. Royal Institute of Technology, Sweden; 4. Murdoch University, Australia

(P006-2016) Novel Particulate Reinforced Multifunctional Composites for Energy Harvesting

R. Lofthus[1]; M. Bahmer*[1]; D. Feguson[1]; S. Gupta[1]; 1. University of North Dakota, USA

(P007-2016) Preparation of functional materials from unused phosphate resources in sewage sludge

A. Fukushima*[1]; A. Nomura[1]; S. Takamatsu[1]; M. Tafu[1]; T. Toshima[1]; T. Nakazato[2]; 1. National Institute of Technology, Toyama College, Japan; 2. Kagoshima University, Japan

(P008-2016) Development of High Thermal Conductivity Silicon Nitride Substrates

D. Kusano*[1]; Y. Zhou[2]; H. Hyuga[2]; K. Hirao[2]; 1. Japan Fine Ceramics Co., LTD, Japan; 2. National Institute of Advanced Industrial Science & Technology, Japan

(P009-2016) Mechanical properties of kenaf-polypropylene Composites with carbon nanotubes as fillers

R. Paskaramoorthy[1]; O. Asumani*[1]; 1. University of the Witwatersrand, South Africa

(P010-2016) High Temperature Exposure and Stability of Calcium Aluminate Cements

J. Zapata[1]; M. Gomez[1]; H. Colorado*[1]; 1. Universidad de Antioquia, Colombia

(P011-2016) Inorganic phosphate cement with battery waste

H. Colorado*[1]; 1. Universidad de Antioquia, Colombia

(P012-2016) A thermo-electro-mechanical vibration analysis of size-dependent functionally graded piezoelectric nanobeams

A. Ashoori*[1]; E. Salari[1]; S. Sadough Vanini[1]; 1. Amirkabir University of Technology, Islamic Republic of Iran

(P013-2016) Growth and characterization of lithium ion conductor $La_{(1-x)/3}Li_xNbO_3$ single crystals

I. Tanaka*[1]; R. Yoshihara[1]; C. Nakazawa[1]; N. Satoh[1]; M. Nagao[1]; S. Watauchi[1]; 1. University of Yamanashi, Japan

(P014-2016) Inhibition of Crystal Growth of In-Ga-Zn Oxide Film by Silicon Incorporation

T. Takasu*[1]; N. Ishihara[1]; M. Oota[1]; Y. Ishiguro[1]; Y. Yamada[1]; T. Hiramatsu[1]; M. Nakashima[1]; K. Dairiki[1]; M. Tsubuku[1]; S. Yamazaki[1]; 1. Semiconductor Energy Laboratory Co.,Ltd., Japan

(P015-2016) Hierarchically ordered SiOC monoliths made by freeze casting

H. Zhang*[1]; A. L. Serva[1]; M. Wilhelm[1]; K. Rezwan[1]; 1. University of Bremen, Germany

(P016-2016) High-temperature Mechanical Properties of Silica Aerogel Composites Reinforced by Mullite Fibers

Y. Jiang*[1]; F. Junzong[1]; F. Jian[1]; S. Chunxiao[1]; 1. National University of Defense Technology, China

(P017-2016) Machinability and mechanical properties of porous ceramics for medical applications

H. Muto*[1]; Y. Akiyama[1]; K. Ikegai[1]; 1. Adamant Co., Ltd., Japan

(P018-2016) Alkaline activation for the enhancement of capacitive property of carbon spheres synthesized by hydrothermal carbonization process

M. Inada*[1]; R. Okazaki[1]; N. Enomoto[1]; J. Hojo[1]; K. Hayashi[1]; 1. Kyushu University, Japan

(P019-2016) Effect of fibers orientation on the mechanical behavior of mullite fibrous ceramics with a 3D skeleton structure

H. Du*[1]; 1. Tianjin University, China

(P020-2016) Effect of microstructures in gelation freezing derived porous silica based ceramics on thermal conductivity

C. Matsunaga*[1]; H. Hyuga[1]; Y. Yoshizawa[1]; 1. National Institute of Advanced Industrial Science and Technology (AIST), Japan

(P021-2016) Microstructure Control of A Porous Ceramic with Cylindrical and Incorporation Pores

S. Ueno*[1]; 1. Nihon University, Japan

(P022-2016) Effects of Boron and Aluminum Additives on In–Situ Grain Growth of Porous SiC Ceramics

K. Yoshida*[1]; M. Takahashi[1]; T. Yano[1]; 1. Tokyo Institute of Technology, Japan

(P023-2016) Fabrication of porous ceramics by gelcasting method with agar and reservoir sediment in Tunisia

Y. Arioka*[2]; M. Sensui[2]; M. Fuji[3]; M. Tafu[1]; T. Kawakami[4]; M. Irie[2]; 1. National Institute of Technology, Toyama College, Japan; 2. University of Tsukuba, Japan; 3. Nagoya Institute of Technology, Japan; 4. Toyama Prefectural University, Japan

(P024-2016) Effect of calcium salt on reactivity of dicalcium phosphate dihydrate (DCPD) with fluoride ion
S. Muroyama*[2]; M. Tafu[1]; S. Takamatsu[3]; Y. Matsushita[4]; 1. National Institute of Technology, Toyama College, Japan; 2. National Institute of Technology, Toyama college, Japan; 3. National Institute of Technology, Toyama, Japan; 4. Chiyoda Ute Co. Ltd., Japan

(P025-2016) The effect of heat exposure on microstructure and mechanical properties of Al_2O_3/Si/SiC coating system
R. Inoue*[1]; K. Chikamoto[1]; Y. Kogo[1]; H. Kakisawa[2]; 1. Tokyo University of Science, Japan; 2. National Institute for Materials Science (NIMS), Japan

(P026-2016) Thick Aluminum nitride Coatings by Reactive DC Plasma
M. Shahien*[1]; M. Shahien[2]; M. Yamada[1]; M. Fukumoto[1]; 1. Toyohashi University of Technology, Japan; 2. Central Metallurgical Research & Development Institute (CMRDI), Egypt

(P027-2016) Effects of intrinsic defects on electronic structure and optical properties of Boron-doped ZnO using first-principles calculations
H. Wu[1]; C. Chen[1]; H. Lin*[2]; 1. Ming Chi University of Technology, Taiwan; 2. National United University, Taiwan

(P028-2016) The improvement on mechanical and thermal properties of SiC/SiC composites via introducing CNTs into PyC interface
X. Liu*[1]; W. Feng[1]; Y. Liu[1]; L. Zhang[1]; L. Cheng[1]; 1. Northwestern Polytechical University, China

(P029-2016) A feasibility study on SiC_f/SiC composite using SiC fibers with various oxygen contents fabricated by liquid silicon infiltration process
Y. Seong*[1]; J. Choi[1]; S. Kim[1]; I. Han[1]; S. Woo[1]; 1. Korea Institute of Energy Research(KIER), Republic of Korea

(P030-2016) Film Boiling Chemical Vapor Infiltration controled by electrical current
I. Regiani*[1]; R. L. Novais[1]; 1. Instituto Tecnológico de Aeronáutica, Brazil

(P031-2016) High-temperature flexural property of SiC coated PIP-C/SiC composites
Y. Xiang*[1]; F. Cao[1]; 1. National University of Defense Technology, China

(P032-2016) The effect of fiber volume fraction of CFRP on liquid silicon infiltration process and properties of C/SiC composite
S. Kim*[1]; S. Woo[1]; I. Han[1]; Y. Seong[2]; J. Choi[1]; 1. Korea Institute of Energy Research, Republic of Korea; 2. Korea Institute of Energy Research(KIER), Republic of Korea

(P033-2016) The effect of filament winding angle of C/SiC composite material on mechanical properties fabricated by LSI process
S. Woo*[1]; S. Kim[1]; I. Han[1]; Y. Seong[2]; J. Choi[1]; 1. Korea Institute of Energy Research, Republic of Korea; 2. Korea Institute of Energy Research(KIER), Republic of Korea

(P034-2016) Spark plasma sintering of silicon carbide with carbon and boron as additives
J. Yang[1]; J. Jiao*[1]; L. Wang[1]; B. Li[1]; 1. AVIC Composite Technology Center, China

(P035-2016) Improvement on mechanical properties of C/SiC composites via laser machined assisted CVI
J. Wang*[1]; L. Cheng[1]; Y. Liu[1]; L. Zhang[1]; Q. Zhang[1]; 1. Northwestern Polytechical University, China

(P036-2016) Preparation and Oxidation Behavior of C/SiC Composites Protected by Varied UHTC Coatings
L. Gao*[1]; X. Zhang[1]; S. Dong[1]; 1. Shanghai Institute of Ceramics, Chinese Academy of Sciences, China

(P037-2016) Rapid concept for the elaboration of C/C composites: the film boiling chemical infiltration
A. Lorriaux[2]; N. Bertrand[2]; Y. Le Petitcorps[2]; A. Delehouze[3]; P. David[4]; L. Maillé*[1]; 1. University of Bordeaux - Laboratory for Thermostructural Composites (LCTS), France; 2. University Bordeaux, France; 3. Herakles, France; 4. CEA, France

(P038-2016) A new concept for the elaboration of C/C composites: the supercritical fluid chemical infiltration
M. Clavel[1]; C. Aymonier[2]; N. Bertrand[1]; Y. Le Petitcorps[1]; A. Guette[1]; L. Maillé*[1]; 1. University Bordeaux, France; 2. CNRS, France

(P039-2016) Microwave Heated Chemical Vapour Infiltration of ceramic matrix composites
A. D'Angio[1]; D. Kothanda Ramachandran*[1]; J. Binner[1]; 1. University of Birmingham, United Kingdom

(P040-2016) C/SiC-ZrC composites and study of its properties
H. L. Pi*[1]; 1. Beijing Aerospace Technology Institute, China

(P041-2016) Properties of C/SiC composites fabricated using liquid polycarbosilane as precursor
X. B. Chen*[1]; L. S. Tang[1]; Z. Wang[2]; 1. Beijing Aerospace Technology Institute, China; 2. Shanghai Institute of Ceramics, Chinese Academy of Sciences, China

(P042-2016) Ablation behavior of C/SiC composites fabricated through liquid silicon infiltration
L. S. Tang*[1]; J. Li[1]; S. Dong[2]; J. Hu[2]; 1. Beijing Aerospace Technology Institute, China; 2. Shanghai Institute of Ceramics, Chinese Academy of Sciences, China

(P043-2016) Evaluation of SiBCN-based composites for re-usable application
P. Chen*[1]; H. L. Pi[2]; S. Dong[3]; Z. Wang[3]; 1. Beijing Aerospace Technology Institute, China; 2. Beijing Institute of mechanical and electrical engineering, China; 3. Shanghai Institute of Ceramics, Chinese Academy of Sciences, China

(P044-2016) Influence of addition and holding times on the microstructure and mechanical properties of in-situ Al/TiB_2 composites
R. Paskaramoorthy*[1]; 1. University of the Witwatersrand, South Africa

(P045-2016) Manufacture of SiC/$CoSi_2$ composites: Study of surface properties of Si-Co melts
M. R. Caccia*[1]; S. Amore[2]; D. Giuranno[2]; R. Novakovic[2]; E. Ricci[2]; R. Nowak[3]; N. Sobczak[3]; J. Narciso[1]; 1. Alicante University, Spain; 2. Institute for Energetics and Interphases (IENI), Italy; 3. Foundry Research Institute, Poland

(P046-2016) Capability of $TiSi_2$ binary alloy as healing agent for crack-healing in oxide ceramics
Y. Tamagawa*[1]; 1. Yokohama National University, Japan

(P047-2016) Tantalum diboride: Obtaining, oxyacetylene torch testing and characterization
J. Laszkiewicz- Lukasik*[1]; L. Jaworska[1]; P. Putyra[1]; 1. The Institute of Advanced Manufacturing Technology, Poland

(P048-2016) Precursor Synthesis of TaC-SiC Ultrahigh Temperature Ceramic Nanocomposites
Y. Lu*[1]; W. Qiu[1]; L. Ye[1]; Y. Zhang[1]; T. Zhao[1]; 1. Institute of Chemistry, Chinese Academy of Sciences, China

(P049-2016) Combustion-mediated synthesis of hollow carbon nanospheres from polymer for high-performance cathode material
J. Lee*[1]; H. Nersisyan[2]; 1. Chungnam National University, Republic of Korea; 2. Rapidly Solidified Materials Research Center, Republic of Korea

(P050-2016) Enhanced Densification of Polymer Derived SiC Ceramic Powders Using a B precursor
A. Tavakoli*[1]; S. Arreguin[2]; C. Gervais[3]; F. Babonneau[3]; R. Bordia[1]; 1. Clemson University, USA; 2. University of Washington, USA; 3. Collège de France, France

(P051-2016) Design and preparation of fiber/matrix interphase in C/SiC composites
Y. Zhu*[1]; X. Li[1]; S. Song[1]; X. Wu[1]; Z. Huang[1]; 1. Shanghai Institute of Ceramics, Chinese Academy of Sciences, China

(P052-2016) Fabrication of hollow/porous SiOC fibers by coaxial electrospinning
A. Guo*[1]; H. Du[1]; J. Liu[1]; X. Tao[1]; X. Dong[1]; 1. Tianjin University, China

(P053-2016) Tubular open-porous polymer-derived ceramic structures with tailored permeability
T. Konegger*[1]; T. Prochaska[1]; A. Ziebell[1]; 1. TU Wien - Vienna University of Technology, Austria

(P054-2016) Vibration analysis of higher-order shear deformable functionally graded beams with porosities
E. Salari[1]; A. Ashoori*[1]; S. Sadough Vanini[1]; 1. Amirkabir University of Technology, Islamic Republic of Iran

(P055-2016) First principles study of atomic arrangement of Si, Al and oxygen vacancy and diffusion behavior in mullite
T. yokoi[1]; M. Yoshiya*[1]; 1. Osaka University, Japan

(P056-2016) Thermal cycling and thermal shock evaluations on environmental barrier coatings fabricated by plasma spray
K. Lee*[1]; Y. Chae[1]; J. Park[2]; 1. Kookmin University, Republic of Korea; 2. Korea Atomic Energy Research Institute, Republic of Korea

(P057-2016) Preparation of $Y_2Si_2O_7$-mullite eutectic structure using glass powder
S. Ueno*[1]; 1. Nihon University, Japan

(P058-2016) $TaSi_2$-$MoSi_2$-Borosilicate Glass Double Layer Coating on Fibrous Porous Ceramics for Enhanced Radiation
X. Tao*[1]; L. Guo[1]; A. Guo[1]; H. Du[1]; J. Liu[1]; 1. School of Materials Science and Engineering, Key Lab of Advanced Ceramics and Machining Technology of Ministry of Education, Tianjin University, China

(P059-2016) Development and Property Evaluation of Selected HfO_2-Silicon and Rare Earth-Silicon Based Bond Coat and Environmental Barrier Coating Systems for SiC/SiC Ceramic Matrix Composites
D. Zhu*[1]; 1. NASA Glenn Research, USA

(P060-2016) Mechanical properties and ablation properties of SiCf/SiC-TaC composites
K. Jian*[1]; J. Wang[1]; H. Wang[1]; 1. National University of Defense Technology, China

(P061-2016) Experimental Research on Air Permeability of Fiber Reinforced Aerogel
Y. Ma*[1]; F. Zhang[1]; Q. Xiong[1]; 1. Beijing Aerospace Technology Institute, China

(P062-2016) Strength degradation of carbon fiber in C/SiC composite evaluated through fiber bundle mini composite
Y. Nakauchi*[1]; K. Goto[2]; S. Yoneyama[1]; S. Arikawa[3]; 1. AoyamaGakuin Univ, Japan; 2. Department of Space Flight System, Japan; 3. Meiji Univ., Japan

(P063-2016) Electrical Resistance as a Method to Measure Crack Growth in SiC-Based Ceramic Composites
R. Mansour*[1]; G. N. Morscher[1]; Y. Singh[1]; 1. University of Akron, USA

(P064-2016) Microstructure and wear behavior of SiC-$FeSi_2$ composites obtained by reactive infiltration
A. Camarano[1]; M. R. Caccia[2]; J. Narciso*[1]; 1. Alicante University, Spain; 2. University of Alicante, Spain

(P065-2016) Effect of vacuum on microstructure and mechanical properties of silicon carbide produced by reactive infiltration
A. Camarano[2]; M. R. Caccia*[2]; J. Narciso[1]; 1. Alicante University, Spain; 2. University of Alicante, Spain

Wednesday, June 29, 2016

G1. Powder Processing Innovation and Technologies for Advanced Materials and Sustainable Development

Novel Shaping, Forming, Sintering Technology and Nano/microstructure Control

Room: Trinity III

Session Chairs: Di Zhang, Shanghai Jiao Tong University; Junichi Tatami, Yokohama National University

8:30 AM

(G1-027-2016) Bioinspired function materials templates by nature species (Invited)
D. Zhang*[1]; J. Gu[1]; W. Zhang[1]; Q. Liu[1]; H. Su[1]; 1. Shanghai Jiao Tong University, China

9:00 AM

(G1-028-2016) Orientation of graphene coating particles using an innovative low magnetic field
T. Takahashi*[1]; N. Sugimoto[2]; M. Sado[2]; J. Tatami[2]; M. Iijima[2]; 1. Kanagawa Academy of Science and Technology, Japan; 2. Yokohama National University, Japan

9:20 AM

(G1-029-2016) Effect of Strain on Photoluminescence Properties of Yttrium Oxide
H. Razavi-Khosroshahi*[1]; K. Edalati[2]; Z. Horita[2]; M. Fuji[1]; 1. Nagoya Institute of Technology, Japan; 2. Kyushu University, Japan

9:40 AM

(G1-030-2016) Smart powder processing for advanced materials and sustainable development
M. Naito*[1]; T. Kozawa[1]; A. Kondo[1]; M. Matsuoka[1]; 1. JWRI, Osaka University, Japan

10:00 AM

Break

10:20 AM

(G1-031-2016) Fabrication and Some Properties of Textured Ti_2AlN Ceramics
Y. Sakka*[1]; 1. National Institute for Materials Science (NIMS), Japan

10:40 AM

(G1-032-2016) A Stochastic Modeling for Ceramic Granule Collapse during Cold Isostatic Pressing
K. Yasuda*[2]; S. Tanaka[3]; M. Naito[1]; 1. JWRI, Osaka University, Japan; 2. Tokyo Institute of Technology, Japan; 3. Nagaoka University of Technology, Japan

11:00 AM

(G1-033-2016) Advanced Sintering of ZnS-$CaLa_2S_4$ Composite Infrared Optical Ceramics
Y. Li*[1]; Y. Wu[1]; 1. Alfred University, USA

11:20 AM

(G1-034-2016) Porous honeycomb alumina with unidirectional pore fabricated by molding in a magnetic field using a micro resin mold
J. Tatami*[1]; E. Takahashi[1]; S. Mori[1]; 1. Yokohama National University, Japan

G2. Functional Nanomaterials for Sustainable Energy Technologies

Functional Nanomaterials for Sustainable Energy Technologies III

Room: York A

Session Chair: Bruce Koel, Princeton University

9:00 AM

(G2-014-2016) Multifunctional materials for electronics and photonics (Invited)
F. Rosei*[1]; 1. INRS, Canada

9:30 AM

(G2-015-2016) Potential and Limitations of Near-Infrared Excited Lanthanide-Doped Nanostructures as Multifunctional Players (Invited)
E. Hemmer*[2]; F. Vetrone[1]; F. Légaré[1]; 1. Institut National de la Recherche Scientifique, Canada; 2. University of Ottawa, Canada

10:00 AM

Break

10:20 AM

(G2-016-2016) Complex metal and oxide materials for renewable energy (Invited)
G. Westin*[1]; 1. Uppsala University, Sweden

10:50 AM

(G2-017-2016) Some fundamentals of catalysis in energy conversion reactions
E. Roduner*[1]; 1. University of Pretoria, South Africa

11:10 AM

(G2-018-2016) High-rate CO_2 Photoreduction to CH_4 and CO on Metal-Nitride Nanowires
S. Vanka*[1]; B. AlOtaibi[1]; Z. Mi[1]; 1. McGill University, Canada

11:30 AM

(G2-019-2016) Mesoscopic Modeling of Semiconductor-Liquid Junctions

A. Iqbal*[1]; K. H. Bevan[1]; 1. McGill University, Canada

G4. Ceramics for Sustainable Infrastructure: Geopolymers and Sustainable Composites

Green Building Materials

Room: Trinity IV

Session Chairs: Henry Colorado, Universidad de Antioquia; Waltraud Kriven, University of Illinois at Urbana-Champaign

8:30 AM

(G4-001-2016) Potassium Geopolymer-Bamboo Composite: A Sustainable Construction Material (Invited)

R. A. Sa Ribeiro[2]; M. G. Sa Ribeiro[2]; K. Sankar[1]; W. M. Kriven*[1]; 1. University of Illinois at Urbana-Champaign, USA; 2. National Institute for Amazonian Research, Brazil

9:00 AM

(G4-002-2016) Wool-geopolymer composite boards with insulating and fireproof properties (Invited)

A. Natali Murri*[1]; V. Medri[1]; E. Landi[1]; 1. National Research Council of Italy, Italy

9:30 AM

(G4-003-2016) Optimization of Mechanical Properties of Pond Ash Based Geopolymer as Construction Material (Invited)

M. Panigrahi*[1]; P. Rana[1]; R. Dash[1]; R. Ganguly[1]; 1. Gandhi Institute of Engineering and Technology, India

10:00 AM

Break

10:20 AM

(G4-004-2016) Effect of Electric Arc Furnace Dust on Phosphate Cement (Invited)

H. Colorado*[1]; 1. Universidad de Antioquia, Colombia

10:50 AM

Open Discussion

G5. Advanced Materials, Technologies, and Devices for Electro-optical and Medical Applications

Optical Material II

Room: Trinity V

Session Chairs: Nobuhiro Kodama, Akita University; Romain Gaume, University of Central Florida

8:30 AM

(G5-021-2016) Development of Multi-Component Halides Scintillators (Invited)

E. Bourret*[1]; 1. Lawrence Berkeley National Laboratory, USA

9:00 AM

(G5-022-2016) Transparent Ceramic Scintillators (Invited)

N. Cherepy*[1]; Z. M. Seeley[1]; S. A. Payne[1]; P. Beck[1]; E. Swanberg[1]; H. Steven[1]; D. Schneberk[1]; G. Stone[1]; B. Wihl[1]; S. Fisher[1]; P. Thelin[1]; N. Harvey[1]; T. Stefanik[2]; J. Kindem[3]; 1. LLNL, USA; 2. Nanocerox, USA; 3. Cokiya, USA

9:30 AM

(G5-023-2016) Highly-sensitive stoichiometric analysis by Laser-Induced Breakdown Spectroscopy (LIBS): A diagnosis tool for the preparation of advanced optical ceramics (Invited)

R. M. Gaume*[1]; R. Locke[1]; S. J. Pandey[1]; M. Julian[1]; M. Baudelet[1]; V. Motto-Ros[2]; 1. University of Central Florida, USA; 2. Universite de Lyon, France

10:00 AM

Break

10:20 AM

(G5-024-2016) Transparent Ceramics with Tailored Composition

Z. M. Seeley*[1]; N. Cherepy[1]; S. A. Payne[1]; 1. Lawrence Livermore Nat'l Lab, USA

10:40 AM

(G5-025-2016) Highly transparent polycrystalline ceramics synthesized by full crystallization from glass (Invited)

M. Allix*[1]; E. Véron[1]; C. Genevois[1]; F. Fayon[1]; S. Alahraché[1]; K. Al-Saghir[1]; S. Chenu[1]; M. Suchomel[3]; F. Porcher[4]; C. Dujardin[2]; G. Matzen[1]; 1. CNRS (CEMHTI), France; 2. ILM, France; 3. Argonne National Lab, USA; 4. LLB, France

11:10 AM

(G5-026-2016) Transparent optical materials for infrared devices (Invited)

M. Prakasam*[1]; A. Largeteau[1]; 1. ICMCB-CNRS, France

G6: Porous Ceramics for Advanced Applications Through Innovative Processing

Membranes and High SSA Ceramics

Room: Trinity I/II

Session Chairs: Rénal Backov, CRPP UPR CNRS 8641; Dong-pyo Kim, POSTECH

8:30 AM

(G6-029-2016) Grignard functionalization: A new versatile technology to tune surface properties of porous ceramics (Invited)

A. Buekenhoudt*[1]; M. Dorbec[1]; D. Ormerod[1]; K. Wyns[1]; V. Meynen[2]; 1. VITO, Belgium; 2. University of Antwerpen, Belgium

9:00 AM

(G6-030-2016) The preparations and characterizations of the low-cost porous ceramic support layers for microfiltration

J. Ha*[1]; J. Lee[1]; I. Song[1]; 1. Korea Institute of Materials Science, Republic of Korea

9:20 AM

(G6-031-2016) Processing of Frit-Bonded SiC Membrane Supports

Y. Kim*[1]; S. Kim[1]; H. Yeom[1]; J. Ha[2]; I. Song[2]; 1. University of Seoul, Republic of Korea; 2. Korea Institute of Materials Science, Republic of Korea

9:40 AM

(G6-032-2016) Template-Assisted Polymer-Derived Ceramic Route: From Mesoporous Powders to Monoliths with Hierarchical Porosity

B. Anthony[1]; V. NGuyen[1]; P. Miele[1]; S. Bernard*[1]; 1. CNRS, France

10:00 AM

Break

Innovations in Processing Methods of Porous Ceramics

Room: Trinity I/II

Session Chairs: Young-Wook Kim, University of Seoul; Samuel Bernard, CNRS

10:20 AM

(G6-033-2016) Integrative Chemistry: From Bio-inspired Strategies toward Advanced Functional Macrocellular Ceramics (Invited)

R. Backov*[1]; 1. CRPP UPR CNRS 8641, France

10:50 AM

(G6-034-2016) Interfacial Synthesis of Metal-Organic Frameworks Structures by Microfluidics and Hollow Mold (Invited)

D. Kim*[1]; 1. POSTECH, Republic of Korea

11:20 AM

(G6-035-2016) Mesoporous Ce-containing silicon oxycarbonitride nanocomposite membranes for green fuel generation

A. Tamayo*[1]; B. García[2]; 1. Institute of Ceramics and Glass, CSIC, Spain; 2. Universidad Autonoma de Madrid, Spain

G8. Multifunctional Coatings for Sustainable Energy and Environmental Applications

Functional Coatings and Thin Films

Room: York B

Session Chairs: Tetsuo Tsuchiya, National Institute of Advanced Industrial Science and Technology (AIST); Hiroaki Nishikawa, B.O.S.T., Kinki Univ.

8:30 AM

(G8-018-2016) Low temperature growth technique to achieve transparent conductive oxide semiconductors films with high carrier transport (Invited)

T. Yamamoto*[1]; J. Nomoto[1]; H. Makino[1]; 1. Kochi University of Technology, Japan

9:00 AM

(G8-019-2016) Room temperature deposition of organic/oxide hybrid gate dielectrics for emergent oxide devices (Invited)

H. Tanaka*[1]; 1. Osaka University, Japan

9:30 AM

(G8-020-2016) Development of Functionalized Materials by Surface Chemical Modification (Invited)

T. Nakamura*[1]; 1. National Institute of Advanced Industrial Science and Technology, Japan

10:00 AM

Break

10:20 AM

(G8-021-2016) Preparation of fluoroalkyl end-capped oligomers/talc composites – encapsulated cross-linked polystyrene: Application of these composites to the separation of oil and water

H. Sawada*[1]; 1. Hirosaki University, Japan

10:40 AM

(G8-022-2016) Plasmonic thin films structured by Glancing Angle Deposition and their applications to optofluidics (Invited)

K. Namura*[1]; 1. Kyoto University, Japan

11:10 AM

(G8-023-2016) 2D Oxide Nanosheet: A New Platform for High-Temperature electronics (Invited)

M. Osada*[1]; 1. National Institute for Materials Science, Japan

11:40 AM

(G8-024-2016) Electronic properties of $LaFeO_3$/$SrTiO_3$ heterointerface

H. Nishikawa*[1]; 1. B.O.S.T., Kinki Univ., Japan

H2: Design and Development of Advanced Ceramic Fibers, Interfaces, and Interphases in Composites- A Symposium in Honor of Professor Roger Naslain

Oxide Fibers for Ceramic Matrix Composites

Room: Salon D

Session Chair: Bernd Clauss, DITF

8:30 AM

(H2-018-2016) Novel oxide fibres to reinforce ceramic and metal matrices (Invited)

S. T. Mileiko*[1]; 1. Institute of Solid Physics, Russian Federation

9:00 AM

(H2-019-2016) Recent developments of oxide ceramic fibers for high performance composites

S. Pfeifer*[1]; B. Clauss[1]; M. R. Buchmeiser[2]; 1. DITF, Germany; 2. University of Stuttgart, Germany

9:20 AM

(H2-020-2016) Microstructure evolution and long term performance of a novel mullite fiber at high temperatures

R. S. Almeida*[1]; K. Tushtev[1]; K. Rezwan[1]; 1. University of Bremen, Germany

9:40 AM

(H2-021-2016) Alumina ceramic fibers: Effects on the structure because of exposure to high temperatures

T. Go*[1]; G. Seide[1]; T. Gries[1]; 1. Institute of Textile Technology, RWTH Aachen University, Germany

H3. Innovative Design, Advanced Processing, and Manufacturing Technologies

Innovative Design IV

Room: Bay

Session Chairs: Laifei Cheng, Northwestern Polytechnical University; Thomas Konegger, TU Wien - Vienna University of Technology

8:30 AM

(H3-024-2016) Crystallization behavior of amorphous Si-B-C-N ceramic sintered at ultra-high pressure and high temperature (Invited)

D. Jia*[1]; Z. Yang[1]; B. Liang[1]; Y. Zhou[1]; X. Duan[1]; 1. Harbin Institute of Technology, China

9:00 AM

(H3-025-2016) Infiltration Kinetics and Defect Evolution during 1st Infiltration in Polymer Impregnation and Pyrolysis processing of Ceramic Matrix Composites

N. M. Larson*[1]; F. W. Zok[1]; 1. University of California, Santa Barbara, USA

9:20 AM

(H3-026-2016) Rapid concepts for the elaboration of carbon or carbide matrix for CMC: The superccritical fluid chemical infiltration and the film boiling chemical vapor infiltration

L. Maillé*[1]; A. Lorriaux[1]; M. Clavel[1]; N. Bertrand[1]; C. Aymonier[2]; Y. Le Petitcorps[3]; 1. University of Bordeaux - Laboratory for Thermostructural Composites (LCTS), France; 2. ICMCB-CNRS, France; 3. University Bordeaux, France

9:40 AM

(H3-027-2016) Wet-chemical based coatings as interphases of C-fiber preforms

C. Spatz*[1]; W. Freudenberg[1]; N. Langhof[1]; W. Krenkel[1]; 1. University of Bayreuth, Germany

10:00 AM

Break

10:20 AM

(H3-028-2016) Thermoplastic Carbon Precursors for Ceramic Matrix Composites (Invited)

W. Krenkel*[1]; N. Langhof[1]; F. Reichert[1]; 1. University of Bayreuth, Germany

10:50 AM

(H3-029-2016) Development, Manufacturing and Testing of Active Cooled Ceramic Matrix Composites in Propulsion Environment for Hypersonic- or Fast Transportation

S. Schmidt-Wimmer*[1]; S. Beyer[1]; M. Schroeferl[1]; C. Wilhelmi[2]; F. Meistring[2]; 1. Airbus Defence and Space, Germany; 2. Airbus Group Innovations, Germany

11:10 AM

(H3-030-2016) Si-C-N ceramics and Si-C-N matrix composites fabricated by CVI/CVD with excellent mechanical and electromagnetic absorbing properties

F. Ye*[1]; X. Yin[1]; L. Zhang[1]; L. Cheng[1]; Y. Liu[1]; 1. Northwestern Polytechical University, China

11:30 AM

(H3-031-2016) Coatings and Matrices Improving the Oxidation Resistance of Carbon Fiber Reinforced Composites for Ultra-High Temperature Applications (Invited)

X. Zhang*[1]; S. Dong[1]; L. Gao[1]; H. Zhou[1]; J. Hu[1]; Z. Wang[1]; P. He[1]; Y. Kan[1]; Y. Ding[1]; 1. Shanghai Institute of Ceramics, Chinese Academy of Sciences, China

12:00 PM

(H3-032-2016) Microstructure and properties of Diamond/SiC composites via pouring forming and CVI using large particle size of diamond

Z. Zhao*[1]; Y. Liu[1]; Q. Zhang[1]; W. Feng[1]; L. Zhang[1]; L. Cheng[1]; 1. Northwestern Polytechnical University, China

Thursday, June 30, 2016

G2. Functional Nanomaterials for Sustainable Energy Technologies

Functional Nanomaterials for Sustainable Energy Technologies IV

Room: York A

Session Chair: Gunnar Westin, Uppsala University

8:30 AM

(G2-020-2016) Photo/Electrocatalysis: Mechanistic Insight and Catalyst Design from Density Functional Theory (Invited)

M. Li*[1]; 1. Xi'an Jiaotong University, China

9:00 AM

(G2-021-2016) Managing photons and carriers for photocatalysis (Invited)

H. Robatjazi[1]; S. Bahauddin[1]; C. Doiron[1]; X. Liu[1]; T. Tumkur[1]; W. Wang[1]; P. Wray[1]; I. Thomann*[1]; 1. Rice University, USA

9:30 AM

(G2-022-2016) Exploring the optoelectronic properties of Cu-based alloys for solar energy applications (Invited)

C. Persson*[1]; 1. University of Oslo, Norway

10:00 AM

Break

10:20 AM

(G2-023-2016) Melanin pigments: en route towards environmentally benign electronics (Invited)

C. Santato*[1]; G. Albano[1]; E. Di Mauro[1]; P. Kumar[1]; 1. Ecole Polytechnque de Montreal, Canada

10:50 AM

(G2-024-2016) Quantum Resistive Sensors functionalized by supramolecular assembly of cyclodextrins and graphene to detect ppb of VOC in the atmosphere (Invited)

J. Feller*[1]; S. Nag[1]; M. Castro[1]; P. Guegan[2]; 1. European University of Brittany (UEB), France; 2. Univ. Pierre & Marie Curie, France

11:20 AM

(G2-025-2016) The eSHHA homogeneous platform: Quantitative detection of biomarkers directly in whole blood

S. S. Mahshid*[1]; 1. University of Toronto, Canada

11:40 AM

(G2-026-2016) Nanostructured WO_3 films for photoelectrochemical applications

F. Quenneville*[2]; X. Meng[2]; E. Di Mauro[2]; C. Santato[1]; 1. Ecole Polytechnque de Montreal, Canada; 2. École Polytechnique de Montréal, Canada

G3: Novel, Green, and Strategic Processing and Manufacturing Technologies

Novel, Green, and Strategic Processing I

Room: York B

Session Chairs: Surojit Gupta, University of North Dakota; Satoshi Wada, University of Yamanashi

8:30 AM

(G3-001-2016) The Role of Interface Complexions on Processing Ceramic Matrix Nanocomposites (Invited)

W. D. Kaplan*[1]; 1. Technion - Israel Institute of Technology, Israel

9:00 AM

(G3-002-2016) Bio-process Inspired Synthesis and Processing of New Structures and Materials (Invited)

Z. Fu*[1]; 1. Wuhan University of Technology, China

9:30 AM

(G3-003-2016) Heat-resistant Inorganic Fibers (Invited)

T. Ishikawa*[1]; H. Oda[2]; 1. Tokyo University of Science, Yamaguchi, Japan; 2. UBE Industries, Ltd., Japan

10:00 AM

Break

10:20 AM

(G3-004-2016) On the Design and Characterization of Novel MRM (MAX Reinforced Metals) (Invited)

F. AlAnazi[1]; S. Ghosh[1]; R. Dunnigan[1]; S. Gupta*[1]; 1. University of North Dakota, USA

10:40 AM

(G3-005-2016) Crystal Structure of In-Ga-Zn Oxide with Composition Shift

K. Dairiki*[1]; Y. Yamada[1]; R. Yamauchi[1]; M. Oota[1]; N. Ishihara[1]; Y. Kurosawa[1]; E. Kikuchi[1]; T. Takasu[1]; M. Tsubuku[1]; S. Yamazaki[1]; 1. Semiconductor Energy Laboratory Inc., Japan

11:00 AM

(G3-006-2016) Novel Structural Ceramics by Microstructure Design

S. Gupta[1]; A. Stoker*[1]; J. Steen[1]; W. Steidl[1]; Q. Tran[1]; T. Gorron[1]; E. Downward[1]; 1. University of North Dakota, USA

11:20 AM

(G3-007-2016) Electrical and Mechanical Properties of Pressureless Sintered SiC–Ti_2CN Composites

T. Cho*[1]; Y. Kim[1]; 1. University of Seoul, Republic of Korea

11:40 AM

(G3-008-2016) Surface Modifications of Aluminum and Magnesium alloys by Environment friendly Friction stir processing with addition of ceramic and rare earth materials

K. Singh Sandhu*[1]; H. Singh[2]; G. Singh[1]; 1. Punjabi University, India; 2. Yadavindra College of Engineering, India

Novel, Green, and Strategic Processing II

Room: York B

Session Chairs: Yiquan Wu, Alfred University; Young-Wook Kim, University of Seoul

1:30 PM

(G3-009-2016) Deposition Mechanism of Ceramic Layer with Room Temperature Impact Consolidation (RTIC) (Invited)

J. Akedo*[1]; 1. AIST, Japan

2:00 PM

(G3-010-2016) Preparation of Oxide-based Nano-complex Ceramics by Solvothermal Solidification Method with External-fields and Their Piezoelectric and Dielectric Property (Invited)

S. Wada*[1]; 1. University of Yamanashi, Japan

2:30 PM

(G3-011-2016) Electrical and Thermal Properties of SiC-Nitride (BN, AlN, Si_3N_4, Ti_2CN) Composites (Invited)

Y. Kim*[1]; S. Jang[1]; 1. University of Seoul, Republic of Korea

3:00 PM

Break

3:20 PM

(G3-012-2016) Fabrication of c-axis oriented AlN by a rotating magnetic field and SPS

T. S. Suzuki*[1]; K. Imai[2]; T. Nishimura[1]; H. Kiyono[2]; Y. Sakka[1]; 1. National Institute for Materials Science (NIMS), Japan; 2. Shibaura Institute of Technology, Japan

3:40 PM

(G3-013-2016) Spark Plasma Sintering of Si_3N_4-Y_2O_3-MgO using nanocomposite particles

J. Tatami*[1]; M. Iijima[1]; K. Jeong[1]; T. Nishimura[2]; 1. Yokohama National University, Japan; 2. National Institute for Material Science, Japan

4:00 PM

(G3-014-2016) Field-assisted processing for single crystal by a solid-state conversion

Y. Liu*[1]; Y. Wu[1]; 1. Alfred University, USA

4:20 PM

(G3-015-2016) Corrosion studies of synthesized nano-Al_2O_3 reinforced 6061 metal matrix composite in 3.5% NaCl solution

I. B. Singh*[3]; V. Shrivastava[1]; S. Kale[2]; 1. Academy of Scientific and Innovative Research, India; 2. Barktullah University, India; 3. CSIR-Advanced Materials and Processes Research Institute, India

G5. Advanced Materials, Technologies, and Devices for Electro-optical and Medical Applications

Optical Material III

Room: Trinity V

Session Chairs: Nerine Cherepy, Lawrence Livermore Nat'l Lab; Hanna Dabkowska, McMaster University

8:30 AM

(G5-027-2016) Aggregates of silver nanostructures for SHG enhancement at metal-nonlinear dielectric interfaces (Invited)

L. Sanchez-García[1]; C. Tserkezis[2]; M. Ramirez[1]; P. Molina[1]; J. Carvajal[3]; M. Aguilo[3]; F. Diaz[3]; J. Aizpurua[4]; L. E. Bausa*[1]; 1. Universidad Autonoma de Madrid, Spain; 2. Technical University of Denmark, Denmark; 3. Universitat Rovira i Virgili, Spain; 4. Center for Materials Physics (CSIC-UPV/EHU) and Donostia International Physics Center, Spain

9:00 AM

(G5-028-2016) Optical and elctro-optical properties of molybdate and tungstate crystals (Invited)

X. Tao*[1]; 1. Shandong University, China

9:30 AM

(G5-029-2016) Glass and polycrystal thin films for monolithic photonic integration (Invited)

J. Hu*[1]; X. Sun[2]; Q. Du[1]; T. Goto[3]; M. Onbasli[1]; C. Ross[1]; L. Li[1]; H. Lin[1]; D. Kita[1]; J. Michon[1]; C. Smith[4]; K. Richardson[4]; 1. MIT, USA; 2. Harbin Institute of Technology, China; 3. Toyohashi University of Technology, Japan; 4. University of Central Florida, USA

10:00 AM

Break

10:20 AM

(G5-030-2016) Chalcogenide glass fibers for mid-infrared sensing: Biomedical applications and CO_2 detection (Invited)

B. Bureau*[1]; C. Boussard[1]; V. Nazabal[1]; J. Troles[1]; 1. University of Rennes 1, France

10:50 AM

(G5-031-2016) Red-emissive Mn-doped tetragermanate phase: Synthesis and spectroscopic study (Invited)

Y. Takahashi*[1]; J. Kunitomo[1]; R. Suzuki[1]; N. Terakado[1]; T. Fujiwara[1]; 1. Tohoku University, Japan

11:20 AM

(G5-032-2016) Preparation of Europium-Activated $SrAl_2O_4$ Glass Composites using the Frozen Sorbet Technique (Invited)

T. Nakanishi*[1]; 1. Hokkaido University, Japan

Optical Material IV

Room: Trinity V

Session Chair: Xutang Tao, Shandong University

1:30 PM

(G5-033-2016) Morphology of surface nanostructures in oxide crystals and glasses fabricated by femtosecond laser ablation or focused ion beam etching (Invited)

N. Kodama*[1]; 1. Akita University, Japan

2:00 PM

(G5-034-2016) Silicon nitride and Indium Tin Oxide Nanostructures for dielectrophoretic manipulation of DNA

S. Mahshid*[1]; M. Ahamed[2]; W. Resiner[3]; R. Sladek[3]; 1. University of Toronto, Canada; 2. university of Windsor, Canada; 3. McGill University, Canada

2:20 PM

(G5-035-2016) Color centers in $Y_3Al_5O_{12}$ single crystals grown by the EFG technique

T. Tokairin*[1]; H. Junichi[3]; V. Garcia[4]; K. Shimamura[2]; 1. Ibaraki University, Japan; 2. National Institute for Materials Science, Japan; 3. Shinko Manufacturing, Japan; 4. National Institute for Materials Science (NIMS), Japan

2:40 PM

Break

Ferro/Piezo I

Room: Trinity V

Session Chairs: Qiang Li, Tsinghua University; Anilkumar Gopinathan Nair, Noritake Co., Ltd

3:20 PM

(G5-036-2016) Reliability Design for Multilayer Ceramic Capacitors with Ni electrodes (Invited)

H. Kishi*[1]; 1. Taiyo Yuden Co., Ltd., Japan

3:50 PM

(G5-037-2016) Crystal Structure of Nanostructured Electroceramic Film using Aerosol-type Nanoparticle Deposition for Microelectronics and Energy Application (Invited)

Y. Imanaka*[1]; 1. Fujitsu Laboratories Ltd., Japan

4:20 PM

(G5-038-2016) Texture Engineering of Lead-Free Piezoelectric Ceramics (Invited)

J. Jeon*[1]; H. Cha[1]; 1. Korea Institute of Materials Science, Republic of Korea

*Denotes Presenter

4:50 PM

(G5-039-2016) Interests of high pressure in materials science (Invited)

A. Largeteau*[1]; 1. ICMCB-CNRS, France

G7: Advanced Functional Materials, Devices, and Systems for Environmental Conservation and Pollution Control

Advanced Functional Materials, Devices, and Systems for Environmental Conservation and Pollution Control I

Room: Trinity III

Session Chairs: Nobuhito Imanaka, Osaka University; Shinobu Fujihara, Keio University

9:00 AM

(G7-001-2016) Magnetic field-assisted fabrication of oriented K_2NiF_4-type nickelate cathode for SOFC (Invited)

M. Matsuda*[1]; A. Murata[1]; T. Uchikoshi[2]; T. S. Suzuki[2]; Y. Sakka[2]; 1. Kumamoto University, Japan; 2. National Institute for Materials Science, Japan

9:30 AM

(G7-002-2016) Atomic-scale characterization of ion conduction, structure and stability of ceria-based catalysts and related materials: Present status and problems (Invited)

M. Yashima*[1]; K. Fujii[1]; E. Niwa[1]; 1. Tokyo Institute of Technology, Japan

10:00 AM

Break

10:20 AM

(G7-003-2016) Bio-inspired intellgient and self-healing materials for clean water production

P. Wang*[1]; 1. King Abdullah University of Science and Technology, Saudi Arabia

10:40 AM

(G7-004-2016) Mesocrystal Nanowire Comprised of Oriented Nanoparticles for Cathode Material of Na-ion batteries

E. Hosono*[1]; S. Kajiyama[1]; M. Okubo[1]; J. Kikkawa[2]; 1. National Institute of Advanced Industrial Science and Technology (AIST), Japan; 2. National Institute for Materials Science (NIMS), Japan

11:00 AM

(G7-005-2016) Low-temperature Crystallization of Ion-conductive Cubic $Li_7La_3Zr_2O_{12}$ Nanoparticles (Invited)

H. Suzuki[1]; P. J. Kumar[1]; M. Senna[1]; K. Nishimura[1]; N. Sakamoto[1]; N. Wakiya*[1]; 1. Shizuoka University, Japan

11:30 AM

(G7-006-2016) Thin-film type Protonic Electrochemical Capacitors with Metal-oxide Nanosheet Electrodes (Invited)

M. Miyayama*[1]; S. Suzuki[1]; 1. The University of Tokyo, Japan

Advanced Functional Materials, Devices, and Systems for Environmental Conservation and Pollution Control II

Room: Trinity III

Session Chairs: Nobuhito Imanaka, Osaka University; Shinobu Fujihara, Keio University

1:40 PM

(G7-007-2016) Functional mixed anion compounds for environmental challenges (Invited)

H. Kageyama*[1]; 1. Kyoto University, Japan

2:10 PM

(G7-008-2016) A facile process for the bulk synthesis of $LiMn_2O_4$ nanorods using pre-synthesized γ-MnOOH nanowires

I. B. Singh*[1]; 1. CSIR-Advanced Materials and Pprocesses Research Institute, India

2:30 PM

(G7-009-2016) Catalytic Combustion-type Carbon Monoxide Novel Gas Sensor with Oxide Ion Conducting Solid (Invited)

N. Imanaka*[1]; 1. Osaka University, Japan

3:00 PM

Break

3:20 PM

(G7-010-2016) Dielectric Enhancement of Nanostructured Composite Capacitors Prepared by Wet Chemical Method

S. Ueno*[1]; Y. Sakamoto[1]; K. Nakashima[1]; S. Wada[1]; 1. University of Yamanashi, Japan

3:40 PM

(G7-011-2016) Mesoporous titania-based electrodes by hydrothermal processes for dye-sensitized solar cells (Invited)

J. Hojo*[1]; M. Inada[1]; 1. Kyushu University, Japan

4:10 PM

(G7-012-2016) Materials Tuning of Titania Nanotubes for Enhancing Physical-photochemical Multifunctions (Invited)

K. Fujii[1]; H. Nishida[1]; T. Goto[1]; S. Chou[1]; S. Lee[2]; T. Sekino*[1]; 1. Osaka University, Japan; 2. Sun Moon University, Republic of Korea

4:40 PM

(G7-013-2016) Precursor-derived Porous ZnO Materials and Their DSSC Applications (Invited)

S. Fujihara*[1]; H. Kajihara[1]; E. Tanaka[1]; T. Enomoto[1]; H. Ohashi[1]; M. Hagiwara[1]; 1. Keio University, Japan

H1. Computational Modelling and Design of New Materials and Processes

Atom-scale Modeling I

Room: Bay

Session Chair: Jingyang Wang, Institute of Metal Research

1:50 PM

(H1-001-2016) Ab initio Molecular Dynamics Simulations of the Irradiation Response of Ceramics (Invited)

W. J. Weber*[1]; B. Liu[2]; B. Petersen[1]; J. Wang[3]; H. Xiao[4]; Y. Zhang[1]; 1. University of Tennessee, USA; 2. Shanghai University, China; 3. Institute of Metal Research, China; 4. University of Electronic Science and Technology of China, China

2:20 PM

(H1-002-2016) DFTFIT: Potential Generation for Molecular Dynamics Calculations

C. N. Ostrouchov*[1]; F. Yuan[1]; Y. Zhang[2]; W. J. Weber[1]; 1. University of Tennessee, USA; 2. Oak Ridge National Lab, USA

2:40 PM

(H1-003-2016) Mechanical properties of pyrocarbons – from molecular to macroscopic scale

J. Leyssale[1]; A. Gamboa[2]; B. Farbos[2]; S. Jouannigot[1]; G. Couégnat[1]; A. P. Gillard[2]; M. Charron[2]; G. L. Vignoles*[2]; 1. CNRS, France; 2. University Bordeaux, France

3:00 PM

Break

Atom-scale modeling II

Room: Bay

Session Chair: William Weber, University of Tennessee

3:20 PM

(H1-004-2016) Giant phonon anharmonicity and anomalous pressure dependence of lattice thermal conductivity in Yttrium silicates (Invited)

J. Wang*[1]; 1. Institute of Metal Research, Chinese Academy of Sciences, China

3:50 PM

(H1-005-2016) Computational high throughput exploring advanced structural-functional integrated materials

Q. Zeng*[1]; L. Zhang[1]; L. Cheng[1]; 1. Northwestern Polytechical University, China

4:10 PM

(H1-006-2016) Study of Core/Shell Synthesis of ZrC/SiC nanocomposites using DFT and Atomistic Thermodynamic Modelling

E. Osei-Agyemang*[1]; S. Cristol[1]; R. Lucas[2]; 1. Universite Lille 1, France; 2. Centre Européen de la Céramique, France

4:30 PM

(H1-007-2016) Thermodynamic calculations in the Y-Si-C-O-H system for yttrium silicate based EBCs

I. J. Markel*[1]; D. M. Cupid[1]; M. Steinbrück[1]; H. J. Seifert[1]; 1. Karlsruhe Institute of Technology, Germany, Germany

H3. Innovative Design, Advanced Processing, and Manufacturing Technologies

Innovative Design V

Room: Bay

Session Chairs: Shaoming Dong, Shanghai Institute of Ceramics, Chinese Academy of Sciences; Hagen Klemm, FhG IKTS Dresden

8:30 AM

(H3-033-2016) Liquid silicon infiltration of carbon-based preforms embedded in powder field modifiers heated by microwaves (Invited)

A. Ortona*[1]; P. Vavassori[2]; M. Mallah[3]; S. Gianella[4]; M. Nagliati[5]; 1. SUPSI, Switzerland; 2. Petroceramics, Italy; 3. Fricke und Mallah Microwave Technology GmbH, Germany; 4. Erbicol, Switzerland; 5. Brembo SGL Carbon Ceramic Brakes, Italy

9:00 AM

(H3-034-2016) Microstructure Analysis and Properties Evaluation of SiBCN-based Composites fabricated through high-efficient PIP process

Z. Wang*[1]; S. Dong[1]; Y. Ding[1]; 1. Shanghai Institute of Ceramics, Chinese Academy of Sciences, China

9:20 AM

(H3-035-2016) The effect of ZrC matrix geometry on ablation properties of C/SiC-ZrC composites

H. Zhou*[1]; 1. Shanghai Institute of Ceramics, Chinese Academy of Sciences, China

9:40 AM

(H3-036-2016) Microstructure and mechanical properties of ZrC-modified C/SiC composites

J. Dai*[2]; J. Shao[1]; J. Sha[1]; W. Krenkel[3]; 1. Dalian University of Technology, China; 2. Dalian University of technology, China; 3. University of Bayreuth, Germany

10:00 AM

Break

10:20 AM

(H3-037-2016) Computational Study of Various Heating Methods in Thermal Gradient CVI Process (Invited)

A. Kulik*[2]; V. Kulik[1]; M. Ramm[2]; M. Bogdanov[2]; 1. Baltic State Technical University "VOENMEH", Russian Federation; 2. STR Group, Inc., Russian Federation

10:50 AM

(H3-038-2016) Optical design, preparation and thermal insulation performance of multi-layer coatings on a CMC (Invited)

Y. Liu*[1]; X. Zhang[1]; Q. Shao[1]; H. Zhang[1]; 1. Southeast University, China

11:20 AM

(H3-039-2016) Manufacturing of Oxide Fiber Composites with Water-based Slurries

T. Wamser*[1]; S. Scheler[1]; B. Martin[1]; G. Puchas[1]; W. Krenkel[1]; 1. University of Bayreuth, Germany

H4. Materials for Extreme Environments: Ultrahigh Temperature Ceramics (UHTCs) and Nano-laminated Ternary Carbides and Nitrides (MAX Phases)

New Precursors for Powders, Coatings, and Matrix or Fibers of Composites

Room: Salon C

Session Chair: Dhavanesan Kothanda Ramachandran, University of Birmingham

8:30 AM

(H4-001-2016) Single-Source-Precursor Synthesis and Properties of Hf-Containing Ultrahigh-Temperature Ceramic Nanocomposites (UHTC-NCs) (Invited)

E. Ionescu*[1]; 1. Technical University Darmstadt, Germany

9:00 AM

(H4-002-2016) "Ductile" and "Soft" YB_6 and YB_4 Ceramics with Heterogeneous Strong σ Bond and Weak τ Bond for Ultrahigh-Temperature Applications

Y. Zhou*[1]; 1. Aerospace Research Institute of Materials & Processing Technology, China

9:20 AM

(H4-003-2016) Preparation of TiC, TiB_2 and TiC-TiB_2 powders from a novel carbon coated precursors method and their sintering properties with high entropy alloy

Z. Fu*[1]; R. Koc[1]; 1. Southern Illinois University Carbondale, USA

9:40 AM

Break

Methods for Improving Damage Tolerance, Oxidation and Thermal Shock Resistance

Room: Salon C

Session Chair: Emanuel Ionescu, Technical University Darmstadt

10:20 AM

(H4-004-2016) Creating ultra-high temperature ceramic matrix composites

J. Binner[1]; D. Kothanda Ramachandran*[1]; 1. University of Birmingham, United Kingdom

10:40 AM

(H4-005-2016) Processing and Testing of Ultrahigh Temperature Fiber-reinforced Ceramics

J. Stiglich*[1]; B. Williams[1]; V. Arrieta[1]; 1. Ultramet, USA

11:00 AM

(H4-006-2016) Oxidation of HfB_2 and HfB_2-20 vol% SiC at 1500°C in Air: Effect of Compressive Stress

A. DeGregoria[1]; M. Ruggles-Wrenn*[1]; 1. Air Force Institute of Technology, USA

11:20 AM

(H4-007-2016) Thermodynamic Predictions for the Oxidation of Entropy-Stabilized UHTCs

L. Backman*[1]; E. Opila[1]; 1. University of Virginia, USA

11:40 AM

(H4-008-2016) Preparation and characterization of carbon reinforced ZrC composites via combined slurry impregnation and volumetrically heated RF-CVI processing

D. Kothanda Ramachandran*[1]; A. D'Angio[1]; J. Binner[1]; 1. University of Birmingham, United Kingdom

Novel Processing Methods (Bulk, Coatings and Thin Films)

Room: Salon C

Session Chair: Hui Gu, Shanghai University

1:30 PM

(H4-009-2016) Carbide Based Ultra High Temperature Ceramics: Preparation and Properties (Invited)

G. Zhang*[1]; 1. Donghua University, China

2:00 PM

(H4-010-2016) Core-rim structure in diboride-based ultra-high temperature ceramics

D. Hu*[1]; H. Gu[1]; 1. Shanghai University, China

2:20 PM

(H4-011-2016) Temperature Dependences of the Elastic Moduli of Single-crystal and Polycrystalline SiC to 1273 K

M. Manghnani*[1]; 1. University of Hawaii, USA

2:40 PM

Break

Structure-property Relationships of Existing Systems

Room: Salon C

Session Chair: Marina Ruggles-Wrenn, Air Force Institute of Technology

3:20 PM

(H4-012-2016) Abnormal Thermal Shock Behavior of a Cr_2AlC ceramic in Different Quenching Media (Invited)

S. Li*[1]; 1. Beijing Jiaotong University, China

3:50 PM

(H4-013-2016) Oxidation of SiC_f/SiC graded composites under Laser Heating

C. Carney*[1]; D. King[2]; M. Cinibulk[1]; 1. Air Force Research Lab, USA; 2. UES, Inc., USA

4:10 PM

(H4-014-2016) Solid-solution as monitor for phase and microstructure evolution in multi-phased ultra-high-temperature ceramics

H. Gu*[1]; D. Hu[1]; 1. Shanghai University, China

4:30 PM

(H4-015-2016) Fabrication and densification of highly concentrated HfC-SiC slurries for the preparation of an ultra-high temperature ceramic matrix composites

L. Feng*[1]; S. Lee[1]; 1. Korea Institute of Materials Science, Republic of Korea

4:50 PM

(H4-016-2016) Strengthening and Tribological Surface Self-Adaptability of Ti_3AlC_2 by Incorporation of Sn to Form $Ti_3Al(Sn)C_2$ Solid Solutions

Z. Huang*[1]; 1. Beijing Jiaotong University, China

5:10 PM

(H4-017-2016) Synthesis of textured MAX bulk ceramics by pressure assisted sintering

X. Duan*[1]; D. Jia[1]; Y. Zhou[1]; L. Shen[2]; S. Wim[2]; S. V. Zwaag[2]; 1. Harbin Institute of Technology, China; 2. Delft University of Technology, Netherlands

H6. Advanced Thermal and Environmental Barrier Coatings: Processing, Properties, and Applications

Environmental Barrier Coating Processing and Development

Room: Trinity IV

Session Chairs: Dongming Zhu, NASA Glenn Research; Satoshi Kitaoka, Japan Fine Ceramics Center

8:30 AM

(H6-001-2016) Mechanics of Polymer Derived Composite Ceramic Coatings and Joints (Invited)

R. Bordia*[1]; 1. Clemson University, USA

9:00 AM

(H6-002-2016) Multifunctional High Temperature Coatings for Gas Turbine Components via Directed Vapor Deposition (Invited)

B. Gogia*[1]; D. Hass[1]; 1. Directed Vapor Technologies Intl, USA

9:30 AM

(H6-003-2016) Self-healing EBC material for gas turbine applications

W. Kunz*[1]; H. Klemm[1]; A. Michaelis[1]; 1. Fraunhofer IKTS, Germany

9:50 AM

(H6-004-2016) Mass-transfer Mechanisms in Yb-silicate under Oxygen Potential Gradients at High Temperatures

S. Kitaoka*[1]; M. Wada[1]; T. Matsudaira[1]; N. Kawashima[1]; D. Yokoe[1]; M. Takata[1]; 1. Japan Fine Ceramics Center, Japan

10:10 AM

Break

10:30 AM

(H6-005-2016) Ytterbium silicate environmental barrier coatings by laser chemical vapor deposition (Invited)

A. Ito*[1]; M. Sekiyama[1]; T. Goto[1]; 1. Tohoku University, Japan

11:00 AM

(H6-006-2016) Combined Thermomechanical and Environmental Durability of Environmental Barrier Coating Systems on SiC/SiC Ceramic Matrix Composites

D. Zhu*[1]; B. J. Harder[1]; R. Bhatt[2]; 1. NASA Glenn Research, USA; 2. Ohio Aerospace Institute, USA

11:20 AM

(H6-007-2016) Calcium-magnesium aluminosilicate (CMAS) interactions with ytterbium disilicate ($Yb_2Si_2O_7$) environmental barrier coating material

V. L. Wiesner*[1]; D. Scales[2]; N. Johnson[3]; B. J. Harder[1]; N. P. Bansal[1]; 1. NASA Glenn Research Center, USA; 2. University of Washington, USA; 3. College of Wooster, USA

11:40 AM

(H6-008-2016) Resistance of Yttrium Di-Silicate Environmental Barrier Coatings to Calcium-Magnesium-Aluminum-Silicate Attack

J. H. Shaw*[1]; N. Verma[1]; C. G. Levi[1]; F. W. Zok[1]; 1. UC Santa Barbara, USA

Environmental Barrier Coating Processing, Characterizaton and Modeling

Room: Trinity IV

Session Chairs: Peter Mechnich, DLR - German Aerospace Center; Valerie Wiesner, NASA Glenn Research Center

1:30 PM

(H6-009-2016) Comparison of Different Environmental Barrier Coating Systems (Invited)

R. Vassen*[1]; E. Bakan[1]; C. Gatzen[1]; D. E. Mack[1]; O. Guillon[1]; 1. Forschungszentrum Juelich, Germany

2:00 PM

(H6-010-2016) Environmental barrier coatings for SiC/SiC-CMCs: Manufacturing and behaviour under cyclic oxidation and flowing water vapour

V. Leisner*[1]; U. Schulz[1]; P. Mechnich[1]; 1. DLR - German Aerospace Center, Germany

2:20 PM

(H6-011-2016) Preparation of Yb silicate layers by dual electron beam PVD

N. Yamaguchi*[1]; T. Yokoi[1]; T. Matsuda[1]; S. Kitaoka[1]; M. Takata[1]; 1. Japan Fine Ceramics Center, Japan

2:40 PM

(H6-012-2016) Silica Depletion in Rare Earth Silicate Environmental Barrier Coatings in High-Temperature High-Velocity Water Vapor

C. G. Parker*[1]; E. Opila[1]; 1. University of Virginia, USA

3:00 PM

Break

3:20 PM

(H6-013-2016) ab initio Calculations of Rare Earth Silicates for Environmental Barrier Coatings (Invited)

M. Yoshiya*[1]; A. Ioki[1]; Y. Akada[1]; T. Yokoi[1]; 1. Osaka University, Japan

3:50 PM

(H6-014-2016) Theoretical Prediction and Experimental Investigation on the Thermal and Mechanical Properties of Yb_2SiO_5 and β-$Yb_2Si_2O_7$

Y. Zhou*[1]; 1. Aerospace Research Institute of Materials & Processing Technology, China

4:10 PM

(H6-015-2016) Evaluation of interface adhesion in multilayer environmental barrier coating for SiC/SiC composites

H. Kakisawa*[1]; T. Nishimura[1]; 1. National Institute for Materials Science (NIMS), Japan

4:30 PM

(H6-016-2016) Thermal Behavior and Mechanical Properties of Y_2SiO_5 Coatings after Isothermal Heat Treatment

B. Jang*[1]; F. Feng[1]; K. Lee[2]; E. Garcia[3]; S. Kim[4]; Y. Oh[4]; H. Kim[4]; 1. National Institute for Materials Science (NIMS), Japan; 2. Kookmin University, Republic of Korea; 3. Institute of Ceramics and Glass, CSIC, Spain; 4. Korea Institute of Ceramic Engineering and Technology (KICET), Republic of Korea

4:50 PM

(H6-017-2016) EBC Development for Al_2O_3/Al_2O_3 CMC Combustor Liners

P. Mechnich*[1]; 1. DLR - German Aerospace Center, Germany

5:10 PM

(H6-018-2016) Characterization of protection efficiency of silicate environmental barrier coating (EBC)

S. Arnal*[1]; F. Rebillat[2]; F. Mauvy[3]; 1. LCTS - CNRS, France; 2. University Bordeaux, France; 3. ICMCB-CNRS, France

H7. Thermomechanical Behavior and Performance of Composites

Creep, Rupture, and Fatigue of CMCs

Room: Salon D

Session Chair: Triplicane Parthasarathy, UES

8:30 AM

(H7-001-2016) Influence of Constituents on Creep Properties of SiC/SiC Composites

R. Bhatt*[1]; 1. Ohio Aerospace Institute, USA

8:50 AM

(H7-002-2016) Fatigue behavior of an advanced SiC/SiC ceramic composite at 1300°C in air and in steam

M. Lee[1]; M. Ruggles-Wrenn*[1]; 1. Air Force Institute of Technology, USA

9:10 AM

(H7-003-2016) Creep and Stressed Oxidation Testing and Modelling of Different Fiber Type and Content SiC/SiC Minicomposites

A. S. Almansour*[1]; G. N. Morscher[1]; 1. University of Akron, USA

9:30 AM

(H7-004-2016) Variability in the Stress Rupture Behavior of N720/AS

J. Pierce*[2]; L. Zawada[1]; C. P. Przybyla[1]; R. John[1]; K. Davidson[1]; 1. Air Force Research Laboratory, USA; 2. University of Dayton Research Institute, USA

9:50 AM

Break

Environmental Effects at Elevated Temperatures

Room: Salon D

Session Chair: Craig Smith, Ohio Aerospace Institute

10:30 AM

(H7-005-2016) Thermal oxidation of SiC/BN/SiC CMCs during dry and wet oxygen exposures to explore crack-sealing

M. Wilson*[1]; E. Opila[1]; 1. University of Virginia, USA

10:50 AM

(H7-006-2016) Strength recovery and crack-filling behaviour of alumina/ TiC self-healing ceramics

S. Yoshioka*[1]; W. Nakao[1]; 1. Yokohama National University, Japan

Modeling Thermo/mechanical/environmental Behavior of CMCs

Room: Salon D

Session Chair: Marina Ruggles-Wrenn, Air Force Institute of Technology

1:30 PM

(H7-007-2016) Toward Understanding Microstructure-Sensitive Damage Initiation and Progression in SiC-SIC Ceramic Matrix Composites in Service Environments (Invited)

C. P. Przybyla*[1]; S. E. Bricker[3]; J. P. Simmons[1]; N. A. Engel[4]; K. N. Kollins[4]; R. Krishnamurthy[2]; T. A. Parthasarathy[2]; P. Mogilevsky[2]; M. V. Braginsky[3]; T. L. Whitlow[3]; E. L. Jones[1]; M. D. Uchic[1]; 1. Air Force Research Laboratory, USA; 2. UES, USA; 3. University of Dayton Research Institute, USA; 4. Southwest Ohio Council for Higher Education, USA

2:00 PM

(H7-008-2016) Modeling Environmental Degradation of SiC-Fiber Reinforced CMCs

T. A. Parthasarathy*[2]; Q. Yang[3]; B. Cox[4]; D. B. Marshall[5]; C. P. Przybyla[1]; M. Cinibulk[1]; 1. Air Force Research Laboratory, USA; 2. UES, Inc., USA; 3. University of Miami, USA; 4. Consultant, USA; 5. Teledyne Scientific, USA

2:20 PM

(H7-009-2016) Micromechanical modeling for fatigue hysteresis loops of fiber-reinforced ceramic-matrix composites under arbitrary loading stress levels

L. Li*[1]; 1. Nanjing University of Aeronautics and Astronautics, China

2:40 PM

(H7-010-2016) Analysis of Delamination Growth in Ceramic Matrix Composites

R. S. Kumar*[1]; G. Ojard[1]; R. Kevin[2]; 1. United Technologies Research Center, USA; 2. Pratt & Whitney, USA

3:00 PM

Break

Elevated Temperature Test Techniques

Room: Salon D

Session Chair: Longbiao Li, Nanjing University of Aeronautics and Astronautics

3:20 PM

(H7-011-2016) LCF and TMF Behaviour of a Ceramic Matrix Composite

J. P. Jones*[1]; M. R. Bache[1]; M. Whittaker[1]; P. J. Doorbar[2]; P. Jones[1]; 1. Swansea University, United Kingdom; 2. Rolls-Royce plc, United Kingdom

3:40 PM

(H7-012-2016) Electrical resistance changes of melt infiltrated SiC/SiC subject to long-term tensile loading at elevated temperatures

C. Smith*[1]; G. N. Morscher[2]; 1. NASA Glenn Research Center, USA; 2. University of Akron, USA

H9. Component Testing and Evaluation of Composites

Characterization of Ceramic Matrix Composites

Room: Trinity I/II

Session Chairs: Xingang Luan, Northwestern Polytechical University; Tatsuya Hinoki, Kyoto University

8:30 AM

(H9-001-2016) Monitoring Damage of MI CMCs with Stress Concentrations Utilizing Acoustic Emission and Electrical Resistance (Invited)

G. N. Morscher*[1]; R. Maxwell[1]; 1. University of Akron, USA

9:00 AM

(H9-002-2016) Mechanical behavior of a wound all-oxide ceramic matrix composite

S. Hackemann*[1]; 1. DLR - German Aerospace Center, Germany

9:20 AM

(H9-003-2016) In-situ SEM Investigation of Microstructural Damage Evolution in a Melt Infiltrated SiC/SiC Composite

K. M. Sevener*[2]; J. Tracy[3]; Z. Chen[2]; S. Daly[2]; J. D. Kiser[1]; 1. NASA Glenn Research Center, USA; 2. University of Michigan, USA; 3. Stanford University, USA

9:40 AM

(H9-004-2016) Damage Evolution and Fracture in SiC_f/SiC Specimens

C. D. Newton*[1]; Z. Quiney[1]; M. R. Bache[1]; A. L. Chamberlain[2]; 1. Swansea University, United Kingdom; 2. Rolls-Royce Corporation, USA

10:00 AM

Break

10:20 AM

(H9-005-2016) Damage analysis in 3D woven SiC/SiC ceramic matrix composites

B. Legin*[1]; Z. Aboura[1]; J. Marteau[1]; F. Bouillon[2]; 1. University of Technology of Compiègne, France; 2. Safran Herakles, France

10:40 AM

(H9-006-2016) Asymmetric Four Point Bending Test Method for Interlaminar Shear Strength in Ceramic Matrix Composites

S. C. Zunjarrao*[1]; D. Patro[1]; M. Kashfuddoja[1]; P. Jadhav[1]; S. Nagarajan[1]; K. Sriram[1]; S. Subramanian[1]; B. Zhou[2]; D. Carper[2]; 1. GE Global Research, India; 2. GE Aviation, USA

11:00 AM

(H9-007-2016) The Wedge-Loaded Double Cantilever Beam Test: A Friction Based Method for Measuring Interlaminar Fracture Properties in Ceramic Matrix Composites

R. Mansour*[1]; M. Kannan[1]; G. N. Morscher[1]; F. Abdi[2]; C. Godines[2]; S. DorMohammadi[2]; 1. University of Akron, USA; 2. AlphaSTAR Corporation, USA

CMC Properties under Severe Conditions

Room: Trinity I/II

Session Chairs: Hagen Klemm, FhG IKTS Dresden; Christian Wilhelmi, Airbus Group Innovations

1:30 PM

(H9-008-2016) Long duration testing of cooled CMC micro combustion chambers by using the ERBURIG[K] test facility in the European Program ATLLAS2 (Invited)

C. Wilhelmi*[1]; K. Bubenheim[1]; M. Bouchez[2]; S. Schmidt-Wimmer[3]; S. Beyer[3]; R. Behr[3]; J. Goergen[3]; 1. Airbus Group Innovations, Germany; 2. MBDA, France; 3. Airbus Defence and Space, Germany

2:00 PM

(H9-009-2016) Improved method for assessing erosion of ceramic materials under high speed water vapor jet

O. Sudre*[1]; M. Calabrese[1]; Y. Chen[1]; D. B. Marshall[1]; S. Lucato[1]; A. L. Chamberlain[2]; 1. Teledyne Scientific Company, USA; 2. Rolls-Royce, USA

2:20 PM

(H9-010-2016) Effect of curvature on foreign object damage of SiC/SiC composites

M. J. Presby*[1]; R. Mansour[1]; M. Kannan[1]; G. N. Morscher[1]; F. Abdi[2]; C. Godines[2]; S. R. Choi[3]; 1. University of Akron, USA; 2. Alpha Star Corporation, USA; 3. NAVAIR, USA

2:40 PM

(H9-011-2016) Mechanical properties and thermal stability of TiC/Ni (TiC. 60 Vol. %) composites by liquid infiltration

M. Braulio*[1]; C. A. Leon Patiño[1]; E. A. Aguilar[1]; 1. Universidad Michocana de San Nicolas de Hidalgo, Mexico

3:00 PM

Break

3:20 PM

(H9-012-2016) Hot gas stability of various ceramic matrix composites (Invited)

H. Klemm*[1]; T. Wamser[3]; W. Kunz[1]; A. Rüdinger[4]; R. Weiss[5]; A. Lauer[5]; C. Wilhelmi[6]; S. Hofmann[7]; D. Koch[2]; T. Machry[6]; 1. FhG IKTS Dresden, Germany; 2. Institute of Structures and Design, Germany; 3. Uni Bayreuth, Germany; 4. FhG ISC Würzbirg, Germany; 5. Schunk Kohlenstofftechnik GmbH, Germany; 6. Airbus Group Innovations, Germany; 7. DLR - German Aerospace Center, Germany

3:50 PM

(H9-013-2016) Thermomechanical Evaluation of Hybrid Composite for High Temperature Applications

M. Y. Chen*[1]; R. A. Brockman[2]; T. J. Whitney[2]; G. P. Tandon[2]; C. Tseng[3]; R. Ko[2]; 1. Air Force Research Lab, USA; 2. University of Dayton Research Institute, USA; 3. UES, Inc., USA

4:10 PM

(H9-014-2016) Fracture and Hydrothermal Corrosion Behavior of Silicon Carbide and Its Composite

D. Kim*[1]; H. Lee[1]; J. Park[1]; W. Kim[1]; 1. Korea Atomic Energy Research Institute, Republic of Korea

4:30 PM

(H9-015-2016) Compact, Lightweight, Ceramic Matrix Composite Based Acoustic Liners for Reducing Subsonic Jet Aircraft Engine Noise

J. D. Kiser*[1]; C. J. Miller[1]; L. S. Hultgren[1]; J. E. Grady[1]; M. G. Jones[2]; 1. NASA Glenn Research Center, USA; 2. NASA Langley Research Center, USA

4:50 PM

(H9-016-2016) Effect of Interphase on the high-temperature mechanical properties of single tow SiC mini-composite

K. Kawanishi*[1]; S. Muto[1]; T. Nakamura[1]; 1. IHI Corporation, Japan

Friday, July 1, 2016

G3: Novel, Green, and Strategic Processing and Manufacturing Technologies

Novel, Green, and Strategic Processing III

Room: York B

Session Chairs: Tohru Suzuki, National Institute for Materials Science; Junichi Tatami, Yokohama National University

8:30 AM

(G3-017-2016) Paper-Derived Ceramics (Invited)

N. Travitzky*[1]; P. Greil[1]; 1. University of Erlangen-Nuremberg, Germany

9:00 AM

(G3-018-2016) Stereolithographic Additive Manufacturing of Functional Ceramic Components (Invited)

S. Kirihara*[1]; 1. Osaka University, Japan

9:30 AM

(G3-019-2016) Development of Novel Microstructures and Improvement of Materials Properties through Reactive Processes in Advanced Non-Oxide Ceramics (Invited)

G. Zhang*[1]; 1. Donghua University, China

10:00 AM

Break

10:20 AM

(G3-020-2016) Processing of Re:YAG transparent ceramics from synthesized nanopowder

X. Chen*[1]; T. Lu[2]; Y. Wu[1]; J. Qi[2]; 1. Alfred University, USA; 2. Sichuan University, China

10:40 AM

(G3-021-2016) Recent Developments in the Design of MAX-Polymer (MAXPOL) Multifunctional Composites

S. Ghosh[1]; R. Dunnigan[1]; F. AlAnazi[1]; S. Gupta*[1]; 1. University of North Dakota, USA

11:00 AM

(G3-022-2016) Advanced processing of optical ceramic materials (Invited)

Y. Wu*[1]; 1. Alfred University, USA

11:20 AM

(G3-023-2016) Macro-porous ceramics: Freezing process and properties

M. Fukushima*[1]; H. Hyuga[1]; C. Matsunaga[1]; Y. Yoshizawa[1]; 1. National Institute of Advanced Industrial Science and Technology (AIST), Japan

G5. Advanced Materials, Technologies, and Devices for Electro-optical and Medical Applications

Ferro/Piezo II

Room: Trinity V

Session Chair: Yoshihiko Imanaka, Fujitsu Laboratories Ltd.

8:30 AM

(G5-040-2016) Material Design in Piezoelectric Ceramics Including Lead-Free by Elastic Constants (Invited)

T. Ogawa*[1]; 1. Shizuoka Institute of Science and Technology, Japan

9:00 AM

(G5-041-2016) Elastic Constants Evaluated by Sound Velocities in Relaxor Single-Crystal Plates Applying to Ultrasonic Probe for Medical Uses (Invited)

T. Ogawa*[1]; 1. Shizuoka Institute of Science and Technology, Japan

9:30 AM

(G5-042-2016) Polarization Rotation and Temperature-induced Mc-C Phase Transition in PMN-PT Single Crystal near MPB (Invited)

C. Xu[1]; Q. Li*[1]; Q. Yan[1]; N. Luo[1]; Y. Zhang[1]; X. Chu[1]; 1. Tsinghua University, China

10:00 AM

Break

10:20 AM

(G5-043-2016) Electrocaloric Properties of PZT- and $BaTiO_3$ based ceramics and KTN Crystals (Invited)

H. Maiwa*[1]; 1. Shonan Institute of Technology, Japan

10:50 AM

(G5-044-2016) Advanced materials development for energy application (Invited)

A. M. Gopinathan Nair*[1]; 1. Noritake Co., Ltd, Japan

11:20 AM

(G5-045-2016) Single Crystal Phosphors for High-Brightness White LEDs and LDs (Invited)

K. Shimamura*[1]; E. García Víllora[1]; S. Arjoca[1]; D. Inomata[2]; K. Iizuka[2]; 1. National Institute for Materials Science, Japan; 2. Tamura Corporation, Japan

G7: Advanced Functional Materials, Devices, and Systems for Environmental Conservation and Pollution Control

Advanced Functional Materials, Devices, and Systems for Environmental Conservation and Pollution Control III

Room: Trinity III

Session Chairs: Nobuhito Imanaka, Osaka University; Shinobu Fujihara, Keio University

8:40 AM

(G7-014-2016) New Design Concept of Long Wavelength-emitting LED Phosphors

K. Toda*[1]; S. Kim[1]; K. Uematsu[1]; M. Sato[1]; 1. Niigata University, Japan

9:00 AM

(G7-015-2016) Multiplet Energy Map of MnO_6^{8-} Cluster with D_{3d} Symmetry for Theoretical Design of Novel Red Phosphor Materials (Invited)

K. Ogasawara*[1]; 1. Kwansei Gakuin University, Japan

9:30 AM

(G7-016-2016) Functional materials and systems for prevention of soil pollution by recycled waste plasterboard (Invited)

M. Tafu*[1]; 1. National Institute of Technology, Toyama College, Japan

10:00 AM

Break

10:20 AM

(G7-017-2016) Magnetic Functionalities of Iron Oxide-based Thin Films (Invited)

K. Tanaka*[1]; K. Fujita[1]; 1. Kyoto University, Japan

10:50 AM

(G7-018-2016) Piezoelectric silicate single crystals for combustion pressure sensor applications

M. Hagiwara*[1]; T. Hoshina[2]; H. Takeda[2]; T. Tsurumi[2]; S. Fujihara[1]; 1. Keio University, Japan; 2. Tokyo Institute of Technology, Japan

*Denotes Presenter

11:10 AM

(G7-019-2016) Effect of Iron Doping on the Spontaneous Spinodal Phase Separation of Binary Oxide Composites and Their Semiconducting Properties

W. Jiang*[1]; T. Goto[1]; T. Sekino[1]; 1. Osaka University, Japan

H1. Computational Modelling and Design of New Materials and Processes

Large-scale Modeling I

Room: Bay

Session Chair: Alexey Kulik, STR Group, Inc.

8:30 AM

(H1-008-2016) Different scales of oxidation modeling inside ceramic matrix composites (Invited)

F. Rebillat[1]; G. L. Vignoles*[2]; 1. University Bordeaux, France; 2. University of Bordeaux 1, France

9:00 AM

(H1-009-2016) Simulation and Experimental Validation of Cyclic Thermal Shock Damage in Ceramic Laminated Composites

S. E. van Kempen[1]; N. Giang[1]; U. A. Özden[1]; A. Bezold[1]; C. Broeckmann[1]; R. Hammerbacher[2]; A. Roosen[2]; C. Nikasch[3]; F. Lange*[3]; 1. RWTH Aachen University, Germany; 2. Friedrich-Alexander-University Erlangen-Neurnberg, Germany; 3. Siemens A.G., Germany

9:20 AM

(H1-010-2016) A Simulation Approach to Predict Deformation and Stochastic Failure Behavior of Components made of an Oxide/Oxide CMC with Porous Matrix

T. Becker*[1]; C. Dresbach[1]; S. Reh[1]; 1. DLR - German Aerospace Center, Germany

9:40 AM

(H1-011-2016) Modeling of failure strength and strain of an all oxide ceramic composite material

Y. Shi*[1]; J. Neraj[1]; S. Hackemann[2]; S. Hofmann[1]; D. Koch[1]; 1. DLR - German Aerospace Center, Institute of Structures and Design, Germany; 2. DLR - German Aerospace Center, Institute of Materials Research, Germany

10:00 AM

Break

Large-scale Modeling II

Room: Bay

Session Chair: Thomas Becker, DLR - German Aerospace Center

10:20 AM

(H1-012-2016) Influence of Image Processing Parameters on the Computed Elastic Properties in X-Ray μ-CT Scans of C/C Composites

M. Charron[1]; O. Caty[2]; G. Couégnat[1]; G. L. Vignoles*[2]; 1. LCTS - CNRS, France; 2. University of Bordeaux 1, France

10:40 AM

(H1-013-2016) Numerical Simulation of CVI Process for Complex Shaped Preforms

A. Kulik*[2]; V. Kulik[1]; M. Ramm[2]; M. Bogdanov[2]; 1. Baltic State Technical University "VOENMEH", Russian Federation; 2. STR Group, Inc., Russian Federation

11:00 AM

(H1-014-2016) Analysis and modeling of the surface state of porous ablators for atmospheric reentry

P. Blaineau[1]; C. Levet[2]; F. Panerai[3]; A. Turchi[4]; G. L. Vignoles*[1]; 1. University of Bordeaux 1, France; 2. University Bordeaux & CEA, France; 3. University of Kentucky, USA; 4. von Karman Insitute for Fluid Dynamics, Belgium

H4. Materials for Extreme Environments: Ultrahigh Temperature Ceramics (UHTCs) and Nano-laminated Ternary Carbides and Nitrides (MAX Phases)

Novel Characterization Methods and Lifetime Assessment; Other High Temperature Material and Properties

Room: Salon C

Session Chairs: Alexandre Allemand, CEA; Zhezhen Fu, Southern Illinois University Carbondale

8:30 AM

(H4-018-2016) Oxidation Resistant Mechanism of TiAlSiCN and TiCrSiCN Compositions made by Plasma Spark Sintering at 1200

A. Manulyk*[1]; 1. National Technical University Kyiv Polytechnical Institute, Canada

8:50 AM

(H4-019-2016) Synthesis of high quality TiB_2 from novel carbon coated precursors method and its hot press properties

Z. Fu*[1]; R. Koc[1]; 1. Southern Illinois University Carbondale, USA

9:10 AM

(H4-020-2016) Synthesis by spark plasma sintering (SPS) of a composite of barium aluminosilicate ($BaAl_2Si_2O_8$) reinforced by oxide fibers

A. Allemand*[1]; Y. Le Petitcorps[2]; R. Billard[2]; 1. CEA, France; 2. LCTS - CNRS, France

9:30 AM

(H4-021-2016) Wettability and interfacial interactions between TiB_2 ceramic and Ni-Al melts

I. Kaban*[1]; L. Xi[1]; R. Nowak[2]; G. Bruzda[2]; N. Sobczak[2]; J. Eckert[3]; 1. IFW Dresden, Germany; 2. Foundry Research Institute, Poland; 3. Erich Schmid Institute of Materials Science, Austria

9:50 AM

(H4-022-2016) Tribological Behavior of TiCN Based Cermets Processed via Conventional Sintering against Cemented Carbide in sliding wear

V. Verma*[1]; 1. Indian Institute of Technology Roorkee, India

H6. Advanced Thermal and Environmental Barrier Coatings: Processing, Properties, and Applications

Advanced Thermal and Environmental Barrier Coatings

Room: Trinity IV

Session Chairs: Makoto Hasegawa, Yokohama National University; Byung-Koog Jang, National Institute for Materials Science (NIMS)

8:40 AM

(H6-019-2016) Fabrication and environmental barrier performance of the coatings with thermal energy reflection formed by aerosol deposition technique

M. Tanaka*[1]; S. Hori[2]; S. Kitaoka[1]; O. Sakurada[2]; N. Shishido[3]; S. Kamiya[3]; K. Nishioka[4]; Y. Kagawa[4]; 1. Japan Fine Ceramics Center, Japan; 2. Gifu University, Japan; 3. Nagoya Institute of Technology, Japan; 4. University of Tokyo, Japan

9:00 AM

(H6-020-2016) Effect of Heat Treatment on Aerosol Deposited Mullite Coating for EBCs

M. Hasegawa*[1]; T. Mizuno[1]; A. Iuchi[1]; 1. Yokohama National University, Japan

9:20 AM

(H6-021-2016) Defect formation and migration in $Y_2Ti_2O_7$ pyrochlore

T. Ogawa*[1]; A. Kuwabara[1]; C. Fisher[1]; H. Moriwake[1]; S. Kitaoka[1]; 1. Japan Fine Ceramics Center, Japan

9:40 AM

(H6-022-2016) Vacuum Plasma Sprayed Ultra High Temperature Ceramic Coatings on Ceramic Matrix Composites

Y. Yoo*[1]; E. Byon[1]; U. Nam[1]; M. Jeon[1]; 1. Korea Institute of Materials Science, Republic of Korea

10:00 AM

Break

10:20 AM

(H6-023-2016) Vacuum Plasma Spray Processes for TBC Coating System Applications

R. V. Gansert*[1]; R. Herber[2]; L. Guggenheim[2]; S. Keller[2]; 1. Advanced Materials & Technology Services, Inc., USA; 2. AMT AG, Switzerland

10:40 AM

(H6-024-2016) The toughening effects in the yttrium-doped lanthanum zirconate pyrochlore/fluorite solid solutions

Y. Wang*[1]; R. Liu[1]; Y. Cao[1]; P. Xiao[2]; 1. National University of Defense Technology, China; 2. University of Manchester, United Kingdom

11:00 AM

(H6-025-2016) Influence of topcoat-bondcoat interface on lifetime in suspension sprayed thermal barrier coatings

M. Gupta*[1]; N. Markocsan[1]; X. Li[2]; 1. University West, Sweden; 2. Siemens Industrial Turbomachinery AB, Sweden

11:20 AM

(H6-026-2016) Thermal barrier coatings: Effective characterization of mechanical and thermal properties

K. Lilova*[1]; J. Nickerson[2]; 1. Setaram Inc., USA; 2. C-Therm Technologies Ltd., Canada

11:40 AM

(H6-027-2016) Effect of Hafnium Concentration on Microstructural and Oxidation Resistance of βNiAl Compounds

A. D. Chandio*[1]; P. Xiao[1]; 1. The University of Manchester, Pakistan

12:00 PM

(H6-028-2016) The factors influencing solid solubility in metallic bond coat alloys of Thermal barrier coating systems

T. B. Usubaliyev*[1]; 1. National Aviaition Academy, Azerbaijan

Monday, June 27, 2016

Plenary Session

Room: Salon A/B
Session Chair: Mrityunjay Singh, Ohio Aerospace Institute

9:00 AM

(PL-001-2016) Discovery of Indium Gallium Zinc Oxide (CAAC-IGZO) and Its Applications in Next Generation Information Display Devices

S. Yamazaki*[1]; 1. Semiconductor Energy Laboratory Co., Ltd., Japan

IGZO having layered crystal morphology of c-axis aligned crystalline indium gallium zinc oxide (CAAC-IGZO) was discovered in 2009. CAAC-IGZO has features that crystals are highly c-axis-aligned with no clear grain boundaries while crystals are not aligned in the a-b plane direction. Field-effect transistors (FETs) with an active layer of CAAC-IGZO exhibit high field-effect mobilities of 30-40 $cm^2V^{-1}s^{-1}$. They also show extremely low off-state current of 10yA/μm at 85° C and on-off ratio of 10^{20} digits. CAAC-IGZO products have already mass-produced successfully, and its application to extreme-low-power-consumption LSIs and computers is further expected. We did combined analyses using TEM observations and computer simulations and found that CAAC-IGZO have new crystal morphology. Based on the results, we propose a deposition model of CAAC-IGZO that minute crystal nuclei laterally grow and connected to each other at the initial stage of the deposition so that they form characteristic layered crystal morphology.

9:40 AM

(PL-002-2016) The Science of Materials: Impactful Solutions to Big Global Challenges

A. N. Sreeram*[1]; 1. The Dow Chemical Company, USA

Humanity faces a number of big challenges. Providing energy that is safe and clean. Providing water to a thirsty planet. Feeding a growing global population. Protecting and preserving nature and the modern infrastructure. Dow Chemical is a world leader in the application of chemistry and material science, uniquely positioned to address big global challenges. Technologies that reduce energy use, provide clean water, make cars safer and more efficient, protect and preserve crops, and protect and preserve food are some of the examples of the impactful technologies made possible by mastery of material science.

10:40 AM

(PL-003-2016) SiC/SiC Ceramic Matrix Composites for Jet Engines

K. A. Stevens*[1]; 1. GE Aviation, USA

Aircraft engines operate more efficiently at higher temperatures and pressures, but the industry is running into the temperature limits of even the most advanced metal superalloys. SiC/SiC Ceramic Matrix Composites (CMCs) provide greater temperature capability, weigh about a third as much, and survive better in a variety of environments around the world – all of which significantly expand their potential usage. SiC/SiC CMCs have now moved beyond development programs and into certified engines for commercial aircraft. Currently, over 10,000 jet engines incorporating CMCs in the "hot section" are on order, with the first entering airline service later this year. This talk will cover the state-of-the art in SiC/SiC materials, design, and verification, including the large amount of testing underway from material coupons to engine components in flight tests. It will also describe the associated manufacturing supply chain that has been created and will conclude by summarizing requirements for the next generation of CMC systems.

11:20 AM

(PL-004-2016) Ceramic Matrix Composites (CMCs): Enabling Materials for Competitive Aero-Engines

J. Esslinger*[1]; 1. MTU Aero Engines AG, Germany

Today, we witness the first steps of a trend towards an extended use of novel, non-metallic materials in the hot section of aero engines. These materials will be a substantial enabler to realize the tremendous technical demands to be competitive at the future engine market: Increase in materials' temperatures of more than hundred Kelvin and parts' weight reduction well above twenty percent. Promising, in some cases competing, candidates are intermetallics and fiber reinforced composites. In this group, the CMCs involve the maximum potential as a high-temperature-and-low-weight material, however, simultaneously the highest challenges to come up with an economical competitive, stable production and a reliable design for the application in aviation. Whereas CMCs have a long history in research and other industrial applications, aero engines' requirements for materials' quality result in the need of substantial additional efforts to enable a broad application. The successful implementation of titanium aluminides, the first "non-metallic game changer" to load-bearing hot-section components, revealed some basic key factors of success: Highly integrated development teams of research, suppliers, and engine manufacturer; Upper management attention and willingness of all parties to invest in a future technology; Strategies to enable delivered quantities sufficient to justify invests and to reduce production costs. Further, there are CMC-specific tasks that still challenge developers: Materials and coatings withstanding extended aero engines' life requirements; Automatization of production processes for a stable and economic production; Maturity of material-and-production-appropriate designing and qualification; Quality inspection and repair procedures. If and only if all of these targets are achieved consistently, CMCs will win the competition with other materials' solutions in aero engines sustainably.

H3. Innovative Design, Advanced Processing, and Manufacturing Technologies

Innovative Design I

Room: Bay
Session Chairs: Shaoming Dong, Shanghai Institute of Ceramics, Chinese Academy of Sciences; Christian Wilhelmi, Airbus Group Innovations

1:30 PM

(H3-001-2016) Non-oxide ceramic matrix composites for application in hot gas atmospheres – requirements and potential (Invited)

H. Klemm*[1]; K. Schönfeld[1]; W. Kunz[2]; C. Steinborn[1]; 1. FhG IKTS Dresden, Germany; 2. Fraunhofer IKTS, Germany

Caused by the steady increasing energy price and the stronger requirements in environmental protection the focus of future generations of advanced gas turbines will be emphasized on an increased efficiency with a simultaneous reduction of the emissions. From technical point of view, these goals can be obtained only by higher operating temperatures in the system in combination with lower amount of cooling air. Non-oxide ceramic matrix composites (CMC) offer high potential for application in gas turbines. Significant progress was achieved in the development of high-temperature stable non oxide CMC; however, there are still considerable deficits in the behavior of CMC at elevated temperatures. One of the main challenges was found to be the oxidation and corrosion resistance of the materials in hot gas environment in combination with long-term stability of the damage tolerant behavior of the composites. In the present study, some idea about the design of non-oxide CMC including the composition of the base CMC material and the environmental barrier coating system for oxidation and corrosion protection will be discussed.

2:00 PM

(H3-002-2016) Chemical Vapor Deposition on Multi-element Ceramics in Si-B-C-N Systems (Invited)

Y. Liu*[1]; L. Cheng[1]; L. Zhang[1]; 1. Northwestern Polytechical University, China

Multi-element Si-based ceramics in Siliconboron carbonitride (SiBCN) system, such as Si-C-N, Si-B-C, Si-B-N and Si-B-C-N have excellent structural and functional properties, for example the fascinating mechanical, oxidation and dielectric properties. Now, they were widely used as interphase, matrix and coatings of ceramic matrix composites. Chemical vapor deposition and infiltration processing is an advanced and based technology for deposition of multi-element Si-based ceramics in siliconboron carbonitride (SiBCN) system successfully. In this paper, we summarized the deposition thermodynamic, kinetic and deposition mechanism of Si-C-N, Si-B-C, Si-B-N and Si-B-C-N in SiBCN system via LPCVD/CVI technology . Finally, the related applications of these Si-based ceramics were demonstrated.

2:30 PM

(H3-003-2016) Co-toughened C-SiC-based composites by SiC nanofibers and carbon fibers (Invited)

J. Sha*[1]; J. Dai[1]; Z. Zhang[1]; J. Li[1]; W. Krenkel[2]; 1. Dalian University of Technology, China; 2. University of Bayreuth, Germany

Ceramics have been used for high performance structure. Generally, the main drawback of ceramics is low tensile strength and being easy to crack, which seriously affects the strength, durability, and safety of structures. Therefore, the carbon fibers and silicon carbide fibers were mainly used as the reinforcements to improve the toughness of ceramics by decreasing the sensitivity to defects and delaying the transformation of cracks. These fibers increased tensile strength and diffused large cracks into a dense of tiny cracks at microscale, but there was little effect in resisting crack initiation at nanoscale. With the development of nanotechnology, ceramics can be modified by the incorporation of nano-sized reinforcing phases, such as one-dimensional nanotubes and nanofiber. Particularly, one-dimensional nanofibers, their strength, toughness, and specific surface area are far superior to those of traditional fibers, may improve the toughness of ceramics at micro and nanoscale. In the present work, the SiC nanofibers were introduced into the space among carbon fibers by in-situ growth to form co-toughened preform for reinforcing the C-SiC-based composites. The influence of SiC nanaofibers on the microstructure and mechanical properties of C-SiC-based composites was investigated. Research achievements indicate that SiC nanofiber presents a potential opportunity to enhance composites.

3:20 PM

(H3-004-2016) Comparison of Machining Technologies for CMC Materials using Advanced 3D Surface Analysis (Invited)

R. Goller[1]; A. Rösiger*[1]; 1. University of Applied Sciences, Germany

For the future industrial use of high performance Ceramic Matrix Composites (CMCs) the final machining methods have to be developed and optimized. Finally standardization is required to make industrial processes available. Today diamond grinding (DG) is still the only machining method for most of the applications for CMCs (e.g. ceramic brake discs, high temperature components. Alternative machining technologies like abrasive water jet machining, laser cutting or diamond milling are still in the early development stage and their effect on surface quality and structural damage are unknown to a large extend. In the present work three different cutting technologies are applied on a CMC material varying machining parameters and tools. To compare the results a 3d microscopy imaging process has been used. The results show, that the machining method and the respective parameters influence surface quality and delamination.

3:50 PM

(H3-005-2016) Design, fabrication and properties of multifunctional ultra-high temperature ceramic matrix composites

C. Hu*[1]; S. Tang[1]; H. Cheng[1]; 1. Institute of Metal Research, CAS, China

Carbon fiber reinforced ceramic matrix composites are regarded as the promising thermal protection materials (TPMs) for use in the ultra-high-temperature regions of hypersonic space vehicles. As TPMs they are expected to be light weight, non-ablative, high strength and low Z-direction thermal conductivity (TC). Considering that the structure and properties of composites can be diversified by the design of the composition, structure and distribution of matrixes, carbon fibers and pores, it is feasible to build a multifunctional ceramic matrix composite to meet these requirements. In this work, a ZrB_2 modified C_f/C-SiC composite has been designed and fabricated by chemical vapor infiltration (CVI) and slurry infiltration (SI) techniques. This integrated composite contains three layers in Z-direction: a compact C_f/C–ZrB_2–SiC surface layer, a porous C_f/C–ZrB_2–SiC core and a compact C_f/C–SiC bottom layer. Compared to a normal C_f/SiC composite with a density of 2.1 g/cm^3, the as-prepared composite has a 21% lower density (1.65 g/cm^3), a 65% lower TC (3.29 W/mK), while its flexural strength is only 16% lower (260MPa). Its linear ablation rate is 0.79 μm/s after 10-cycle ablation for 1000 s accumulatively at 1850 °C. The porous core contributes to the low density and low TC, while the two compact outer layers contribute to the good mechanical and ablation properties.

4:10 PM

(H3-006-2016) Influence of the annealing process parameters in the production of new short fibre-reinforced C/C-SiC composites

N. Nier*[1]; D. Nestler[1]; K. Roder[1]; E. Paessler[1]; J. Weisshuhn[1]; A. Todt[1]; H. Gurk[1]; L. Kroll[1]; S. Spange[1]; G. Wagner[1]; 1. TU Chemnitz, Germany

A new short fibre-reinforced C/C-SiC composite is developed by using the liquid silicon infiltration (LSI) process, which consists of three processing steps. A carbon-fibre-reinforced plastic (CFRP) composite is fabricated. The shaping of this composite is realised by an injection moulding process. The CFRP composite is converted in a porous C/C composite by pyrolysis. Liquid silicon is infiltrated to form a dense C/C-SiC composite. An additional heat treatment (annealing process) of the cured CFRP composite completes the crosslinking of the polymer and thus a higher carbon yield is achieved. In addition, the microstructure (closed porosity, crack network) along the whole process route is strongly influenced. In this paper the influence of the annealing parameters are examined. The starting materials (carbon fibre, polymer, curing agent and lubricant) as well as the microstructures of the composites (cured CFRP, annealed CFRP, C/C and C/C-SiC composites) are characterised. These investigations show a direct relationship between the used parameters of annealing process and the forming of the porosity. In regards to the optimisation of the process an optimal process condition is specified.

4:30 PM

(H3-007-2016) Manufacturing of non oxide Ceramic Matrix Composites by microwave heating applied to Chemical Vapor Infiltration

A. Lazzeri*[1]; G. Annino[2]; M. Coltelli[1]; L. Aliotta[1]; V. Gigante[1]; 1. National Interuniversity Consortium of Materials Science and Technology (INSTM) c/o University of Pisa, Italy; 2. National Research Council of Italy, Italy

Chemical Vapor Infiltration (CVI) is one of the most employed method for preparing non oxide ceramic matrix composites (CMCs), in particular those reinforced with Carbon (C) or Silicon Carbide (SiC), having a matrix of SiC or C. These materials can be used in aerospace field, in nuclear plant or in high performing car parts for their high resistence to temperature higher than 1500°C. The matrix is synthetized inside SiC or C preforms thanks to the reaction, occurring at a temperature of 900-1200°C of a gaseous precursor inside preforms pores. The main disadvantage of this method is the very long time required to obtain a suitable density, especially in thick preforms. Moreover, the conventional heating of the furnace, being not selective for the sample volume, leads to deposition in not desired region of the reactor thus determining low yield of the process. The microwave technology was used in a pilot MW-CVI plant to obtain a rapid and homogeneous heating more focused on the preform volume, thus leading to the deposition of SiC on SiC or C preforms at a rate higher than the conventional CVI method. Although the process requires further optimization in order to achieve a better control of homogeneity and final properties of materials, the results about were quite encouraging.

4:50 PM

(H3-008-2016) Updating Composite Materials Handbook-17 Volume 5—Ceramic Matrix Composites

J. D. Kiser*[1]; K. David[2]; C. Davies[3]; R. Andrulonis[4]; C. Ashforth[5]; 1. NASA Glenn Research Center, USA; 2. The Boeing Company, USA; 3. Federal Aviation Administration/Materials & Structures, USA; 4. Wichita State University, USA; 5. Federal Aviation Administration, USA

A wide range of issues must be addressed during the process of certifying CMC (ceramic matrix composite) components for use in commercial aircraft. The Composite Materials Handbook-17 (CMH-17), Volume 5 on ceramic matrix composites is being revised to help support FAA certification of CMCs for hot structure and other elevated temperature applications. The handbook supports the development and use of CMCs through publishing and maintaining proven, reliable engineering information and standards that have been thoroughly reviewed. Volume 5 will contain detailed sections describing CMC materials/processing, design/analysis guidelines, testing procedures, and data analysis and acceptance. A review of the status of this document, with emphasis on the efforts of the Materials & Processes Working Group, will be presented along with a description of how CMH-17, Volume 5 could be used by the FAA (Federal Aviation Administration) and others in the future. Volume 5 is part of a 6 volume series covering polymer, metal, and ceramic matrix composite materials.

5:10 PM

(H3-009-2016) Oxide-Oxide CMCs: Enabling Widespread Industry Adoption

B. Jackson*[1]; L. Visser[2]; A. Beaber[2]; A. Barnes[2]; J. Lincoln[3]; 1. Composite Horizons, USA; 2. 3M, USA; 3. Axiom Materials, Inc., USA

Oxide-oxide ceramic matrix composites are gaining increasing attention as a mainstream material option for high temperature components in the aerospace and advanced energy sectors. As the material moves from bench to production, cost reductions are required to ensure that the solutions are market-competitive with titanium and other high temperature alloys. In parallel, a more comprehensive portfolio of fabric geometries and data are desirable to enable flexibility in both engineering and design. 3M, maker of Nextel ceramic fibers, joins CMC prepregger, Axiom Materials, Inc., and CMC parts designer and fabricator, Composites Horizons, in developing data for the present work. The team jointly compares properties of Oxide-Oxide CMCs fabricated from a conventional Nextel fabric architecture with properties of new, lower cost fabric designs.

H5. Polymer Derived Ceramics and Composites

PDC Composites I

Room: Trinity IV
Session Chair: Paolo Colombo, University of Padova

1:30 PM

(H5-001-2016) Polymer derived ceramic matrix composites – potential and limits (Invited)

D. Koch*[1]; 1. Institute of Structures and Design, Germany

Ceramic matrix composites CMC show a high potential for critical applications at high temperature and corrosive atmosphere as they promise classical properties of monolithic technical ceramics combined with enhanced toughness due to use of reinforcing fibers. In general fibrous preforms are produced via different methods like filament winding or layup of fabrics. Beside ceramic slurry infiltration (CSI) and chemical vapor infiltration (CVI) the impregnation with polymers is an attractive method to build up the matrix. Different kinds of polymers may be used and form a polymeric matrix, accordingly. After succeeding pyrolysis the matrix is then converted to a ceramic like matrix. The pyrolysis always induces shrinkage resulting in pore and crack formation in the matrix. For achievement of tough behavior these pores are either used for crack deviation in the matrix, known as weak matrix composite, or the matrix is further densified via several reinfiltration steps. Then the fiber matrix interface must be adjusted by fiber coating in order to fulfil the concept of weak interface composites. According to the various microstructures the properties of polymer derived composites will be assessed and their properties at room and high temperature are interpreted. The properties are correlated with manufacturing constraints and potential of further development of these composites will be discussed.

2:00 PM

(H5-002-2016) Sandwich structured composites from polymer derived matrices (Invited)

A. Ortona*[1]; 1. SUPSI, Switzerland

Sandwich structured ceramic matrix composites have a elevated potential in high temperature applications in the fields of aeronautics, aerospace, automobile and industrial heat recovery. Indeed ceramic sandwich structures can exploit multiple characteristics by combining mechanical behavior, thermo fluid dynamics, acoustics, electromagnetic shielding. This paper reviews the work performed and mostly some of the applications For thermo-structural applications, skins must be made of Ceramic Matrix Composites (CMC) because of their strength, their resistance to high temperatures (beyond 1000°C), and their low densities. Concerning foam cores, some carbides (e.g. SiC) are, for their outstanding thermo-mechanical properties, the most appropriate. These foams can withstand long oxidative exposing conditions with low material degradation. This paper presents an assembly method of SiC based sandwich structured CMC. It is performed during sandwich manufacturing in an integrated fashion and allows the production of complex shapes at low costs. Produced flat sandwiches panels, characterized by three point bending tests, showed a marked toughening behavior.

2:30 PM

(H5-003-2016) Investigation on Interlaminar Strength of 3D-Basalt Fiber Reinforced SiOC-Hybrid-Composites

P. Weichand*[1]; R. Gadow[1]; 1. Institute for Manufacturing Technologies of Ceramic Components and Composites, University of Stuttgart, Germany

In this study the influence of different types of three-dimensional reinforcement on the mechanical properties of basalt fiber reinforced SiOC-composites was investigated. Basalt fiber reinforced, polymer derived SiOC-composites are able to bridge the gap between low

temperature polymer matrix composites (PMC) and high temperature ceramic matrix composites (CMC). They combine the benefits of cheap raw materials and adapted state of the art polymer manufacturing technologies with an increased thermal and tribological stability compared to PMC. Limiting factors are the weak interlaminar strength values attributable to the pyrolysis step. In order to increase these values, a variety of 3-dimensional reinforcements were evaluated with standardized test samples to qualify the influence. Sample plates composed of basalt fabric were manufactured. In the preforming step 6 different types of thru thickness reinforcement were applied to the preform and infiltrated via RTM. After pyrolysis and subsequent PIP steps, the samples were evaluated regarding bending strength, interlaminar shear strength and orthogonal adhesion strength. The obtainable values compared to a non-reinforced composite are, in some cases, significantly higher. Additionally the influence on shrinkage, porosity and their qualification for a series production were evaluated with respect to potential and already proven applications.

PDC Composites II

Room: Trinity IV

Session Chair: Dietmar Koch, Institute of Structures and Design

3:30 PM

(H5-004-2016) Matrix Concepts and Processing Protocols for Robust SiC-Based CMCs (Invited)

F. W. Zok*[1]; N. M. Larson[1]; R. B. Reitz[1]; C. G. Levi[1]; 1. University of California, Santa Barbara, USA

The talk will focus on microstructure evolution during PIP processing of SiC-based CMCs and concepts to both mitigate processing defects and to attain nearly-fully dense matrices. The origins and evolution of defects has been studied by synchrotron X-ray computed tomography of unidirectional minicomposites, both in situ and ex situ. New insights have been gleaned into infiltration kinetics and infiltration non-uniformities as well as evolution of cracks during subsequent pyrolysis. Strategies for mitigating the processing defects and for subsequent reactive melt infiltration to produce matrices with high temperature (1500°) capabilities will be discussed.

4:00 PM

(H5-005-2016) Fiber-Matrix adhesion in CFRC greenbodies and its influence on microcrack formation during carbonization process

S. J. Haug*[1]; W. M. Mueller[1]; M. G. Sause[1]; S. Horn[1]; 1. University of Augsburg, Germany

In this study, we investigate the polymer infiltration and pyrolysis (PIP) production route of carbon fiber reinforced carbon (CFRC), in particular the formation of the crack pattern during carbonization and its connection to the chemical functionality of the carbon fiber surface. To this end, two types of unidirectional CFRP greenbodies were prepared, using carbon fibers with high and low chemical surface functionality (HF, LF) embedded in a phenolic resin matrix. The fiber matrix adhesion in these greenbody composites was evaluated applying cyclic single fiber push-out measurements. The development of the crack pattern during carbonization was monitored using in situ acoustic emission measurements (AE) for both sample types and then, after carbonization by X-Ray computer tomography (CT) and scanning electron microscopy (SEM). The interplay of stresses arising in the composites due to volumetric shrinkage of the matrix and fiber matrix adhesion are key to an understanding of the emerging crack pattern in CFRC materials. Composites with LF-fibers and low adhesion prior to pyrolysis show dominantly fiber-matrix debonding, while composites with HF-fibers and high adhesion prior to pyrolysis show dominantly matrix cracking. In conclusion, we have shown that the crack pattern in CFRC can be controlled by functionalization of the original carbon fibers.

4:20 PM

(H5-006-2016) SiOC based fiber reinforced composites, their manufacturing, processing and special applications (Invited)

R. Gadow*[1]; P. Weichand[1]; 1. Institute for Manufacturing Technologies of Ceramic Components and Composites, University of Stuttgart, Germany

Polymer matrix composites (PMC) are widely used in lightweight applications. The manufacturing technologies are fully developed and raw materials are cheap. The major limiting factor of these reinforced polymers is the maximum service temperature. Standard matrices like epoxy or polyester are capable for temperatures up to 200 °C. Ceramic Matrix Composites (CMC) are suitable for service temperatures up to over 1200 °C. These composites are composed of ceramic matrices combined with ceramic fibers. This class of composites is handicapped by the high cost of processing and raw materials and therefore only attractive for applications in astronautics and aviation. Intermediate ceramic composites with an amorphous SiOC matrix combined with alternative basaltic fibers are suitable for bridging the gap between PMC and CMC. Such competitive free formable Hybrid-composites are capable for service temperatures up to 600-1000 °C in oxidative atmosphere. In order to make the material attractive for series applications, manufacturing technologies like RTM, filament winding or warm pressing are employed. Beside the improved thermal resistivity in comparison to PMC and light metals, a major benefit of SiOC composites is investigated in the field of friction materials. The excellent properties in wear resistance and a high coefficient of friction make it an interesting alternative to CFC and CMC.

4:50 PM

(H5-007-2016) Lightweight telescope mirrors and structural components development with polymer derived ceramics for future space telescopes

R. Eng*[1]; 1. NASA Marshall Space Flight Center, USA

One of the challenges for future large space telescopes is the need for multi-meter mirror substrates and structural components with high modulus and thermal conductivity with low density, coefficient of thermal expansion (CTE), and lower fabrication cost. Such properties can lead to lighter yet stiffer telescope mirrors with lower cost than current low expansion glass ceramic, light metals, and ceramics mirrors. Recent NASA funded mirror substrates and composite structures developed using polymer derived ceramics (PDC) have yielded some promising results. While previous attempts failed to produce any mirror substrate with damage free optical surfaces using PDC, a 0.25 meter, crack-free, with open-back for lightweighting, SiOC mirror was recently demonstrated by pyrolysis of partially cured PDC granules pressed into a mirror mold. The optical surface was polished and coated suitable for infrared telescopes, additional challenge lies still ahead to polish and coat the substrate to produce extremely smooth mirrors for ultraviolet and visible wavelengths telescopes. In addition, extremely lightweight panels have been demonstrated by polymer infiltration pyrolysis of carbon fiber honeycomb structures between top and bottom carbon fiber sheets with PDC to produce near zero CTE panels suitable for optical benches and telescope components.

5:10 PM

(H5-008-2016) Effects of SiC filler materials on the properties of SiC_f/SiC composites made by precursor impregnation and pyrolysis process

B. Yoon*[1]; S. Lee[1]; S. Singh[1]; J. Yin[1]; 1. Korea Institute of Materials Science, Republic of Korea

SMP-10 polycarbosilane (PCS) precursor, SiC fillers and Tyrano-SA grade 3 woven fabrics were used for the fabrication of SiC_f/SiC composites by precursor-impregnation and pyrolysis (PIP) process.

A slurry containing 10 wt% of nano-SiC (50 nm or 170 nm) were prepared for the infiltration of the filler particles in between the fibers. For filling the macro-pores in the fabrics, concentrated SiC slurries with two different particle size and solid loading (0.4 mm, 40 vol% and 170 nm, 55 vol%) were prepared and infiltrated into the fabrics. The relative density and mechanical properties of the CMC without the filler materials were 85.7% and 240 MPa after 7 PIP cycles, while those using the 0.4 mm and 170 nm fillers were 90% - 340 MPa and 86.4% - 165 MPa, respectively. The strength of the CMC without the filler decreased from 225 MPa to 35 MPa after heating at 1500ºC for 2h in Argon atmosphere. The strength of the CMC using 0.4 mm filler decreased to 140, 90 and 60 MPa after heating at 1200, 1300 and 1400ºC, respectively. The strength of the CMC using 170nm filler decreased to 105 MPa after heating at 1400ºC.

5:30 PM

(H5-009-2016) Refractory Adhesives for Bonding of Polymer Derived Ceramics

R. D. Cook*[1]; 1. Lancer Systems, USA

In a world where advanced computer modeling and simulation packages are helping engineers optimize new product designs to increase performance, oftentimes the limiting factors to meeting spec are the mechanical and thermal restrictions inherent to currently available engineering materials. Ceramic matrix composites, or CMCs, provide an entire world of new thermo-mechanical properties, allowing engineers the ability to unlock the potential of some of their most advanced high temperature designs. Ceramic matrix composites, as the name suggests, are composite materials consisting of a ceramic matrix and one or more property-modifying components. Unlike homogeneous materials, CMCs are commonly reinforced with fiber which adds mechanical strength to the ceramic matrix, allowing for utilization in applications where a monolithic ceramic would fail catastrophically due to either impact or thermal shock events. The end result is a family of materials that can withstand temperatures above that of the most advanced high temperature polymers and metals, while at the same time being resilient to the chipping and shattering associated with common monolithic ceramics. An engineering challenge associated with CMCs has been how best to bond both similar and dissmilar CMC materials. It is the goal of this presentation to discuss state of the art refractory adhesives used in the bonding of CMCs for high temperature applications.

H8: Ceramic Integration and Additive Manufacturing Technologies

Ceramic Integration and Additive Manufacturing Technologies

Room: Salon D

Session Chairs: Michael Halbig, NASA Glenn Research Center; Soshu Kirihara, Osaka University

1:30 PM

(H8-001-2016) High-Value Added Ceramic Products Manufacturing Technologies – R&Ds on Additive Manufacturing (Invited)

T. Ohji*[1]; 1. National Institute of Advanced Industrial Science and Technology (AIST), Japan

"High-Value Added Ceramic Products Manufacturing Technologies" project has been conducted since 2014 as a part of Strategic Innovation Promotion Program under the sponsorship of the Japanese government, with target of "removing restrictions of conventional manufacturing". This project deals with two principal technologies; additive manufacturing of ceramics aimed for complex shaping, reducing working-processes, saving cost, etc. and hybrid ceramic coating on 3D polymers/metals for enhancing their reliability and functionality. This paper will introduce the backgrounds, objectives, structure, research contents, research schemes, innovation strategy, etc. of this project. Particular focus is places on the R&Ds on the additive manufacturing, which contains ceramic powder/slurry layer manufacturing and ceramic laser sintering which realizes concurrent forming and sintering. This work was conducted as a part of "High-value added ceramic products manufacturing technologies project" supported by CSTI, SIP, "Innovative design/manufacturing technologies (managed by NEDO)".

2:00 PM

(H8-002-2016) Additive Manufacturing Development for NASA Aerospace Applications

M. C. Halbig*[1]; M. Singh[2]; 1. NASA Glenn Research Center, USA; 2. Ohio Aerospace Institute, USA

Silicon carbide (SiC) ceramics, SiC fiber reinforced/SiC ceramic matrix composites (SiC/SiC CMCs), polymer composite materials, and multi-material systems offer high payoff in aerospace applications due to such characteristics as light weight, high temperature capability, and tailored and gradient properties. Additive manufacturing approaches can offer game changing technologies for the quick and low cost fabrication of parts with much greater design freedom and geometric complexity. New component designs are enabled through complex shapes, sensor integration, innovative cooling, and multi-functional capability. Potential applications will be discussed to include multifunctional panels, turbine engine components, and electric motors. Various approaches for developing SiC-based ceramics and composites will be presented to included modified 3D printing, binder jet SiC powder processing in collaboration with rp+m (Rapid Prototyping+Manufacturing), and laminated object manufacturing (LOM) of CMCs. The plans for utilizing a newly acquired direct print micro-dispensing system (NScrypt) will also be presented.

2:20 PM

(H8-003-2016) Active Metal Brazing and Diffusion Bonding of Ceramics to Metals for Structural and Thermal Applications

M. Singh[2]; M. C. Halbig[1]; R. Asthana*[3]; 1. NASA Glenn Research Center, USA; 2. Ohio Aerospace Institute, USA; 3. University of Wisconsin-Stout, USA

Over the last decade, a number of advanced joining concepts were demonstrated to integrate ceramics, CMCs and porous materials to high-temperature alloys for structural and thermal applications that include heat exchanger, fuel cell, fuel injector, reentry vehicles, gas turbine and other components. Among the joining methods, active metal brazing and diffusion bonding were preferred. Judiciously chosen active braze fillers and metal interlayers (e.g., Ni, W, Ti, Ta, Mo-B) were used to bond ceramics and metals to create metallurgically sound bonds for characterizing the microstructure, composition, and properties of joints. Composite brazes containing fine ceramics (SiC, AlN) or finely distributed refractory alloy powders (Si-X eutectics, X: Ta, Ti, Cr, Hf, B and Y) were also used to examine the structure and integrity in brazed joints. The bonded materials included monolithic ceramics (YSZ, SiC, Si_3N_4, Al_2O_3), ceramic-matrix composites (SiC/SiC, C/SiC, C/C, ZrB_2/SiC), and carbon foams of different densities. The joints were characterized for microstructure (optical, SEM, TEM), composition (EDS), hardness (Knoop), and tensile and compressive shear strengths. The presentation will highlight the potential of brazing and diffusion bonding to create robust joints of difficult-to-machine ceramics and CMCs to high-temperature alloys.

2:40 PM

(H8-004-2016) Stereolithographic Additive Manufacturing of Biological Scaffolds with Structural Fluctuation

S. Kirihara*[1]; 1. Osaka University, Japan

Stereolithographic additive manufacturing has been developed to artificial bones of biological scaffolds including micro lattices with fluctuated porous distribution. The lattice aspect ratio of length to diameter and the spatial coordinates of binding sites were defined using 1/f fluctuation theory. Streamlines of biological fluid flows in the structural fluctuations were simulated and visualized by computational fluid dynamics. Photo sensitive acrylic resins with hydroxyapatite of 2 μm in particle diameter at 45 volume % were spread on a glass substrate with 10 μm in thickness by a mechanical knife edge. An ultraviolet laser beam of 355 nm in wavelength was adjusted from 10 to 100 μm in diameter and scanned on the pasted resin surface. A laser scanner with automatic collimator was equipped to realize precise micro pattering and high speed drawing by finer or larger beam spots, respectively. Irradiation power was changed automatically from 10 to 200 mW to obtain enough solidification depth for layer joining. Cross sectional patterns were laminated to create solid objects. Composite precursors were dewaxed and sintered in the air atmosphere to obtain the biological ceramic component.

3:20 PM

(H8-005-2016) Joining of Silicon Carbide by Laser-Supported Heating – Chances and Limits

M. Herrmann*[1]; S. Ahmad[2]; W. Lippmann[1]; H. J. Seifert[2]; A. Hurtado[1]; 1. Technische Universität Dresden, Germany; 2. Karlsruhe Institute of Technology, Germany

Materials based on silicon carbide play an important role in the field of high temperature engineering. The development of these materials includes further improvement of technologies for the joining what can be provided by laser energy allowing the fast and locally heating. The presentation deals with factors influencing the joining of SiC components realized by laser-supported heating processing: The optical properties depending from the laser wave length determine the heating behavior. The heat distribution inside the components volume as well as the resistance against stresses as result of the high thermal gradients and transients is affected by the materials mechanical and physical properties. The laser-supported joining has to be adapted to the sizes and shapes of the components to be joined because a high joint quality will necessitate a homogeneous heating. The type of joining interlayer will influence the joint quality. The formation of strong bonds between interlayer and substrate materials is a result of time-dependent chemical reactions what counteracts the fast heating by laser beam. New results of joining experiments of SiC materials will illustrate the effect of the listed parameters on the joint quality. The area of technical and economical useful application will be discussed. Finally an outlook will offer the chances and the limits of this technology for the joining of SiC based materials.

3:40 PM

(H8-006-2016) Joining of CVD-SiC and Ceramic Matrix Composites with Ti_3SiC_2 using Spark Plasma Sintering

P. Tatarko*[2]; V. Casalegno[1]; M. Salvo[1]; M. Ferraris[1]; M. Reece[2]; 1. Politecnico di Torino, Italy; 2. Queen Mary University of London, Nanoforce Technology Ltd., United Kingdom

Spark Plasma Sintering (SPS) was used to join ceramic matrix composites CMCs (C_f/SiC and SiC_f/SiC) with a MAX phase, titanium silicon carbide (Ti_3SiC_2). The initial Ti_3SiC_2 powder was sintered using the SPS and grinded down to a final thickness in the range of 30 - 100 μm. The joining process was optimised using the monolithic β-SiC manufactured by chemical vapour deposition (CVD). After the best joining parameters had been found, the same process was applied to join the CMCs. A temperature as low as 1300°C was sufficient to achieve defect-free joints. The pre-sintered Ti_3SiC_2 foil was found to be non-reactive with the CVD-SiC layer. Most importantly, the Ti_3SiC_2 foil showed a significant ductility as it conformed to the rough surface of the CMCs during the joining process. The MAX phase also penetrated into the cracks in the CVD-SiC coating of CMC materials (formed during the processing of the composites), effectively healing the CMC materials. Performance of the joints was evaluated by apparent shear strength measurements using a single lap offset shear test configuration. High temperature mechanical performance of the joints was investigated using the monolithic CVD-SiC components joined with the Ti_3SiC_2. It was found that the strength of the joints starts deteriorating at a temperature ~ 1200°C. This was also confirmed by high temperature creep and low cycle fatigue experiments.

4:00 PM

(H8-007-2016) Preparation and bonding properties of high-temperature organic adhesives prepared by precursor (V-PMS) and fillers

X. Wang*[1]; J. Wang[1]; H. Wang[1]; 1. National University of Defense Technology, China

Two kinds of high-temperature organic adhesives were prepared by using precursor (V-PMS) as matrix, B4C powder and nano SiO2 as fillers, and were successfully applied to join SiC ceramics. The bonding properties of the adhesives were investigated by bonding test and SEM analysis. VP-B was prepared by V-PMS and B4C powder at the mass ratio of V-PMS:B4C=100:40. The room-temperature shear strengths of VP-B treated at 200°C, 400°C, 600°C, 800°C, 1000°C, 1200°C were 17.8MPa, 18.9MPa, 7.3MPa, 52.1MPa, 62.4MPa, 67.5MPa respectively. Additionally, the high-temperature bonding strengths of VP-B tested at 200°C, 400°C, 600°C, 800°C, 1000°C were 12.5MPa, 6.8MPa, 4.2MPa, 6.6MPa, 8.3MPa respectively. VP-BS was prepared by V-PMS, B4C powder and nano SiO2 at the mass ratio of V-PMS:B4C:SiO2=100:40:10. The room-temperature shear strengths of VP-BS treated at 200°C, 400°C, 600°C, 800°C, 1000°C, 1200°C were 18.1 MPa, 19.2MPa, 15.2MPa, 48.8MPa, 55.7MPa, 61.5MPa respectively. Moreover, the high-temperature bonding strengths of VP-BS tested at 200°C, 400°C, 600°C, 800°C, 1000°C were 7.6MPa, 10.1MPa, 8.7MPa, 7.7MPa, 8.4MPa respectively. The excellent performance of the obtained high-temperature organic adhesives makes them as promising candidates for joining SiC ceramics for high-temperature applications.

4:20 PM

(H8-008-2016) Role of interfacial interactions in joining of ceramics by brazing alloys

F. Hodaj*[1]; 1. Grenoble Institute of Technology, France

In non-reactive metal-ceramic systems non-wetting is usually observed. In these systems, wetting can be significantly improved by addition of appropriate reactive alloying elements which form continuous layers of compounds at the interface, by reaction with the ceramic substrate. The purpose of this presentation is to focus on the fundamental issues of wetting and interfacial reactions in metal/ceramic and glass/ceramic systems and to analyse the main thermodynamic and kinetic factors governing them: (i) Thermodynamics analysis of non-reactive and reactive brazing and relationship between wettability and brazability. (ii) The confinement effect in brazing which can lead to a major difference between interfaces obtained in sessile drop and brazing experiments. (iii) The role of atmosphere on the solid liquid interactions in sessile drop and brazing experiments. All these points will be illustrated by analysis of results obtained in sessile drop and brazing experiments in metal/ceramic and glass/ceramic systems.

4:40 PM

(H8-009-2016) The preparation of (SiC, B_4C and TiC)/Cusil hybrid tape and its application in the joining of Silicon carbide ceramics

Y. Liu*[1]; 1. Shanghai Institute of Ceramics, Chinese Academy of Sciences, China

In order to reduce the residual stress caused by the CTE mismatch of ceramics and filler alloys and improve the joining strength at high temperature of SiC/SiC joints, ceramics-reinforced hybrid tape were used to join the silicon carbide ceramics. Tape casting technology was employed to prepare the ceramic-particulate-reinforced composite active filler alloy in order to control the thickness of the joints. Three ceramic particles, including SiC, B_4C and TiC were introduced into the Cusil-ABA powders to prepare the hybrid tapes in order to evaluate the effect of ceramic particles. In addition, the effect of dispersant, binder and solid content of the slurry on the hybrid tapes were systemically investigated and optimized. The hybrid tapes were characterized by optical microscopy, SEM and EDS. Then the tapes were used to join the sintered silicon carbide joints, and the microstructure and joining strength were measured. The results showed that the ceramic particles were randomly dispersed in the Ag-Cu-Ti matrix and the thickness of the tapes can be exactly controlled by the parameter of tape casting. The joint strength both at room temperature and at high temperature were improved due to the effect of ceramic particles.

H11. CMC Applications in Transportation and Industrial Systems

High Performance Friction Materials

Room: Salon C

Session Chair: Bernhard Heidenreich, German Aerospace Center

1:30 PM

(H11-001-2016) Successful Spin-off from Space to Terrestrial Applications: Development, Status and Perspectives of Carbon/Ceramic Brakes (Invited)

W. Krenkel*[1]; 1. University of Bayreuth, Germany

LSI-derived C/C-SiC composites have proven their outstanding performance for frictional applications by demonstrating high coefficients of friction and low wear rates. Today, these composite materials are used as series products for high performance braking systems in automotive and industrial applications (e.g. brake discs, pads for elevator emergency brakes). High coefficients of friction which are constant over a wide range of sliding velocities and pressures can be achieved with appropriate counterpart materials and specific modifications of the C/C-SiC microstructure. The development of an automotive brake system consisting of C/C-SiC brake discs and organic based pads led to a lifetime brake which makes a brake disc change obsolete. The further success of these innovative materials is strongly dependent on the reduction of production costs and the development of light-weight ceramic brakes with life cycle costs (LCC) comparable to the current cast iron brakes. The presentation describes the development and evolution of carbon/ceramic brake discs and pads over the last 20 years, summarizes the state-of-the-art, and gives a perspective to future demands and challenges in process technology and material development.

2:00 PM

(H11-002-2016) Analysis of Friction Materials for Brake Pads of Heavy Loaded Brake Systems with Discs Made of SiC-Matrix Composites (Invited)

V. Kulik*[1]; A. Nilov[1]; A. Garshin[2]; 1. Baltic State Technical University "VOENMEH", Russian Federation; 2. State Polytechnical University, Russian Federation

One of the major problems in developing brake systems on the basis of discs made of Ceramic Matrix Composites (CMC) is selection of efficient brake pads being able to withstand severe operating conditions and having high tribological, mechanical, thermophysical, environmental and economical characteristics. The purpose of this work is analysis of modern friction materials for brake pads to be used in pair with CMC brake discs. CMC with SiC matrix produced by Liquid Silicon Infiltration was employed as a material for brake discs and pads. Frictional metalloceramics on the basis of iron, produced by a powder metallurgy method was used as a material for brake pads. Powders of SiC and AlN were used as solid additives. Frictional tests were carried out for friction couples "CMC–CMC" and "CMC–metalloceramics". Tribotechnical properties (friction coefficient and wear factor) were measured on friction machines allowing tests "plane-plane" or "plane-finger". Tests were held at different sliding velocities and contact pressures. Microstructural study of the initial surface and of the friction surface after the tests was done. Elemental composition of the path of friction was investigated. The wear mechanism in friction pairs was analysed. The correlation between the initial composition of the CMC and tribotechnical properties for different pads is found and discussed.

2:30 PM

(H11-003-2016) The study of C/C-SiC based friction materials on a dynamometer at high braking pressures and speeds (Invited)

W. Krenkel[1]; N. Langhof*[1]; 1. University of Bayreuth, Germany

Low densities (e.g. C/C-SiC ≈ 2 g/cm^3), good mechanical strength and damage tolerance by the C-fiber reinforcement make CMC suitable for frictional applications. Especially, the high temperature resistance enable their application for lifetime brakes in passenger cars. Furthermore, CMC show their favourable performance in emergency brake systems. The aim of this study is to show the potential and the tribological behaviour of C/C-SiC based materials at moderate and high braking pressures (up to 45 MPa) and high speeds (up to 20 m/s) on different disc materials. The tribological performance of the friction couples was investigated on a dynamometer with an optional fly wheel (800 kg, 100 kgm^2) at different speeds and pressures. The brake discs consist of steel (St37) or CMC and the pads based on C/C-SiC (LxWxT up to 30x30x10 mm^3). SemiMets resp. LowMets were studied as reference materials. The coefficient of friction (COF), the wear rate, the temperatures of the friction couples and the braking pressures were determined. In order to study the friction and wear mechanisms, optical and scanning microscopy of the frictional surfaces and cross sections were applied, besides of measuring the surface roughnesses. Finally, this work shows the future possibilities of replacing conventional materials by CMC friction materials and their current limits as well.

3:20 PM

(H11-004-2016) Development of Carbon Fiber Reinforced CMC for aircraft and automobile application (Invited)

K. Kim*[1]; D. Im[1]; Y. Choi[1]; J. Lee[1]; Y. Kang[1]; N. Lee[1]; 1. DACC Carbon Co., Ltd, Republic of Korea

We will introduce our newest developments in the C/C brake discs for aircrafts, and C/SiC brake discs for passenger cars. Our company has been developing C/C brake discs using TG-CVI process, which is a unique technology in contrast to those of other competitors. The braking characteristics through DT and OT were evaluated in the condition of normal, overload, and RTO. The technology for C/C brake discs was then applied to develop C/SiC brake discs synthesized using carbon fiber and matrix consisting of polymer-derived carbon and silicon carbide tailored by SMI process for application in automobiles. The C/SiC composites through SMI process have low density(around 2.3 g/cm^3), low porosity(less than 5 %) and low C.T.E(less than 5×10^{-6}/K at 1100 °C). In addition, the load-bearing part has high thermomechanical shock resistance, and the SiC-rich friction layer has high thermal conductivity of over 135 W/m•K. The braking behavior can be tailored by modifying the compositions and microstructure of the friction layer to match specific design requirements. In AMS test, the developed C/SiC brake discs showed short and stable stop distance(1st stop distance of 36.6 m, 10th stop distance of 37.1 m, 20th stop distance of 36.1 m) along with low brake discs temperature of 477 °C after 20th stop. The braking performance and the safety of our products were also confirmed by a carmaker.

3:50 PM

(H11-005-2016) Carbon-based friction materials: Fabrication, characterization and modeling towards new concepts

G. L. Vignoles*[1]; 1. University of Bordeaux 1, France

Carbon/Carbon composites are choice materials for braking applications ; the associated market being very competitive, important research efforts are being carried out by the leading companies in relation with academy. We will review in this conference: some new concepts for friction materials and the associated processes; recent developments in carbon characterization; modeling efforts aimed at C/C composites performances.

4:10 PM

(H11-006-2016) Damage Evolution Mechanism and Reliability of Short Carbon Fiber Dispersed SiC Matrix Composite (Invited)

Y. Kagawa*[1]; 1. The University of Tokyo, Japan

Short carbon fiber dispersed SiC matrix composite has a low fracture toughness value (~5MPam$^{1/2}$), however, the composite can use as a brake rotor of high performance cars. The performance of the composite highly depends on short crack level microfracture evolution process under service condition. Crack arrest mechanism by short carbon fiber bundle-SiC matrix or carbon fiber bundle-C matrix phases plays very important role on the microfracture evolution process of the composite. The present talk is focused on the unique macroscopic- and microscopic- fracture fracture behaviors of the composite and the role of short crack-heterogeneous microstructure interactions on the crack arrest mechanism. Optimization of the heterogeneous structure for the best performance of the composite as a brake rotor under given constitute phases is also planned.

G1. Powder Processing Innovation and Technologies for Advanced Materials and Sustainable Development

Energy-saving Processing, Smart Recycling of Materials, and Particle Design

Room: Trinity III

Session Chairs: Makio Naito, JWRI, Osaka University; Yoshio Sakka, National Institute for Materials Science (NIMS)

1:30 PM

(G1-001-2016) A smart recycling process for tantalum recovery from WEEEs by selective grinding (Invited)

C. Tokoro*[1]; Y. Tsunazawa[1]; S. Owada[1]; 1. Waseda University, Japan

An appropriate comminution and physical separation process for tantalum (Ta) concentration from printed circuit boards (PCBs) in waste electric and electronic equipments (WEEEs) was investigated in this study. To accomplish this, two-step comminution in which PCBs were detached from WEEEs at first, followed by part detachment from PCBs, was effective because Ta is generally used in a specific part on the board such as "tantalum capacitor". Almost all parts on the board could be detached without destruction by comminution using drum-typed mill with chain-typed agitator. Higher part detachment was achieved by heating to 473 K in the mill because a part of solder was melted and tantalum capacitor could be simply released from the board by milder comminution force. To reveal the mechanism of breakage phenomena in comminution / detachment process of PCBs, computer simulation using discrete element method (DEM) with particle-based rigid body model was carried out. Simulation results successfully corresponded to comminution experimental results and suggested that chain-typed agitator mill promotes inter-action between a board and another board which is most important mechanism for parts detachment from the boards, because the chain could give wide variety of energy to boards due to their deformation.

2:00 PM

(G1-002-2016) Infiltration of molten silicon in a porous body of B_4C under microwave heating

M. Dutto*[1]; S. Marinel[2]; D. Goeuriot[1]; S. Saunier[1]; 1. Mines Saint-etienne, France; 2. CRISMAT Laboratory UMR 6508 CNRS-ENSICaen-UCBN, France

Boron Carbide is an attractive material for various applications that require high hardness and neutron absorption. Boron carbide is usually fabricated by hot pressing at temperatures above 2000 °C. Therefore the production cost is very high, that constitutes the major drawback for widespread applications in the fields of defense and nuclear energy. A specific route to decrease the production cost of this material is the reaction-bonded technique (RBBC). In this latter, a preform of porous B_4C is obtained by compaction and partial densification. Then the material is infiltrated by molten metal or alloy. This technique was extensively studied using conventional furnace but the use of microwave as a source of heating, as not used for this purpose so far, or only in a very few attempts. In the present study the microstructure and mechanical properties of reaction bonding B_4C using microwave heating will be presented. The results will be discussed in the light of conventional RBBC.

2:20 PM

(G1-003-2016) Development of Novel Soft Chemistry

K. Toda*[1]; S. Kim[1]; K. Uematsu[1]; M. Sato[1]; 1. Niigata University, Japan

Since Ionic-diffusion in ionic crystal is very slow at room temperature, the solid-state reaction method requires a high temperature to synthesize the ceramic materials. Recently, we have proposed the novel synthesis methods, such as water assisted room temperature solid state reaction (WASSR) method and solid hydratethermal reaction (HSR) method, to synthesize the ceramic materials in a single phase form at low temperature. These methods are very simple and can be synthesized the ceramic materials just by mixing of raw materials added a small amount of water in the case of WASSR method and by storing the mixture of raw materials added a samll amount of water in a reactor at low temperature below 373 K in the case of HSR method. We can successfully synthesized numerous ceramic materials, such as YVO_4, $SrMoO_4$, $BaTiO_3$ at low temperature below 373 K by the novel synthesis methods proposed. In this study, we demonstrated that the reaction mechanism of novel low temperature synthesis methods is different from the conventional solid state reaction and solution reaction.

2:40 PM

(G1-004-2016) Preparation of carbamate-containing calcium carbonate for radioactive waste water treatment

J. Nakamura*[1]; Y. Sakka[1]; T. Kasuga[2]; 1. National Institute for Materials Science (NIMS), Japan; 2. Nagoya Institute of Technology, Japan

Since the accidents at Fukushima Daiichi Nuclear Power Plants, the leakage of radioactive nuclides including ^{90}Sr into the sea has been concerned as the one of environmental threat. Vaterite is the least thermodynamically-stable calcium carbonate. The vaterite quickly dissolves to provide carbonate ion in aqueous media, which precipitate the strontium as carbonate salts with aragonite-type crystal structure. Aminopropyl siloxane (Ap-S) is known to react with CO_2 gas and form carbamate groups (NH-COO$^-$), which expected to act as the nucleation site for the structure, leading to the enhanced efficiency of the strontium collection. In the present work, calcium carbonate particles were prepared by CO_2 bubbling method in the presence of Ap-S. The achieved calcium carbonate particles possessed a compressed-spherical morphology with the mean diameters of about 450 nm. FT-IR spectra of the particles showed the presence of carbamate-functionalized siloxane originated from the Ap-S. XRD analysis revealed their dominant crystalline phase to be vaterite. In particular, the vaterite showed (00l)-plane preferred orientation. When the SiV particles were soaked into strontium chloride solution, the concentrations of Sr^{2+} ion were decreased from 5.0 to 0.4 mmol/L after 12 h of soaking. An XRD of samples showed the formation of calcian strontianite ($(Sr,Ca)CO_3$) crystals within 30 min of soaking.

3:20 PM

(G1-005-2016) Carbon Nanotube – Ceramic Matrix Composites: Processing and Characterizations (Invited)

M. Estili*[1]; Y. Sakka[1]; 1. National Institute for Materials Science (NIMS), Japan

Our recent achievements in the processing of defect-free multi-walled carbon nanotube (MWCNT) – ceramic matrix composites and a direct characterization of interfacial shear resistance and mechanical response of individual MWCNTs while embedded in the ceramic matrix will be briefly presented. We also highlight a new concept, which led to the fabrication of the first and most CNT–concentrated ceramic material ever (20 vol% MWCNT) with full density (~99%), which shows unprecedented electrical transport and strain tolerance characteristics suitable for various functional and structural applications. Furthermore, we discuss how a recently discovered nanoscale in-MWCNT load-transfer process, at an optimized, high loading of MWCNTs (10 vol%) and in a pore-free and uniform matrix structure, could lead to unprecedented, simultaneous enhancement in strain tolerance (81%; average 0.0019), fracture toughness (52.2%; average 6.71 MPa.m$^{0.5}$), and flexural strength (22%; average 483.19 MPa) of the Al_2O_3 ceramic matrix.

3:50 PM

(G1-006-2016) Study on preparation of exfoliated mica nanosheets for mica-resin composite as insulation materials

Y. Tominaga*[1]; Y. Hotta[1]; K. Fukushima[2]; Y. Takezawa[2]; 1. National Institute of Advanced Industrial Science and Technology, Japan; 2. Hitachi Chemical Co., Ltd., Japan

Muscovite, which is one of the most important structures of mica, has been used as fillers for polymer composites with high electrical insulating property. Because the performance of its polymer composite is dependent on the aspect ratio of laminated filer in case of mica, the exfoliation of laminated filer is very important. Therefore, the reduction of interlayer force by the intercalation of organic compound into mica layers is necessary for effective exfoliation. However, the intercalation of mica is difficult due to non-swellability of mica. In this study, we will demonstrate to intercalate alkylammonium ion to the interlayer of mica by swelling the distance between the layers of mica with thermal treatment at the decomposition temperature of mica. The powder X-ray diffraction (XRD) patterns showed that the interval between mica layers was spread slightly without breaking the crystal structure by the thermal treatment, resulting that the intercalation of alkylammonium ion to the mica was dramatically progressed as compared to non-heated one. Furthermore, the intercalated mica could be exfoliated effectively by the wet-jet milling process. One important consequence in this work is that the thermal treatment is of importance for swelling the interlayer of mica and exfoliation of mica with high aspect ratio.

4:10 PM

(G1-007-2016) Synthesis and alalysis of novel AlN filler for high thermal conductivity resin composite

Y. Kanechika*[1]; Y. Fukunaga[1]; M. Wan[1]; S. Fujii[1]; K. Sugawara[1]; T. Kawamura[1]; J. Tatami[2]; 1. TOKUYAMA Corp., Japan; 2. Yokohama National University, Japan

High packaging density and downsizing of electronic device have a problem relating to increase of heat density. Therefore, development of high thermal conductivity material for packaging is expected. Aluminum nitride (AlN) has promise as a electronic packaging material from their properties, such as high thermal conductivity and electrical insulation. AlN powder is suitable for high thermal condcutivity filler for resin composite such as TIM (Thermal Interface Material), phase change sheet, grease and so on. It is very important to control particle size and morphology of AlN particles. Large and spherical morphology is desired to AlN filler in their applications. In this study, large AlN powder was synthesized by the carbo thermal reduction nitridation (CTRN) of Al2O3. Various additives were added to enhance the carbo thermal reduction nitridation reaction of Al2O3. The full convertion from Al2O3 to AlN ocuured by adding CaF2. Shape of the synthesized AlN particle was spherical and their inside was hollow. In additon, various shapes and size AlN filler were synthesized and their properties were investigated. The properties of novel AlN filler for resin composite will be discussed.

4:30 PM

(G1-008-2016) Synthesis of hollow silica nanoparticles using poly (acrylic acid) with aliphatic amines

C. Takai*[1]; H. Imabeppu[1]; H. Razavi Khosroshahi[1]; M. Fuji[1]; 1. Nagoya Institute of Technology, Japan

Synthesis of hollow silica nanoparticles using poly (acrylic acid) (PAA)-amine aggregates as nano-sized template was proposed. The PAA-amine mixtures dissolve in water, but not in ethanol, therefore the mixtures can be the template for hollow particle in ethanol and can be removed from the core-shell particle by addition of water. In order to investigate effect of amines on hollow particle formation, four kinds of amines; ethylenediamine (EDA), N,N,N',N'-tetramethylethylenediamine (TED), 3,3'-diaminodipropylamine (DDA), triethylenetetramine (TTA), which interact with carboxylic acid of PAA were chosen. The PAA-each amine nanoparticles were formed with around 200 nm by dropping of PAA/amine mixtures in ethanol under the optimum conditions. Using the PAA-DDA template, hollow silica nanoparticles with spherical form were successfully prepared for the shortest reaction time in four hours. The primary amines and secondary amine of DDA work as not only cross-linker for PAA, but also sol-gel reacting catalyst. It can be clear from that the EDA with two primary amines also worked as sol-gel catalyst while the TED with two tertiary amines didn't. Acknowledgement This work is supported by Advanced Low Carbon Technology Research and Development Program (ALCA), Japan.

4:50 PM

(G1-009-2016) Research and development of wet-chemical process for lanthanum germanate oxyapatite

K. Kobayashi*[1]; Y. Igarashi[2]; T. Higuchi[2]; Y. Sakka[1]; 1. National Institute for Materials Science (NIMS), Japan; 2. Tokyo Univeristy of Science, Japan

Lanthanum gernamate oxyapatite is a new oxide ion conductor having higher oxide ion conductivity than that of yttria stabilized zirconia. However, its synthesis is quite difficult because of the high volatility and low meting point of germanium dioxide which is usually employed as raw materials. With respect to a water-based wet chemical synthesis of lanthanum germanate, no route has been reported because there is no water soluble germanium salt especially under acidic region. In this study, we discover a proess to prepare the homogeneous aqueous solution containing of lanthanum and germanium, and several powder synthesis routes were developed from our homogeneous solution. In this presentation, we will present our noble synthesis process, ceramic fabrication and its oxide-ion conductivity using our synthetic powder.

5:10 PM

(G1-010-2016) $BaTiO_3$/Silicone Composites for Mechanical Sensor

C. Guo*[1]; C. Takai[1]; H. Razavi Khosroshahi[1]; M. Fuji[1]; 1. Nagoya Institute of Technology, Japan

Mechanical sensors fabricated by electric functional fillers and elastomers not only have low manufacturing costs but can also be utilized for many potential applications areas. $BaTiO_3$ is a kind of ceramics with high dielectric constant while silicone is a kind of elastomer with low elastic modules, composites made by witch could obtain both the advantages of them and have time-dependence property that are suitable for detecting the motion energies of moving object. To improve the compatibility between $BaTiO_3$ particles and silicone elastomers, surface-modification of $BaTiO_3$ particles by silicone coupling agents and some special mechanical treatments of $BaTiO_3$ particles were studied. The SEM observation and dielectric measurement proved that both of dispersity of $BaTiO_3$ particles and dielectric properties of $BaTiO_3$/silicone Composites were improved after surface modification and mechanical treatments. Membrane of $BaTiO_3$ particles/silicone elastomer were fabricated and the motion energies of moving objects moving object were detected through the variation of dielectric constant caused by collision with the membrane by LCR meter. The relationship between the motion energy of the moving object with the dielectric constant-time curve was discussed. Acknowledgement: This work is supported by Advanced Low Carbon Technology Research and Development Program (ALCA), Japan.

G2. Functional Nanomaterials for Sustainable Energy Technologies

Functional Nanomaterials for Sustainable Energy Technologies I

Room: York B

Session Chair: Lionel Vayssieres, Xi'an Jiaotong University

2:00 PM

(G2-001-2016) Nano-Structured Materials in High-Performance Solar Devices (Invited)

N. P. Kherani*[1]; 1. University of Toronto, Canada

Energy consumption by buildings accounts for approximately 30-40% globally. Integration of sustainable energy technologies can lead to the realization of net-zero or near-zero energy buildings. These include energy generating and energy conserving technologies. On the generation side, the use of solar photovoltaics in its varied forms is evolving into a primary building integrated renewable energy option. On the conservation side, the use of passive and active spectrally selective coatings on windows – which are otherwise open thoroughfares for optical and thermal radiative energy – is indispensable. Nano-thin films play a central role in the development of high performance energy generating and energy conserving devices. Photovoltaic energy generation systems invariably require the use of coherent light trapping structures that govern spectral and directional utilization of solar irradiation. Spectrally selective coatings demand control of visible, infrared and mid-infrared regions of the electromagnetic spectrum to effectively control the solar and thermal energy flux across an otherwise open optical via. This talk will present recent development of nano-structured thin films amenable to enhancing the performance of solar photovoltaic and solar control devices. Specifically, novel conducting photonic crystal – photovoltaic devices and diamond-like carbon based spectrally selective solar coatings will be discussed.

2:30 PM

(G2-002-2016) Near-infrared Photon Harvesting in Solar Cells and Photocatalysis by using Semiconductor and/or Plasmonic Nanostructures (Invited)

Z. Xu[1]; D. Ma*[1]; 1. INRS, Uni. Quebec, Canada

Harvesting near infrared (NIR) photons represents an attractive approach to improve the efficiency of photovoltaics and photocatalysis. In this regard, quantum dots (QDs) are promising for solar cell applications because of their size-tunable bandgaps, even in the NIR range. Moreover, they show advantages of low cost solution processibility, and high potential for multiple exciton generation and for the facile fabrication of multi-junction solar cells. On the other hand, plasmonic nanostructures have recently been explored for enhancing the efficiency of solar cells and photocatalysis via several mechanisms, such as hot electron transfer and enhanced photon absorption. Herein, I will present some of our recent developments in the NIR QDs (mainly PbS/CdS core/shell QDs) and plasmonic nanostructures (based on Au and Ag) that have strong resonances in the NIR regime, and their application in solar cells and photocatalysis.

3:20 PM

(G2-003-2016) Solution Phase Strategies for VLS-like growth on Colloidal Plasmonic Substrates (Invited)

J. Millstone*[1]; 1. University of Pittsburgh, USA

Multicomponent and composite architectures promise to synergistically combine properties of their constituent materials. One attractive class of these materials is the combination of plasmonically active nanoparticles with catalytic or magnetic materials. However, the architectures of these secondary components can be difficult to control, and is often either templated by the underlying structure (e.g. core-shell or "framed" nanoparticle colloids) or by an external template (e.g. porous anodized aluminum oxide). Here, we demonstrate the use of nanoparticle surface chemistry to create linear arrangements of discrete, 1D Pt nanoparticle alloys directly on the surface of a thin triangular gold nanoprism substrate. The synthesis of both components is accomplished in the solution phase and leverages several aspects of the growth chemistry including the supramolecular assembly of the surfactant and speciation of the platinum precursor. The reaction is followed by electron microscopy techniques, as well as X-ray photoelectron spectroscopy, inductively coupled plasma mass spectrometry, and ^{195}Pt-NMR.

3:50 PM

(G2-004-2016) Shape-Controlled Metal/Semiconductor Nanocrystals in a Well-Controlled Kinetic Process and Their Application for Electrocatalysis or Photocatalysis

M. Liu*[1]; X. Wang[1]; L. Zhao[1]; 1. Xi'an Jiaotong University, China

Nanocrystals are fundamental to modern science and technology. Controlling the shape or morphology of nanocrystals is central to their enhanced catalytic properties. This presentation will show a short discussion of current research activities of our group that center on shape-controlled synthesis of metal and semiconductor nanocrystals. Based on simply employing a syringe pump for dropwise growth for kinetic control, the shape-controlled process involving nucleation, seed formation, monomer deposition, surface capping, and surface diffusion has been elucidated. It is believed that these jobs not only advance our knowledge on the growth mechanism of metal and semiconductor crystals, but also illustrate a robust method to targeted crystal design towards optimizing their associated catalytic activities.

4:10 PM

(G2-005-2016) Growth control of molybdenum disulfide nanostructure on carbon paper by thermal chemical vapor deposition for highly efficient hydrogen evolution

H. Wang*[1]; D. Chua[2]; 1. National University of Singapore, Singapore; 2. Nagaoka University of Technology, Singapore

As a promising substitute of Pt for hydrogen evolution reaction (HER), earth-abundant molybdenum disulfide (MoS_2) shows an economic advantage with comparable performance to Pt. However, the limitation of active sites restricts the application of MoS_2 as HER catalyst. In this article, we report a facile method to grow MoS_2 onto carbon paper directly by thermal chemical vapor deposition (TCVD) with commercial sulfur and molybdenum oxide (MoO_3) as precursors. The deposition temperature and duration are extensively investigated. Thereafter, the MoS_2 nanostructure is confirmed by scanning electron microscopy (SEM), Raman spectroscopy, X-ray photoelectron spectroscopy (XPS) and X-ray powder diffraction (XRD). As a result, flower-like nanoflakes, protruding vertically on the surface of fibers of carbon paper, provides numerous potential active sites for HER. In the end, we investigated the HER activity of as-grown MoS_2/carbon paper in a typical 3-electrode setup, where the relation between outstanding HER performance and MoS_2 structure is studied. Our results demonstrate that as HER catalyst MoS_2's structure and property can be easily engineered by growth temperature and duration of TCVD method, which enables potential mass production for industrial purposes.

G5. Advanced Materials, Technologies, and Devices for Electro-optical and Medical Applications

Semiconductor I

Room: Trinity V

Session Chairs: Naoki Ohashi, National Institute for Materials Science (NIMS); Didier Chaussende, CNRS

1:30 PM

(G5-001-2016) Advances in Basic Ammonothermal Growth of Bulk Gallium Nitride Crystals (Invited)

S. Pimputkar*[1]; S. Griffiths[1]; T. Malkowski[1]; S. Suihkonen[2]; J. S. Speck[1]; S. Nakamura[1]; 1. University of California, Santa Barbara, USA; 2. Aalto University, Finland

GaN is a versatile semiconductor enabling devices ranging from white LEDs to highly efficient power electronics. Existing technology is built on sapphire substrates resulting in heavily defected material. While LEDs can still operate efficiently, long life-time lasers and vertical power electronics need higher quality material necessitating GaN substrates. This talk will provide an overview of advances on improving purity and growth rate of GaN grown using the basic ammonothermal method, along with newly gained insight into the fundamental aspects of the solvent system, paving the way for future improvements. Development of a self-pressure balancing capsule made of ultra-high purity material enabled a marked improvement in grow rate, resulting in total c-plane growth rates of up to 350 μm/day. Using the same system, transition metal impurities were significantly reduced resulting in free carriers and hydrogenated gallium vacancies to be the dominant sub-band gap optical absorbers. For the first time, the degree of ammonia decomposition has been experimentally determined under ammonothermal conditions and optimized process conditions were computationally determined to enhance equilibrium concentrations of ammonia during growth using a newly developed equation of state for NH_3-N_2-H_2 mixtures.

2:00 PM

(G5-002-2016) High Quality Bulk GaN Crystal Grown by Acidic Ammonothermal Method (Invited)

M. Saito*[1]; Q. Bao[1]; K. Kurimoto[2]; D. Tomida[1]; K. Kojima[1]; Y. Kagamitani[3]; R. Kayano[2]; T. Ishiguro[1]; S. Chichibu[1]; 1. Tohoku University, Japan; 2. The Japan Steel Works, Japan; 3. Mitsubishi Chemical Corp., Japan

Acidic ammonothermal method is one of the most promising techniques which enables the mass production of large diameter bulk GaN crystal. State-of-the-art high-power light-emitting diodes and laser diodes are usually fabricated on GaN substrates grown by hydride vapor phase epitaxy. However, to realize vertically conducting high-power GaN switching devices, bowing-free large-diameter GaN substrates are essential, because the size of such devices is much larger than that of optical devices. The ammonothermal growth of GaN was carried out using 4 kinds of ammonium halide mineralizers. A baffle plate was placed at the center in the autoclave to separate the growth region and nutrient region. After charging the precursor and the seed crystals, ammonium halide powder was added. Then, NH_3 gas was fed into the autoclave. The convection causes the mass transport, by the temperature gradient between the two regions. The crystal quality and the growth rate are strongly influenced by mineralizer species. We have also studied the dependence on temperature and pressure, and found it possible to achieve the growth rate faster than 1000μm/day in the optimum growth condition. The full width at half-maximum of the (0002) x-ray ω-rocking curve was smaller than 30 arcsec. Based on these studies and optimization above, we have successfully demonstrated high speed bulk GaN growth by this method at the pressure condition at 100MPa.

2:30 PM

(G5-003-2016) Effects of lattice defects on thermal and optical properties of aluminum nitride ceramics (Invited)

Y. Kanechika*[1]; S. Fujii[1]; K. Sugawara[1]; 1. TOKUYAMA Corp., Japan

Aluminum nitride (AlN) is attractive material with both high thermal conductivity and electrical insulation. Therefore, AlN have promise as one of the material for electrical parts of high power devices. Especially, AlN substrate has been used for high power IGBT (Insulated Gate Bipolar Transistor) and LED (Light Emitting Diode) which is energy saving type devices. Recently, moreover, high function and performance with suitable price are required to AlN ceramics to expand their applications. AlN powder manufactured by the carbo thermal reduction nitridation (CTRN) method is thought to be suitable for raw material to prepare the high performance AlN ceramics. It is very important to study the relation between thermal and optical properties and lattice defects of AlN ceramics made of AlN powder by CTRN method in order to improve their performance. Therefore, the investigation of lattice defects analysis of AlN ceramics were carried out. The results of property control and alalysis of AlN ceramics will be discussed.

3:20 PM

(G5-004-2016) Development of Liquid Crystal Display with RGB Laser Backlight (Invited)

Y. Fujii*[1]; 1. Mitsubishi Electric Corporation Advanced Technology R&D Center, Japan

In Japan, 8K/Super Hi-Vision broadcasts are due to begin in 2020. 8K/Super Hi-Vision broadcasts will provide images with 8K-resolution and a wide color gamut defined in Recommendation ITU-R BT.2020. Although many electric companies have been launching TVs with 8K-resolution, none of them could fully satisfy the wide color gamut. Therefore, it is an urgent business to improve a color purity of light sources used in TV backlights. As light sources which have high color purity, laser diodes (LDs) are well known. Then, we have focused on installing laser light sources into backlight systems. In fact, we have already launched liquid crystal television sets (LS1 series) which used red LDs and cyan LEDs. Then, LS1 series have achieved more than 80% coverage of the wide color gamut. To enhance the coverage of the color gamut, in this article, we developed a liquid crystal display (LCD) with a backlight using LDs of three primary colors, which we called RGB laser backlight. In this RGB laser backlight system, we used light guide rods with LDs mounted on edge sides of rods. The light guide rod was made by polymer containing particles to achieve a surface-emission as a backlight. Our developed LCD using RGB laser backlight successfully achieved 98% coverage of the wide color gamut. Moreover, our development was publicly disclosed at Open House 2015 held in NHK Science & Technology Research Laboratories.

3:50 PM

(G5-005-2016) Investigation of defects and impurity in oxides for optoelectronic applications (Invited)

N. Ohashi*[1]; 1. National Institute for Materials Science (NIMS), Japan

Oxide materials gain a lot of attention because of its wide range of applications, such as transparent conductors, transistors and sensors. For further development of those materials and devices, it is necessary to clarify fundamental physical and chemical properties of those materials. For instances, it is necessary to reveal chemical reactivity for further improvement of their durability and improvement of doping efficiency, and defects management are critical for the enhanced electronic properties. Moreover, thermal behaviors, such as enhanced migration at elevated tempeature, is getting more important for high-power and high-temperature applications. In this context, we have been working to correlate its chemical composition and defect structures to their electronic and optical properties. In this paper, a review on defect structurs in wide-band-gap oxides and oxide dielectrics will be given and issues for further development of oxide semiconductors will be discussed.

4:20 PM

(G5-006-2016) Polarity control of well-ordered epitaxial ZnO nanowire arrays by selective area growth

E. Sarigiannidou*[1]; E. Appert[1]; S. Guillemin[1]; A. Bocheux[1]; F. Donatini[2]; G. Bremond[3]; I. Robin[4]; V. Consonni[1]; 1. Univ. Grenoble Alpes, CNRS, LMGP, France; 2. Univ. Grenoble Alpes, CNRS, Inst NEEL, France; 3. Institut des Nanotechnologies de Lyon, France; 4. CEA, LETI, France

A key advantage of ZnO is its ability to grow with the nanowire (NW) shape by low-cost and surface scalable deposition techniques such as chemical bath deposition (CBD). However, the control of the polarity of ZnO NWs in addition to the uniformity of their structural morphology in terms of position, vertical alignment, length, diameter, and period is still a technological and fundamental challenge for device integration. In this work, ZnO NWs are grown by CBD on electron-beam pre-patterned polar c-plane ZnO single crystals. By combining CBD with selective area growth, we achieved the growth of both O- and Zn-polar ZnO NWs with a highly controlled structural morphology and a high optical quality. Notably, the polarity of ZnO NWs can be switched from O- to Zn-polar, depending on the polarity of the pre-patterned ZnO single crystals, as shown by convergent beam electron diffraction. Furthermore, the single O- and Zn-polar ZnO NWs additionally exhibit distinctive cathodoluminescence spectra.

4:40 PM

(G5-007-2016) Amorphous Oxide Semiconductors: Present technology status, materials science, and new materials (Invited)

T. Kamiya*[1]; H. Kumomi[1]; H. Hosono[1]; 1. Tokyo Institute of Technology, Japan

Amorphous oxide semiconductors (AOSs) represented by a-In-Ga-Zn-O (a-IGZO) have several advantages over conventional amorphous semiconductors such as amorphous Si; therefore, it is now employed in a variety of flat-panel displays ranging from high-resolution smartphone liquid-crystal displays to large-size (up to 77 inches) organic light-emitting diode TVs. In this talk, we will first give a brief review of the present status and future products of AOS-based displays and electronic circuits. Then, we will talk about materials science of AOSs, e.g., their atomic structures, electronic structures, and defect structures, in order to explain why AOSs have such superior properties compared to Si. As for the defect structures, it has been revealed that many kinds of defects are contained in AOSs, which include impurity hydrogen-related defects and oxygen-related defects. In particular, impurity hydrogen affects also on growth and chemical composition of the AOS films deposited by sputtering. By understanding the science of the defects in AOSs, we can develop new functional materials such as ultrawide bandgap materials and light-emitting thin films. More details will be given at the conference.

G6: Porous Ceramics for Advanced Applications Through Innovative Processing

Innovative Characterizations, Modeling and Mechanical Responses of Porous Ceramics

Room: Trinity I/II
Session Chair: Manabu Fukushima, National Institute of Advanced Industrial Science and Technology (AIST)

1:30 PM

(G6-001-2016) Integrated Experimental and Computational Investigation of the Processing and Properties of Hierarchical Porous Ceramics (Invited)

R. Bordia*[1]; C. Martin[2]; 1. Clemson University, USA; 2. Université de Grenoble - Alpes, France

One of the focal areas of our current research is the development of processing strategies to control the microstructure of porous ceramics at different length scales. Many of the applications of porous ceramics demand optimization of a multitude of properties some of which have conflicting requirements on the microstructure. Materials with designed anisotropic and/or hierarchical microstructures have the potential to optimally address the requirements. We will present results from an integrated experimental and simulation project focused on microstructural control in hierarchical and/or anisotropic porous ceramics. Porous ceramics are used in a broad range of technologies including electrochemical applications like electrodes for solid oxide fuel cells. In this case, the properties of interest are mechanical, thermal, electrical and ionic conductivity, gas diffusion and chemical reactivity. In this presentation, results will be presented on the processing approaches to make these designed microstructures, the quantification of the 3D microstructure at different length scales and meso-scale simulations to simulate the mechanical and transport properties and their comparison with experimental results. The coupling between 3D images obtained by X-ray tomography and meso-scale simulations will also be highlighted.

2:00 PM

(G6-002-2016) Application of 3-parameter Weibull Distribution to Porous Ceramics

K. Yasuda*[1]; H. Kita[2]; M. Takahashi[3]; Y. Takahashi[4]; S. Tanaka[5]; S. Honda[6]; T. Mitsuoka[7]; H. Muto[8]; S. Yamamoto[9]; Y. Yoshizawa[10]; 1. Tokyo Institute of Technology, Japan; 2. Nagoya Univ., Japan; 3. Ehime Univ., Japan; 4. Noritake Company Limited, Japan; 5. Nagaoka Univ. Tech., Japan; 6. Nagoya Tech., Japan; 7. NGK Spark Plug Co., Ltd., Japan; 8. Toyohashi Univ. Tech., Japan; 9. Asuzac, Japan; 10. AIST, Japan

Strength reliability of porous ceramics becomes a topic of the day because porous ceramics are considered to be key materials in the advanced systems such as SOFC, high capacity batteries, filters, sensors, and bioceramics etc. To estimate its reliability, the strength distribution must be expressed with accuracy. In this presentation, we apply Weibull distribution to bending strength data obtained from the round robin tests in Japan, and discuss its validity. Samples are porous Al_2O_3, and NiO/8mol%YSZ electrode material. The number of specimens is 30 for both materials. The dimension of the specimens are 8mm * 6mm * 80mm. For NiO/8mol%YSZ electrode material, its strength distribution can be expressed by 2-parameter Weibull distribution; however, strength data of porous Al_2O_3 fits in well with 3-parameter Weibull distribution, not depending on the type of bending (3 point or 4 point). It suggests that we should take 3-parameter Weibull distribution into account for porous ceramics. This work was supported in part by METI, Japan.

2:20 PM

(G6-003-2016) Internal pore structure in porous ceramics evaluated by micro x-ray CT

S. Tanaka*[1]; K. Yasuda[2]; H. Kita[4]; M. Takahashi[5]; Y. Takahashi[6]; S. Honda[7]; T. Mitsuoka[8]; H. Muto[3]; S. Yamamoto[9]; Y. Yoshizawa[10]; 1. Nagaoka University of Technology, Japan; 2. Tokyo Institute of Technology, Japan; 3. Toyohashi University of Technology, Japan; 4. Nagoya University, Japan; 5. Ehime University, Japan; 6. Noritake Co. Ltd., Japan; 7. Nagoya Institute of Technology, Japan; 8. NGK Spark Plug Co., Ltd, Japan; 9. Asuzac, Japan; 10. AIST, Japan

The various types of porous ceramics have been developed for solid oxide fuel cell, gas filters, vacuum chuck, and catalyst support, etc. For sustainable use, mechanical strength and their fluctuations must be examined as well as functional property. To control the mechanical property, it is important to relate the internal pore structure to the mechanical properties. The internal pore structures, which involve the amount, size, shape and network of pores, are very important from view point of mechanical property. The objective of this study is to evaluate the internal structures in bulk porous ceramics by micro-focus x-ray computer tomography (μ-CT). The feature of μ-CT is 3 dimensional and nondestructive observation. Various types of porous ceramics with several ten microns were used as samples. Using the μ-CT, the 3 dimensional networks of pores or the largest pore were observed easily. Porous alumina ceramics, which was prepared from pore former, showed spherical pores connecting one another with bottle neck pores, and their size of spherical pores were determined by size of pore former. Particularly, for alumina with 60% in porosity, the largest size pores with 200μm were rely contained, and they affected the mechanical strength and fluctuations. This work was supported in part by METI, Japan.

2:40 PM

(G6-004-2016) Elastplastic Indentation on Porous Ceramic Materials (Invited)

H. Muto*[1]; 1. Toyohashi University of Technology, Japan

Porous ceramic is one of the important key materials for advanced engineering due to a set of attractive properties, including low density, large surface area, favorable permeability, high thermal shock resistance, low thermal expansion coefficient and so on. The porous ceramics have been widely used as structural component such as filters, thermal insulators, heat exchangers, sound-absorbing materials and damping buffers. Therefore, it is very important to understand the mechanical properties of porous ceramics for practical applications. In order to evaluate mechanical properties, the stress-versus-strain curve (S-S curve) have used in compressive or flexural tests. However, a limited information such as elastic modulus and fracture strength was obtained even if the large size of specimen was used in such conventional techniques. On the other hand, the elastplastic information on the microscopic processes and mechanisms of indentation-induced surface deformation and damage is all included in the indentation load P versus penetration depth h hysteresis curve in a loading / unloading cycle. Not only stress / strain-based analysis of P-h curve, but also the energy-derived principal for P-h hysteresis loop energy has been extensively utilized for examining as well as characterizing the mechanical properties of various type of porous ceramic materials.

Advanced Processing Methods and Characterization Technologies of Ceramic Foams I

Room: Trinity I/II

Session Chairs: Tobias Fey, Friedrich-Alexander University Erlangen-Nürnberg; Enrico Bernardo, University of Padova

3:20 PM

(G6-005-2016) Insight into geopolymers porosity (Invited)

V. Medri*[1]; E. Papa[1]; A. Natali Murri[1]; E. Landi[1]; P. Benito[2]; A. Vaccari[2]; 1. National Research Council of Italy, Italy; 2. University of Bologna, Italy

Geopolymers are produced by reacting an alumino-silicate powder with an aqueous alkali hydroxide and/or alkali silicate activating solution. Geopolymers constitute a family of materials with variable properties within those characteristic of ceramics, cements, zeolites or refractories, depending on formulation. Metakaolin based geopolymers are intrinsically mesoporous and exploiting both direct and indirect foaming techniques, a hierarchical porosity can be constructed. Water affects the intrinsic meso-porosity of the geopolymer matrix, since it acts as a pore former during the polycondensation stage. By ice-templating, water can be used as a sacrificial template and porous architectures with main unidirectional anisotropic macro-pores can be obtained. Rounded ultra-macro-porosity can be obtained by direct foaming, by using blowing agents to generate gas evolution or surfactants to entrap and stabilize air bubbles. Finally, the addition of reactive or inert fillers results in a further functionalization of the materials. Silica fume or silicon carbide can be used as reactive fillers since they contain small quantities of free metallic silicon as impurity. Porous, coarse, natural or mineral inert fillers can be selected to obtain porous composites. A wide range of applications has been and is currently under investigation (insulation, adsorption, wicking, catalysis, etc.) due to the versatility of the process in tailoring the material properties.

3:50 PM

(G6-006-2016) Monolithic Hybrid Ceramics prepared by Emulsion based Process (Invited)

M. Wilhelm*[1]; F. Schlüter[1]; K. Rezwan[1]; 1. University of Bremen, Germany

Emulsion based synthesis is a versatile process to adjust pore sizes on different length scales and to receive monolithic structures at the same time. Beside the generation of polymeric structures, this process was rather rarely used with polysiloxanes containing a high degree of organic groups as starting material so fare. This work focuses on using an emulsion based process to synthesize organo-silica-based monolithic hybrid ceramics with tunable surface characteristics and pore size distribution. Polymethylsiloxane (MK) and polymethylphenylsiloxane (H44) were used as precursors to generate monolithic structures. The addition of a metal salt allows the preparation of hybrid materials containing metal nano particles. Pyrolysis of the cross-linked materials results in micro/macroporous structures. The specific surface area and hydrophilicity or hydrophobicity of the emulsion based monoliths can be adjusted by using different compositions of MK and H44 and pyrolysis temperatures. By varying the oil/water ratios of the emulsion, a further tailoring of the pore sizes and pore size distribution is possible. Additionally, the influence of the surfactants on the material properties will be discussed.

4:10 PM

(G6-007-2016) Electrical and thermal conductivity of ceramic foam (Invited)

M. Scheffler*[1]; S. Rannabauer[1]; U. Betke[1]; 1. University of Magdeburg, Germany

The interest in ceramic foams is steadily growing for a great variety of applications. Potential applications are, for instance, supports for heat storage materials or for catalysts, and therefor tailored electrical and thermal conductivities are inevitable. Reticulated foams possess hollow struts, and infiltration methods offer the feasibility to fill these spaces. In this respect, a novel processing route was developed to provide electrical conductivity and to increase the thermal conductivity of the reticulated ceramic foams by metal precursors infiltration. Advantage of this processing route is to avoid high temperatures necessary for melting the metals. The metal/ceramic composite foams were characterized with respect to their thermal and electrical conductivity. It was found that the method of applying an electrical contact to the foams influences significantly the measured value of current and voltage. Due to an increased mechanical stability of these foams novel applications will be discussed in this paper

4:40 PM

(G6-008-2016) Microcellular Silicon Carbide Foams from boron-modified polycarbosilanes

C. Durif*[1]; P. Miele[1]; S. Bernard[1]; F. Grasset[3]; O. Lacroix[3]; P. Colombo[2]; 1. European Membrane Institute, France; 2. University of Padova, Italy; 3. AREVA Technical Center, France

Recently, silicon carbide (SiC) attracted interest for environmental and energy applications according to its mechanical and chemical properties at high temperature. Yet, most of the actual and future industrial challenges of silicon-based ceramics require materials with compositions, shapes and textures tuned on demand. Common techniques are energy-ineffective and limit the shape and texture complexities of the parts made. Moreover, the control of the product purity and crystalline form is restricted. These difficulties can be overcome by synthetic paths where molecular chemistry and chemistry of materials are combined rationally, like the Polymer-Derived Ceramics (PDCs) route. This process is applied here to make boron-modified SiC foams. The polymer was synthesized by reaction of allylhydridopolycarbosilane (AHPCS) with borane dimethyl sulfide to get highly crosslinked polymers. The polymers are fully characterized by infrared and solid state NMR. By mixing the polymer with PMMA spheres, then applying a warm-pressing, hybrid pellets are made. A pyrolysis up to 1000°C under argon allowed converting the inorganic part into SiC and removing the organic part leaving voids in the pellets. This produced microcellular foams are characterized by mercury porosimetry and SEM. The structural evolution of the amorphous SiC has been followed by XRD and Raman spectrometry. Application will be briefly described.

5:00 PM

(G6-009-2016) High temperatures oxidation behavior of SiC based periodic and random cellular architectures in calm and flowing air

E. Rezaei[2]; A. Ortona*[1]; 1. SUPSI, Switzerland; 2. EPFL, Switzerland

This work reports on the properties evolution of SiC based cellular architectures during their high temperature oxidation in calm air and in the real working conditions of a porous burner at 1400°C. Si-SiC and systems were employed as skeleton material because they, previously produced as monolithic bars, showed promising oxidation behavior at high temperatures. Regular arrays of different periodic structures were first designed by CAD, 3D printed, and finally converted into ceramic by replica and reactive silicon infiltration. The surface area of each sample was calculated and specific weight variations evaluated as a function of time. During testing in calm air and in a porous burner clear differences were observed proving that oxidation in a hot air flow gives rise to different phenomena on the material's surface .

5:20 PM

(G6-010-2016) Foam-reinforced Thermal Insulation for High Temperature and Cryogenic Temperature Applications

J. Stiglich*[1]; B. Williams[1]; V. Arrieta[1]; 1. Ultramet, USA

Ultramet has developed a highly insulating and lightweight thermal protection material composed of open-cell carbon or ceramic foam with an ultralow-density aerogel filler. The foam serves as an easily machinable structural reinforcement for the low-strength aerogel insulator and defines the shape of the component. The aerogel exists in discrete cells and is supported by the foam skeleton. The combined density of the composite insulator is as low as 0.1 g/cm^3, and the thermal conductivity is <1 W/mK at 2000°C. Aerogel-filled foam has also been shown to be beneficial for cryogenic insulation applications. Single panels up to 30" square are feasible and can be press-fit over complex features. The benefits of reinforcing chopped fiber phenolic ablators with structural foam have also been demonstrated in arcjet testing to heat flux levels of >1000 W/cm^2 in which low erosion rates and heat transfer were indicated. The foam helps retain the char layer by physical reinforcement, and the network of passages allows pyrolysis gases to escape with minimal disruption of the char layer.

Young Professionals Forum - Next Generation Materials for Multifunctional Applications and Sustainable Development, and Concurrent Societal Challenges in the New Millennium

Young Professional Forum I: Funding, Academia, Industry, and Beyond

Room: York A

Session Chairs: Surojit Gupta, University of North Dakota; Eva Hemmer, University of Ottawa; Adam Stevenson, Saint-Gobain

1:30 PM

(YPF-001-2016) Funding Opportunities in Materials Engineering at the National Science Foundation (Invited)

A. Lewis*[1]; 1. National Science Foundation, USA

Funding opportunities for research related to Materials Science and Engineering at the National Science Foundation will be discussed, with an emphasis on those opportunities in the Engineering directorate. An in-depth description of the Materials Engineering and Processing program will be presented, as well as larger-scale grant opportunities including Designing Materials to Revolutionize and Engineer our Future (DMREF) – NSF's response to and participation in the Materials Genome Initiative. Cross-cutting NSF opportunities such as the CAREER program and opportunities for international collaboration will be discussed, as well as general budget trends and current focus areas throughout NSF.

2:00 PM

(YPF-002-2016) Biopolymer-based Nanoparticles: Dynamic Materials for Drug Delivery (Invited)

P. R. Wich*[1]; D. Bamberger[1]; M. Fach[1]; L. Radi[1]; 1. Johannes Gutenberg-University Mainz, Germany

Biopolymers, such as polysaccharides and proteins show a remarkable versatility as multifunctional materials for therapeutic applications. They can be easily modified with the toolkit of bioorganic chemistry and are particularly attractive because of their degradability and biocompatibility. Polysaccharides represent an interesting material for polymeric drug delivery systems. We showed that a chemical modified polysaccharide can be formulated into nano- und microparticles using a variety of common emulsion-based techniques. It is possible to encapsulate proteins, DNA and RNA, as well as small hydrophobic drugs. The particles can release their encapsulated payload under mild acidic conditions. The low-toxicity and payload versatility makes it an ideal platform for a wide range of biotherapeutic delivery applications. We also present a new universal approach for the preparation of protein-based nanoparticles for the delivery of therapeutic payloads. A surface modification of proteins allows the use of solvent evaporation techniques for the formation of nanoparticles without denaturation

of the proteins. The particles are stable under physiological conditions without the need of additional crosslinking steps. The material shows low toxicity at high concentrations and successfully delivers drugs, for example chemotherapeutics to cancer cells.

2:30 PM

(YPF-003-2016) Zero-Waste Sustainable Infrastructure Materials (Invited)

R. Riman*[1]; 1. Rutgers University, USA

We have invented new processes for manufacturing both cement and concrete. Relative to conventional concrete, our concrete reaches peak hardness faster, is more durable, and reduces maintenance costs. This concrete uses $CaSiO_3$ cement, which cures with CO_2 instead of water. Curing occurs via a carbonation reaction permanently sequestering CO_2 via $CaCO_3$ formation. The use of $CaSiO_3$ instead of Ca_2SiO_4 and Ca_3SiO_5 phases enables the cement to be manufactured with less limestone at temperatures 250°C lower than Portland cement. Thus, in sum, the consumption of CO_2 and reductions in reaction temperature and limestone enable concrete to be produced with a 30% energy reduction in and a 70% net reduction in CO_2 emissions. Carbonate cement concrete has been used to make a wide range of precast products along with new methodologies to make cast-in-place concrete. If all concrete construction projects in the US employed carbonate cement, a reduction of 70 million tonnes of CO_2 per year is possible. Carbonate cement manufacturing technology has been proven at full scale thereby ensuring a reliable cement supply chain. However, the industrial supply chain for CO_2 cannot sustain the concrete industry because CO_2 production levels are too low. A zero-waste sustainable solution will be presented to address the CO_2 deficiency but also yields resource, environmental and societal benefits that goes well beyond that of reducing CO_2 emissions.

Young Professional Forum II: Health and Materials

Room: York A

Session Chairs: Sankha Banerjee, California State University, Fresno; Peter Wich, Johannes Gutenberg-University Mainz

3:20 PM

(YPF-004-2016) Nanoparticles Excited With Near Infrared Light: Shining the Light on Multi-Modality (Invited)

F. Vetrone*[1]; 1. Institut National de la Recherche Scientifique (INRS), Université du Québec, Canada

The ability to stimulate luminescent nanoparticles with near-infrared (NIR) light has made possible their use in a plethora of biological and medical applications. In fact, the biggest impact of such materials would be in the field of disease diagnostics and therapeutics, now commonly referred to as theranostics. The use of NIR light for excitation mitigates some of the drawbacks associated with high-energy light (UV or blue) excitation, for example, little to no background autofluorescence from the specimen under investigation as well as no incurred photodamage. Moreover, one of the biggest limitations is of course, that of penetration. As such, NIR light can penetrate tissues much better than high-energy light especially when these wavelengths lie within the so-called biological windows. Thus, significant strides have been made in the synthesis of nanomaterials whose excitation as well as emission bands fall within one of these three optically transparent biological windows. Here, we present the synthesis of various NIR excited (and emitting) core/shell nanostructures and demonstrate their potential use in nanomedicine. Furthermore, we will show how such nanoparticles can be used as building blocks towards developing multifunctional nanoplatforms for the simultaneous diagnostics and therapeutics of diseases such as cancer.

3:50 PM

(YPF-005-2016) Nanoparticles as "Contrast Agents" in Imaging Applications (Invited)

R. Naccache*[1]; A. Mazhorova[3]; M. Clerici[2]; H. Breitenborn[3]; L. Razzari[3]; F. Vetrone[3]; R. Morandotti[3]; 1. Concordia University, Canada; 2. University of Glasgow, United Kingdom; 3. University du Quebec, Institut National de la Recherche Scientifique, Canada

In recent years, nanomaterials have garnered significant attention in the effort to develop novel applications and technologies, or for the improvement of already existing ones. In particular, a strong emphasis has been placed on nanoparticle-based probes than can be used in imaging and therapeutics. Of particular interest are metal nanoparticles, which following resonant excitation with light, show a surface plasmon resonance effect and transfer of energy to the environment in the form of heat. We have used gold nanoparticles as "contrast agents" in combination with terahertz radiation to develop a contact-free approach for heating, temperature sensing and imaging. Specifically, we exploit the change in the refractive index of water, induced by localized NIR heating of plasmonic gold nanorods. We observe a linear relationship correlating change in the reflected terahertz amplitude and area under the curve as a function of increasing temperature. This was translated to a thermometric relationship allowing for temperature sensing following an induced heat stimulus. We extended our results to the porcine skin model system in order to mimic hyperthermia and demonstrated the capacity to sense the temperature and map its distribution in the localized injection site, following controlled NIR plasmonic heating. As a result, we have developed a terahertz biological thermometer, or a "teramometer"

4:20 PM

(YPF-006-2016) Biocompatible Polymer-conjugated Inorganic Nanophosphors for Near-infrared in vivo Imaging in the Second Biological Window (Invited)

M. Kamimura*[1]; K. Soga[1]; 1. Tokyo University of Science, Japan

Fluorescence bioimaging has attracted great attention recently in biological research and medical diagnosis applications. Inorganic nanophosphors, such as semiconductor quantum dots (QDs) or rare-earth doped ceramic nanoparticles (RED-CNPs), have been extensively reported as nanophosphors for near-infrared (NIR) fluorescence imaging, due to their unique optical properties. These nanophosphors show NIR emission in the second biological window wavelength region (1000 - 1400 nm) under NIR excitation. NIR light in this wavelength has much higher transparency in biological tissues compared to the below-1000 nm (first biological window) region for current NIR fluorescence imaging. Therefore, NIR emission of these nanophosphors in the second biological window can be applied for the in vivo fluorescence imaging of deeper part of live bodies than conventional ones. In this study, we designed nanocomplexes based on biofunctional poly(ethylene glycol)(PEG) based polymers and inorganic nanophosphors for in vivo NIR fluorescence imaging probe. The NIR emission of polymer conjugated-nanophosphors from the blood stream of live mice was confirmed without dissection. From these results, the obtained polymer conjugated-nanophosphors can be attractive candidates for in vivo NIR fluorescence imaging probe.

4:50 PM

(YPF-007-2016) Exploiting the Near-Infrared Biological Window for Lanthanide-based Temperature Measurements (Invited)

E. Hemmer*[1]; A. Skripka[1]; F. Légaré[1]; F. Vetrone[1]; 1. INRS-EMT, Canada

The detection of thermal singularities in biological tissue and at sub-cellular levels is receiving growing interest taking into account that an increased temperature is often a first indicator of a disease. In this context, the emerging field of nanothermometry aims for the detection of such thermal singularities by use of nanoparticles whose emission spectra are dependent on the surrounding temperature.

With regard to biomedical application, the use of near-infrared (NIR) light is advantagous due to its increased penetration depth into biological tissue when compared to visible or ultraviolet light, known as biological window. Here, lanthanide ions (Ln^{3+}) are of particular interest, due to their emission of NIR light above 1000 nm upon excitation with NIR light of shorter wavelength, providing a perfect match with the biological window. Hence, we are aiming for the development of novel nanothermometers taking advantage of the temperature dependent emission of NIR light under NIR excitation of Ln^{3+} doped $NaGdF_4$ nanoparticles synthesized by thermal decomposition method. The temperature dependent emission intensities of the characteristic Ho^{3+} (1.20 mm), Nd^{3+} (1.34 mm), and Er^{3+} (1.55 mm) peaks were analyzed, and the nanostructures' suitability as ratiometric nanothermometers will be discussed.

Tuesday, June 28, 2016

G1. Powder Processing Innovation and Technologies for Advanced Materials and Sustainable Development

Advanced Characterization and Composite Particles

Room: Trinity III

Session Chairs: Sanjay Mathur, University of Cologne; Masayoshi Fuji, Nagoya Institute of Technology

8:30 AM

(G1-011-2016) "Mechanochemical" is one of the most important phenomena in the future of milling technology (Invited)

M. Kamitani*[1]; 1. Makino Corporation, Japan

We have investigated the mechanochemical effects on several inorganic materials, like aluminous-silicates or calcium-aluminates, using by ball milling method in decades. From the results, it is one of the most important phenomena in powder processing in the points of view from both energy conservation of powder process and synthesizing functional materials. We have got the industrial achievement as cladding boards and inner housing walls by mechanochemical modified kaolin at a Japanese prefabricate housing company in 2001. And going on we are investigating it to achieve the chemical recycling methods on wasted materials including glass materials and animal bones. At this time, we will show some experimental approaches for wastes to reborn functional materials by mechanochemical processing using ball mill including XAFS analysis or some chemical evaluation data.

9:00 AM

(G1-012-2016) Control of mesoscale structure evolution in alumina ceramics (Invited)

S. Tanaka*[1]; T. Hondo[1]; K. Yasuda[2]; F. Wakai[2]; 1. Nagaoka University of Technology, Japan; 2. Tokyo Institute of Technology, Japan

Direct observation of structural evolution on forming and sintering is essential approach for improvement of ceramic processing. Micro focus x-ray computer tomography is a powerful tool for understanding 3-dimentional structures in a bulk sample. The comparison of powder compact and sintered ceramics at the same position reveals that discontinuity of particle packing structures between compressed granules in powder compact becomes a coarse crack by sintering. Furthermore, semi-continuous observation at the same position shows development process of coarse cracks in detail. Sintering of primary particles in granules occur prior to sintering of the interstices of granules, and pores among particles gathers and makes interstices of granules wide. Mesoscale sintering in the range of granule size is crucial for determination of mechanical properties of ceramics. This result also suggest that the particle packing structures of powder compact should be controlled carefully by raw powders and granules characteristics.

9:30 AM

(G1-013-2016) Precise Structure Analysis of Advanced Ceramic Materials through Powder Diffraction (Invited)

M. Yashima*[1]; K. Fujii[1]; E. Niwa[1]; 1. Tokyo Institute of Technology, Japan

We review our recent works on the visualization of chemical bonding and diffusional pathway of mobile ions of advanced ceramic materials through advanced analytical techniques including synchrotron X-ray and neutron powder diffraction experiments. The results are supported by density functional theory (DFT) based electronic calculations and bond valence method. Covalent bonding between a cation and an anion was observed in maximum-entropy method (MEM) electron-density distribution of visible-light responsive photocatalysts $LaTiO_2N$, GaN-ZnO, TaON and $Sm_2Ti_2S_2O_5$. The covalent bonding makes the valence band width wider leading to a narrower band gap, which is responsible for the visible-light response of these materials. Covalent bonding and charge transfer of Si-N bonds in α-Si_3N_4 were visualized in its MEM electron-density distribution. Zr-O covalent bonds were also observed in MEM electron-density distribution of nano-sized (11 nm) zirconium oxide powders. Crystal structure and oxide-ion diffusion paths of nano-sized (10 nm) ceria-zirconia powders were examined as a function of temperature. Defect and distorted fluorite-type materials such as $Ce_{0.5}Zr_{0.5}O_2$, CeO_2, CeO_2-Y_2O_3, Bi_2O_3-Yb_2O_3 and CuI exhibit <111> anisotropic motion and <100> diffusion paths of mobile ions. We also visualized the ion diffusion pathways in perovskite-type oxides, perovskite related materials and apatite-type oxides.

10:20 AM

(G1-014-2016) Metal Oxide Nanosurfaces and Hetero-interfaces for Solar Harvesting Applications (Invited)

S. Mathur*[1]; Y. Gönüllü[1]; T. Fischer[1]; 1. University of Cologne, Germany

Metal oxide nanostructures with hetero-contacts and phase boundaries offer unique platform for designing materials architectures for solar harvesting applications. Besides the size and surface effects, the modulation of electronic behavior due to junction properties leads to modify surface states that promote higher efficiency. The growing possibilities of engineering nanostructures in various compositions (pure, doped, composites, heterostructures) and forms (particles, tubes, wires, films) has intensified the research on the integration of different functional material units in a single architecture to obtain new materials for solar energy harvesting application. In this work we present the deposition and modification of semiconducting metal oxides and their multilayers (TiO_2, Fe_2O_3 and TiO_2/Fe_2O_3) for photoelectrochemical (PEC) hydrogen production. The deposition parameters for thin film creation were optimized with respect to the PEC performance of the resulting materials in both alkali solution and simulated seawater. The long-term performances of the metal oxide photoanodes were determined in alkali and seawater electrolyte, as well. The results presented that the multilayered TiO_2/Fe_2O_3 photonanode yielded higher photocurrent density (1.8 $mAcm^{-2}$ at 1.23 V) with very stable conditions even after 1-week measurement.

10:50 AM

(G1-015-2016) Microstructure control of Al_2O_3/ZrO_2 ceramics using nanocomposite particles prepared by mechanical treatment

M. Matsuoka*[1]; T. Uoji[3]; J. Tatami[3]; M. Naito[1]; C. Tokoro[2]; 1. JWRI, Osaka University, Japan; 2. Waseda University, Japan; 3. Yokohama National University, Japan

Al_2O_3 and ZrO_2 ceramics are typical fine ceramics. It has been known that secondary-phase particles dispersion improved the mechanical properties of ceramics. Al_2O_3/ZrO_2 ceramics have high fracture toughness because of high elastic modulus of Al_2O_3 and phase transformation of ZrO_2. Homogeneous dispersion of these raw materials play a significant role in these composites. In this study, Al_2O_3/ZrO_2

nanocomposite particles were prepared by mechanical treatment to control the microstructure of Al_2O_3/ZrO_2 ceramics. For comparison, ball-milled samples were prepared as well. Dense Al_2O_3/ZrO_2 ceramics were fabricated by using the nanocomposite particles. α-Al_2O_3 and m-ZrO_2 were identified by XRD in both samples. SEM observation shows that the microstructure of Al_2O_3/ZrO_2 ceramics using the nanocomposite particles was finer and more homogeneous than that using ball-milled powder mixture. In particular, Al_2O_3 and ZrO_2 were found to be tangled each other in the sample prepared using the nanocomposite particles. Use of the nanocomposite particles improved the strength, the thermal shock resistance and the fracture toughness of Al_2O_3/ZrO_2 ceramics because of their homogeneous and complexly tangled microstructure.

11:10 AM

(G1-016-2016) Fabrication of Oriented β-SiAlON:Eu^{2+} Phosphor Layer by Magnetic Field-Assisted Electrophoretic Deposition (Invited)

T. Uchikoshi*[1]; 1. National Institute for Materials Science, Japan

β-sialon:Eu^{2+}, one of the important members in the oxy-nitride phosphor family, has been known as a promising green phosphor with very narrow emission band (centered at ~535 nm) and high color purity. Besides, this green phosphor has high thermal and chemical stabilities, due to its stiff framework crystal structure of the host lattice. In this study, electrophoretic deposition (EPD) technique assisted with a 12 T strong magnetic field was utilized to fabricate crystalline-oriented β-sialon:Eu^{2+} phosphor deposits on ITO glass substrates. The direction of the applied magnetic field was perpendicular to that of the electric field for EPD. The influence of the horizontally-applied magnetic field assisted the phosphor particles to be oriented in the suspension, simultaneously, the vertically-applied electric field contributed the deposition of the positively-charged β-sialon colloidal particles onto a cathodic substrate. Therefore, the deposit had dominant characteristic that the a,b-crystal plane of the hexagonal β-sialon phosphor turned to upwards. Photoluminescence (PL) intensity of the oriented deposits was improved by comparing with that of the randomly oriented samples. This technique, EPD process performed in a strong magnetic field, would be a promising method for the packaging of flat LEDs.

11:40 AM

(G1-017-2016) Forming composites of silica nanoparticles deposited on silica porous particles through mechanical treatment and their drying properties

M. Iijima*[1]; M. Hayakawa[1]; J. Tatami[1]; M. Sato[2]; Y. Kakizawa[2]; S. Hiroshima[2]; M. Koide[2]; 1. Yokohama National University, Japan; 2. Lion Corporation, Japan

Drying process is one of the important operation that is widely applied in material processing such as in the field of printing, coating, and evaporating cooling system. On drying process, developing a technique to increase the velocity of water evaporation is essential issue toward energy saving and enhancing evaporating cooling properties. Up to date, various techniques, such as the control of surface textures and chemical structures on plates and fibers, has reported to improve the wetting with water and increase the water/air interface area so as to enhance drying. However, raw particle structure design to realize the rapid cooling property has not been well focused. Herein we report the composite particle design of silica nanoparticles fixed on silica porous particle through high-shear mechanical process to improve drying velocity. It was found that the mechanical process (4000 rpm, 10min.) can simultaneously dis-aggregate the nanoparticles and fix on porous silica particles without collapse. Compared to raw porous particle, the wetting area of 20μl drop of water on the composite powder layer has increased so that relative drying velocity on the powder layer has also successfully increased.

12:00 PM

(G1-018-2016) Simulation of elastic-plastic materials breakage using ADEM

S. Ishihara*[1]; J. Kano[1]; 1. Tohoku University, Japan

Grinding is one of the most effective operations to produce fine particles, and the significance of grinding grows with each passing year due to the development of nanotechnology. Grinding has been used in many fields, for example, foods, cosmetics, medicines, mining, and so on. However, in general, the efficiency of grinding is quite low because the mechanism of grinding have not elucidated. Therefore, it is necessary to clarify the grinding mechanism and also to control the grinding process. In this work, it has been attempted to analyse the grinding phenomena using computer simulation. A new simulation model, ADEM (Advanced Distinct Element Method) has been developed and it can represent both non-spherical particles motion and particle breakage behaviour. In ADEM, single particle is represented by agglomerate of primary particles, and primary particles are connected by joint spring. To express the breakage and plastic deformation, each joint spring has two kind of thresholds. Single particle breakage was analysed by ADEM.

G5. Advanced Materials, Technologies, and Devices for Electro-optical and Medical Applications

Optical Material I

Room: Trinity V

Session Chairs: Luisa Bausa, Universidad Autonoma de Madrid; Bruno Bureau, University of Rennes 1

8:30 AM

(G5-008-2016) Consideration of Silver Plate Corrosion Process on the Surface of CoB type of LED Package (Invited)

M. Bessho*[1]; 1. Toshiba Lighting, Japan

Mechanism of Ag plate corrosion on the surface of CoB type of LED package was considered by a computational equilibrium-kinetic hybrid simulation. Under the normal service condition, Ag_2O is formed on the surface of Ag plate. Ag_2O is transferred to silicone resin according to the diffusion process and they are reduced there by C and Si, which are the constituents of the resin, and form Ag nano-particles. Ag_2S, Ag_2CO_3, and other Ag compounds are also reduced to Ag in the same way in the case S and Cl are included in air as impurities. But reduction ratio depends on the amount of C and Si, which are included in the resin. And Ag compounds will be observed in the case transfer amount of Ag compounds exceed the reduction ability of C and Si.

9:00 AM

(G5-009-2016) Blue laser-driven phosphor ceramic plate for white light generation (Invited)

D. Yoon*[1]; 1. SungKyunKwan University, Republic of Korea

White light-emitting diode (LED) & Laser diode (LD) as next-generation light source have significant interests owing to their outstanding characteristic such as environmental-friendly device, low energy-consumption and high brightness, compared to conventional light source. However, LED undergo saturation of output power with increasing forward-bias current and it affects to deterioration of luminous efficacy which is called efficiency droop. On the other hand, LD does not suffer from this problem and provides faster switching, narrow emission spectrum and higher intensity. Therefore, LD recently came into the spotlight as the most efficient high power source. They are applicable to projections, medical industry, and automotive headlights because of their advantages of directionality, compact size, high luminous flux and low power consumption. In this study, we report our advanced research using the nano-structured $Y_3Al_5O_{12}$: Ce^{3+} ceramic phosphor plate (CPP) directly combined with blue LD for white light generation. We substitute the mixture of organic resin with phosphor powder to $Y_3Al_5O_{12}$: Ce^{3+} CPP. We also optimize the optical properties.

9:30 AM

(G5-010-2016) Ceramic phosphor properties and microstructures of solid state light sources (Invited)

J. F. Kelso*[1]; A. Lenef[1]; M. Raukas[1]; 1. Osram Sylvania, USA

Many semiconductor based light sources require efficient wavelength conversion that takes place in a ceramic phosphor or phosphor containing element. Applications include light sources for general illumination, medical devices, and automotive lighting. The performance and quality of such light sources depend heavily on the phosphor properties and microstructures that get tailored and customized for each specific application for best results. Light wavelength converter phosphors in use include phosphor particles in an organic matrix, phosphor particles in an inorganic matrix and monolithic ceramics and single crystal phosphors. The conversion of light from higher energy blue sources to green, yellow or red light invokes heating in the phosphor material which needs to be removed efficiently to prevent thermal quenching. We will discuss how the optical and thermal character of the converter element can be tailored by the chemical composition and microstructure of the converter element components to determine the performance of converter elements in various applications including demanding applications utilizing high incident pump fluxes and operating temperatures.

10:20 AM

(G5-011-2016) Discovery of New Phosphors by Analysis of Fine Crystals (Single Particle Diagnosis Approach) (Invited)

T. Takeda*[1]; N. Hirosaki[1]; S. Funahashi[1]; R. Xie[1]; 1. National Institute for Materials Science (NIMS), Japan

New efficient and color tuned phosphors are required to develop the white LEDs. The phosphor property is largely dependent on the host material and the search of new phosphor corresponds to the search of new host material. The new host materials have been searched from powder or single crystal. In the powder method, the phase purification of the product is time- and labor-consuming. In the single crystal method, the crystal growth is necessary. We have developed an innovative method (single particle diagnosis approach method) for finding new phosphor. Even if the powder product is not single phase, the each particle (single crystal) is phase pure. The crystal structure of the particle (down to 5 μm size) is analyzed without crystal growth procedure and the luminescence property (emission and excitation spectra, its temperature dependence, quantum efficiency) is also measured from one particle. Here, we explain this approach with an example of Ba_3N_2-(Li_3N)-Si_3N_4-AlN system.

10:50 AM

(G5-012-2016) Synthesis of New Phosphors using Melt-Quenching Method (Invited)

K. Toda*[1]; S. Kim[1]; K. Uematsu[1]; M. Sato[1]; 1. Niigata University, Japan

In order to synthesize LED phosphor materials, we applied novel synthesis technique, "Melt Qenching Synthesis" rather than the conventional solid state reaction technique. The Melt synthesis technique is a powerful tool for rapid screening and improvements of new phosphor materials. Melt synthesis reactor is designed to heat small-size samples up to very high temperature like above 2273 K to melt in clean conditions. In the melt synthesis, the mixture of raw materials is melted in a short period of time (from 1 to 60 s) by a strong light radiation in arc imaging furnace. A spherical molten sample with multiple cations were mixed homogeneously at around 2273 K and directly solidified on a Cu hearth after closing the shutter. The cooling rate was estimated to be more than 100 K/s. Well-crystallized and grown LED phosphors were synthesized by the "Melt Qenching Synthesis". Novel LED phosphorss were obtained in a quite short reaction time, which is a new useful and powerful method for synthesis of LED phosphors.

11:20 AM

(G5-013-2016) From Ceramics to Single Crystals: A Glimpse into the Optical Floating Zone (Invited)

H. A. Dabkowska*[1]; 1. McMaster University, Canada

In recent years a significant part of solid state research was devoted to oxides. High quality, well characterized crystals - or thin films - of transition metal oxides are essential for understanding crystallographic, thermal, magnetic and optical phenomena with help of directionally sensitive methods such as x-ray or neutron scattering, muon experiments and many more. My examples are cubic, congruently melting rare earth pyrochlores $RE_2M_2O_7$ (where RE is a rare earth element and M is either Ti, Sn, V or Zr). For them the Optical Floating Zone [OFZ] technique proves to be an efficient, crucible-free method producing relatively big, high quality single crystals. Using oxidizing, neutral or reducing growth atmosphere it was possible to crystallize the whole plethora of different pyrochlores. Growing in oxygen overpressure single crystals of incongruently melting high temperature oxide superconductors, like $Bi_2Sr_2Ca_{n-1}Cu_nO_{4+2n+x}$ and Ba or Sr doped $LaCu_2O_4$ become possible only when the reproducible method to produce high quality ceramic feed rods was developed. In this presentation the effects of quality of starting ceramics and of growth conditions on quality and crystal properties of all these oxides will be discussed. I will also comment on great possibilities provided by OFZ in producing crystals of even more exotic magnetic oxides like borates, nickelates, cobaltites, chromates, rhodates, ruthenates etc.

G6: Porous Ceramics for Advanced Applications Through Innovative Processing

Novel Sintering Technologies for Porous Ceramics

Room: Trinity I/II

Session Chairs: Mary Anne White, Dalhousie University; Shunkichi Ueno, Nihon University

9:00 AM

(G6-011-2016) Porous Nano-SiC as Thermal Insulator: Wisdom on Balancing Thermal Stability and Low Thermal Conductivity (Invited)

J. Wang*[1]; 1. Institute of Metal Research, China

The crucial challenge for current thermal insulation materials, such as Al_2O_3 and SiO_2 nano-particle aggregates, is to solve the trade-off between extremely low thermal conductivity and bad thermal stability (namely high sintering activity). We herein show that by integrating multi-enhanced nano-scale phonon scattering mechanisms, including thermal resistances from interfaces, stacking faults, and porous microstructure, SiC (which intrinsically has very high lattice thermal conductivity) could demonstrate promising thermal insulation property. β-SiC nano-particle (~35 nm) packed bed displays a thermal conductivity of as low as 0.068 W m^{-1} K^{-1}. Most impressively, the nano-SiC particle aggregate possesses good thermal stability up to 1500 °C. Sintering the nano-SiC particle packed beds at 1500 to 1800 ºC, we obtain the porous material with a porosity of 57% and it exhibits a specific balanced mechanical strength and very low thermal conductivity (~2 W m^{-1} K^{-1}). Our results may provide an alternative strategy to approach ultra low thermal conductivity through interfacial engineering in advanced ceramics with excellent thermal stability, regardless their high intrinsic lattice thermal conductivities.

9:20 AM

(G6-012-2016) Porous Si_3N_4 ceramics prepared via nitridation of Si powder

Y. Zeng*[1]; 1. Shanghai Institute of Ceramics, Chinese Academy of Sciences, China

Porous silicon nitride ceramics (Si_3N_4) show superior properties compared with other porous ceramic materials in strength, toughness, thermal shock resistance due to the interlocking microstructure of β-Si_3N_4 grains. In this work, porous silicon nitride matrix composites were prepared via reaction bonded Si_3N_4 (RBSN) and post-sintering, the influence factors, such as, heating program, silicon particle size, Y_2O_3 content on the mechanical properties were investigated. To investigate the relationship bending strength and microstructure porous Si_3N_4, different processing methods, such as, conventional powder forming processing, slip casting, and freeze-drying process, were used in preparation Si green bodies and the second phase, such as BN, C/SiC etc. were added to modify the mechanical properties of porous Si_3N_4. The results indicated that processing methods, second phase, as well as the sintering program have great effect on the mechanical properties and microstructure of porous Si_3N_4 ceramics. The oxidation resistance properties, high temperature properties, as well as thermal shock properties of porous Si_3N_4 ceramics were also investigated.

9:40 AM

(G6-013-2016) Highly porous interpenetrating network reaction-bonded silicon nitride

R. Nikonam Mofrad*[1]; R. Drew[1]; M. Pugh[1]; 1. Concordia University, Canada

The production and development of porous silicon nitride (Si_3N_4) bodies with high porosity and good mechanical properties have been the subject of some attention in recent years. A homogeneous and stable porous structure with high pore interconnectivity has been obtained by developing a process that utilizes a sacrificial template technique, along with gel-casting and nitriding processes. Using this technique, porous silicon nitride is formed with a structure that is occupied with a huge number of Si_3N_4 whiskers which is an issue in applications where high pore permeability has a significant importance. In this research, the formation of porous Si_3N_4 via reaction bonding and a post sintering process is investigated in the presence of different amounts of MgO as an additive. Using various analysis techniques such as X-Ray diffraction (XRD) and scanning electron microscopy (SEM), the phases and morphology of the prepared materials are studied. With the aid of a resin infiltration technique, pore interconnectivity is investigated which showed that whisker formation is completely hindered in the presence of small amounts of MgO and the Si_3N_4 morphology is completely modified from a mixture of matte and whiskers to a porous network of interconnected silicon nitride hexagonal grains.

Recent Innovations in Freeze Casting

Room: Trinity I/II

Session Chairs: Yu-Ping Zeng, Shanghai Institute of Ceramics, Chinese Academy of Sciences; Jingyang Wang, Institute of Metal Research

10:20 AM

(G6-014-2016) Freeze-Cast Methods to Make Porous Ceramics: Principles and Examples (Invited)

M. White*[1]; J. Conrad[1]; S. Ellis[1]; C. Romao[1]; 1. Dalhousie University, Canada

The control of porosity in technical ceramics is central to many applications due to the relationship between porosity and physical properties, such as toughness, strength, thermal conduction, etc. Furthermore, porous ceramics can form the basis for hybrid materials, including bioceramics. Here we present the principles of freeze-cast methods to make porous ceramics. As examples of their applications, we will present results from several of our studies of freeze-cast ceramics and ceramic scaffolds for hybrid materials, with applications ranging from solar cells to controlled thermal expansion and thermal conductivity.

10:40 AM

(G6-015-2016) Formation mechanism of lotus type porous ceramics with high porosity through solidification process (Invited)

S. Ueno*[1]; 1. Nihon University, Japan

Porous alumina whose pores were aligned in one direction was fabricated by unidirectional solidification method under pressurized hydrogen atmosphere. The porous structure is formed at solid-liquid interface during the solidification due to hydrogen solubility gap at the melting point. The hydrogen gas is dissolved into molten alumina according to Sieverts' law and unsoluble gas evolves from the solid phase during the unidirectional solidification to form the pores. The porosity of the solidified samples was increased with increasing environmental pressure where the environmental gas is consisted with hydrogen and argon. There is a reverse proportion relation between the porosity and the environmental pressure according to Boyle's law. The pore diameter is also controlled by the environmental pressure according to Boyle's law. The uniforming of pores size increases with the environmental pressure.

11:00 AM

(G6-016-2016) Thermal conductivity, strength and energy-saving effect of mullite thermal insulators prepared by gelation freezing route

M. Fukushima*[1]; T. Ohji[1]; Y. Yoshizawa[1]; 1. National Institute of Advanced Industrial Science and Technology (AIST), Japan

Mullite based thermal insulators with very high porosity up to 91vol% have been prepared by gelation freezing route with quartz and zirconia additives. The porosity of obtained insulators could be controlled by the solid loading of initial slurry, the additive cntents and sintering temperature. The microstructures showed unidirectional oriented pores parallel to the freezing direction. While thermal conductivities of the insulators decreased with decreased solid loading and quartz content, while the compressive strength values increased with increased sintering temperature and zirconia content. The insulators obtained showed higher compressive strength than those of commercial firebricks and comparable thermal conductivity with those of fibrous insulators.

11:20 AM

(G6-017-2016) Fabrication and thermal insulation properties of highly porous silica based ceramics via gelation-freezing of diatomite based slurry

C. Matsunaga*[1]; M. Fukushima[1]; H. Hyuga[1]; Y. Yoshizawa[1]; 1. National Institute of Advanced Industrial Science and Technology (AIST), Japan

Refractory ceramics fibers (RCF) with good thermal insulation properties and low cost have been widely utilized in various industrial furnaces at elevated temperature. However, RCF and ceramic fibers are categorized as Group 2B (a possible human carcinogen) as stipulated by the WHO (World Health Organization). Thus, the fibrous insulators have to be carefully reviewed. Our group has tried to develop the substitutes prepared by gelation freezing route, in which we focus on diatomite, as a raw material, with low cost and meso- or micro-porous structures to affect thermal conductivity. The relationship between porosity of insulators obtained and process parameters with initial solid concentration in gels, freezing conditions and sintering temperatures will be discussed.

11:40 AM

(G6-018-2016) Macroprous SiOC ceramics made by freeze casting for cryogenic applications

H. Zhang*[1]; C. L. Fedelis[1]; M. Wilhelm[1]; K. Rezwan[1]; 1. University of Bremen, Germany

Cryogenic engineering has been applied in the fields of superconductivity, nuclear power, and space technology. One application is the delivery of cryogenic propellants by capillary transport via porous medium, such as metallic weave, allowing for propellants being transported without gravitational force. Compared to metallic weaves, macroporous monolithic ceramics have a low density, high mechanical strength, and excellent corrosion resistance, being considered as a potentially excellent medium. Polymer-derived ceramics (PDC) are advantageous due to tailorable surface characteristics and pore size distributions. Producing PDC by freeze-casting, polymethysiloxane cross-linked with 3-aminopropyl) triethoxysilane being mixed with silica sol to form a green body, allows for tailoring surface characteristics and porous structure at different scales. A meso-/macropore SiOC ceramic was obtained after pyrolysis at 1000°C. The thermal and mechanical properties of the ceramics were investigated from cryogenic to room temperature. The preliminary results showed anisotropic compressive strengths and higher compressive strengths at cryogenic temperatures compared to ambient temperature. The anisotropic thermal expansion coefficients, thermal diffusivity, thermal conductivity are also observed from cryogenic to room temperature.

G8. Multifunctional Coatings for Sustainable Energy and Environmental Applications

Coatings for Engineering Applications

Room: York B

Session Chairs: Jun Akedo, AIST; Motofumi Suzuki, Kyoto University

8:30 AM

(G8-001-2016) High Temperature Functional Ceramic Coatings for Energy Saving Applications (Invited)

Y. Kagawa*[1]; 1. The University of Tokyo, Japan

In high temperature coatings, optimum design of thermal conductivity and thermal radiation properties are possible mechanisms to achieve high temperature energy saving coatings. Especially at temperatures above 1000°C, thermal radiation energy becomes significantly high because the energy is proportional to T^4, where T is the temperature. Ceramic coatings for high reflection/transmission of thermal radiation energy are designed and fabricated, then, the performances are evaluated. Used mechanism for the design includes interaction between thermal radiation (electromagnetic wave) and materials and color of the materials. Simulation procedure and analytical procedure of the coating based on the interaction are also developed. Based on the set of these results, potential of the developed coatings will be discussed.

9:00 AM

(G8-002-2016) High Temperature Oxidation Behavior and Improvement of Interface Strength of Thermal Barrier Coatings Using Oxide Ceramics-Containing Bond Coatings (Invited)

K. Ogawa*[1]; 1. Tohoku University, Japan

It is required to improve the delamination resistance of the thermal barrier coating (TBC) for advanced gas turbines. In our previous studies, it has reported that, by using a Ce added bond coat material, a wedge-like TGO was formed at the interface. As a result, delamination resistance of the TBC by four-point bending tests was improved. From this study, it was observed that wedge-like TGO grew towards the Ce oxide, which formed in the bond coating under high temperature conditions. Therefore, it is thought that the wedge-like TGO formed and grew because the Ce oxide became an oxygen ion diffusion channel. However, the wedge-like TGO formed under 1373K environment, which is higher than the operating temperatures of real plants. Therefore, the aim of this study is to suggest the formation of wedge-like TGO under 1100°C and to improve interface strength using some oxide ceramics containing BC materials. And also, the technique of decreasing the temperature for formation of the wedge-like TGO was suggested.

9:30 AM

(G8-003-2016) Suspension plasma spray of yttria stabilized zirconia thermal barrier coatings (Invited)

J. Mostaghimi*[1]; L. Pershin[1]; T. Coyle[1]; P. Xu[1]; 1. University of Toronto, Canada

Suspension plasma spray (SPS) using submicron powders suspension as feedstock can achieve deposits with nano or submicron structures. In this study, thermal barrier coatings were fabricated through SPS process with sub-micrometer yttria-stabilized-zirconia suspension. The plasma torches used are F4-VB troch from Oerlikon Metco operating with Ar-H2 plasma gas mixture and a torch designed at the Centre for Advanced Coating Technologies which employs CO_2-CH_4 mixture as plasma gases. The arc behavior of each torch during spraying was analyzed and compared by real-time arc voltage fluctuation measurement and fast Fourier transform method. The process parameters effect on the microstructures were investigated. The optimized parameters for each torch were determined and used for spraying. Coatings microstructure were studied and compared. The thermal conductivity tof the coatings were measured and compared.

10:20 AM

(G8-004-2016) Hybrid aerosol deposition (HAD): A new challenge to fill a gap between aerosol deposition and thermal spray (Invited)

K. Shinoda*[1]; T. Saeki[1]; M. Mori[2]; J. Akedo[1]; 1. National Institute of Advanced Industrial Science and Technology (AIST), Japan; 2. Ryukoku University, Japan

Ceramic coatings onto three-dimensional objects that are consisting of metals, ceramics, and polymers will provide us a new tool for additive manufacturing and a new design for lightweight components and heat resistant components. Thermal spray technology has several advantages such as its applicability to three-dimensional objects with a combination to an industrial robot but is yet to solve several issues such as thermal damage to substrates, adhesion strength between coatings and substrates, and density of coatings. Aerosol deposition technology is a relatively new method that can fabricate dense ceramic coatings that adhere strongly to substrates without thermal damage. If we can combine advantages of these two technologies, it can be a strong and promising tool for coating ceramics onto three-dimensional objects. Therefore, in this study we present our recent challenge to explore a boundary between thermal spray and aerosol deposition and provide some implications obtained here. This work was supported in part by NEDO SIP, Innovative Design /Manufacturing Technologies, High-Value Added Ceramic Products Manufacturing Technologies.

10:50 AM

(G8-005-2016) Suspension Thermal Spray Coatings for Sustainability and Environmental Applications (Invited)

C. Moreau*[1]; 1. Concordia University, Canada

Suspension thermal spray (STS) is an emerging coating technology in which the feedstock material consists of nano- or submicron-sized particles in suspension in a liquid (commonly ethanol or water). This suspension is injected in a plasma or flame to produce coatings with unique microstructures, one or two orders of magnitude finer than those achieved normally in thermal spray. The resulting grain size, typically between 30 to 100 nm, provides distinctive characteristics to the deposited layers. This emerging technology has attracted much attention over the last decade for environmental applications as well as in transportation and energy generation applications. In this presentation, an overview of the STS technology will be provided with a focus on key opportunities for sustainable energy and environmental applications. Examples will be discussed illustrating how STS can be used to tailor the structure of spray coatings to enhance their performance in specific applications. In particular, the coating surface can tailored at the micron and nanoscale to produce superhydrophobic coatings and electrodes for hydrogen production by electrolysis.

11:20 AM

(G8-006-2016) Using an Axial Feeding DC-Plasma Spray Gun for Fabrication of Ceramic Coatings

M. Shahien*[1]; M. Shahien[2]; M. Suzuki[1]; 1. National Institute of Advanced Industrial Science and Technology (AIST), Japan; 2. Central Metallurgical Research and Development Institute (CMRDI), Egypt

Thermal DC-plasma spray is widely used technology for fabrication of ceramic coatings with high deposition rates, high application speed and relatively low cost. The process is based on supplying the feedstock powder material into a very high temperature plasma jet, where it is rapidly heated and accelerated with a high velocity. The molten or semi-molten particles collide on the substrate surface and rapidly solidify. Then the accumulated particles form a coating. Generally the powder can be injected either from inside the nozzle of the plasma torch (axial or internal injection) or at a very short distance downstream of the plasma torch exit (radial or external injection). The axial injection has the unique advantages of precise location of the powders and more inclusive heating of the particles. Therefore it can be fully entrapped inside and melted within the plasma before being deposited on the substrate surface. Furthermore, the axial feeding is promising in case of using the nano-size particles in the form of suspension. This study will show our efforts of developing a new DC-plasma spray system using axial feeding for fabrication of ceramic coatings.

11:40 AM

(G8-007-2016) Microstructure Control of Ceramic Coatings by Axial Feeding DC-Plasma Spray System

M. Suzuki*[1]; M. Shahien[1]; 1. National Institute of Advanced Industrial Science and Technology (AIST), Japan

Suspension plasma spray technique is now appealed as one of the promissing process for the next generation of high performance energy system, such as TBCs/EBCs in gas turbine and electrode/electorite of SOFCs. In this study, yttria stabilized zirconia coatings were facricated with using an axial feeding dc-plasma spray system, and their depositing mechanism was evaluated in terms of microstructure control. It was found that the diameter of deposited ceramic particles was the dominant factor to control the coating microstructure. Effect of diameter of spraying powder and concentration of ceramic powder, as controlable parameters, was then evaluated as well.

H2: Design and Development of Advanced Ceramic Fibers, Interfaces, and Interphases in Composites- A Symposium in Honor of Professor Roger Naslain

Introduction to Ceramic Matrix Composites / Novel SiC Fibers and Properties of SiC Fibers

Room: Salon D

Session Chairs: Sergei Mileiko, Institute of Solid Physics; Randall Hay, Air Force Research Laboratory

8:30 AM

(H2-001-2016) A Journey in the Field of Ceramic Matrix Composites (Invited)

R. R. Naslain*[1]; 1. University Bordeaux, France

This contribution recalls the main steps that occurred in the development of ceramic matrix composites (CMCs) since their discovery in the late 70s up to their present use in jet engines and potential in high temperature nuclear reactors. The origin of the story has been in the attempts to improve the HT behavior of C/C composites in oxidizing atmospheres by replacing partly or totally the carbon matrix by SiC (step 1) and the carbon fibers by SiC fibers (step 2) when they became available. This has been mainly achieved through the development of the CVI process firstly for the infiltration of SiC and further for that of other refractory materials (BN, B4C, TiC, Al2O3, ZrO2). The third key step has been the discovery that toughness of CMCs could be dramatically increased through a control of FM bonding and use of an interphase with a layered structure or microstructure (PyC, BN, (PyC-SiC)n multilayers), this key advancement alloying the use of CMCs in place of refractory metals. The last breakthrough (step 4) has been the invention of the so-called multilayered self-healing matrices, such as (SiC-BN)n to arrest or slow down the in-depth diffusion of oxygen still increasing the lifetime of SiC/SiC composites in a broad range of temperature in oxidizing atmospheres.

9:00 AM

(H2-002-2016) Physical and chemical properties of silicon carbide fibers

S. Loison*[1]; C. Huguet[1]; 1. HERAKLES, France

Developed in the 80’s, silicon carbide fibers find increasing applications nowadays as reinforcements for high-temperature composite materials. An overview of their properties is proposed, including dimensions, morphology, chemical composition, microstructure, fracture behaviour, etc ... Characterization of SiC fibers after handling or weaving are reported. Different SiC fibres are compared, including polymer-derived fibers and SiC whiskers obtained by reaction of silicon and carbon.

9:20 AM

(H2-003-2016) Oxidation Rates, Microstructure, and Mechanical Properties of SiC Fibers Heat-Treated in $Si(OH)_4$ Saturated Steam

R. Hay*[1]; 1. Air Force Research Laboratory, USA

Hi-Nicalon^{TM}-S SiC fibers were heat-treated for 1 – 100 h at 500 to 1500°C in $Si(OH)_4$ saturated steam, which allows only passive oxidation. Experiment procedures necessary for $Si(OH)_4$ saturation are discussed. Fiber microstructure, SiO_2 scale thickness, and scale crystallization were characterized by TEM. Fiber tensile strengths were measured using 30 single filament tensile tests. Compared to dry air oxidation, oxidation rates and scale crystallization rates are much faster in $Si(OH)_4$ saturated steam, and fiber strengths are usually lower. Unusual phenomena, such as dewetting of SiO_2 glass scales at 800°C, were observed. Models for oxidized SiC fiber strength after oxidation in dry air, based on the effect of scale residual stress on SiC strength limiting flaws, are applied to SiC fibers oxidized in steam,

and modifications to the model that may be appropriate for this environment are discussed. Extension of these models to BN and C-coated SiC fibers in CMCs, and the oxidation conditions that may prevail during oxidation of a microcracked CMC, are also discussed.

9:40 AM

(H2-004-2016) Effects of the microstructure, and degradation reaction under heat-treatment on mechanical properties of SiC polycrystalline fiber

H. Oda*[2]; T. Ishikawa[1]; 1. Tokyo University of Science, Yamaguchi, Japan; 2. UBE Industries, Ltd., Japan

SiC fibers are attractive structural materials with excellent mechanical properties up to very high temperatures. In particular, stoichiometric SiC polycrystalline fibers have an excellent heat-resistance up to 2000°C. Presently, our company (Ube Industries, Ltd.) produces a stoichiometric SiC polycrystalline fiber (Tyranno SA^R), and its higher strength has been desired. Accordingly, to achieve increase in the strength, we have to detect actual defects in the first fracture surface. In order to obtain the first fracture surface, we developed a new method for capturing the all fragments during the monofilament tensile testing using liquid paraffin. Using this method, we detected the fracture origin, and then the relationship between the tensile strength and each fine structure has been studied for obtaining more excellent SiC polycrystalline fiber. By the way, Tyranno SA^R is synthesized by further heat-treatment of an amorphous Si-Al-C-O fiber (intermediate fiber), which is synthesized from polyaluminocarbosilane. This intermediate fiber was heat-treated at higher temperatures in Ar atmosphere. During this heat-treatment, degradation reaction accompanied by the release of CO gas proceeds. After that, a sintering proceeded in each filament by the existence of aluminum. In this paper, the important things for controlling the strength will be reported.

10:20 AM

(H2-005-2016) Development of non-oxide ceramic fibers and their coatings (Invited)

A. Noeth*[1]; A. Rüdinger[1]; M. Rothmann[3]; W. Humbs[3]; B. Heidenreich[2]; 1. Fraunhofer ISC, Germany; 2. German Aerospace Center, Germany; 3. BJS Ceramics GmbH, Germany

At Fraunhofer Center HTL ceramic fibers are developed from the precursor to the final ceramic fiber. In this paper, we will describe the different processing steps for the development of non-oxide ceramic fibers starting from the precursor synthesis and the fiber spinning technology to pyrolysis and sintering. Various issues during the processing controlling the properties of the ceramic fibers will be discussed. Other aspects to be illustrated are the challenges in upscaling the fabrication process, which is important for commercialization of the ceramic fibers. To achieve a damage-tolerant fracture behavior of dense ceramic matrix composites, an appropriate fiber-matrix interface is needed, which is typically realized by coating the ceramic fibers. In this paper, we will present the development of viable fiber coatings based on BN, SiC/BN, and Al_2O_3/BN to achieve damage-tolerant SiC/SiC(N) composites. The fiber coatings were applied by a wet-chemical deposition route using liquid coating solutions. We describe the development of the deposition technology and show how the coating quality was improved by variation of the deposition parameters like precursor concentration, draw speed, drying and curing temperatures. The coated fibers were used to fabricate SiC/SiC(N) composites. We discuss the properties of the composites in dependence of the different types of coatings, fiber architecture, fiber volume content, etc.

10:50 AM

(H2-006-2016) StarFire SMP-10 as a Potential SiC Fiber Precursor

Z. D. Apostolov*[1]; S. Potticary[1]; M. Cinibulk[1]; 1. Air Force Research Lab, USA

While SMP-10 is a widely used matrix-former in PIP processing of C/SiC and SiC/SiC composites, its potential as a fiber precursor has yet to be sufficiently investigated. There are a number of challenges which exclude the polymer from conventional (i.e. dry and melt) fiber-spinning methods, among which the facts that it is liquid at room temperature, and once cured it is both infusible and insoluble. Its high purity and yield, plus negligible oxygen content, however, make it a very attractive candidate for the processing of SiC fibers for continuous applications in oxidizing environments at temperatures in excess of 1400°C. This work will present a novel approach to fiber spinning, which uses the polymer without any compositional alteration, and focuses on rheology modifications accomplished by simple thermal treatments only. The behavior of the complex modulus, loss tangent, and viscosity are investigated and adjusted, so that the rheological state required for spinning is obtained. It is demonstrated that if the onset of gelation can be captured, a long, self-supported strand of still-liquid polymer can be obtained. This in turn leads to the ability to maintain a long filament after spinning through an orifice, and the possibility to achieve curing of this filament if spinning it directly into a heating column.

11:10 AM

(H2-007-2016) Characterization of the Microstructure, Interfacial Composition, Phases and Elastic Properties in CFCCs Using Interdisciplinary NDE Techniques

M. Manghnani*[1]; R. M. Lemor[3]; M. Prasad[2]; 1. University of Hawaii, USA; 2. Colorado School of Mines, USA; 3. kibero GmbH, Germany

Interfacial microstructure, crystal-chemical composition, phases, orientation of fibers, and their elastic properties play important roles in the high-temperature performance of continuous ceramic fiber composites (CCFCs). We report here the variations in the elastic properties (modulus and impedance contrast) and microstructure in three types of SiC(Nicalon)$_{fiber}$/SiC$_{matrix}$ CFCCs with different fiber orientations which have been characterized using Ernst Leitz Scanning Acoustic Microscope (ELSAM), in frequency range 0.8 -1.0 GHz with resolution of 1.5 - 2.0 microns. The deployment of the ELSAM technique, in conjunction with micro-Raman scattering, enhances the capability of imaging the variations in the crystal-chemical, and crystallinity characteristics, microstructure, and elastic properties of the fibers, coatings, and matrix. We have also investigated the fiber orientation dependence of the elastic moduli and elastic anisotropy of the thermal treated enhanced CFCCs by ultrasonic measurements of compressional Vp and shear Vs velocities. The above results and their implications are discussed in light of better understanding of the interfacial properties and improved modeling and processing of tailored CFCCs.

H3. Innovative Design, Advanced Processing, and Manufacturing Technologies

Innovative Design II

Room: Bay
Session Chairs: Walter Krenkel, University of Bayreuth; Xiaoming Duan, Harbin Institute of Technology

8:30 AM

(H3-010-2016) Characterization of SiC_f/SiC composite tube prepared by CVI (Invited)

J. Park[1]; S. Jeong[1]; S. Kim[1]; D. Kim[1]; H. Lee*[1]; W. Kim[1]; 1. Korea Atomic Energy Research Institute, Republic of Korea

Silicon carbide (SiC) is known to have excellent material properties as regards thermal resistance, corrosion resistance and high strength. Among SiC ceramics, SiC_f/SiC composite is material that combines the refractoriness and environmental stability of ceramics with the toughness and damage tolerance. Therefore, that is promising material for high temperature structural applications. The tubular geometry is applied to the components such as cladding of nuclear fuel, combustor liner of gas turbine, control rod sheath of advance nuclear reactor. The chemical vapor infiltration (CVI) technique is an effective approach for the fabrication of a SiC_f/SiC composite tube with an excellent high temperature mechanical properties. In this study, SiC_f/SiC composite tubes were fabricated by CVI using the Tyranno SA^{TM} fibers with MTS (CH_3SiCl_3). PyC was deposited on the fibers as an interphase between matrix and the fibers. To establish the optimum fabrication conditions, the number of ply, fiber winding angles, infiltration times and the source gas supply routes through thickness of a tube were changed. The density, the microstructures, the mechanical properties and fracture behaviors were compared with the fabrication parameters. The C-ring tests were performed to evaluate the mechanical property of tubes. The microstructures of fracture surfaces and the crack propagation behaviors were observed by SEM and micro-CT.

9:00 AM

(H3-011-2016) Fundamentals of Reactive Alloy Melt Infiltration for SiC/SiC composites

R. B. Reitz*[1]; F. W. Zok[1]; C. G. Levi[1]; 1. University of California, Santa Barbara, USA

Current research aims to develop robust, fully dense composites by developing a fundamental understanding of reactive melt infiltration. The phenomena that occur during this process have been identified and explored by infiltrating carbonaceous samples with silicon and silicon-yttrium alloys. Topics such as infiltration, reactive wetting, reaction choking, thermal excursions, SiC formation, and resulting phase morphologies will be discussed. The interplay between these phenomena will be examined and implications for the optimization of reactive melt infiltration in composite processing will be outlined. An emphasis will be placed on rate limiting steps and on the conversion of free silicon to high melting point residual phases.

9:20 AM

(H3-012-2016) Influencing the mechanical properties of weak matrix C/C composites by means of microstructural design

A. Todt*[1]; D. Nestler[1]; K. Roder[1]; N. Nier[1]; G. Wagner[1]; 1. TU Chemnitz, Germany

Fibre-reinforced ceramic composite materials are characterised by excellent thermal, mechanical and chemical properties. Their intrinsic fibre architecture and porosity grant them a particularly high damage tolerance. As a result of this they offer great dampening characteristics, as do polymer materials. The production of complex structures is time consuming and very expensive. An innovative approach to this topic is the integration of simple geometric ceramic composite materials within complex polymer structures. The hybrid ceramic/polymer material compound combines the individual advantages of the ceramic and polymer components in one material system, which is far easier to produce. This production method opens up many new areas of application, such as the large-scale production of wear-resistant, chemically inert and energy absorbing elements for nuclear reactors or in the field of medical technology. During the course of this contribution, select C/C composite materials with a defined porosity were produced while adjusting the resin/hardening agent-ratio, as well as the processing parameters. After the production, different wetting tests were conducted with a polymer component. The final part of the contribution is comprised of the microstructural analysis and the explanation of the mechanical relationships.

9:40 AM

(H3-013-2016) High temperature wet oxidation behavior of SiC fiber-reinforced SiC-based composites fabricated by melt infiltration using Si binary alloys

T. Tsunoura*[1]; K. Yoshida[1]; T. Yano[1]; T. Aoki[2]; T. Ogasawara[3]; 1. Tokyo Institute of Technology, Japan; 2. Japan Aerospace Exploration Agency, Japan; 3. Tokyo University of Agriculture and Technology, Japan

SiC fiber-reinforced SiC based composites are one of the promising materials for hot-components and under extreme condition due to excellent properties. In our previous works, SiC fiber-reinforced composites were successfully fabricated by melt-infiltration method using Si-8.5at%Hf and Si-16at%Ti eutectic alloys below 1400°C. In this study, their wet oxidation behaviors up to 1200°C under steam were evaluated. Three-dimensional SiC fiber-preforms consisting of amorphous SiC fibers were used as the reinforcement. The fibers were coated with CVI-C and CVI-SiC. Then, the preforms were heated up to 1375-1390°C with Si-8.5at%Hf or Si-16at%Ti alloy. Oxidation tests were carried out at 800-1200°C for 100 hours under humid-air flow. The composites using Si-Hf alloy had thick oxidation layer or they showed pest oxidation behavior at 800°C. On the other hand, the composites using Si-Ti alloy showed superior oxidation resistance similar to the composites using Si. These results were explained based on thermodynamics. SiO_2 has Gibbs free energy of formation ranged between the formation HfO_2 from $HfSi_2$ and the formation TiO_2 from $TiSi_2$. Therefore, it is expected that these composites using Si-Hf or Si-Ti alloys show completely different oxidation behaviors.

10:20 AM

(H3-014-2016) Application of Electrophoretic Deposition for Interphase Formation on Polycrystalline and Amorphous SiC Fibers in SiC_f/SiC Composites (Invited)

K. Yoshida*[1]; T. Kikuhara[1]; N. Mizuta[1]; T. Ajito[1]; T. Yano[1]; M. Kotani[2]; T. Aoki[2]; T. Ogasawara[3]; 1. Tokyo Institute of Technology, Japan; 2. Japan Aerospace Exploration Agency (JAXA), Japan; 3. Tokyo University of Agriculture and Technology, Japan

Continuous silicon carbide fiber-reinforced silicon carbide matrix (SiC_f/SiC) composites have been expected to be applied for aerospace industries, high-temperature gas turbines and future nuclear and fusion applications. It has been well-known that fiber/matrix interfaces act as an important role for toughening and strengthening SiC_f/SiC composites. Currently, carbon or hexagonal-boron nitride has been applied as the interphase for SiC_f/SiC composites. These interphases have been generally formed by chemical vapor infiltration (CVI), chemical vapor deposition (CVD) or solution-coating/pyrolysis process. However, these processes generally require long manufactuiring time and complicated apparatuses, and they use or generate toxic, flammable or combustible gases, resulting in an increase in environmental load and much higher production cost. Present authors have developed novel process to form interphases on SiC fibers in SiC_f/SiC composites based on electrophoretic deposition (EPD) method. In this talk, our process to form interphases on polycrystalline (electric conductive) and amorphous (low electric conductive) SiC fibers in SiC_f/SiC composites based on EPD method will be reviewed, and mechanical properties of the SiC_f/SiC composites will be discussed.

10:50 AM

(H3-015-2016) Polymer-precursor-based processing approaches towards layered and bulk ceramic composites (Invited)

T. Konegger*[1]; C. Drechsel[1]; 1. TU Wien - Vienna University of Technology, Austria

Polymer-derived ceramics (PDC) present a versatile alternative to conventional ceramic processing techniques towards the fabrication of oxide and nonoxide ceramic materials and CMCs. One of its primary advantages is the accessibility of processing variants to prepare bulk, porous, and layered materials, which will be demonstrated using examples for the preparation of various PDC-based composite materials recently developed in our group. The first example involves the generation of multilayer structures for high temperature membrane applications. Here, the focus is set on the development of a SiCN/Si_3N_4 composite layer responsible for bridging the macroporous structure of the membrane support with the microporous, thin membrane layer. As a second example for the application of PDCs in the field of CMCs, the use of preceramic polymers as reactive agents for the generation of oxide-based particle-reinforced materials will be presented. In this case, the importance of the compounding method will be highlighted, correlating processing technique with spatial distribution of the reinforcing phase, and, subsequently, with resulting properties of the materials. Contributing to this objective, a versatile tool for the evaluation and quantitative description of the spatial distribution of reinforcing phases is presented, which is deemed applicable to a wide variety of composite systems.

11:20 AM

(H3-016-2016) Powder injection moulding of zirconia-alumina ceramic matrix composite using water-soluble binder system

N. Chuankrerkkul*[1]; 1. Chulalongkorn University, Thailand

Zirconia-alumina ceramic matrix composites were fabricated by powder injection moulding. The ceramic powders were mixed with polymeric binder to form feedstocks. The binder composed mainly of polyethylene glycol (PEG) which is a water-soluble constituent. Injection moulding was carried out with a plunger-typed machine. The moulded components were subjected to binder removal using water immersion method. The remaining backbone polymeric binder was subsequently eliminated during ramping up to the sintering temperatures. Several sintering cycles were completed to investigate the effect of sintering temperature, heating rate and soaking time. Specimens were subjected to physical and mechanical properties evaluation, namely, density, hardness and flexural strength. Scanning electron microscope was employed for the characterisation of microstructures of the sintered products. It was found that sintering temperature strongly affected the physical and mechanical properties of the ceramic matrix composites. The powder composition also played an important role in the mechanical properties and microstructure of the specimens. The densities of the injection moulded ceramic matrix composites achieved were 97-98 % of the theoretical value with the optimised condition carried out in this work.

H5. Polymer Derived Ceramics and Composites

PDC Fibers

Room: Trinity IV

Session Chair: Samuel Bernard, CNRS

8:30 AM

(H5-010-2016) State of the Art and New Developments of Polymer Derived Ceramic Fibers (Invited)

B. Clauss*[1]; 1. DITF, Germany

The presentation shall give an overview about the state of the art of non-oxide ceramic fibers, which are derived from inorganic polymers. Commercially available fibers will be addressed as well as new developments published in the literature. The increasing interest in CMC materials based on SiC fibers, mainly in the field of gas turbines, has pushed the installation of additional production capacities of the well-known high end SiC fibers. However, there are also ongoing attempts in research to establish new non-oxide fibers, using different raw materials and production routes. One of the goals is the reduction of production costs for this fiber type.

9:00 AM

(H5-011-2016) Synthesis, Properties and Applications of SiC Ultrathin Fibers via Electrospining Combined with Polymer-derived Ceramics Route (Invited)

Y. Wang*[1]; 1. National University of Defence Technology, China

SiC, macro-meso-microporous SiC, ZrO_2/SiC, TiO_2/SiC and SnO_2/SiC ultrathin fibers were successfully fabricated via electrospinning combined with polymer-derived ceramics route or hydrothermal method. The compositions and microstructures of these SiC-based ultrathin fibers were characterized in detail. The SiC ultrathin fibers exhibited a high specific extinction coefficient of 160 $m^2\ kg^{-1}$. Enhanced mass transport and high-temperature erosion resistance were got on the macro-meso-microporous SiC ultrathin fibers. The ZrO_2/SiC ultrathin fibers with radial gradient compositions are found to have high-temperature resistant to basic. The hierarchical TiO_2/SiC fibers exhibited high sensitivity (19.2) and selectivity toward acetone and a high photocatalytic hydrogen production rate of 1206.1 $\mu mol\ g^{-1}\ h^{-1}$ under simulated solar light while the hierarchical SnO_2/SiC fibers presented ultrafast response rate (6 s) and high sensitivity (23.5) toward ethanol. These SiC-based ultrathin fibers have demonstrated potential applications in composites, sensors, catalyst and solar fuel.

9:30 AM

(H5-012-2016) Preceramic polymer derived porous ceramics, nanowires and ceramic fibers (Invited)

M. Fukushima*[1]; K. Kita[1]; P. Colombo[2]; H. Hyuga[1]; Y. Yoshizawa[1]; N. Kondo[1]; 1. National Institute of Advanced Industrial Science and Technology (AIST), Japan; 2. University of Padova, Italy

Preceramic polymers, including organic and inorganic polymers with a continuous Si–R network (R =O, C, N and B), can provide ceramic materials as residue through their decomposition at elevated temperature. In this study, we tried to fabricate silicon carbide or oxycarbide/nitride based ceramic products: porous ceramics, ceramic nanowires (NWs) decorated on the ceramic foams and ceramic fibers. Processing routes included blowing polycarbosilane (PCS), catalyst assisted pyrolysis of polysilsesquioxane (PSQ) to grow ceramic nanowires and PCS based melt spinning. We investigated the effect of blowing condition on volume expansion during foaming, conversion of preceramic polymer with metal catalyst into ceramic nanowires and the relationship between molten viscosity of PCS and spinnability, respectively. Microstructure and mechanical properties of pyrolyzed products will be also discussed, in terms of mixing ratio of preceramic polymer and pyrolysis conditions.

Applications of PDCs

Room: Trinity IV
Session Chair: Gabriela Mera, Technical University Darmstadt

10:20 AM

(H5-013-2016) Polymer-Derived Ceramics: From Single Phase to Nanocomposite Structures with Tailored Porosity for Hydrogen Production (Invited)

S. Bernard*[1]; 1. CNRS, France

PEM fuel cell-based systems are attractive alternatives to current energy conversion technologies due to their potential to directly convert hydrogen into electrical energy. However, one of the most critical issues is the hydrogen source to meet the overall energy requirements for civil vehicle applications because it is produced from natural gas which means evolution of CO_2. Liquid-phase hydrogen carriers are more attractive alternatives. The conditions to generate hydrogen from these compounds are usually severe. For that purpose, we develop polymer-derived ceramics (PDCs) with tailored porosity for the growth of metallic nanoparticles and the use of the resulting materials for the catalytic generation of hydrogen from liquid-phase hydrogen carriers. Interesting, such PDCs may act co-catalysts for the reactions as a function of their composition and structure. Here, we report the preparation of silicon nitride as well as titanium nitride/silicon nitride nanocomposites as mesoporous monoliths through the hard template-assisted polymer-derived ceramic route. Our main results concerning structural, textural and functionalization of these materials are reported. Their performance is discussed. Results show that PDCs are promising nanocatalysts in pursuit of practical implantation of boron- and/or nitrogen-based hydrides as a hydrogen source for fuel cells.

10:50 AM

(H5-014-2016) Additive Manufacturing with Preceramic Polymers

P. Colombo*[1]; 1. University of Padova, Italy

This paper will report on the fabrication of porous structures starting from pure preceramic polymers (e.g. silicone resins) and of silicone resins plus reactive fillers (to produce advanced silicate ceramic phases suitable for different applications). Different types of additive 3D manufacturing techniques were employed, including: a) direct printing using a stereolithographic printer; b) direct printing using a paste extrusion printer (Direct Ink writing); c) direct printing using a fused deposition printer; d) indirect printing using a powder bed-based printer (in collaboration with researchers from BAM, Berlin, Germany). Advantages and disadvantages of the different processing techniques employed, in relation to the use of preceramic polymers, will be discussed, and examples of produced and characterized porous structures for potential use in different applications will be presented.

11:10 AM

(H5-015-2016) Polymer-derived Bioactive Wollastonite-Diopside Glass-ceramics: from Foams to Direct Ink Writing

E. Bernardo*[1]; 1. University of Padova, Italy

Wollastonite-diopside glass-ceramics have been successfully obtained from commercial silicone resins, filled with $CaCO_3$ and $Mg(OH)_2$ microparticles, coupled with sodium borate or sodium phosphate (<5 wt% of the final ceramic). Since the liquid phase provided by the secondary fillers, upon firing at 1100 °C, remains as a glass phase after cooling at room temperature, the product (crystalline silicates in a glass phase) may be considered as a new glass-ceramic ("polymer-derived glass-ceramic"), although not derived from a homogeneous glass. A high porosity (>70%) may be obtained either by direct foaming or by application of 3D printing. In the first case, borate and phosphate salts, used in hydrated form, do not act simply as fluxes but contribute significantly to the foaming, owing to the release of water vapor from their dehydration, at 300-350 °C, in the silicone matrix before its ceramic conversion at higher temperatures. In the second case, silicone-based pastes can be exploited for direct ink writing. The phase assemblage does not change for silicone-based mixtures comprising the Ca-Mg silicate glass powders as further filler (30-70 wt% of the final ceramic). Both foams and 3D scaffolds exhibited a remarkable compressive strength (even exceeding 5 MPa); preliminary cell studies demonstrated the excellent biocompatibility and biocompatibility of foams.

H11. CMC Applications in Transportation and Industrial Systems

Materials and Manufacturing Processes for Serial Production

Room: Salon C
Session Chair: Roland Weiss, Schunk Kohlenstofftechnik GmbH

8:30 AM

(H11-007-2016) Production and Development of Composites for Industrial High Temperature Applications (Invited)

R. Weiss*[1]; 1. Schunk Kohlenstofftechnik GmbH, Germany

Industrial requirements for high temperature applications depend on their final use. Typical applications are brake materials, high temperature furnace equipment, materials for photovoltaic and semi conductor industry as well as components for heat treatment of metals. Therefore, all CMC composites have to be tailored according the customer requirements. The mechanical, physical and chemical properties have to be fulfilled by using the most cost effective composite material. Tailoring of CMC materials and structural components will be shown in particular for applications in high temperature furnaces in order to optimize their homogeneity of temperature distribution. The cost decrease for photovoltaic cells is directly combined with the requirement of low cost carbon carbon grades. However, such grades are difficult to machine. It will be shown how to solve this problem. Heat treatments of metals are always combined with corrosion effects. Possible solutions with CMC materials will be shown and discussed in more detail.

9:00 AM

(H11-008-2016) Continuous siliconization process for a mass production of CMC brake discs (Invited)

M. Orlandi*[1]; M. Valle[2]; D. Coslovi[1]; M. Marschall[3]; 1. BSCCB, Italy; 2. Petroceramics SpA, Italy; 3. BSCCB GmbH, Germany

Fibres-reinforced carbon (C) and silicon carbide (SiC) composites - also known as Ceramic Matrix Composites (CMC) - have rapidly become some of the most exploited materials in the advanced ceramics industry for high temperature demanding applications. Engineered CMCs are becoming more and more used in several strategic sectors such as transports, energy generation, tooling machines, personal protective equipments. Their lightweight, high thermal stability and functional properties such as low thermal expansion and good tribological behaviour play an increasing importance for several new commercial applications. CMC brakes production includes today many steps, among which a crucial step is the siliconization of the carbon preforms. A continuous automated process for silicon infiltration of CMC preforms was developed and it will bring about some major advantages: increase the production throughput, and thus optimizing production cycles; save processing time together with associated energy and costs; replace manual operation with an automated controlled process, thus leading to reduction of the number of defected components We present a new approach to infiltration in which the reaction is controlled by keeping high residaul pressure above the melting point of silicon till the desired moment to start the siliconization is reached

9:30 AM

(H11-009-2016) Effects of hot-spot formation during MW-assisted synthesis via reactive infiltration of C_f/SiC composite materials

M. R. Caccia*[2]; A. Camarano[2]; J. Narciso[1]; 1. Alicante University, Spain; 2. University of Alicante, Spain

Synthesis of SiC-based composites using MW-assisted reactive infiltration is a promising route to obtain these materials while reducing production time and energy consumption. The main issue of MW technologies is the lack of capacity to control the temperature during the process. This is due to the different dielectric properties of the various phases involved in the process, and its temperature dependence. Therefore hot spots could be formed during the synthesis of the material. To study the effect that these hot spots have on the microstructure and mechanical properties of the final materials, C_f/SiC composites obtained with classical resistance technologies have been subjected to high temperature treatments (1800, 2000, 2200 C). Microstructure, mechanical and tribological properties were evaluated. A strong decrease in mechanical properties was observed when increasing the temperature of the treatment. This is a direct consequence of the generation of porosity due to Si evaporation, and cracking due to volume changes in the sample. Damage to the carbon fibers is observed as high temperature increases their reactive with Si. Tribological properties are less influenced by high temperature as the friction coefficients remains constant. However, samples become more rigid and fragile with the treatments and present greater volume changes during abrasion tests.

Oxidation and Corrosion of Hot Structures in Realistic Environments

Room: Salon C

Session Chair: Shaoming Dong, Shanghai Institute of Ceramics, Chinese Academy of Sciences

10:20 AM

(H11-010-2016) Corrosion Behavior of SiC_f/SiC Composites in Molten Fluoride Salts (Invited)

S. Dong*[1]; H. Wang[1]; Y. Kan[1]; H. Zhou[1]; 1. Shanghai Institute of Ceramics, Chinese Academy of Sciences, China

SiC fiber reinforced SiC ceramic matrix composites (SiC_f/SiC) show good mechanical properties, excellent irradiation resistance and nice compatibility with molten fluoride salt, making them ideal candidate for thorium molten salt reactor. However, there are few studies focused on the property and structure evolution of SiC_f/SiC in molten fluoride. In present study, the corrosion behavior of SiC_f/SiC fabricated by chemical vapor deposition (CVI) and reaction sintering (RS) techniques in molten fluoride salt was investigated. CVI-SiC_f/SiC, which had high crystallized SiC matrix, showed good corrosion resistance. While RS samples exhibited poor corrosion resistance due to the residual silicon in the matrix. The corrosion process of CVI-SiC_f/SiC was systematically studied and corrosion kinetics was simulated. The simulation result indicates that the corrosion reaction is zero-order reaction associated with Arrhenius equation. The corrosion mechanism was also proposed through the assistance of thermodynamic calculations. In order to improve the resistance corrosion further, PyC and PyC/SiC protecting coatings were exerted on the surface of CVI-SiC_f/SiC composites. Compared with CVI-SiC_f/SiC composites without coating, the mass loss rate of sample protected by PyC/SiC coating decreased an order of magnitude under the same corrosion conditions.

10:50 AM

(H11-011-2016) Hydrothermal oxidation of carbon fiber reinforced ceramic matrix composite (Invited)

X. Luan*[1]; J. Yuan[2]; X. Hai[1]; Y. Zou[1]; R. Riedel[2]; E. Ionescu[2]; 1. Northwestern Polytechical University, China; 2. Technische Universität Darmstadt, Germany

Si-based ceramic matrix composites are suitable materials to be used in high-temperature applications such as gas turbines, combustion systems or supercritical water-cooled reactor due to their excellent decomposition, corrosion and oxidation resistance. However, most potential applications involve hydrothermal oxidation because water or water vapor is included in their atmosphere. In this present work, carbon fiber reinforced Si-based ceramic matrix composites (such as C/SiC, C/SiCN, C/SiHfBCN, etc, prepared via CVI, PIP or PIP+CVI) were tested in hydrothermal atmosphere at the temperature range from 100 to 1400 ºC. Effects of processing, component and temperature were discussed based on microstructure and weight change, etc. Damage mechanisms of these composites also were discussed in this work. It is found that more reasonable to calculate mass loss of carbon fiber reinforced ceramic composite based specific surface area. Mass loss rate of C/SiC prepared by CVI is similar to that of CVD SiC. Weight change rate and corrosion production of Cf/SiCN highly depend on Vwater/Ssample. No damage happens to carbon fiber, oxidation of Si3N4 is the major reaction for SiCN. The results indicate that the incorporation of Hf and B into SiCN matrix leads to a significant improvement of its hydrothermal corrosion performance.

11:20 AM

(H11-012-2016) Ceramic Matrix Composite Design and Behavior for Aero Engines Gas Turbines Components

E. Bouillon*[1]; D. Marsal[1]; A. Mouret[1]; 1. Safran Herakles, France

Ceramic Matrix Composites (CMC) has been developed as the next generation of materials offering higher temperature capability than the current state-of-the-art metallic superalloys. CMC components design and manufacturing will enable aircraft engines to operate at higher temperature, improving performance and weight-saving. Initially developed from both military and power generation, enhanced CMCs are emerging as candidate materials for commercial aircraft. For overcoming this new challenge, an important effort has been done to SAFRAN-Herakles, for more than 15 years, in the implementation of carbide based CMC and oxide based CMC. The CMC technology development requires an extensive work of thermomechanical damage behavior analysis, based on elementary coupons and sub-element part tests, and, in a last step, ground and flight test of prototype components. The aim of this paper is to briefly review the CMC behavior in engines components environment, including the determination of material allowable, sub-element behavior and life duration approach. A focus will be done on last technical progress which have been done with the objective of increasing the CMC technology maturity for internal and external engines components.

11:40 AM

(H11-013-2016) Mechniacal properties and original features of fiber-reinforced self-healing ceramics

W. Nakao*[1]; 1. Yokohama National University, Japan

Self-healing ceramics are anticipated to be one candidate of next generation high temperature structural materials. Self-healing ceramics needs to design the management of crack propagation by inserting the extra consistent. Thus, micro-structure affects strongly the total performance of self-healing ceramics. The paper is to aims to demonstrate the relationship between micro-structure and the performance of fiber-reinforced self-healing ceramics.

Young Professionals Forum - Next Generation Materials for Multifunctional Applications and Sustainable Development, and Concurrent Societal Challenges in the New Millennium

Young Professional Forum III: Multifunctional Materials, Porous, and Catalytic Materials

Room: York A

Session Chairs: Alexis Lewis, National Science Foundation; Richard Riman, Rutgers University; Matteo Clerici, University of Glasgow

8:30 AM

(YPF-008-2016) Structure Property Relations in Anisotropically Porous Ceramics (Invited)

A. Stevenson*[1]; J. Seuba[1]; S. Deville[2]; 1. Saint-Gobain, France; 2. CNRS, France

Macroporous ceramics are widely used in applications such as filtration, thermal insulation, scaffolds for tissue engineering, SOFCs, or OTM's. They must combine mechanical stability with at least one other functional property such as high permeability, low thermal conductivity, or biocompatibility. However, strength is usually increased by decreasing the total pore volume even though this may degrade the other functional properties. Beyond porosity content, morphological parameters such as pore size, shape, or tortuosity, can become crucial to maximize the performance while maintaining high strength. For example, a significant improvement can be achieved by engineering anisotropic structures to mechanically reinforce the direction of the main stress, similarly to natural materials such as trabecular bone, cork, or wood. The purpose of this work is first, tailor the pore architecture of specimens processed by ice-templating to then, determine the main microstructural parameters that control the compressive strength, mechanical reliability, and air permeability of unidirectional porous materials. Furthermore, the applicability of mechanistic and gas flow models will be discussed in the context of the structured pore morphologies. Finally, we will provide some guidelines to produce tubular ice-templated samples with controlled porosity.

9:00 AM

(YPF-009-2016) NMR techniques to study the formation, structure, and use of small nanoparticle alloys (Invited)

J. Millstone*[1]; 1. University of Pittsburgh, USA

Metallic nanoparticles exhibit size, shape, and surface chemistry dependent physical properties that are promising in a wide range of energy and medical applications. Realization of this promise requires robust and stable syntheses, which are facilitated by chemical understanding of particle formation, structure, and physical properties. These studies are often challenging, in part due to fundamental aspects of particle formation itself. For example, solution phase metal nanoparticle growth reactions and the resulting nanoparticles contain both hard and soft matter, and approaches for the characterization of solid inorganic materials and solution phase molecular species are often disparate. One powerful technique to address this gap is nuclear magnetic resonance (NMR) spectroscopy, which can facilitate routine, direct, molecular-scale analysis of nanoparticle formation and morphology in situ, in both the solution and solid phase. A growing body of work indicates that NMR analyses yields an exciting complement to the existing canon of nanoparticle characterization methods such as electron microscopy. Here, we demonstrate several NMR techniques in the elucidation of noble metal alloy nanoparticle synthesis pathways, and specifically correlate the ligand chemistry of the particle with growth pathways and emergent physical properties such as photoluminescence and catalytic reactivity.

9:30 AM

(YPF-010-2016) Tuning the hydrothermal gelation of graphene oxide (Invited)

K. Hu*[1]; X. Xie[2]; T. Szkopek[1]; M. Cerruti[1]; 1. McGill University, Canada; 2. Sichuan University, China

Graphene hydrogels/aerogels are emerging three dimensional graphene macroscopic assemblies of potential use in many applications including energy storage, pollutant adsorption, gas sensing and tissue engineeering. Conventional graphene hydrogels are often prepared via solution based assembly route involving the reduction of graphene oxide (GO) sol through various chemical reduction or hydrothermal methods. Often, the hydrogel is formed with a shell structure enveloping the interior porous bulk. Here, we show that the colloidal chemistry of the starting GO sol can significantly impact the structure and properties of the resulting graphene gel. Two specific examples are shown here to illustrate this point. In the first example, we demonstrate that a slight increase in the hydrophobicity of GO can result in the production of a "shell-less" graphene gel with different properties. In the second case, we show that highly homogeous composite graphene gel can be prepared by enhancing the electrostatic stabilzation between GO and the other component. All these gels are more attractive to the aformentioned applications due to their unique properties.

9:50 AM

(YPF-011-2016) Embedded chip-scale supercapacitors with novel functionalized architecture and tailored ionic liquid-based electrolyte

T. Colling*[1]; V. Scott[2]; J. Ready[3]; 1. Georgia Institute of Technology, USA; 2. NASA Jet Propulsion Laboratory, USA; 3. Georgia Tech Research Institute, USA

Energy storage and delivery is a topic of high interest, especially in applications demanding high energy, low mass, and low volume energy storage devices. Supercapacitors have been drawing significant interest in fields such as space exploration, computer technology, and the automotive industry due to their high power densities and cyclability. This research focused on the development of carbon nanotube embedded electrochemical double layer supercapacitors (ECDL) that feature a novel functionalized pseudocapacitive architecture and tailored ionic liquid-based electrolyte. The architecture was created using graphination and functionalization with TiO_2. Similar projects exist involving various forms of carbon electrodes but these projects do not utilize a tailored ionic liquid electrolyte and fall short of the requirements for many applications. Utilizing a carefully constructed design of experiments, various ionic liquids were tested against the novel architecture. These results guided the development of the novel tailored ionic liquid-based electrolyte and, in turn, a new series of ECDL capacitors. Development of this technology has already increased the specific capacitance and energy density making this technology already relevant to applications in the aforementioned fields. Herein, development of the electrodes and the design of experiments are discussed.

Young Professional Forum IV: Health, Energy, and Emerging Technologies

Room: York A

Session Chairs: Jill Millstone, University of Pittsburgh; Rafik Naccache, Institut National de la Recherche Scientifique

10:20 AM

(YPF-012-2016) Polymer Matrix Based Multiphasic Piezoelectric Composites: Fabrication and Characterization (Invited)

S. Banerjee*[1]; 1. California State University, Fresno, USA

Piezoelectric sensors and actuators are needed for a wide range of applications from physiological measurement to industrial monitoring systems. Sensors that can be easily integrated with the host,

while maintaining high sensitivity and reliability over a wide range of frequencies are not readily feasible and economical with homogenous piezoelectric materials. It is well known that two-phase piezoelectric-polymer composites offer several benefits over their single phase counterparts, as the properties of the constituent phases combine to improve the range of applicability. However, the piezoelectric properties of these materials suffer from the electrically insulating properties of the polymer matrix. The electrical properties of the matrix may be enhanced by including electrically conducting inclusions however, less is known about the mechanisms that drive the changes in these properties. Hence the experimental investigation of piezo-composite materials aims to understand the roles that specific fabrication parameters and inclusion composition play in determining the piezoelectric and dielectric performance the aforementioned composites.

10:50 AM

(YPF-013-2016) Novel nonlinear effects and detection schemes at THz frequencies (Invited)

M. Clerici*[1]; M. Peccianti[2]; A. Mazhorova[3]; S. Ho[6]; B. Schmidt[3]; L. Caspani[4]; A. Pasquazi[2]; A. Couairon[5]; F. Vidal[3]; L. Razzari[3]; J. Ali[6]; F. Légaré[3]; T. Ozaki[3]; D. Faccio[4]; R. Morandotti[3]; 1. University of Glasgow, United Kingdom; 2. University of Sussex, United Kingdom; 3. INRS, Canada; 4. Heriot-Watt University, United Kingdom; 5. École Polytechnique, France; 6. Universiti Teknologi Malaysia, Malaysia

Intense terahertz field (THz) can be generated by laser-induced gas ionization, e.g. when a two-color field drives the ionization. We report on the generation of intense THz pulses by two-colour gas ionization using long wavelength pump pulses, and on the novel nonlinear effects observed with such intense fields, both in gasses and in solid state media. We shall discuss the process of coherent emission in the UV spectral region triggered and controlled by intense THz fields interacting with optically excited Nitrogen molecules. Furthermore, we will illustrate the process of dispersive wave emission upon the interaction of THz and 800 nm pulses in diamond. Finally, building on the control of the nonlinear interaction in transparent material, we propose and discuss the experimental results of a novel, broadband THz time-domain measurement technique that relies on a chip-size detector.

11:20 AM

(YPF-014-2016) Preparation and Methane Adsorption of Two-dimensional Carbide Ti_2C

A. Zhou*[1]; F. Liu[1]; 1. Henan Polytechnic University, China

Here a novel material for methane adsorption was synthesized and studied, which is graphene-like two-dimensional (2D) carbide (Ti_2C, a member of MXenes), formed by exfoliating Ti_2AlC powders in a solution of lithium fluoride (LiF) and hydrochloric acid (HCl) at 40°C for 48 h. Graphite characteristic peaks (D band and G band) are detected in Ti_2C's Raman spectrum. Based on first-principles calculation, theoretically perfect Ti_2C with O termination has a specific surface area (SSA) of 671 m^2 g^{-1} and methane storage capacity is 22.9 wt.%. Experimentally, 2.85% exfoliated Ti_2C with mesopores shown methane capacity of 11.58 cm^3 (STP: 0°C, 1 bar) g^{-1} (0.82 wt.%) under 5 MPa and the SSA was 19.1 m^2 g^{-1}. For fully exfoliated Ti_2C, the methane capacity was supposed to be 28.8 wt.% or 1148 V (STP) v^{-1}. Ti_2C theoretically has much larger volume methane capacity than current methane storage materials, though its SSA is not very high.

11:40 AM

(YPF-015-2016) 3D Printing of MAX Reinforced Composites

R. Dunnigan[1]; S. Ghosh[1]; F. AlAnazi[1]; S. Gupta*[1]; 1. University of North Dakota, USA

The integral process of depositing thin layers of material, one after another, until the designed component is created is collectively referred to as Additive Manufacturing (AM). Fused deposition process (FDP) is a very common type of technique. During this technique, feedstock is extruded into filaments which then are deposited by 3D printing. The subsequent solidification occurs during cooling of the melt. In this presentation, we will present recent studies on developing novel polymer matrix composites and their .tribological behavior.

G1. Powder Processing Innovation and Technologies for Advanced Materials and Sustainable Development

Composite and Porous Structure Control

Room: Trinity III
Session Chairs: Kevin Ewsuk, Sandia National Laboratories; Yuji Hotta, National Institute of Advanced Industrial Science and Technology (AIST)

1:30 PM

(G1-019-2016) From Biomimetic Concept to Engineering Reality – Design of Ceramic Reinforcement (Invited)

W. Tuan*[1]; Y. Yu[1]; 1. National Taiwan University, Taiwan

The applications of ceramics are limited by their brittleness. Though the toughness of ceramics can be improved by adding hard and strong toughening agents, their damage tolerance is still poor. Novel concept derives from fish scale is explored and used to design alternative toughening agent. The microstructure of fish scale exhibits hierarchical complexity. There are many weak interfaces within the scale. As fish scales are used directly as the toughening agent, the toughness of ceramics can be enhanced. The toughness enhancement can be related to the crack deflection within fish scale. Based on the observation, the ceramic reinforcement with internal weak interfaces is recommended as the toughening agent. A feasibility study of using such concept for engineering application is proposed.

2:00 PM

(G1-020-2016) Nanoporous Composites as Advanced Electrodes for Supercapacitors (Invited)

J. Kang*[1]; 1. Tianjin Polytechnic University, China

Because of the fast redox reaction happened on or near the electrode/electrolyte surface, Pseudocapacitors have the merits of high power density compared to battery, and higher energy density than electronic double layer capacitors. However, the poor electric conductivity and cyclic stability of transition metal oxide/hydroxide restricted their practical applications as candidate of electrode materials for high-performance supercapacitors. To address these, we propose a strategy of three-dimensional nanoporous architechture, in which transition metal oxides are self-grown on the ligaments of nanoporous metal by electrochemical polarization through paradigm of domain matching epitaxy. The resulted core-shell nanoporous metal/oxide electrodes possess not only high electron/ion conductivity but also ultrahigh cyclic stability due to their special structure. Furthermore, the valence and composition of the oxides can be easily controlled by adjusting the component and polarization process of the nanoporous metal, which directly determines the supercapacitor performance of the electrodes.

2:30 PM

(G1-021-2016) Characterization and Modeling to Design and Develop Particle-Filled-Glass Composites (Invited)

K. Ewsuk*[1]; 1. Sandia National Laboratories, USA

Particle-filled-glass composites (FGCs) are being developed with processing and properties engineered for materials joining. Relative to conventional sealing glasses, tailored-property FGCs have significant potential as improved performance and reliability hermetic glass-to-metal (GtM) seals. Additionally, compared to process sensitive crystallizable glasses, FGCs offer broader processing latitude and robustness, with enhanced microstructure and property control. This paper will present and discuss work being completed to develop FGCs using a combination of fundamental materials science and materials engineering, employing: 1) experimentally-validated molecular modeling to better understand and control bulk and interface glass chemistry-structure-property relations to improve seal performance and reliability; and 2) composite property and process modeling to facilitate FGC design, and to optimize FGC manufacturability and properties. Results of modeling and characterization of barium aluminosilicate glass chemistry-structure relations will be presented. Additionally, the processing and properties of FGcs will be presented. Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

3:20 PM

(G1-022-2016) Bioinspired Graphene-Copper Matrix Nanocomposites (Invited)

D. Xiong*[1]; M. Cao[1]; Q. Guo[1]; Z. Tan[1]; G. Fan[1]; Z. Li[1]; D. Zhang[1]; 1. Shanghai Jiao Tong University, China

Metals can be strengthened by adding hard reinforcements, but such strategy usually compromises ductility and toughness. Natural nacre consists of hard and soft phases organized in a regular 'brick-and-mortar' structure and exhibits a superior combination of mechanical strength and toughness,which is an attractive model for strengthening and toughening artificial composites, but such bioinspired metal matrix composite has yet to be made. Here we prepared nacre-like reduced graphene oxide (RGrO) reinforced Cu matrix composite based on a preform impregnation process, by which two-dimensional RGrO was used as 'brick' and inserted into '[]-and-mortar' ordered porous Cu preform (the symbol '[]' means the absence of 'brick'), followed by compacting.This process realized uniform dispersion and alignment of RGrO in Cu matrix simultaneously. The RGrO-and-Cu artificial nacres exhibited simultaneous enhancement on yield strength and ductility as well as increased modulus, attributed to RGrO strengthening, effective crack deflection and a possible combined failure mode of RGrO. The artificial nacres also showed significantly higher strengthening efficiency than other conventional Cu matrix composites, which might be related to the alignment of RGrO.

3:50 PM

(G1-023-2016) Bioinspired Fabrication, Properties and Applications of Nanocarbon Reinforced Aluminum Composites (Invited)

Z. Li*[1]; G. Fan[1]; Z. Tan[1]; D. Xiong[1]; Q. Guo[1]; Y. Su[1]; D. Zhang[1]; 1. Shanghai Jiao Tong University, China

Nanocarbons, such as Carbon Nano Onion (CNO), Carbon Nanotube (CNT), Graphene Nanosheets (GNS) are regarded as the ideal reinforcements for high performance metal matrix composites (MMCs). However, the nano carbon reinforced nanocomposites prepared by conventional methods usually showed a tradeoff between promising strength and desirable ductility, due to the lack of effective fabrication method and architecture design, which is a fatal drawback to their practical applications. Herein, a new strategy of bio-inspired design and fabrication was explored to uniformly distribute nanocarbon in MMCs and coordinate the strength-ductility dilemma. In this report, CNT/Al and GNS/Al composites with reinforcements aligned along the extrusion direction between Al lamellae was fabricated by an approach of flake powder metallurgy, which resorts to make the nanocarbons and metal matrix more compatible both in the surface properties and geometries. Then the nano reinforcement-coated Al nanoflakes were used as building blocks for stack assembly, and then a nacre-like nanolaminate structure could be eventually formed by controlled deformation processing. Compared to the composites of the same reinforcement content but random distribution, the bio-inspired nanolaminate composites exhibited a simultaneous enhancement in strength, modulus and uniform elongation.

4:20 PM

(G1-024-2016) Energy-saving Housing Materials using Nano Porous Ceramics Structure (Invited)

N. Isu*[1]; 1. LIXIL Corp., Japan

The future manufacturing for the recirculation-based society needs to take into consideration environmental impact for the earth and functions for people simultaneously. The energy consumption for air conditioning of houses and buildings accounts for about 8% of Japan's total energy consumption (14,394 PJ), and energy conservation in this field is an important challenging issue. One of the most effective methods of reducing the amount of energy is to improve the autonomously humidity control property and the thermal conductivity of the indoor materials. The authors have investigated the functional indoor housing materials having nanopore structure. Two examples using the nano technology to build healthy and comfortable dwelling space were explained. One is mesoporous ceramic tile using soil to control indoor humidity autonomously and adsorb VOCs. From the results of the calculations based on Kelvin's equation of capillary condensation, pore radii between 3.2nm to 7.4nm is required to keep the comfortable humidity range of 40 to 70%. The other example is the vacuum insulation panels (VIP) having thermal conductivity of 0.005W/mK. The nano-porous silica particle used had the mean particle size of 5 μm and the mean pore diameter of about 30nm. The VIPs reduced the electrical power consumption by 25 to 54% in the field test, showing the effectiveness of energy-saving renovation.

4:50 PM

(G1-025-2016) Development of Ceramic Mold for Rapid Forming of CFRP Composite Using Microwave

Y. Hotta*[1]; D. Shimamoto[1]; Y. Tominaga[1]; 1. National Institute of Advanced Industrial Science and Technology, Japan

Carbon fiber reinforced plastic (CFRP) is attracting attention as a light-weight material at various industrial fields. Developments of rapid forming of CFRP are expected for improvement of productivity. Particularly, in case of CFRP consisted of thermoplastics, the CFRP can be formed by heating. However, the forming is necessary to be long time because the mold is a heating and cooling system. Microwave processing is one of the rapid heating techniques of CFRP because the carbon fibers in CFRP are heated selectively by microwave. However, it is known that metal mold reflects microwave and plastic mold has a problem of precision due to thermal expansion and thermal degradation. On the other hand, ceramic mold not only reflect microwave, but also thermal degradation and expansion are not caused. In this work, we investigated how a rapid forming of CFRP using microwave was achieved from a viewpoint of thermal management of ceramic mold and matrix. The ceramic mold was prepared from ZrO_2 with low thermal conductive property. It was found that the heating emitted from microwave-irradiated CFRP could be storage between molds by controlling microstructure such as sintered grain size, resulting that the CFRP forming was rapidly achieved at 45 sec. One important consequence in this work is that the ceramic technologies are of importance and effectiveness for rapid CFRP forming using microwave.

5:10 PM

(G1-026-2016) Particle size blending effect on the heat transfer property of BN particle packed bed

S. Yamashita*[1]; H. Kita[1]; 1. Nagoya University, Japan

Boron Nitride particles had excellent thermal and physical properties such as high thermal conductivity, low thermal expansion, low friction and high thermal stability. Then, hexagonal graphitic boron nitride (h-BN) was used as heat transfer filler and low friction filler for resin package in electric device or machinable ceramics. However, BN particles was difficult to disperse in water at high volume friction because their strong particle interaction and anisotropic structure. It is difficult to fabricate high dense green body. On the other hands, the heat transfer property of powder packed bed greatly decreased from their dense property because the contact point between particles behaved thermal resistance. In this study, the packing density and heat transfer property of BN packing bed was improved by blending different size of BN particles. The effect of BN particle size and volume friction of BN slurry on packed structure and heat transfer property was investigated.

G2. Functional Nanomaterials for Sustainable Energy Technologies

Functional Nanomaterials for Sustainable Energy Technologies II

Room: York A
Session Chair: Sanjay Mathur, University of Cologne

2:00 PM

(G2-007-2016) Insights from Surface Science into Surface and Interface Properties of Photoelectrocatalysts for Solar Fuels (Invited)

B. E. Koel*[1]; C. X. Kronawitter[1]; P. Zhao[1]; Z. Chen[1]; 1. Princeton University, USA

A surface science approach using well-defined model catalysts and detailed spectroscopic characterization can greatly advance our understanding of the structure and reactivity of photoelectrocatalysts for solar fuels. In studies of thin films of α-Fe_2O_3(0001) for water oxidation catalysis, we found that Ni doping caused a new termination for the films and induced formation of more stable surface-bound OH groups. We also used the well-defined morphologies of Co_3O_4 nanocubes and nanooctahedra to demonstrate that the (111) surfaces vastly out-perform the (100) surfaces for oxygen evolution reaction (OER) activity (overpotential and current density). Finally on GaP(110), a semiconductor that is known to enable selective CO_2 reduction to methanol in aqueous solutions of CO_2 and nitrogen-containing heteroaromatics, we have spectroscopically identified in situ the surface-bound species on GaP(110) associated with exposure to water using ambient pressure photoelectron spectroscopy (APPES), and used low-temperature scanning tunnelling microscopy (STM) to enable orbital-resolved imaging of the adsorbed state of pyridine on GaP(110) and identify the sites susceptible to nucleophilic attack. These observations on model systems afford further analysis and discussion of the role of surface-bound species in mechanisms for catalyzed water oxidation and CO_2 reduction.

2:30 PM

(G2-008-2016) New Design Strategy for Advanced Photocatalysts (Invited)

L. Vayssieres*[1]; 1. Xi'an Jiaotong University, China

Due to global climate change seriously endangering our environment and health and the sharp increase in energy demand from emerging countries, a substantial worldwide renewed interest in the field of materials for renewable and clean energies has occurred within the last decade. However, the high cost of energy production and relatively low efficiency of currently used systems do pose an intrinsic limitation. New materials development and design strategy are required to achieve the necessary increases in power generation and conversion efficiency and so at low cost. A general strategy for the modeling, design and fabrication of low cost metal oxide heteronanostructures consisting of quantum dots and oriented quantum rods-based large bandgap semiconductor structures and devices by low cost aqueous chemical growth will be presented and demonstrated. Moreover, synchrotron-based x-ray spectroscopy studies along with DFT calculation have been carried out to probe the effect of interfacial electronic structure, confinement effects and orbital character and symmetry on the band edges and bandgaps as well as surface chemistry of these advanced oxide-based heteronanostructures. The results reveal important fundamental and applied knowledge of direct relevance for photoelectrochemical and optoelectronic devices as well as for sustainable hydrogen generation from seawater.

3:20 PM

(G2-009-2016) Local Atomic and Electronic Structures of Energy Materials Characterized by Synchrotron X-ray Spectroscopy (Invited)

C. Dong*[1]; 1. Tamkang University, Taiwan

Recent years have witnessed increasing environmental concern and demand for energy. A new era of energy is dawning and material scientists are devoted to search new sources of clean energy. The new energy materials that have efficient energy conversion/generation/storage are the most pressing challenges. In many important energy-material systems such as artificial photosynthesis, nanostructured catalysts, and smart materials, the change of atomic/electronic structure near the interfacial region upon the reaction provide fundamental understanding of physical and chemical properties of a material. Investigation of these interfacial phenomena provides critical information to better design the material and thus optimize its performance. Synchrotron x-ray spectroscopies, including x-ray absorption and x-ray emission spectroscopies can be used to study the local unoccupied and occupied electronic structures. Use of in situ/in operando technique, determination of the change of atomic/electronic structures of the energy material under its operando condition now becomes possible. This presentation will report the emerging in situ/in operando characterization on energy relevant materials by synchrotron x-ray spectroscopy. New characterization tool and a number of recent studies of atomic/electronic structures of energy-related materials will be presented in this talk.

3:50 PM

(G2-010-2016) One-pot synthesis of heterostructured photocatalysts for improved solar-to-hydrogen conversion (Invited)

Y. Chen*[1]; Z. Qin[1]; X. Guan[1]; M. Liu[1]; 1. Xi'an Jiaotong University, China

Photocatalytic hydrogen production has been considered as a promising route for solar energy conversion. However, most of semiconductor photocatalysts own poor activity due to rapid charge recombination. Coupling semiconductors with different energy levels to form heterostructure has been demonstrated to be useful to achieve effective charge separation. The basic requirement for the improved property is to form a high-quality heterojunction. In general, heterostructured photocatalysts are prepared by a two-step route. One component is initially prepared, and the other is coupled via a subsequent physical/chemical treatment. In this case, large amount of individual components can aggregate together, leading to reduced contacts between two phases. Meanwhile, the contact can be loose, since individual components are separately synthesized. The poor contact is detrimental to the charge separation. In our study, a facile one-pot method is introduced to synthesize hybrid photocatalysts, where two phases are intergrown with each other. Strong coupling between different components, together with favorable physicochemical properties can be expected. Compared with those prepared by the common two-step method, heterostructured photocatalysts prepared by the one-pot route showed apparently superior hydrogen generation.

4:20 PM

(G2-011-2016) Fabrication of Low Adsorption Energy Ni-Mo Clusters Co-catalyst in Metal-Organic Frameworks for Visible Photocatalytic Hydrogen Evolution

G. Lu*[1]; 1. Lanzhou Institute of Chemical Physics, China

By using the density-functional theory (DFT) and front molecular orbital (FMO) theory calculation analysis, the hydrogen adsorption free energies on Ni-Mo alloy (458 kJ mol^{-1}) is found to be lower than that of Ni itself (537 kJ mol^{-1}). Inspired by this results, a novel, highly efficient cocatalyst NiMo@MIL-101 for photocatalytic hydrogen evolution reaction (HER) was fabricated by double solvents method (DSM). Compared with Ni@MIL-101 and Mo@MIL-101, the NiMo@MIL-101 exhibited an excellent photocatalytic performance (740.2 μmol per hour for HER), stability and high apparent quantum efficiency (75.7%) under 520 nm illuminations at pH 7. The NiMo@MIL-101 catalyst also showed a higher transient photocurrent, lower over-potential (-0.51V) and longer fluorescence lifetime (1.57 ns). The results uncover the the dependence of photocatalytic activity of HER on the free energy of Ni-Mo ($MoNi_4$) alloy nanocluster, i.e., lower free energy corresponding to higher HER activity for first time. The NiMo@MIL-101 catalyst could be a promising substitute for noble-metals in photocatalytic hydrogen generation.

4:40 PM

(G2-012-2016) Photocatalytic Seawater Splitting on Metal-Nitride Nanowires

X. Guan*[1]; F. Chowdhury[2]; L. Vayssieres[1]; L. Guo[1]; Z. Mi[2]; 1. Xi'an Jiaotong University, China; 2. McGill University, Canada

Photocatalytic water splitting has been considered as a promising way for direct conversion of solar energy into fuels. During the past decades, tremendous efforts have been dedicated to the development of various materials for pure water splitting. However, few studies were carried out in seawater that accounts for 93% of water on earth. Compared to pure water, the abundant Cl^- ions in seawater are kinetically easier to be oxidized, which makes it more attractive for practical applications. In this work, p-type metal-nitride nanowire arrays with controlled surface band bending, which have been previously demonstrated to efficiently split pure water, were applied to photocatalytic seawater splitting without any sacrificial agent. NaCl solution, with the same concentration as in seawater, was used as the solution. It was demonstrated that compared to pure water splitting, H_2 production activity from seawater splitting was enhanced by a factor of 27%. This enhancement could be attributed to the faster oxidation process of Cl^- ions in seawater, which facilitated the separation of charge carriers upon photo-excitation on metal-nitride nanowires. Future work will focus on the detection of oxidation product from Cl^- ions.

5:00 PM

(G2-013-2016) Synthesis of Ca-Al Hydrotalcite with Li^+, K^+, and Ti^{4+} Promoter as Heterogeneous Solid Base Catalyst

E. D. Magdaluyo*[1]; 1. University of the Philippines, Philippines

The layered double hydroxides, commonly known as hydrotalcites, are typically used as solid base catalysts due to their homogeneous interdispersion of elements, high specific surface area and strong basic properties. For biodiesel production process, the Mg-Al hydrotalcite has shown high catalytic activity. In this study, the Ca-Al hydrotalcite was synthesized as possible substitute for Mg-Al hydrotalcite system. The effects of the different promoters such as Li^+, K^+ and Ti^{4+}in the structural properties and infra-red spectral behavior, surface morphology and thermal degradation of the synthesized Ca-Al base material were also investigated. The Ti^{4+} promoter shows best crystallinity and specific surface area, resulting to high catalytic activity in the production of biodiesel from vegetable oil by the transesterification process.

G5. Advanced Materials, Technologies, and Devices for Electro-optical and Medical Applications

Semiconductor II

Room: Trinity V

Session Chairs: Toshio Kamiya, Tokyo Institute of Technology; Eirini Sarigiannidou, Grenoble INP

1:30 PM

(G5-014-2016) Growth of hexagonal boron nitride films on sapphire substrates by the chemical vapor deposition using BCl_3 and NH_3 as sources (Invited)

K. Hara*[1]; N. Umehara[1]; A. Masuda[1]; T. Shimizu[1]; T. Kouno[1]; H. Kominami[1]; 1. Shizuoka University, Japan

The hexagonal BN (h-BN) films were grown by chemical vapor deposition using BCl_3 and NH_3 as sources on c-plane sapphire substrate. The growth at 20 kPa led to the significant improvement of crystalline quality compared to those grown at an atmospheric pressure. The dependence on the growth temperature (T_g) for the low-pressure growth indicated that the crystalline quality is most improved for the sample grown at 1200 °C, in which the uniform in-plane orientation was confirmed. This condition enhanced the lateral growth, resulting in the formation of grains with flat top surfaces. We have also found from the T_g dependence of CL that the structural and luminescent properties are strongly correlated with each other. It is suggested that reducing the growth pressure to 10 kPa improves the luminescence property, resulting in the first observation of the intrinsic exciton emission at room temperature from the h-BN films grown on sapphire substrates.

2:00 PM

(G5-015-2016) Luminous complex point defect structure in Ce doped cubic boron nitride

R. Ishikawa*[1]; N. Shibata[1]; F. Oba[2]; T. Taniguchi[5]; S. Findlay[3]; I. Tanaka[4]; Y. Ikuhara[1]; 1. University of Tokyo, Japan; 2. Tokyo Institute of Technology, Japan; 3. Monash University, Australia; 4. Kyoto University, Japan; 5. National Institute for Materials Science (NIMS), Japan

Cubic boron nitride (cBN) is the hardest material next to diamond and has many mechanical applications because of its excellent chemical stability. cBN is also well known the lightest III-V semiconductor and therefore it should be a promising system for opto-electronic applications. Owing to the strong covalent bonding nature and their small atomic size, it has been extremely difficult to dope luminous elements such as transition metals or rare-earth atoms. Recently we have achieved stable rare-earth doping in cBN host lattice using high-pressure and high temperature (5.5 GPa, 1773 K) flux method, and the millimeter size single crystal exhibits blue-colored luminescence. Here, we show the direct determination of the atomic site and valence state of Ce dopants using sub-angstrom resolution scanning transmission electron microscope imaging and electron energy-loss spectroscopy. Combining with the systematic first-principles calculations, we uncover the mechanism as to how such the huge dopants are accommodated into the strong covalent cBN host lattice. We found the single Ce dopants are randomly distributed but substituted for the anion N anti-site. Moreover, the valence state is determined to be 3+ by single-atom sensitive spectroscopy. Combining with first-principles calculations, we conclude the most preferable defect structure is negatively charged (Ce-4VB)6-, surrounding four B vacancies.

2:20 PM

(G5-016-2016) Synthesis of nitride nanoparticles using $NaNH_2$ melt (Invited)

A. Miura*[1]; M. Higuchi[1]; K. Tadanaga[1]; 1. Hokkaido University, Japan

Nitrides have been attracted as optical, electronic, magnetic and catalytic materials, and their nanoparticles have advantages of their high dispersion and surface area. However, the syntheses of these nitrides often need high temperature treatment under a large amount of toxic ammonia gas, resulting in the growth of crystalline size. Here, we show the low-temperature process for synthesis of indium, manganese and iron nitrides from oxides by using $NaNH_2$ molten salt below 300°C. InN crystals with hexagonal habits below a few nanometer in size were grown in $NaNH_2$ flux using $LiInO_2$ as a starting material. Fe_3N and MnN powders exhibited similar morphology as these of starting oxides. The thermodynamic driving force of this nitridation is the formation of NaOH byproduct. The developed low-temperature process has the advantage to produce nitride nanoparticles by preventing their particle growth.

3:10 PM

(G5-017-2016) Impact of hydrogen doping for defect formation behavior in CZ-Si crystal growth (Invited)

W. Sugimura*[1]; T. Ono[1]; M. Hourai[1]; K. Higashida[2]; 1. SUMCO Corporation, Japan; 2. Kyushu University, Japan

To investigate an effect of hydrogen doping for grow-in defect formation, CZ-Si crystals have grown under hydrogen partial pressure of range from 120Pa to 320Pa. The hydrogen is introduced in silicon influences grow-in defects formation, in particular, an aggregation of dislocation clusters is significantly suppressed. On the other hands, hydrogen forms huge defects in grow-in defects regions.

3:40 PM

(G5-018-2016) Advanced SiC power devices with trench structures and the high temperature operations of these devices (Invited)

T. Nakamura*[1]; 1. ROHM Co., Ltd., Japan

SiC power devices have the potential to reduce energy losses in high power applications. However SiC devices have yet to achieve ideal performance levels. This paper presents SiC MOSFETs with advanced trench structures. These devices succeeded in improving performance by reduction of the internal electric field. Double-trench MOSFETs show extremely low on-resistance. The advantages of the SiC devices shown above are low on-resistance and high temperature operation. We confirmed stable operation at 380°C of SiC MOSFET actually. No degradation of the switching loss was observed at 380°C. Therefore, new assembly technologies are necessary to bring out their maximum potential. To take advantage of these SiC features, many manufacturers have been using case-type designs despite the fact that transfer-molded modules allow for further miniaturization of the module made with materials capable of withstanding temperatures of up to 250°C. This is also because conventional transfer-molded modules have been unable to withstand temperatures greater than 200°C. To make the most of SiC potentials, we have developed a transfer-molded design with a new encapsulation resin which is able to be used at 200°C and above.

4:10 PM

(G5-019-2016) Solution growth of Silicon Carbide: State of the art and perspectives (Invited)

D. Chaussende*[1]; Y. Shin[1]; K. Ariyawong[1]; J. Dedulle[1]; T. Ouisse[1]; E. Sarigiannidou[1]; O. Chaix-Pluchery[1]; 1. CNRS, Univ. Grenoble Alpes, France

4H-SiC (silicon carbide) is considered as the most realistic material for most of the power electronic applications, especially when very high power is required. The growth of SiC ingots from the vapor phase (seeded sublimation method) has established as the industrial process able to encounter the increasing demand of wafers with large diameter (currently 6 inch) and crystalline quality compatible with most applications. The top seeded solution growth (TSSG) method has recently emerged as an alternative for achieving high crystalline quality ingots. Major achievements and current state of the art of TSSG will be presented, with a special focus on growth front stability.

4:40 PM

(G5-020-2016) Al-Si-C ternary alloys: A "new" family of wide band gap semiconductors (Invited)

E. Sarigiannidou*[1]; O. Chaix-Pluchery[1]; H. Le Tran[1]; M. Modreanu[2]; L. Pedesseau[3]; D. Chaussende[1]; 1. Univ. Grenoble Alps, CNRS, LMGP, France; 2. Tyndall National Institute, University College Cork, Ireland; 3. UMR FOTON, CNRS, INSA Rennes, France

The Al-Si-C system contains an important class of ternary ceramic carbides with the general formula $Al_4C_3(SiC)_n$. Because of their high thermal conductivity, high strength and good wear resistance; the Al-Si-C-based ceramic materials are used in both modern power electronics as heat-exchange materials and in weight sensitive applications. Considered the viewpoint of structural materials, it is only recently the electronic structure of Al_4SiC_4 ternary alloy has been investigated theoretically through the ab initio calculations resulting to an indirect bandgap of 1.05eV. The combination of both semiconducting and ceramic type properties makes these compounds "new" candidates for many applications which require wide bandgap, high thermal conductivity, high temperature resistance.... such as power electronics. Our group has achieved the growth of Al_4SiC_4 single crystals in the mm scale that are transparent to visible light indicating a wide band gap in contradiction to the theoretical prediction. The implementation of the crystal growth process of this compound together with the first experimental and theoretical results regarding their physical properties such as electronic or optical will be presented.

G6: Porous Ceramics for Advanced Applications Through Innovative Processing

Advanced Processing Methods and Characterization Technologies of Ceramic Foams II

Room: Trinity I/II
Session Chair: Miki Inada, Kyushu University

1:30 PM

(G6-019-2016) Novel gel casting process for the manufacturing of glass foams (Invited)

E. Bernardo*[1]; A. Rincon Romero[1]; 1. University of Padova, Italy

A new technique for the production of glass foams was developed, based on gel casting. The new process is less expensive and more environmentally friendly than the current procedures, based on glass powders mixed with foaming agents, which decompose and release gases at temperature well exceeding the glass softening point. The alkali activation of soda-lime waste glass allows the obtainment of well-dispersed concentrated suspensions, undergoing gelification by treatment at low temperature (80 °C), owing to the formation of calcium-rich silicate hydrates. An extensive direct foaming was achieved by mechanical stirring of partially gelified suspensions, comprising also a surfactant. The suspensions were carefully studied in terms rheological behavior, so that the final microstructure (total amount of porosity, cell size) can be directly correlated with the degree of gelification. A sintering treatment, at only 700 °C, was finally applied to stabilize the structures, particularly for limiting the leaching of alkaline ions. An extension of the approach to alumino-boro-silicate glass from the recycling of pharmaceutical vials will be presented as well.

2:00 PM

(G6-020-2016) Synthesis of porous carbon materials with hierarchical structure

M. R. Caccia*[2]; D. Zabiegaj[3]; F. Ravera[3]; J. Narciso[1]; 1. Alicante University, Spain; 2. University of Alicante, Spain; 3. National Research Council of Italy, Italy

Hierarchical structures are a breakthrough in porous systems. With these structures more efficient gas storage systems for energy vectors (CH_4 and H_2) can be generated. Activated carbon (AC) has been successfully used for this purposes. While AC powder with tunable porosity and pore size distribution is rather easy to obtain, the production of mechanically stable high-surface monoliths is quite challenging. Attempts of producing ordered microporous monoliths were done by pressing particulate AC with a suitable polymeric binder. This results in a very fragile monolith that cannot withstand real operating conditions. In this work, a novel method is proposed for the production of hierarchal porous materials based on the foaming of an AC colloidal dispersion in presence of a short chain ionic surfactant (CTAB) and Poly(vinyl alcohol) followed by the in situ polymerization by cross-linking with 2,5-dimethoxy-2,5-dihydrofuran (DHF). Particle stabilized wet foams were used as templates for gel-casting, yielding a macroporous structure with microporous AC particles distributed at the surface of the cells. Samples were carbonized to obtain mechanically stable carbon monoliths with macro and micro interconnected porosity. Morphology of the samples was evaluated using SEM. Macropores were investigated using mercury porosimetry and the microporosity was evaluated using N_2 and CO_2 adsorption at 77K and 273K.

2:20 PM

(G6-021-2016) Fracture behavior of Three-dimensionally Networked Porous Carbon Material under Stress Concentration

R. Inoue*[1]; E. Kojyo[1]; Y. Kogo[1]; 1. Tokyo University of Science, Japan

A new type of porous carbon material, three-dimensionally networked porous carbon (TNPC), was developed. The TNPC has open-pore structure with three different average pore size of 7, 10, and 14 μm. Pore volume fraction is ~75%, and apparent density of 0.37 g/cm^3. Different from form materials, uniform pores are connected each other, and almost no closed pores are observed. In this presentation, mechanical properties of the TNPCs under tensile loading will be focused. Double edge notched tension (DENT) specimen with different notch length was prepared. The notch was introduced by a razor blade. The fracture toughness test was carried out using a screw driven mechanical testing machine. After the test, fracture surface was observed using a scanning electron microscope (SEM). TNPC showed linear elastic behavior close to final fracture. A macroscopic crack initiated from notch tips and extended perpendicular to the loading direction just before the maximum load. These fracture behaviors were independent of pore size. Fracture toughness calculated from maximum load was 0.1-0.5 MPam$^{1/2}$, which are higher than that of conventional porous carbon material. In addition, fracture toughness of TNPC strongly depends on pore size. In this presentation, the effect of pore size on fracture toughness of TNPC will be discussed based on the experimental results.

2:40 PM

(G6-022-2016) Radiative properties of silicon carbide open-cell foams up to 1300 K: A multi length-scale modelling approach

B. Rousseau*[1]; S. Guevelou[1]; A. Mekeze-Monthe[1]; G. Domingues[1]; J. Vicente[2]; A. Fussel[3]; D. Haase[3]; J. Adler[3]; L. Del Campo[4]; D. De Sousa Meneses[4]; 1. LTN UMR CNRS 6607, France; 2. IUSTI UMR CNRS 7343, France; 3. Fraunhofer IKTS, Germany; 4. CEMHTI UPR CNRS 3079, France

Knowledge of the thermal radiative properties of refractory open-cell foams under air are mandatory in order to determine heat transfers within high-temperature systems (T~1300 K) in which they are involved. However, up to now, only room-temperature spectral radiative properties are easily available for these materials because their high-temperature experimental characterizations are difficult to lead. Alternatively, multi-length scale modelling based on the handling of 3D digitalized images allow to simultaneously take account of intrinsic optical parameters at the struts scale and extrinsic textural parameters at the foam scales. In the following infrared emission spectroscopy measurements performed on alpha silicon-carbide single crystals will be used to extract the spectral dependence of the complex refractive indices up to T = 1300 K. These data will be then applied to predict the thermal radiative properties of open-cell foams with growing porosities and nominal pore diameters through a numerical code based on a Monte Carlo Ray Tracing procedure. Special precautions will be taken to conduct the numerical calculations within exact Representative Elementary Volumes. Results will be discussed by bearing in mind the effects of oxidation.

Novel Developments and Engineering Applications of Porous Ceramics

Room: Trinity I/II

Session Chairs: Alberto Ortona, SUPSI; Ulrich Vogt, Empa, Swiss Federal Laboratories for Materials Science and Technology

3:20 PM

(G6-023-2016) Solar-Thermal Redox Reaction for Syngas Production on CeO_2 Foam Ceramics (Invited)

U. F. Vogt*[1]; A. Bonk[1]; M. V. Schlupp[1]; C. Battaglia[1]; A. Steinfeld[2]; 1. Empa, Swiss Federal Laboratories for Materials Science and Technology, Switzerland; 2. ETH Zürich, Switzerland

H_2O and CO_2 can be reduced to H_2 and CO by a CeO_2 based solar thermochemical RedOx reaction. Due to its excellent high temperature-, thermodynamic-, and kinetic properties, cerium dioxide is a very promising metal oxides for this application. In a 2-step solar thermochemical cycle, above 1400°C and under oxygen deficient atmosphere, Ceria releases oxygen from its lattice by forming oxygen vacancies ($CeO_{2-\delta}$). In a following step below 1000°C, the oxygen vacancies react with H_2O and CO_2 to form H_2 and CO. Stoichiometric CeO_2 is regained and the RedOx cycle closed. Doping of CeO_2 with tetravalent cations ($M_xCe_{1-x}O_{2-d}$, M = Hf, Zr) was investigated to prove the impact on Redox properties, phase stability and microstructural development. As the transport of concentrated solar energy to the reactants H_2O and CO_2 as well as the removal of H_2 and CO is essential, CeO_2 based reticulated porous ceramics (RPC) with dual scale porosity, based on carbon pore formers, have demonstrated high conversion efficiencies for this Solar to Fuel conversion process.

3:50 PM

(G6-024-2016) Kinetic approach for the adsorption-photodecomposition properties of mesoporous silica-titania (Invited)

M. Inada*[1]; K. Hayashi[1]; J. Hojo[1]; 1. Kyushu University, Japan

We have fabricated mesoporous silica-titania by a sol-gel method and evaluated the photocatalytic activity using acetaldehyde. The synthesized mesoporous silica-titania was effective for the removal of acetaldehyde from gas phase by adsorption and photodecomposition. In this study, the kinetic approach was carried out in order to clarify the adsorption-photodecomposition property of mesoporous silica-titania. The adsorption, direct photodecomposition and concerted adsorption-photodecomposition can be separately described in our simulation curves, which indicates that the adsorbability strongly affects the removal of acetaldehyde in the early stage and the photodecomposition after the strong adsorption of acetaldehyde on mesoporous silica-titania is important for the complete removal of acetaldehyde from gas phase.

4:10 PM

(G6-025-2016) Optimized Ceramic for Hypersonic Applications with Transpiration Cooling - OCTRA (Invited)

C. Dittert*[1]; M. Kütemeyer[1]; 1. DLR - German Aerospace Center, Germany

High temperature management is a key technology to enable sustained hypersonic flight. The research focus for the Institute of Structures and Design in this field lies on both high temperature ceramic matrix composites (CMC) and active thermal management. This paper addresses the development of porous fiber reinforced ceramic material. Since porous material can be used for active cooling, as porous injectors or as ultrasonically absorptive TPS material. These applications are of fundamental importance for the realization of a hypersonic vehicle, since the requirements for these applications are high temperature resistance, mechanical strength and oxidation resistance. Due to its natural permeability, Carbon/Carbon (C/C) was the material of choice for these applications. However, C/C has several disadvantages. Besides the structural weakness, the low oxidation resistance is a problem. To solve these problems, this paper will introduce a new material development, so called OCTRA, based on C/SiC fiber reinforced ceramics. Contrary to the C/SiC, the porosity and permeability of OCTRA can be adapted. The optimization of the material is achieved through a selective insertion of cavities into the fabrics. This paper describes the processing and characterization of the material. Finally, OCTRA will be compared to C/C and the potential for the introduced hypersonic application will be assessed.

4:30 PM

(G6-026-2016) Loop heat pipe wicks of biomorphous SiC ceramic

B. Weisenseel[1]; B. Zierath[1]; P. Greil[1]; T. Fey*[1]; 1. Friedrich-Alexander University Erlangen-Nürnberg, Germany

As a novel wick material for flat evaporator loop heat pipes (LHP), biomorphous silicon carbide (SiC) is a compromising candidate. This easily machinable ceramic can be modified with macroscopic channel networks aligned parallel or orthogonal to the heated surface. Its thermal resistance and start-up behavior was tested in a special custom build LHP. Different to commercial heat pipes a wick change is possible to test different materials in the same setup. Thermal performance of the ceramic structures are compared to a reference bronze (CuSn10-alloy) wick. A minimum thermal resistance of 0.4225 °C/W was obtained for unmodified SiC at a stable start-up power input of 200 W. Horizontal macro channels lead to an improved thermal resistance of 0.3875 °C/W, instead vertical channels increased the thermal resistance to 0.4475 °C/W, but reduced the input power down to 50 to 25 W. Comparing the thermal performance of unmodified and modified SiC wicks with the commercial optimized metallic reference CuSn10 0.3975°C/W the non-optimized biomorphous silicon carbide shows even a 2.5% higher performance. Further optimization of the wick will lead to higher performance increase.

4:50 PM

(G6-027-2016) Reactivity of SiC single crystal with Ir at high temperature

A. Camarano[3]; D. Giuranno[2]; E. Ricci[2]; J. Narciso*[1]; 1. Alicante University, Spain; 2. CNR-IENI, Italy; 3. University of Alicante, Spain

One of the problems that are still present today is the use of at high temperature catalysts. Catalytic systems consist of catalyst is the active phase, and a support which serves to disperse the active phase to increase efficiency. The only support that can work at temperatures around 1000-1200 ° C is the SiC, especially in adverse conditions. While it is well known that noble metals, especially Pt, catalyze the combustion reactions. Nevertheless the Pt-SiC system operates properly only intermediate temperatures (700-800 ° C) because the two components react at temperatures above 900 ° C. Nonetheless energy efficiency is greater the higher the combustion temperature, so it is necessary to find a catalyst system that can work at high temperatures still one of the candidates is the system Ir-SiC. The main objective of this paper is to explore the limits of stability in the system Ir-SiC. To do this we studied the reactions that take place between these two compounds in the range of temperatures comprised between 1200 and 1450 ° C. The reactions were conducted in experimental equipment devoted to measuring the contact angle. It has been determined that the system is stable up to temperatures of 1200 ° C, and at temperatures above 1400 ° C causes the apparition of a liquid Ir. Morphology and the microstructure of the samples was evaluated using SEM. For the evaluation of the reaction products micro-XRD has been used.

5:10 PM

(G6-028-2016) Porous alumina derived from the mixed powder including aluminum and alumina

K. Kita*[1]; M. Fukushima[1]; N. Kondo[1]; 1. National Institute of Advanced Industrial Science and Technology (AIST), Japan

By using the mixed powder including aluminum and alumina, the porous ceramics could be obtained easily. The value of open porosity of the ceramics after sintering at 1600 degree C was 30 vol% over and the compressive strength of the ceramics was about 285 MPa. The neck area of the ceramics sintered at 1200 degree C consisted of aluminum silicate and that sintered at 1600 degree C consisted of mullite. Moreover, the volume of the ceramics after sintering at 1600 degree C was expanded compared with that before sintering.

G8. Multifunctional Coatings for Sustainable Energy and Environmental Applications

Coatings for Energy and Environmental Applications

Room: York B

Session Chairs: Kentaro Shinoda, National Institute of Advanced Industrial Science and Technology (AIST); Tetsuya Yamamoto, Kochi University of Technology; Minoru Osada, National Institute for Materials Science

1:30 PM

(G8-008-2016) Highly Transparent Scratch-resistant Coating using Aerosol Deposition Process (Invited)

J. Park*[1]; D. Kim[1]; M. Lee[1]; J. Lim[1]; S. Oh[1]; 1. IONES, Republic of Korea

In recent, advanced surface modifications in, semiconductor equipment, car components, medical-coating and energy device industry would be developing with novel powder coating technology based on kinetic powder spray including aerosol deposition (AD), cold spray (CS), warm spray (WS), nano particle deposition (NDP) and room temperature granule spray in vacuum (RTGSV) as well as solution plasma spray (SPS) and so on. Also, such advances in surface engineering technologies have resulted in more complicated surface properties from micro- and nanometer scales, including the morphology, chemistry, crystal structure, physical, and mechanical properties. In this study, we experimentally demonstrate the highly transparent and scratch-resistant coating using aerosol deposition (AD) process for against to circumstantial damages complicated objects. Therefore, we will also present on AD processed sapphire layer for mobile cover glass.

2:00 PM

(G8-009-2016) Insulating Ceramic layers Prepared by Aerosol Deposition for Heat Dissipation Circuit Boards of High Power Devices

J. Akedo*[1]; H. Tsuda[1]; 1. AIST, Japan

High breakdown insulating ceramic layer is demanded for high power electronics devices such as circuit board in the inverter modules of hybrid automobiles and heat dissipation substrates of high power LED array illumination, if the ceramic layer has strong adhesion with the metal substrate. An aerosol deposition(AD) method based on an impact adhesion of the fine particles for forming of thick ceramic layers can be deposited ceramic thick films on metal substrates (e.g. Al, Cu and so on) directly because of room temperature process. Therefore, high performance heat dissipation circuit board without the solder are expected to be created by AD method. In this study, a-Al2O3 dense ceramic layers with a thickness of 10-30 um were deposited on Al and Cu substrates by the AD method, and their insulating and mechanical properties have investigated. The breakdown voltage was reached over 4kV, respectably.

2:20 PM

(G8-010-2016) Erosion Behavior of Yttrium Oxide film prepared by Aerosol Deposition Method in the Plasma Process

H. Ashizawa*[1]; M. Kiyohara[1]; 1. TOTO Ltd., Japan

Aerosol deposition (AD) method is a technology for ceramics coating with impact consolidation at room temperature. The Y_2O_3 film prepared by AD method has highly dense structure of nano crystal grains. AD Y_2O_3 film has been used for plasma resistance coating and has helped to reduce the generation of particles in plasma etching device. We investigated plasma erosion behavior of AD Y_2O_3film compared with dense sintered Y_2O_3 bulk. Samples were exposed with CF_4/O_2 plasma for 2 hours. The plasma exposed surface of erosion depth, surface roughness (A stylus-type surface roughness meter), elemental composition (XPS) and microstructure (laser microscope and SEM) were evaluated. The erosion depth and elemental composition were not much different between AD Y_2O_3 film and sintered Y_2O_3bulk. On the other hand, the roughness and microstructure were obviously different. The roughness and crater size which were formed by plasma erosion of AD Y_2O_3 film were smaller than those of sintered Y_2O_3 bulk. The difference of erosion behavior between AD Y_2O_3 film and sintered Y_2O_3 bulk was caused by the structure of crystal grain. We consider that nano crystal grains structure which is characteristic of AD Y_2O_3 film is effective for reducing the generation of particles.

2:40 PM

(G8-011-2016) Sintering of YOF Ceramics and Their Properties (Invited)

K. Yoshida*[1]; T. Tsunoura[1]; T. Yano[1]; 1. Tokyo Institute of Technology, Japan

Structural and coating materials with excellent plasma resistance have been required for semiconductor production equipment. Alumina (Al_2O_3) and yttria (Y_2O_3) have been conventionally used as parts inside the chamber of semiconductor production equipment. Present authors have paid attention to yttrium oxyfluoride (YOF) as a novel ceramic material applied for semiconductor production equipment because YOF is expected to be a higher plasma resistant material than Y_2O_3 and yttrium fluoride (YF_3). In this study, YOF ceramics were sintered by pressureless-sintering and hot-pressing, and their sintering behavior was evaluated. In addition, their mechanical and thermal properties such as hardness, fracture toughness, elastic modulus, bending strength, thermal expansion, and thermal conductivity were studied. Furthermore, plasma resistance of YOF ceramics against CF_4-O_2 plasma was investigated. From the results, it is suggested that YOF showed enough mechanical properties and excellent plasma resistance to be used in semiconductor production equipment.

3:30 PM

(G8-012-2016) Enhanced Li ion conductivity of sulfide solid electrolyte films by aerosol deposition method and its application to all-solid-state Li ion batteries

M. Suzuki*[1]; T. Takemoto[2]; Y. Ishiguro[2]; J. Akedo[1]; 1. National Institute of Advanced Industrial Science and Technology, Japan; 2. Toyota Motor Corp., Japan

In order to obtain enhanced battery performances, application of sulfide solid electrolyte (SE) films with binder-free to all-solid-state Li ion batteries has been strongly demanded. Since an aerosol deposition (AD) method based on room temperature impact consolidation (RTIC) phenomena allows us to supply fully-dense ceramic films of simple or complex composition at a room temperature, it has been regarded as a promising process for obtaining remarkable battery performances. In this study, we prepared the SE films by the AD method (AD-SE films) and by a conventional wet coating process, respectively. Their Li ion conductivities and microstructures have been investigated. Both of the films had fully-dense microstructure after the press process. Compared with the SE films fabricated by the conventional wet coating process required use of binder, the AD-SE films represented the superior Li ion conductivity, which was almost the same as that of starting raw powder. The highly Li ion conductivity of the AD-SE films is attributed to the fact that AD method can deposit the SE films with binder-free. Additionally, we demonstrated that the Li ion batteries with use of AD-SE films indicated a large calculated capacity density of 434 Wh/L and a high calculated energy density of 3.0 kW/L.

3:50 PM

(G8-013-2016) Photocurrent and Photovoltaic Properties of $BiFeO_3$ Thin Films on ITO/Glass Substrates Prepared by Chemical Solution Deposition

W. Sakamoto*[1]; T. Katayama[1]; K. Hayashi[1]; T. Yogo[1]; 1. Nagoya University, Japan

Multifunctional $BiFeO_3$-based materials have been extensively studied because of their potential application in several novel devices. In such a situation, $BiFeO_3$ has recently been receiving much attention for its photovoltaic properties under visible light irradiation. Photo-induced electrical properties of $BiFeO_3$-based perovskite oxides are strongly related to their optical properties (including the band gap) and ferroelectric domain configuration. On the other hand, when we apply such materials in photovoltaic devices, thin-film fabrication onto transparent glass-based substrate is very important. In this study, preparation of $BiFeO_3$ thin films on ITO/silica glass substrates was performed by chemical solution deposition. Similar photocurrent behavior and photovoltaic effect of $BiFeO_3$ thin film on Pt/Si under visible light irradiation were observed for the $BiFeO_3$/ITO/silica glass. For further enhancement of the photo-induced properties, Al-doped ZnO/$BiFeO_3$-layered thin films were fabricated on ITO/silica glass. The layered films exhibited approximately hundredfold photocurrent compared to the $BiFeO_3$ single-layer films. The large photocurrent is attributed to the formation of Al-doped ZnO(n-type)/$BiFeO_3$(p-type) p-n junction in the layered films. The mechanism of photo-induced properties enhancement of the synthesized films are also discussed.

4:10 PM

(G8-014-2016) Functional Ceramic Coatings by Solution Precursor Plasma Spray Deposition

T. Coyle*[1]; Y. Gazman[1]; Y. Cai[1]; P. Xu[1]; J. Mostaghimi[1]; 1. University of Toronto, Canada

Solution precursor plasma spray deposition is a thermal spray process capable of producing deposits with nanocrystalline grains and a large fraction of uniform, micron and sub-micron scale porosity. Therefore applications which require high surface area and highly active fine particles are of particular interest. We will describe the deposition of a variety of functional ceramic coatings and preliminary data regarding their properties of interest for specific applications, including MoO_3 and Mo_2N for pseudo-capacitors electrodes, $LiFePO_4$ for battery electrodes, and super-hydrophobic transition metal oxide coatings.

4:30 PM

(G8-015-2016) Development of Innovative Atmospheric-Pressure Epitaxial Growth Technique “Mist Chemical Vapor Deposition” based on Leidenfrost state droplets (Invited)

T. Kawaharamura*[1]; 1. Kochi University of Technology, Japan

Various electronic devices make our lives comfortable and prosperous in the past several decades. Recently, development of energy saving devices have been promoted, considering the influence on the environment. However, thin film fabrication processes for the devices are operated under vacuum condition, and are hard to say that energy saving has been investigated. Therefore, the transformation from vacuum to non-vacuum thin film fabrication processes has attracted great attention in order to reduce environment load. Thus, we have developed an open-air atmospheric-pressure solution-based thin film fabrication technology using mist droplets, called Mist Chemical Vapor Deposition (Mist CVD). In the development of mist CVD, we have developed a high level control technology of precursor flow and ambient temperature with the invention of novel mist gas straightener and reactor for preparing uniform thin films and the use of Leidenfrost state droplets for obtaining high-quality thin films. As the results, mist CVD has been established successfully as a fabrication technology of large-area uniform and high-quality thin films under atmospheric pressure. Mist CVD could be a driving force in the future device fabrication towards a green and sustainable industry. We would like to report in detail and discuss them in the meeting.

5:00 PM

(G8-016-2016) Advanced Phosphor Thin Films fabricated by Photoinduced Chemical Solution Deposition

T. Tsuchiya*[1]; T. Nakajima[1]; Y. Uzawa[1]; 1. National Institute of Advanced Industrial Science and Technology (AIST), Japan

In order to decrease the power consumption for the lightning system, recently, LED device has been developed. However, LED exhibits strong light emission from the point light source, it is difficult to control the homogeneous flat elimination. Cathodoluminescence and electroluminescent devices displays the flat lightning with higher resolution and higher brightness. Rare earth ions doped semiconductors such as ZnO, ZnS SnO_2, β-Ga_2O_3 thin films etc. have received special attention due to their applications in thin-film electroluminescent (TFEL) devices, or cathodoluminescence devices. For the development of the new optical devices, our strategies are the preparation of the epitaxial thin film and flexible thin film. To achieve these aims, we have developed the photo-induced chemical solution deposition such as excimer laser-assisted metal organic deposition (ELAMOD)and photo reaction of nano-particle method (PRNP) for the preparation of the patterned metal oxide thin film on organic, glass and single crystalline substrates. In this presentation, we will talk about epitaxial phosphor thin film and flexible thin film by using the photo-induced chemical solution deposition, and its prominent Properties of the thin films.

5:20 PM

(G8-017-2016) Transfer process of epitaxially grown piezoelectric $BaTiO_3$ thin films to flexible polymer sheets

H. Nishikawa*[1]; M. Yokura[2]; S. Kaneko[3]; T. Endo[4]; 1. B.O.S.T., Kinki Univ., Japan; 2. Grad. School Eng., Mie Univ., Japan; 3. Kanagawa Ind. Technol. Center, Japan; 4. Fac. Eng., Gifu Univ., Japan

Since the report of transparent flexible thin-film transistors consisting of oxide materials, the field of flexible oxide devices has been rapidly developing. Because the polymer sheets have low heat-resistive property, the key of the studies has been to reduce the growth temperature. In order to realize the low growth temperature, one of the most conventional studies is to explore an amorphous oxide material with excellent properties. On the other hand, one of the most “traditional” applications of the oxide materials has not been examined yet in this field, i.e., harmonization of the various electronic functions. To realize the application, multilayered epitaxial oxide system is required. However, the epitaxial growth of the functional oxides is impossible on the flexible polymer sheet due to its low heat-resistive property. In this study, we propose a process to prepare the epitaxial thin films of piezoelectric $BaTiO_3$ (BTO) on flexible polymer sheets. An epitaxial BTO thin film was deposited on MgO (100) by pulsed laser deposition. The thin film surface was then bonded to polymer sheet using a direct bonding with oxygen plasma irradiation. The sample was soaked in phosphoric acid aqueous solution to dissolve the MgO. By the process, the epitaxial BTO bonded to the flexible polymer remains. The piezoelectricity of the BTO thin films on flexible polymer sheets are reported.

H2: Design and Development of Advanced Ceramic Fibers, Interfaces, and Interphases in Composites- A Symposium in Honor of Professor Roger Naslain

SiC/SiC and C/C Composite Materials / Interfaces and Interphases in CMCs

Room: Salon D

Session Chairs: Bernd Clauss, DITF; Andreas Noeth, Fraunhofer ISC; Weigang Zhang, Institute of Process Engineering/CAS

1:30 PM

(H2-008-2016) From Hybrid Polymers to Composite Ceramics: Metallocenes Catalytic Insertion Polymerization of Silenes (Invited)

W. Zhang*[1]; M. Ge[1]; X. Lv[2]; Y. Tian[2]; S. Yu[1]; 1. Institute of Process Engineering/CAS, China; 2. University of Chinese Academy of Sciences, China

A novel hybrid polymer of polymetallocenenecarbosilanes (PMCS) was synthesized via metallocenes (Ti, Zr and Hf) catalytic insertion polymerization during dechlorination of dichloromethylesilanes by sodium. Pyrolysis of these polymers leads to formation of composite ceramics of SiC-MC in the form of continuous ceramic fiber or composite matrix. Microstructure investigation of these SiC-ZrC composite ceramics indicate that nanoscale ZrC and ZrB_2 particles are dispersed in continuous SiC. These kinds of homogeneously dispersed composite ceramics have better oxidation resistance and thermal stability than pure SiC.

2:00 PM

(H2-009-2016) HRTEM investigation of local damage mechanisms at fiber/matrix interface of SiC/SiC composites

C. Fellah*[1]; J. Braun[1]; S. Poissonnet[1]; M. Berger[2]; C. Sauder[1]; 1. CEA, France; 2. MINES ParisTech, France

The behavior of fiber/matrix bonding leading to poor/fair damage tolerance of SiC/SiC composites was investigated through the observation of the local damage mechanisms in this interface region. SiC_f/SiC_m composites reinforced with last generation small diameter SiC fibers are promising candidates for thermomechanical applications in nuclear environments. The ability of these SiC_f/SiC_m composites to sustain damage is dictated by the fiber/matrix coupling mode, achieved through a pyrolytic carbon (PyC) interphase. In this study, opposite coupling behaviors were compared. Push-out tests were conducted on SiC/SiC composites. Indented fibers were extracted by FIB (Focused Ion Beam) and the microstructural organization of the carbon interface around a dislodge fiber were analyzed by HRTEM (High Resolution Transmission Electronic Microscopy).

The experimental results have demonstrated the key role of the characteristics of SiC fibers surface and of its structure of carbon rich multi-layers on the macroscopic mechanical behavior of the SiC/SiC composite. It has also been proved that crack deflection occurred near the fiber/PyC region rather than near the matrix/PyC one. This technique is promising for the understanding and the improvement of the interfacial properties of the ceramic composite materials.

2:20 PM

(H2-010-2016) The micro-scale and macro-scale crack propagation behaviors of SiC nanowires reinforced SiC_f/SiC composites

J. Hu*[1]; S. Dong[1]; 1. Shanghai Institute of Ceramics, Chinese Academy of Sciences, China

SiC nanowires (SiCNWs), grown on fiber surface via chemical vapor deposition method, were introduced into the microscale matrix of SiC_f/SiC composite to alleviate properties dominated by brittle matrix. In this work, the mechanical properties of microscale areas, such as fiber-matrix interface, SiCNWs reinforced matrix, and fiber-SiCNWs-Matrix in SiCNWs reinforced SiC_f/SiC hybrid composite were evaluated. A combination of Vickers indentation and nanoindentation technique was adopted to elucidate the relationship between microscopic and macroscopic mechanical properties of composite. Nanoindentation was used to test the interfacial bonding strength between fiber and matrix and the hardness of matrix embedded with SiCNWs. Vickers indentation was used to study the failure behavior of fiber-SiCNWs-matrix units. In addition, the crack propagation behavior of microscale regions were also evaluated using the indentation methods. The evolutions of transverse cracks and interlaminar cracks under varied strains were performed to verify the crack propagation limit by SiCNWs.

2:40 PM

(H2-011-2016) Mechanical properties of three-dimensional carbon/carbon composites with vertically-aligned carbon nanotubes

Q. Song*[1]; L. Feng[1]; H. Li[1]; 1. Northwestern Polytechnical University, China

Vertically-aligned carbon nanotubes (CNTs) were grown in situ on the surface of carbon cloths and then the hybrid cloths were stacked and densified by chemical vapor infiltration to obtain 3D C/C composites. Effects of the length (5.2–21.8 μm) of aligned CNTs on the microstructures and mechanical properties of the composites were investigated. Results show that aligned CNTs not only directly stiffen the matrix within the reach of CNTs, but also give indirect reinforcement to the matrix out of the reach of CNTs by inducing the formation of small granular pyrocarbon that interlock with each other. Both the direct and indirect reinforcements on the matrix can be dramatically increased by extending CNT length. Therefore, 3D C/C composites with 21.8 μm-long CNTs show the most notably improvements of matrix-dominated mechanical properties: 63 % and 275 % improvements in out-of-plane and in-plane compressive strength; meanwhile, 13 % improvements in fiber-dominated flexural strength. Compared with z-pinning and stitching, the use of vertically-aligned CNTs would pave a meaningful way for effectively improving the global mechanical performance of woven-fabric C/C composites.

3:20 PM

(H2-012-2016) The Role of Interfaces and Interphases in Life Limiting Behavior of Ceramic Composites

R. J. Kerans*[1]; 1. Air Force Research Lab, USA

Much of the life-limiting behavior of SiC-based ceramic composites is intertwined with degradation of the fiber/matrix interface region. The progression of damage is affected by incidental matrix cracking, intermediate temperature effects, fatigue mechanisms, interaction of fatigue and oxidation, and wear characteristics of the fibers and fiber coatings. While many of the details of the convolved mechanisms remain speculative, it is informative to consider the likely progression toward failure with an eye towards more definitive experimental and modeling work. Consideration of this progression also suggests approaches to design and life management for improved life.

3:40 PM

(H2-013-2016) BN interphases processed by LPCVD with different microstructures and characterized using SiC/SiC minicomposites

C. Chanson[2]; S. Jouannigot[1]; E. Martin[3]; S. Jacques*[1]; 1. CNRS, France; 2. LCTS - CNRS, France; 3. University of Bordeaux, France

Three BN interphases were deposited in Hi-Nicalon S fiber tows by low pressure chemical vapor deposition (LPCVD) from NH_3 and BCl_3 before the SiC matrix deposition. The first two interphases called “BN-900” and “BN-1200” were deposited at a constant temperature of 900 and 1200°C, respectively. The third one called “BN-3” was deposited by varying the temperature from 900 to 1200°C and then to 900°C while maintaining a constant precursor gaseous flow in the LPCVD reactor. From transmission electron microscope observations, interphase BN-3 appears to be made of 3 layers with different textures. The first layer and third layer, both deposited at 900°C, are poorly organized and crystallized on the contrary to the second layer deposited at 1200°C. Thus a structural gradient is evidenced in interphase BN-3. No differences in mechanical behavior emerge from unidirectional minicomposite tensile tests at room temperature between the three interphases. However, the interfacial shear stress obtained from push-out tests is three times higher for interphase BN-900 than for interphase BN-1200, while that for interphase BN-3 is in between. During both tensile and indentation tests a debonding occurs preferentially at the interface fiber/interphase, close to the interphase/matrix interface and in the middle of the interphase respectively for interphases BN-900, BN-1200 and BN-3.

4:00 PM

(H2-014-2016) Rare earth disilicate fiber coatings for SiC/SiC CMCs: Coating process design and evaluation

P. Mogilevsky*[2]; E. E. Boakye[2]; T. Key[2]; M. Cinibulk[1]; R. Hay[1]; S. Opeka[2]; 1. Air Force Research Laboratory, USA; 2. UES, Inc., USA

Rare-earth disilicates ($RE_2Si_2O_7$) are considered as potential oxidation-resistant alternatives to carbon or BN fiber coatings for SiC/SiC CMCs. Measurements of their mechanical properties (hardness and modulus), thermal expansion, and sliding stress and debond energies of SCS-0 SiC fibers in rare earth disilicate matrices support this assertion. However, so far there has been no experimental proof of concept demonstration that rare earth disilicates will indeed work as a weak interface in fiber-reinforced SiC/SiC CMCs, since no technology currently exists to deposit RE disilicate coatings on thin SiC fiber tows. In this report, a thermodynamic analysis is presented for making in-situ rare earth disilicate coatings on SiC fibers from available precursors. Based on this analysis, different processing routines are then proposed and discussed along with TEM/XRD/SEM data on the morphology and phase composition of the resulting coatings.

4:20 PM

(H2-015-2016) Processing of $RE_2Si_2O_7$ Fiber–Matrix Interphases for SiC–SiC Composites

E. E. Boakye*[2]; P. Mogilevsky[2]; T. A. Parthasarathy[2]; K. Keller[2]; T. Key[2]; S. Opeka[2]; R. Hay[1]; M. Cinibulk[1]; 1. Air Force Research Laboratory, USA; 2. UES Inc., USA

Rare-earth disilicates ($RE_2Si_2O_7$) are potential oxidation-resistant alternatives to carbon or BN fiber coatings for SiC/SiC CMCs. Hardness values of 5.5-7 GPa were determined for α, β, γ-$Y_2Si_2O_7$ and γ-$Ho_2Si_2O_7$. The sliding stress and debond energies of SCS-0 SiC fibers incorporated in α-, β, and γ-$RE_2Si_2O_7$ matrices were measured by fiber push-out test. The average sliding stress values of 30 – 50 MPa and debond energies of 2 – 4 J/m^2 are indicative that $RE_2Si_2O_7$ may function as a weak oxidation-resistant interface in SiC/SiC composites. The application of $Re_2Si_2O_7$ coatings in SiC/SiC composites will require coatings on fiber tows. The formation of dense, uniform, and continuous coatings that retain fiber strength is desired. This presentation will discuss coatings of $RE_2Si_2O_7$ on Hi-Nicalon S fibers. The tensile strengths and fractography of Hi-Nicalon S/ $RE_2Si_2O_7$/SiC minicomposites will also be discussed.

4:40 PM

(H2-016-2016) Fiber Interface Coatings via UVCVD for High Temperature Fiber-reinforced Ceramic Matrix Composites

J. Stiglich*[1]; B. Williams[1]; J. Brockmeyer[1]; V. Arrieta[1]; 1. Ultramet, USA

Ultraviolet-activated chemical vapor deposition (UVCVD) is a rapid, low cost method of applying oxide, nitride, and multiple-layer interface coatings to carbon and silicon carbide fibers at temperatures as low as 200°C, thus avoiding problems associated with fiber damage during conventional high temperature deposition. The broad selection of interlayer coating materials allows in-service fiber protection to be optimized for specific high temperature combustion environments. The thin, strain tolerant, fully dense, and high-purity coatings applied by UVCVD exhibit few defects and enhance fiber load distribution. UVCVD coatings have been effectively applied to individual fiber tows as well as woven and braided fabric. Continuous coating reactors have also been demonstrated. Ultramet's use of interface coatings on fibers is mainly directed to the fabrication of fiber-reinforced ceramic matrix composites used in advanced rocket and turbine engines to significantly increase safety, enhance performance, reduce weight, improve durability, and lower total fabrication cost. UVCVD interface coating processing and the results of hot-gas testing of ceramic composites with the fiber interface coatings will be presented.

5:00 PM

(H2-017-2016) Preparation of CVD-SiBCN coatings and its effects on the oxidation resistance of SiC_f/SiC composites

J. Li*[1]; 1. National University of Sciences and Technology, China

SiBCN coatings were deposited on KD-II SiC fibers by chemical vapor deposition (CVD) using lab-produced borazine and liquid polycarbosilane(LPCS) as precursors.The deposited coatings were characterized by scanning electron microscopy (SEM), Electronic Differential System(EDS), X-ray diffraction (XRD) and High Resolution Transmission Electron Microscopy(HRTEM). The microstructure of CVD-SiBCN coatingscrystallization state of CVD-SiBCN coatings and its effects on the oxidation resistance of SiC_f/SiC composites fabricated by polymer infiltration pyrolysis (PIP) process were investigated.The results revealed that the oxidation resistance of SiC_f/SiC composites was improved by adding SiBCN interphase.The reason that the SiBCN interphase exhibited better oxidation resistance was discussed.

H3. Innovative Design, Advanced Processing, and Manufacturing Technologies

Innovative Design III

Room: Bay

Session Chairs: Alexey Kulik, STR Group, Inc.; Dileep Singh, Argonne National Lab

1:30 PM

(H3-017-2016) Three-Dimensional Multi-Reinforced Ceramic Composites with Enhanced Through-Thickness Thermal Conductivity (Invited)

C. Xu*[1]; 1. Florida State University, USA

Traditional fiber reinforced ceramic matrix composites have demonstrated excellent in-plane mechanical properties, however, bearing considerate weak inter-laminar fracture toughness, which significantly limit their broader application when through-thickness properties are needed. In this paper, we proposed a new manufacturing method to fabricate one kind of three-dimensional multi-reinforced ceramic matrix composites where carbon nanotubes are embedded within the orthogonal direction's inter-bundle of each carbon fiber sheet and also are infiltrated in between each two adjacent carbon fiber sheets. This manufacturing method is low cost and does not involve any chemical reaction, and materializes a true three-dimensional composite structure without necessity of altering anything to carbon fiber sheet. The high thermal conductivity of the CNTs in the thickness direction improves the transverse thermal conductivity of the composite by about 30%. This paper also focus on simulation analysis for the enhanced thermal property.

2:00 PM

(H3-018-2016) Processing of Tyranno ZMI fiber/$TiSi_2$–Si matrix composites for high-temperature structural application (Invited)

T. Aoki*[1]; T. Ogasawara[3]; T. Tsunoura[2]; K. Yoshida[2]; T. Yano[2]; 1. Japan Aerospace Exploration Agency, Japan; 2. Tokyo Institute of Technology, Japan; 3. Tokyo University of Agriculture and Technology, Japan

A Tyranno ZMI fiber/$TiSi_2$–Si matrix composite was fabricated via melt infiltration (MI) of a Si–16at%Ti alloy at 1375°C under vacuum. The Si–Ti alloy was used as an infiltrant to conduct MI processing below 1400°C and inhibit the strength degradation of the amorphous SiC fibers. The alloy matrix formed was dense and comprised primarily of $TiSi_2$–Si eutectic structures. The $TiSi_2$–Si matrix composite melt-infiltrated at 1375°C showed a pseudo-plastic tensile stress–strain behavior followed by final fracture at ~290 MPa and ~0.9% strain. When the MI temperature was increased to 1450°C, however, substantial reduction in the stiffness and ultimate strength occurred under tensile loading. Microstructural observations revealed that these degradations were attributed to the damages that occurred on the reinforcing fibers and pyrolytic carbon interfaces during the MI process. The present experimental results clearly demonstrated the effectiveness of the low-temperature MI process in strengthening Tyranno ZMI fiber composites and reducing the processing cost.

2:30 PM

(H3-019-2016) Ultra-high Temperature Ceramic Matrix Composites Fabricated by an improved RMI Method (Invited)

S. Dong*[1]; D. Jiang[1]; 1. Shanghai Institute of Ceramics, Chinese Academy of Sciences, China

Carbon fiber reinforced ultra high temperature ceramic matrix composites (C_f/UHTC) combine the advantages of UHTCs and ceramic matrix composites, making them candidate materials for thermal structural elements applied over 1800°C. But it is very difficult to obtain composites with UHTC phase homogenously distributed and high content by current preparation process. In present study, C_f/UHTC composites are fabricated by a modified reaction melt infiltration method (RMI). Sol-gel method is employed to prepare the porous body that for melt infiltration and reaction process. The influence of sol-gel parameter on the microstructure of the porous body are investigated. Porous body with homogenously distributed nano pores of about 200nm can be obtained by optimized the sol-gel process. Using such porous body for melt infiltration, C_f/UHTC composites with UHTC phase homogenously distributed are fabricated. The microstructures, phase assemblages, as well as mechanical and ablative properties of the materials are studied. Both microstructure and phase evolution during the oxidation and ablation process are investigated and the mechanism is analyzed. The composites shows good ablation property, mainly due to the formation of UHTC oxides on the material surface during testing.

3:20 PM

(H3-020-2016) Fabrication and dynamic compressive properties laminated ceramics by reactive hot pressing and reactive jointing method (Invited)

L. Cheng*[1]; L. Li[1]; L. Zhang[1]; 1. Northwestern Polytechnical University, China

In order to obtain materials with structural integrity and high energy absorptivity, two novel methods, reactive hot pressing (RHP) and reactive jointing method (RJM), were proposed to fabricate soft and hard interbedded laminated ceramics as impact resistance materials. The chemical reaction processes at interfaces and in ZrO-Zr_2CN layers were researched, and the effects of properties of interfaces, thicknesses of hard layers and microstructure of soft layers on the dynamic compressive properties of the laminated ceramics were investegated. Both of the methods shown well interfacial controllability and microstuctural designability The laminated ceramics shown high dynamic compressive strengths, well dynamic pseudoplastic behaviors and good dynamic energy absorption capacity, which could well meet all the requirements of high-speed/high-energy impact resistance concept. The chemical reaction model and the dynamic failure models consisting of a three-part process of multi-reflection of stress waves, crack initiation and crack deflection at the interfaces were established.

3:50 PM

(H3-021-2016) Manufacture of SiC /$ZrSi_2$ composite materials

O. Coloma[2]; A. Camarano[2]; M. R. Caccia[2]; J. Narciso*[1]; 1. Alicante University, Spain; 2. University of Alicante, Spain

SiC remains the leading candidate for the manufacture of the major components of the fusion reactor, due to the resistance of SiC to neutrons. Nonetheless the first difficulty for exclusive use of this material is that it has not sufficient fracture toughness. In order to avoid this problem has been developed different solutions to increase the fracture toughness of these materials, emphasizing two: i) manufacture of composite SiC /SiC_f, ii) manufacture composite SiC/MSi_2 (M = Mo, W, Nb, Ta). The first solution although right is only valid for small components and parts. The second solution is valid for this application only in the case that the metal is W. Another important factor is the cost of these materials when they are obtained by hot pressing is too high. An alternative low cost way of production is the reactive infiltration which SiC pieces are obtained. These pieces can have complex shapes and large size, The main objective of this work is the manufacture of SiC/$ZrSi_2$ composite, which can be used in high temperature applications and/or fusion reactors. The method selected to manufacture these composites materials are the reactive infiltration of Si-Zr alloys into SiC/C porous preforms. We have studied the effect of temperature (1400-1600 ° C) and reaction time (1-5 hours), it has also been studied the content of Zr in the alloys.

4:10 PM

(H3-022-2016) Development of superfine nano-composites antifouling coatings for Ship Hulls (Invited)

A. S. Khanna*[1]; 1. IIT Bombay, India

Efforts are being made to use alternative methods to develop antifouling coatings for ship hulls. One of the most accepted concept is to develop antifouling coatings by creating so smooth and fine coatings where the sea-weeds and barnacles unable to stick. This can be possible by incorporating nano particles which provide a smooth coating with surface roughness value in the range of 10-50nm. The other requirements of such antifouling coatings are strong adherence, erosion resistant, corrosion resistant. Such a coating was made with epoxy as the base resin modified in several steps. The coating was first modified with silica nano-particles to achieve a smooth fine coating. This was then modified with a fluro-based polymer to make it low surface energy saturated coating which also makes it hydrophobic. The coating so prepared was tested for various characteristics such as surface composition, morphology, contact angle and surface roughness using AFM. The coating roughness was in the range of 10-20nm. The performance of the coating was determined using EIS as well as using actual tests, carried out by exposing the panels in sea to observe the anti-fouling properties, which was measured using an equipment which measures the force required to remove the barnacles from the surface. The coated surface showed a significantly lower force than the uncoated surface or a pure epoxy coated surface.

4:40 PM

(H3-023-2016) High Temperature Oxidation of Yttrium Silicides

R. A. Golden*[1]; E. J. Opila[1]; 1. University of Virginia, USA

Current Silicon Melt-Infiltrated (SMI) Ceramic Matrix Composites (CMCs) are limited by the melting temperature of silicon (1410°C) and the volatility of the thermally grown SiO_2 scale in high-temperature water vapor environments. Replacement of the MI silicon with a rare-earth (RE) silicide offers the potential to address both limitations of SMI CMCs. This study focuses on the ability of yttrium-silicides (YSi_x) to form yttrium-silicates in high-temperature oxidizing environments, phases with greater stability than SiO_2 in high-temperature water vapor. YSi_x with compositions from 25 to 95 at% Si were fabricated using arc melting. Specimens were oxidized at 1000-1300°C for up to 24 hours in air. Scanning Electron Microscopy, Energy Dispersive X-ray Spectroscopy and X-ray Diffraction were performed before and after exposure. A non-protective Y_2O_3 scale formed on Y-rich compositions (≤ 41 at% Si) during oxidation. Yttrium-silicates were observed to form around Si-rich regions near the center of the alloy. Si-rich YSi_x (≥ 67 at% Si) formed a slow growing SiO_2 scale during oxidation. Neither the non-protective Y_2O_3 scale formed on Y-rich silicides nor the SiO_2 scale formed on Si-rich silicides offers advantages over the current SMI CMCs. Experimentally observed phases are compared to thermochemical predictions for yttrium-silicide oxidation. Results are utilized to examine the viability of other RE-silicides as CMC matrix materials.

H5. Polymer Derived Ceramics and Composites

PDC Precursors and Microstructure

Room: Trinity IV

Session Chair: Hans-Joachim Kleebe, Technical University of Darmstadt

1:20 PM

(H5-016-2016) From Chemistry to Processing of Boron-Modified Silicon Carbide Matrix Composite Precursors

M. Schmidt*[1]; S. Bernard[1]; G. Chollon[2]; 1. European Membrane Institute, France; 2. Laboratoire des Composites Thermostructuraux, France

Silicon carbide (SiC) has attracted interest for environmental and energy applications due to its high temperature properties. Future industrial challenges for SiC, particularly in aeronautics, require to tune the materials composition and shape on demand. These inherent difficulties can be overcome by synthetic paths where molecular chemistry and chemistry of materials are combined, like the Polymer-Derived Ceramics route. The chemistry, processing properties and reactivity (thermal and chemical) of related polymers can be controlled and tailored to supply, after shaping and pyrolysis processes, ceramics with the desired compositional phase distribution and homogeneity. This method is used to prepare boron-modified SiC. Polymers were synthesized by the reaction of allylhydridopolycarbosilane (AHPCS) with borane dimethylsulfide. We demonstrate that the boron content has an effect on the chemistry and processability of precursors, as well as the properties of the resulting materials. This study gives us informations about the chemical and physical properties of boron-modified SiC precursors

based on infrared, NMR spectroscopies and elemental analyses. Their pyrolysis behavior is investigated by solid-state NMR coupled with TGA. Final materials are characterized by XRD, elementary analysis, Raman spectroscopy. Applications of PDC route to process ceramic matrix composite will be discussed.

1:40 PM

(H5-017-2016) From Chemistry to Processing of Boron-Modified Polycarbosilazanes: Toward the Preparation of Bulk SilicoBoron (Carbo)Nitride Ceramic

D. Fonblanc*[1]; F. Rossignol[2]; S. Bernard[1]; 1. European Membrane Institute, France; 2. Science des Procédés Céramiques et de Traitements de Surface, France

Silicon-based non-oxide ceramics (SiC, Si_3N_4) have attracted much attention due to their good properties and reliability at high temperatures which can be enhanced by addition of a second ceramic (nano)phase. However, their preparation is a challenging task as conventional processes lead to inhomogeneities and impurities affecting the properties. The Polymer-Derived Ceramics (PDCs) route is an alternative strategy using a "ceramic through chemistry" concept. Preceramic polymers have allowed obtaining multi-element ceramics with controlled chemical composition by incorporating elements to provide high temperature resistant materials. In this study, boron is added to polycarbosilazanes to obtain silicoboron carbonitride (Si/B/(C)/N) ceramics after pyrolysis. We investigate through FTIR, solid-state NMR, the chemistry of boron-modified polycarbosilazanes as well as their pyrolysis behavior combining TG experiments and solid-state NMR. By controlling the boron content in the polymer at molecular scale, we can deliver after pyrolysis bulk Si/B/(C)/N materials with tailored properties. The high temperature behavior is investigated by thermogravimetric analysis, XRD, elementary analysis and Raman spectroscopy and we show how the boron content and the nature of the atmosphere affect the structural evolution of the Si/B/(C)/N phase at high temperature.

2:00 PM

(H5-018-2016) Effect of Boron Incorporation on the Phase Composition and High-Temperature Behavior of Polymer-Derived Silicon Carbide

E. Ionescu*[1]; 1. Technical University Darmstadt, Germany

Within the present work, boron-containing silicon carbide (SiBC) powders and monoliths were prepared from a polyborocarbosilane. The main aspect addressed here relates to the fate of boron in the prepared SiBC ceramics, which has not been clarified unambiguously so far. X-ray diffraction data, corroborated with XPS, FTIR and Raman spectroscopic results indicate that boron preferably gets incorporated within the segregated carbon phase present in polycarbosilane-derived SiC; thus, the prepared SiBC samples show dispersed boron-containing carbon phases with boron contents from ca. 9 to 18 at%. Interestingly, the B-containing carbon phase does not convert into crystalline boron carbide, even upon annealing at very high temperatures and despite the high boron content. Moreover, processing details concerning the pressureless preparation of dense Si(B)C monoliths are considered in the present paper and their high temperature evolution is analyzed.

2:20 PM

(H5-019-2016) Nanocarbon containing C/SiO(C)-based ceramics: Synthesis approaches and functional properties

G. Mera[2]; R. Riedel[1]; E. Ionescu*[2]; 1. TU Darmstadt, Germany; 2. Technical University Darmstadt, Germany

In the present study, nanocomposite materials consisting of a nano-carbon phase (e.g., few-layer graphene, turbostratic carbon etc.) finely dispersed within an amorphous Si-containing ceramic matrix (i.e., SiO_x, SiOC or SiC) were prepared by using two synthesis techniques. In a first approach, a single-source precursor such as a polysilsesquioxane or a polycarbosilane was used as a single-source precursor for the synthesis of a C/SiOC and a C/SiC nanocomposite, respectively. Whereas the second method involved the sol-gel processing of a nanocomposite consisting of a few-layer-graphene phase (reduced graphene oxide, rGO) embedded within a silica matrix, i.e. rGO/SiO_x. The prepared ceramic nanocomposites were investigated concerning their phase composition and microstructure. Emphasis was put on elucidating the precursor-to-ceramic transformation process and the in situ generation of the nanocarbon phase. Additionally, the synthesized ceramics were evaluated with respect to their functional properties. Thus, the polysilsesquioxane-derived C/SiOC material was shown to exhibit piezoresistive behavior; whereas the synthesis of rGO/SiOx samples with various rGO contents provided compositions with tunable (di)electric properties.

2:40 PM

(H5-020-2016) PDCs route as an alternative method to get self-standing highly crystallized h-BN

B. Toury*[1]; F. Gombault[1]; S. Yuan[2]; C. Journet[1]; A. Brioude[1]; 1. University of Lyon, France; 2. INSA Lyon, France

With the continuous development of the electronic devices field, research on 2D nanomaterials is now remarkably developed. Especially, widespread interest in graphene has been driven by its excellent capacity for charge transport within the atomic plane. However, the promising future development of graphene devices seems strongly linked to the choice of the substrate and hexagonal boron nitride (h-BN), which is isostructural/ isoelectronic with graphene is the most suitable. We recently demonstrated that self-standing highly crystallized h-BN mono-, bi- and few-layers have been obtained for the first time via the PDCs route. In this work, we modify the original synthesis by using polyborazylene mixed with Li_3N micro-powders. Li_3N can be considered as a crystallization promoter allowing the onset of crystallization of h-BN at lower temperatures. Consequently, a high crystallization rate is obtained from 1000 °C (instead of 1600–1800 °C - classical conditions). A series of samples incorporating Li_3N and annealed at various temperatures (600 to 1400°C) was prepared and structurally characterized by Raman, XRD and TEM. A simple ultra sonication process has been used to get h-BN graphene-like few layers. The hexagonal structure was confirmed by both electron and X-ray diffraction. Finally, we demonstrate the real potential of these nanostructures in the preparation of Van der Waals heterostructures.

Microstructure and Properties of PDCs

Room: Trinity IV

Session Chair: Emanuel Ionescu, Technical University Darmstadt

3:20 PM

(H5-021-2016) Correlation Between Microstructure Evolution and High-Temperature Behavior of SiOC-based Polymer Derived Ceramics

H. Kleebe*[1]; E. Ionescu[1]; R. Riedel[1]; 1. Technical University Darmstadt, Germany

Several silicon oxycarbide glasses with different content of carbon were analyzed with respect to their high-temperature creep performance. Compression tests were done at 1100, 1200 and 1300 °C. In this temperature range, the mechanism of creep relies on viscoelastic flow. Viscoelastic recovery was observed in all samples upon release of the applied mechanical stress.This presentation highlights the microstructural evolution of various SiOC based glasses upon annealing characterized by transmission electron microscopy (TEM). In particular, long-term test of the stability of Hf-doped samples will be discussed. Here, exaggerated growth of hafnia precipitates indicates a local change in chemistry close to internal surfaces upon high-temperature anneal. In addition, results in the samples that underwent creep deformation will be presented with the emphasis of addressing local phase separation and/or precipitation of SiC nanoparticles within the amorphous matrix. It will be shown that this particular class of materials can indeed be utilized as high-temperature materials, when processes such as precipitation/growth of nanocrystallites, local phase separation and chemical changes close to internal surfaces are known in detail.

3:40 PM

(H5-022-2016) Single Si atoms and silicon nitride nano-clusters in SiCN polymer-derived ceramics

R. Ishikawa*[2]; G. Mera[1]; E. Ionescu[1]; R. Riedel[1]; Y. Ikuhara[2]; 1. TU Darmstadt, Germany; 2. University of Tokyo, Japan

Polymer-derived silicon carbonitride (SiCN) ceramics have significant high-temperature mechanical and electronic properties, because of their amorphous structure and local strong covalent bonding nature. For the understanding of the physical and chemical stability at high-temperatures, many experimental and theoretical approaches have been involved. However, there is a lack of atomic-scale observations, it is still unclear the crystallization mechanism in amorphous SiCN polymer derived ceramics. In this study, we show the direct evidences of single silicon atoms and nano-scale precipitations in amorphous SiCN ceramics, using atomic-resolution scanning transmission electron microscopy, combining annular bright-field and annular dark-field imaging with electron-energy loss spectroscopy. To track the single Si atom movements, we also collected time-sequential ADF STEM images. In a low temperature heat treatment at 1373 K, SiCN ceramics show relatively uniform amorphous atomic structures but a number of single Si atoms between turbostratic carbon layers, related to single silicon atoms or silicon nitride molecules. In a higher temperature treatment at 1673 K, we found a large number of Si-based nano-clusters. On a basis of EEL spectroscopic analysis, we found Si-based nano-clusters with the diameter of 1 – 2 nm.

4:00 PM

(H5-023-2016) Effect of the Free-Carbon Phase on the Structure of Polymer Derived Silicon Carbide Ceramics

A. Tavakoli*[1]; C. Gervais[2]; F. Babonneau[2]; R. Bordia[1]; 1. Clemson University, USA; 2. Collège de France, France

The high temperature electrical properties of silicon carbide (SiC) can be enhanced by the incorporation of a free-carbon (sp^2-C) phase. The existence of sp^2-C may affect the SiC phase structure, which would eventually impact the electrical properties. Therefore, this work aims at a detailed structural investigation of SiC/C composites with varying sp^2-C contents. For this study, a SiC forming polymer, SMP-10, and a C-modified precursor prepared by mixing SMP-10 and 5 wt.% divinylbenzene were used. These precursors were cross-linked, pyrolyzed and the resulting powders were milled and hot pressed at 2130 °C. The structural analysis of the hot-pressed samples was performed using a combination of spectroscopic and microscopic measurements (X-ray diffraction, nuclear magnetic resonance, Raman, and transmission electron microscopy). Although the SMP-10 derived SiC ceramic appears to be fully crystalline, the microstructure of the carbon-modified sample contains minor amorphous regions, implying the effect of free-carbon on the SiC crystallization kinetics. While the 6H-SiC polytype is the major crystalline phase in the both samples, adding C promotes the formation of 4H-SiC. We conclude that the change in the electrical properties of SiC by incorporating C cannot be interpreted as a sole effect of sp^2-C and the structural change of SiC due to the C addition should also be considered.

4:20 PM

(H5-024-2016) Electromagnetic absorption properties of silicon-based polymer derived ceramics (Invited)

X. Yin*[1]; 1. Northwestern Polytechical University, China

Design and development of advanced materials for electromagnetic applications and bringing these materials into use is one of the most challenging tasks of materials engineering. Silicon-based polymer derived ceramics (PDCs) are natural candidates for these demanding applications due to their very attractive microstructure and properties. Compared with sintered technical ceramics, polymer derived ceramics offer the possibility of flexible plastic-technical processing. The chemical synthesis permits a purposeful optimization of the polymers with respect to workability, ceramic yield and composition by the substitution of different elements in the basic structure as well as the organic side groups. In many cases the microstructure of PDCs was characterized by homogeneous distribution of semiconducting or conducting nano-phases in the amorphous matrix. This can lead to the good microwave absorbing properties. Thus, those materials may not only satisfy the impedance matching but also rapidly attenuate electromagnetic waves. The absorption properties of PDCs can be easily tailored by the design of the molecular precursor, changes in morphology, and volume fraction of the filler particles. Different classes of preceramic polymers are briefly introduced and their absorption properties with adjustable phase compositions and microstructures are presented in this review.

4:50 PM

(H5-025-2016) Evaluation of the thermal behavior of silicon oxycarbide receivers against concentrated solar radiation

A. Tamayo*[1]; A. Mazo[1]; A. Lopez-Delgado[2]; I. Padilla[2]; F. Rubio[1]; J. Rubio[1]; 1. Institute of Ceramics and Glass, CSIC, Spain; 2. Spanish National Research Center for Metallurgy, Spain

Silicon oxycarbide glasses were synthesized from preceramic precursors and shaped onto porous and dense monoliths. The materials presented excellent resistance against oxidation up to 1400 ^{0}C and the determined values of reflectance (below 5%) and mechanical properties (E≈65 GPa) make of these materials suitable candidates of being used in solar volumetric air receivers. Nevertheless, the materials intended for use in such applications, should resist extreme environmental conditions such high humidity and temperature, thermal shocks and even the presence of pollutants and contaminants. The silicon oxycarbide materials subjected up to 100 cycles of thermal shock by using a Fresnel lens and the properties of the materials have been evaluated during the test. The surface properties of the materials have been studied through spectroscopic methods and confocal microscopy. It has been obtained the surface map of each analyzed sample in order to evaluate the footprint of the solar beam incident on the surface. The results revealed that the dense oxycarbide glasses remain almost unaltered after the cycles whereas the porous materials suffer from significant degradation at certain point. No degradation of the materials were observed in the environmental tests indicating that the obtained materials could be excellent substitutes to the actual SiC receivers.

5:10 PM

(H5-026-2016) Oxygen Transport in Sol-Gel Derived and Thermally Grown Borosilicate Glasses (Invited)

B. McFarland[1]; E. J. Opila*[1]; 1. University of Virginia, USA

Thermal oxidation of SiC/BN/SiC ceramic matrix composites (CMCs) in high temperature oxidizing environments results in the formation of borosilicate glasses. It is known that boria affects the silica glass structure, allowing more rapid permeation of oxygen, and thus more rapid CMC oxidation rates. However, a quantitative understanding of the effect of boron content on oxygen transport in borosilicate glasses remains elusive. In this study, borosilicate glasses were synthesized from tetraethyl orthosilicate and trimethoxyboroxine precursors with controlled boron contents. SiC fibers and SiC coupon substrates were coated with thin films of these glasses and exposed to oxidizing conditions at temperatures between 800 and 1300°C for times up to 100 hours. Both free standing and thin film sol-gel derived glasses were extensively characterized for composition, bonding, and phase by elemental quantification, vibrational spectroscopy, and x-ray analysis techniques before and after high temperature exposures. Boria readily volatilized at the

highest temperatures, while significant boria was retained at the lowest temperatures. However, minimal effects of boria on oxygen transport in the glasses were observed at any temperature. Results will be compared to thermally grown borosilicate glasses formed on B-containing SiC with the goal of elucidating borosilicate glass structure on oxygen permeation.

5:40 PM

(H5-027-2016) Precursor-Derived Ceramic Nanowire and Nanosheet Composites for High Power Laser Radiometry

G. Singh*[1]; 1. Kansas State University, USA

Precursor-derived ceramics (PDC) SiCN's optical, electrical and thermal properties can be tuned by controlling the amount and distribution of carbon phase in the ceramic via selection of suitable precursor and processing conditions. Additional tuning is possible by doping and/ or chemical interfacing with nanomaterials. Here, we demonstrate our efforts to functionalize carbon nanotubes (CNTs) and boron nitride nanosheets (BNNS) with SiCN (and doped SiCN with Al and B) to prepare spray coatings that act as durable thermal absorber material. We report a damage threshold value of 15 $kWcm^{-2}$ and an optical absorbance of 0.97 for B-doped SiCN/CNT composite. This is an order of magnitude improvement over multi-walled and single-walled CNT, and carbon paint coatings previously tested at 10.6 μm (2.5 kW CO_2 laser) exposure. Si-Al-C-N/CNT and SiCN/BN offered damage resistance up to 8 kW.cm-2 the 10 kW average power laser. Partial melting of the copper substrate was observed.

H11. CMC Applications in Transportation and Industrial Systems

Novel Application areas and Technology Transfer

Room: Salon C
Session Chairs: Lalit Manocha, SICART; Bernhard Heidenreich, German Aerospace Center

1:30 PM

(H11-014-2016) Non-oxide ceramic matrix composites for industrial and aerospace applications (Invited)

W. Humbs*[2]; M. Rothmann[2]; R. McKown[2]; J. Schull[1]; 1. BJS Composites GmbH, Germany; 2. BJS Ceramics GmbH, Germany

BJS is developing non-oxide ceramic fibers and SiC/SiC ceramic matrix composites consisting thereof. This paper provides an overview of current ceramic matrix composites being developed and manufactured for industrial and aerospace systems. For more than 15 years we have produced SiC/SiC composites in the form of shaft sleeves and bearing rings for industrial pump applications. Primarily, the chemical vapor infiltration (CVI) process is used to build up the matrix. Production of the Material KERAMAN uses this process, and various fiber types and fabrics for reinforcement of these ceramic matrix composites. This variety leads to a wide range of properties such as porosity and bending strength which can be tailored to a specific customer's needs. The experience gained from industrial applications can be transferred towards components for aerospace systems. KERAMAN body flaps for re-entry vehicles have been developed and proven in atmospheric re-entry flight tests. A variety of KERAMAN components produced with the CVI process for turbine applications, demonstrate the versatility of this SiC/SiC material. The primary target is to manufacture these components with our own SiC fiber, called SILAFIL. This paper will also provide an outlook on the development and manufacturing roadmap of BJS's SILAFIL fibers.

2:00 PM

(H11-015-2016) Application of CMC Materials in Rocket Propulsion

F. Olufsen*[1]; E. Orbekk[1]; 1. Nammo Raufoss AS, Norway

Nammo Raufoss AS (Nammo) has substantial experience in the manufacturing and use of CMC materials in rocket propulsion systems. One main benefit is the weight saving potential, as the CMC offers significantly lower density than traditional materials of choice, like refractory metals. At Nammo, CMC components are produced by the highly flexible Liquid Silicon Infiltration (LSI) method. Nammo has produced so called C/C-SiC parts for a decade for use in Thrust Vector Control (TVC) units as well as in blast tubes and nozzle throats. The method also allows a cost-efficient way of producing CMC components. The production process has been fine-tuned and refined over the course of years to fully take advantage of the material properties through tooling design, balanced composition of the raw materials, the use of additives and machining capability. The CMC components have shown good performance when used in extremely hot parts of the rocket motor at temperatures approaching 3000K, withstanding the chemical and physical erosion in a sufficiently low and controllable manner. This has allowed the material to be used as jet vanes in TVC units and as nozzle throat material in tactical rocket motors with relatively long burn times. Work continues to refine the materials that are being produced today, improve the production process, make the production more cost efficient and find new areas of application, both within Nammo and elsewhere.

2:20 PM

(H11-016-2016) C/C-SiC Sandwich Structures for Lightweight and Thermally Stable Components in Satellites and Industrial Applications

B. Heidenreich*[1]; N. Gottschalk[2]; Y. Klett[2]; D. Koch[1]; 1. German Aerospace Center, Germany; 2. University of Stuttgart, Germany

In a new design approach C/C-SiC sandwich structures have been realized via liquid silicon infiltration (LSI) and in situ joining method. Due to their high specific stiffness and strength, low thermal expansion, high environmental stability and temperature resistance, these structures offer a high potential in various application areas, like optical benches in satellites or charging racks for high temperature furnaces. In the first step, carbon fibre reinforced polymer (CFRP) preforms for the planar skin plates as well as for the core structures were manufactured via warm pressing of prepregs based on a 2D C fibre fabric, preimpregnated with phenolic resin. For the core, a single layer of prepreg was folded and a thin walled 3D structure was obtained after moulding and curing. In the second step, the sandwich components were pyrolysed separately, leading to porous C/C preforms. For the build-up of the sandwich structure, two skin plates were joined to the core element, using an adhesive, based on phenolic resin and amorphous C powder. After curing of the adhesive, the C/C sandwich preform was infiltrated with molten Si and both, the SiC matrix and the join, were built up by a chemical reaction of Si and C, leading to a permanently joined C/C-SiC sandwich structure. For mechanical characterization, coupons were tested in bending, shear and compression mode.

2:40 PM

(H11-017-2016) 3D C_f/SiC-C Composites with SiC/PyC Multilayer Matrix Produced by ICVI

U. Andi*[1]; M. Basha[1]; D. K. David[2]; S. Vidyavathy[2]; S. Singh[3]; V. Prasad[3]; 1. CSIR-National Aerospace Laboratories, India; 2. Anna University, India; 3. Defence Metallurgical Research Laboratory, India

New variant of 3-Dimensional C/SiC-C composite with SiC/PyC multilayer matrix has been prepared by isothermal isobaric chemical vapour infiltration (ICVI). Non-interlaced, three dimensional carbon fibre architecture is used as the reinforcement. Boron-doped SiC and SiC seal coating are applied to the test specimens generated from the prepared composite laminates and room temperature flexural properties are studied. The flexural test specimens are also thermal cycled between 1250°C and 140°C for 1000 and 2000 cycles in the oxidizing atmosphere and their flexural strengths are measured. The properties are compared with the properties of ICVI generated 3-D C/SiC composites. 3-D C/SiC-C composite exhibits improved mechanical properties. Multiple crack deflections at the interfaces of SiC and PyC layers in SiC/PyC multilayer matrix contribute to the improved mechanical properties.

3:20 PM

(H11-018-2016) Carbons as reinforcements for Carbon and ceramic matrix Composites (Invited)

L. M. Manocha*[1]; 1. SICART, India

Carbon, because of its electronic structure and inherent physical properties arising out of its processing methods, has been a material of interest as such or as reinforcements in High performance composites with Carbon or Ceramics as matrix system. It could be in the form of macromaterials such as cokes to micromaterials like carbon fibers and to naomaterials from carbon black to grapheme. This is a material which has seen continuous innovations and every five to ten years a new form is developed. A journey to these developments from cokes to graphene will be presented.

3:50 PM

(H11-019-2016) Meso/Macrostructure Porous Ceramics as such and in composites form for valued applications (Invited)

S. Manocha*[1]; 1. GGS IP UNIVERSITY, India

Porous ceramics have been synthesized through template methods. It could be for carbons or carbides using biomorphic templates or silica foams by infiltration of silica sol in to commercial available polymeric foams template having well-ordered structure. Each method has its unique characteristics by way of choosing the template or the processing method etc. The polymeric foams with three dimensional interconnecting strut networks have been used as a macrostructure scaffold. By controlling processing conditions, choice of bio/synthetic templates & studs carbonaceous resins porous silica monoliths with interconnecting porosity with various macroporous structures can be obtained at 550 °C. The characterisation of foams was carried out for crystallinity, surface characteristics, surface morphology and acids resistance. The porous silica foam exhibits interconnected macropores having pore diameter from 100 – 500 μm in diameter, facilitating the fluid flow. Materials organized with such macropores structures can minimize the channel blocking for infiltration of liquid polymers which can be used for development of carbon and ceramic composites.

4:20 PM

(H11-020-2016) Synthesis of C_f/SiC composites with $(PyC/SiC)_{n=4}$ multilayer interface via CVI and their characterization

M. Basha*[1]; S. Murugan[1]; S. Singh[2]; S. Sankaranarayanan[3]; U. Andi[1]; V. Prasad[2]; 1. CSIR-National Aerospace Laboratories, India; 2. Defence Metallurgical Research Laboratory, India; 3. National Institute of Technology Tiruchirappalli, India

Carbon fibre reinforced CVI-SiC matrix (C_f/SiC) composites find applications in space vehicle's thermal protection systems and hot structures, vanes, nozzles and flaps of rocket motors and jet engines and advanced friction systems (aircraft brake disc and brake discs in high end cars) because of their superior properties such as low density, high specific strength and modulus, high fracture toughness and high temperature mechanical properties. To improve the oxidation resistance (long term high temperature application) of C_f/SiC composites, multilayer interface [e.g. $(PyC/SiC)_n$] and self healing seal coating such as glass forming agent (e.g. B-doped SiC) are considered. In the present work, C_f/SiC composite with $(PyC/SiC)_{n=4}$ multilayer interface having a density of ~2.0 $g.cm^{-3}$ are prepared through chemical vapour infiltration (CVI) technique. 8 Harness satin T-300 Carbon fabric layers were stacked one over the other and stitched together in Z-direction. This stitched preform is subjected to PyC and SiC coating for 25 min and 45 min respectively via CVI process. This cycle was repeated for four times to obtain multilayer interface. The thickness of all the layers together [$(PyC/SiC)_{n=4}$] was maintained to <500 nm.

Young Professionals Forum - Next Generation Materials for Multifunctional Applications and Sustainable Development, and Concurrent Societal Challenges in the New Millennium

Young Professional Forum V: Seminar

Room: York A

Session Chairs: Eva Hemmer, University of Ottawa; Surojit Gupta, University of North Dakota

12:00 PM

(YPF-016-2016) Survival Skills for Scientists (Invited)

F. Rosei*[1]; 1. INRS, Canada

In this lecture, I will try to convey a feeling for our course on "Survival Skills for Scientists" [1]. This is a graduate course designed and developed in my department, in which we give basic advice and offer mentorship to our graduate students and post-docs. The central theme of this presentation is that succeeding in Science requires skills (often referred to as 'soft professional skills') beyond those needed for Science. The lecture aims at giving basic guidance and mentoring to young scientists (typically science and engineering undergraduate and first year graduate students). The main topics are: The job market for graduates in science and engineering (industry, national labs and academia; advantages and disadvantages) Funding in modern science Publish or perish; publishing quality papers, having an impact Presenting your work to your peers The fundamental laws of 'scientific survival' (know yourself, plan ahead, and play chess) Ethics in modern science Alternative careers

Poster Session

Room: Salon A/B

(P001-2016) Improvement workability of recycled gypsum powder from waste plasterboard by using dry/aqueous process

Y. Kameda*[1]; M. Matsubara[1]; M. Tafu[1]; S. Takamatsu[1]; T. Toshima[1]; T. Ohshima[2]; 1. National Institute of Technology, Toyama College, Japan; 2. Hokusei Kigyou Co. Ltd, Japan

A huge amount of plasterboards from building sites have been discarded as waste for many years. Because of lack of landfill capacity, it is desirable to recycle waste plasterboard. We previously reported that workability of recycle gypsum powder collected from waste plasterboard is weak than it of reagent-grade gypsum. Workability was studied by measuring water/powder ratio of calcinated waste gypsum and various chemical gypsums. The water/powder ratio of the recycled gypsum was twice of ratio of reagent gypsum. Recycled gypsum contained paper fiber due to plasterboard. Paper fiber in the gypsum powder was removed by dry process using special sieve. We investigated effect of these impurities on workability of the recycled gypsum. In this study, we also tried to improve powder property and workability of recycled gypsum powder by using dissolve/precipitation process in an aqueous solution containing sodium tripolyphosphate (STPP).

(P002-2016) Synthesis and characteristics of thermoelectric $Ca_{3-x}Ce_xCo_4O_{9+\delta}$ powders prepared by sol–gel method

K. Park*[1]; J. S. Cha[1]; D. Hakeem[1]; 1. Sejong University, Republic of Korea

Sol–gel method was used to synthesize thermoelectric $Ca_{3-x}Ce_xCo_4O_{9+\delta}$ powders. Polyethylene glycol (PEG) 400 was added to the sol–gel precursors. The mixed solutions were stirred continuously to form homogeneous precursors. The precursors were heated at 80 °C for 48 h before dried at 120 °C for 12 h. The dried gel was calcined at 700-800 °C for 2 h in air. The prepared powders were investigated by powder X-ray diffraction (XRD), scanning electron microscopy (SEM), thermogravimetric and differential thermal analyses (TG/DTA), Fourier transformation infrared spectroscopy (FTIR), and X-ray photoelectron spectroscopy (XPS). XRD results confirmed the formation of single phase $Ca_{3-x}Ce_xCo_4O_{9+\delta}$. No diffraction peaks from source materials or impurities were found. A mixed valance (+2, +3, and +4) of Co was detected in the $Ca_{3-x}Ce_xCo_4O_{9+\delta}$ powders. We found that the powder characteristics of $Ca_{3-x}Ce_xCo_4O_{9+\delta}$ depended on the processing parameters, such as the amount of PEG and calcination temperature. In this study, the influence of processing parameters on the powder characteristics will be discussed.

(P003-2016) Fabrication of porous metal/carbon composites and their extinction characteristic as smoke interfering materials

Y. Wu*[1]; Y. Mu[1]; Q. Liu[2]; P. Bi[1]; 1. State Key Laboratory of NBC Protection for Civilian, China; 2. Shanghai Jiao Tong University, China

Currently, smoke interfering materials are usually prepared by simple physical mixing processes. As a result, these materials have simple components and structures, providing interfering ability only toward some narrow band of electromagnetic waves. Besides, these materials are usually harmful to the environment. Here, we introduce the fabrication of novel smoke interfering materials using plant materials with porous structures as raw materials. Metallic nanoparticles were incorporated into the porous structures of the plant templates by a simple chemical method, and in the following heat-treatment process, graphitic nanostructures were in-situ catalytically grown with the aid of the metallic nanoparticles to produce porous metal/C nanocomposites. Owing to the combined effects of the absorbing ability of the metallic nanoparticles and scattering effect of the porous structures, the resulted composites showed effective interfering ability toward electromagnetic waves in a broad band frequency. Thus, we established an approach for the design and fabrication of porous metal/carbon composites using natural porous structures as templates and would provide theoretical guidance and experimental validation to the research and development of novel smoke interfering materials.

(P004-2016) Synthesis and photochemical properties of silicon doped TiO_2 nanotubes by hydrothermal method

P. Dao[1]; K. Du[1]; G. Liu[1]; M. Tayyib[1]; K. Wang*[1]; 1. University College of Southeast Norway, Norway

Hydrothermal method has been used to synthesize TiO_2 nanotubes (TNTs) for decades due to its cost-effectiveness, low energy consumption, mild reaction condition and simple equipment requirement. In this paper, we repot the synthesis of silicon doped TiO_2 nanotubes by using silicon and TiO2 power as starting materials through the hydrothermal method. The Si/(Si+Ti) molar ratio is varied from 0.01 to 0.3 in a 100 ml Teflon tube, which is then heated at 150 ºC for 24 hours under stirring condition on a heater. Morphology of the Si-doped TiO_2 nanotubes has been characterized by using Scanning electron microscopy, which shows their diameters are about 10 nm with 20 μm long. X-ray diffraction demonstrates formation of nanocrystalline for the un-doped and as-prepared doped TNTs. The light absorption spectra of doped TNTs exhibits a red shift from 350 nm to 390 nm as compared with that of the un-doped TNTs. Photodegrading aqueous methyl blue solution shows that this red-shift of spectra absorption is desirable for photocatalytic reaction under relatively long wavelength light illumination.

(P005-2016) Dielectric properties of amorphous SiO_2 and their link with those of other SiO_2 polymorphs

O. I. Malyi*[1]; M. Boström[1]; V. V. Kulish[2]; P. Thiyam[3]; D. F. Parsons[4]; C. Persson[1]; 1. University of Oslo, Norway; 2. National University of Singapore, Singapore; 3. Royal Institute of Technology, Sweden; 4. Murdoch University, Australia

Based on the first principles calculations, the analysis of dielectric and electronic properties of amorphous SiO_2 was performed. We find that the SiO_2 properties are volume dependent and the dependence is mainly caused by change of nanoporosity at the atomic scale. In particular, high frequency dielectric constant (ε_∞) and dielectric function at imaginary frequencies ($\varepsilon(i\varsigma)$) of different amorphous SiO_2 samples can be accurately described using the expanded volume average theory, Slater's atomic radii, and dielectric function of continuous media found in this work. From the computed results, we show also that the parametrized dielectric function of continuous media found from amorphous SiO_2 data and the expanded volume average theory can describe both and not only for amorphous SiO_2 but also for other SiO_2 polymorphs having similar band gap energies. Hence, it is clear that the simple model described in this work can be used to identify specific materials having the desired dielectric properties.

(P006-2016) Novel Particulate Reinforced Multifunctional Composites for Energy Harvesting

R. Lofthus[1]; M. Bahmer*[1]; D. Feguson[1]; S. Gupta[1]; 1. University of North Dakota, USA

Green design is integral component of research for the 21st century. In this poster, as a part of undergraduate research, we will present recent developments on the research and development of novel vibration sensitive composites which can perform multifunctional functions like energy harvesting, energy storage, and solid lubrication, among others. Scientists and researchers are being continuously challenged on a variety of global issues, including population growth, rapid urbanization, infrastructure decline, climate change, and water scarcity. There is a potential to deliver game-changing solutions by designing sustainable materials.

(P007-2016) Preparation of functional materials from unused phosphate resources in sewage sludge

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Calcium phosphates such as hydroxyapatite are useful material for biomaterials, catalysts and so on. For usage of HA for catalysts, addition of metal ions such as aluminum (Al), iron (Fe) improve catalytic property of it. To preparation of HA, phosphate resource is needed to import from foreign countries. On the other hands, unused phosphorous resources are stock in sewage sludge, and required to recover and recycle. We have interested to use metal ions contained in the sewage sludge for improvement of catalyst properties of HA. We have choice sewage sludge incineration ash as unused phosphate recourse. The ash washed by acid and extract phosphate. In this study, we prepared Fe containing calcium phosphate from simulated ash extract and investigated effect of Fe content in HA on material properties such as adsorption and catalyst.

(P008-2016) Development of High Thermal Conductivity Silicon Nitride Substrates

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In order to release the heat generated by these power semiconductor devices, insulating substrates with high thermal conductivity are of increasing importance. Recently silicon nitride has attracted much attention as a substrate material for power semiconductor devices because of its excellent mechanical properties and high intrinsic thermal conductivity. Our research group has indicated that a reaction bonding process followed by post-sintering is the sensible approach for fabricating silicon nitride ceramics with both high thermal conductivity and high strength. In this investigation, we worked on the development of high thermal conductivity Silicon Nitrides substrate. Research supported by NEDO, Japan.

(P009-2016) Mechanical properties of kenaf-polypropylene Composites with carbon nanotubes as fillers

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In this study, the effects of carbon nanotubes (CNT) in improving the interfacial bonding in, and consequently the mechanical properties of, kenaf reinforced polypropylene composite are presented. The first set of composite laminates was made with kenaf fiber content of 20%, 25%, 30% and 35% by mass and without any CNTs. Nonwoven kenaf fiber mats were first cleaned using distilled water and treated with NaOH solution of 6% concentration. After this alkali treatment, the fibres were immersed in solutions of 5% by fibre weight of 3-aminopropyltriethoxysilane in a 50% aqueous solution of methanol. Composite laminates were then made by compression moulding. Tensile and flexural strength were found to increase with fibre content until the latter reached 30%. The second set of laminates were made using 30% by mass of kenaf fiber and 0.25%, 0.50%, 0.75% and 1.0% by mass of functionalized CNT. Both mechanical properties showed improvement of varying degrees. The laminates made with 0.5% CNT (and 30% kenaf fiber) showed the highest improvement. SEM examinations of fractured surface indicated comparably fewer instances of fiber pull-out, indicating improvement of fiber-matrix interfacial bonding. Closer examination also revealed the presence of CNTs in the interfacial region which possibly acted as a bridge between the fibers and matrix and contributed to improved mechanical properties.

(P010-2016) High Temperature Exposure and Stability of Calcium Aluminate Cements

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This paper is about the fabrication and characterization of calcium aluminate cements with 51 and 71% of alumina contents exposed to high temperatures. Cement paste samples were made at 0.4 and 0.5 water to cement (W/C) ratios. Both the raw cement powders and their corresponding samples after hydration were characterized in their microstructure by scanning electron microscopy, X-ray diffraction, granulometry, x-ray fluorescence, density, and compression tests. Preliminary high temperature creep data taken at 500 and 1000C is shown for some samples. Thermal and water weakening properties and stability were also evaluated. Samples were exposed to 500 and 1000C in a furnace open to air.

(P011-2016) Inorganic phosphate cement with battery waste

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Inorganic phosphate cement (PC) matrix composites with battery waste contents have been fabricated in this research through a room temperature process. Waste has been obtained from alkaline and batteries processed mechanically. This hazardous waste was added up to 30wt%. Cements were fabricated by mixing an aqueous acidic formulation of phosphoric acid (H_3PO_4) and the mineral wollastonite ($CaSiO_3$). The effect of the battery waste concentration on the compressive strength, density, and microstructure is presented. Samples were characterized by scanning electron microscopy (SEM) and x-ray diffraction (XRD). New phosphates appeared upon the reaction of battery waste and the acid.

(P012-2016) A thermo-electro-mechanical vibration analysis of size-dependent functionally graded piezoelectric nanobeams

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Nowadays, with the development in nanotechnology, functionally graded piezoelectric (FGP) nanostructures have also been employed in micro electro-mechanical systems (MEMS) and nano electro-mechanical systems (NEMS).Thus, establishing an accurate model of FGP nanobeams is a key issue for successful NEMS design. In the present study,thermo-electro-mechanical vibration characteristics of FGP nanobeams subjected to in-plane thermal loads and applied electric voltage are carried out by presenting a numerical type solution. Material properties of FGP nanobeam are supposed to vary continuously throughout the thickness based on power-law model. Eringen's nonlocal elasticity theory is exploited to describe the size dependency of nanobeam. Using Hamilton's principle, the nonlocal equations of motion are obtained for the free vibration analysis of graded piezoelectric nanobeams including size effect. In following a parametric study is accompanied to examine the effects of the several parameters such as temperature change, electric voltage, power-law index and nonlocal parameter on the natural frequencies of the size-dependent FGPnanobeams in detail. Numerical results are presented to serve as benchmarks for the application and the design of nanogenerators, nano-oscillators, and atomic force microscopes (AFMs), in which nanobeams act as basic elements.

(P013-2016) Growth and characterization of lithium ion conductor $La_{(1-x)/3}Li_xNbO_3$ single crystals

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$La_{(1-x)/3}Li_xNbO_3$ (LLN) with an orthorhombic double-perovskite structure is one of candidates for solid electrolyte to develop all solid state battery, since LLN is a high lithium ion conductor and a nontoxic and stable oxide. We discussed the phase relation during solidification from the LLN melt by SCFZ method and growth of LLN single crystals by the TSFZ method. Sintered rods of LLN with x=0.10 – 0.25 were melted, and solidified slowly by SCFZ method using four-mirror type infrared heating FZ furnace. It was found that LLN phase melts incongruently to $LaNbO_4$ phase and a liquid . The effective distribution coefficient and solubility limit of Li into $LaNb_3O_9$ was estimated to be 0.54 and 0.29, respectively. TSFZ growth was performed using the feed rods of x=0.10 and the solvents of 5-10 mol%$LaNbO_4$-poorer than the stoichiometric LLN composition in Ar at the growth rate of 4 mm/h. The grown crystals with the typical size of 5mm in diameter and 15 mm long were black due to oxygen-deficiency, and became colorless by oxygen-annealing at 1000 °C for 24 h. Inclusions of $LaNbO_4$ precipitated in the initial growth region for 5 mol%$LaNbO_4$ poor solvent while inclusions such $LiNbO_3$ or Li_3NbO_8 phase precipitated in the initial growth region for 7 and 10 mol%$LaNbO_4$ poor solvents. The composition of the grown crystals was uniform along the growth direction by EPMA.

(P014-2016) Inhibition of Crystal Growth of In-Ga-Zn Oxide Film by Silicon Incorporation

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Recently, c-axis aligned crystalline In-Ga-Zn oxide (CAAC-IGZO) films with high crystallinity have been actively investigated. The CAAC-IGZO films are formed by sputtering at an elevated substrate temperature. However, the crystal growth may be inhibited by several factors. One of these factors is impurity incorporation into an IGZO film. Hence we investigated the effect of impurity incorporation on the crystal growth of the IGZO film. As an example of an impurity element, silicon is focused on herein because a silicon oxide film is frequently used as a base film for IGZO deposition. To incorporate silicon atoms into IGZO films intentionally, we prepared IGZO sputtering targets mixed with 0.0, 0.02, 0.2, and 2 wt% SiO_2.

CAAC-IGZO films were formed when the amounts of SiO_2 were 0.0, 0.02 and 0.2 wt%, whereas crystal growth did not occur when the amount of SiO_2 was 2 wt%. To explore the cause of the above phenomenon, we examined a structural distortion associated with the silicon incorporation into IGZO by first-principles calculation. After structural relaxation calculation, the structure around Si was distorted. One reasonable explanation for the calculation results is that the Si-O bond length is different from the metal-O bond length in IGZO. Therefore the incorporation of an impurity element with a different bond length can lead to inhibiting the crystal growth of the IGZO film.

(P015-2016) Hierarchically ordered SiOC monoliths made by freeze casting

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Macroporous ceramic monoliths, due to high permeability to gas and liquid flows, are found in various applications, such as catalysis support, continuous flow capillary microreactors, and separation media. The incorporation of micro/mesopores into a macroporous structure can combine improved mass transport with high surface area and large pore volume, significantly broadening the material's range of applications. Polymer derived ceramics have the advantage of tuning pore sizes on different scales, and surface characteristics by chosen processing parameters, while freeze casting can be used to adjust the pore structure and permeability of macroprous monolith. Combination of polymethysiloxane with water based freeze casting, offers the possibility of hierarchically ordered porous monolith. To realize this, the surface characteristics of polymethysiloxane were modified by cross-linking with 3-aminopropyl)triethoxysilane (APTES). The optimization of precursors was achieved by varying the ratios of polymer to APTES, and pyrolysis temperatures. The as obtained hybrid material, was mixed with silica sol (as binder and water phase) during freeze casting. The combination of silica sol with hybrid materials by freeze casting and after pyrolysis leads to a SiOC ceramic monolith with a lamellar pore morphology and a hierarchically-ordered micro/meso/macropore structure, a very promising material for applications mentioned above.

(P016-2016) High-temperature Mechanical Properties of Silica Aerogel Composites Reinforced by Mullite Fibers

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High-temperature mechanical properties of the mullite fiber-reinforced silica aerogel composites were investigated. The composites were treated at 600, 700, 800, 900°C, and 1000°C for 1500s in the chamber. The results showed that with increasing the temperature, the in-plane direction almost has no shrinkage, but the thickness shrinkage in the Z direction increases. The Z direction shrinkage is 12.40% after treated at 1000°C. That the aerogel particles of the composite fused and sintered together at elevated temperatures lead to Z direction shrinkage. The compressive stress and Young's modulus decrease with increasing the temperature. The stress at 1000°C are 0.10MPa, 0.16MPa, which decreased 58.3% and 60.0% than that of room temperature. SEM images showed that the aerogel particles collapsed and sintered in the compression tests.

(P017-2016) Machinability and mechanical properties of porous ceramics for medical applications

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Machine processing of pre-sintered porous ceramics has been widely utilized in dental applications, according to the patient's symptoms. However, chipping and cracking in the body frequently occurred during the processing. The machining performances and surface roughness are depending on variety of products and manufactures. In this study, we will investigate the relationship among manufacturing processes, mechanical properties and machining performances, in which porous bodies pre-sintered at various temperatures have been machined through CAD/CAM and the mechanical properties have been characterized. These results obtained are useful and efficient to produce dental ceramics in order to reduce chipping and cracking during machine processing.

(P018-2016) Alkaline activation for the enhancement of capacitive property of carbon spheres synthesized by hydrothermal carbonization process

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Recently, electric double layer capacitor is attracting attention as an energy storage system. In this study, we synthesized micro/mesoporous carbon spheres by hydrothermal carbonization of glucose and subsequent alkaline treatment, and investigated the relationship between pore structure and capacitive properties. The capacitive property of the carbon spheres was enhanced with an increase in volume of micro- and meso-pores. It was found that the presence of ultramicropores smaller than 0.7 nm improves the capacitance markedly.

(P019-2016) Effect of fibers orientation on the mechanical behavior of mullite fibrous ceramics with a 3D skeleton structure

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The importance of architecture in the thermo-physical and mechanical behaviour of fiber network materials has been studied extensively. In this work, Fibrous ceramics with the mullite fibers as the matrix and silica sol as the binder was fabricated by a molding and freezing method. The orientation of fibers in the network was controlled by the pressure on indenter. The mullite fibrous network with a controllable orientation structure was scanned using a μ-CT systems, The network architectural parameters obtained were used in conjunction with the experimental date of properties of the networks, such as density, porosity, thermal conductivity and mechanical behavior to investigate the effect of fibers orientation on the thermo-physical and mechanical properties. It was found that the thermal conductivity, transverse stiffness, and creep resistance were increased with the increasing in fiber out-of-plane angle, but were not sensitive to the distribution of in-of-plane angle. This mullite fibrous ceramics with random 3D skeleton exhibited low densities (0.325 g/cm^3), low thermal conductivities (0.055 W/mK), relatively high compressive strength (2.51 MPa) and good structure stability which made it a promising high-temperature insulation materials.

(P020-2016) Effect of microstructures in gelation freezing derived porous silica based ceramics on thermal conductivity

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Our group has tried to develop alternatives of refractory ceramics fiber used at approximately 1000°C, in which natural diatomite powder was used as a raw material. Porous silica based ceramics with very low thermal conductivity was successfully fabricated by gelation and freezing of diatomite slurry. The thermal conductivity showed less than 0.1 W/mK. Microstructures of insulators obtained was observed to be nearly honeycomb shaped one and random orientation, and could be strongly affected by slurry preparation. The relationship between structure and thermal conductivity will be also discussed.

(P021-2016) Microstructure Control of A Porous Ceramic with Cylindrical and Incorporation Pores

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A porous ceramics with cylindrical pores and incorporating pores were fabricated through unidirectional solidification of aqueous ceramics powder slurry containing CO_2 gas, vacuum freeze drying and sintering process. The cylindrical pores were formed during the unidirectional solidification under reduced pressure. The formed composite of ice and ceramics powder was sintered at 1250ºC for 5 hours. Because the ice and powder composite was formed by segregation of ice during the solidification, an incorporating structure of ice was formed in the composite bulk. The ice was removed by vacuum freeze drying method. The porosity and pore size was well controlled by the pressure during the solidification and sintering temperature and time.

(P022-2016) Effects of Boron and Aluminum Additives on In–Situ Grain Growth of Porous SiC Ceramics

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Silicon carbide (SiC) has been expected to be an attractive material for structural applications such as aerospace industries, nuclear applications and high-temperature gas turbine. Furthermore, porous SiC has been commercially used as the material for diesel particulate filter. Recently, porous ceramics have received great attention in many fields. The authors have proposed the surface functionalization of porous ceramics based on in-situ grain growth. In our previous studies, it was reported that large plate-like grain growth in porous SiC ceramics was promoted above the sintering temperature of 2000ºC by addition of aluminum, boron and carbon to b-SiC, and porous SiC ceramics with unique morphology was achieved. In this study, porous SiC ceramics were fabricated based on in-situ grain growth by the addition of boron and aluminum, and the effects of boron and aluminum additives on in–situ grain growth of porous SiC ceramics were investigated. In addition, their properties were evaluated.

(P023-2016) Fabrication of porous ceramics by gelcasting method with agar and reservoir sediment in Tunisia

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Reservoir sedimentation that leads to the decline of the reservoir capacity will cause the loss of available water resource. Tunisia is also facing such issue. Although the sediment dredging is the effective method for such problem as a measure, it has not been implemented practically due to huge dredging cost. Therefore, we have been proposing to make the system that valorize for the sediment in order to recover a part of the cost for dredging. It is expected that the porous ceramics using the sediment can be used as a filter for drinking water treatment. In is study, we assessed the character of the sediment by using XRD, TG-DTA and dissolution test, and examined the gel-casting method with agar and the sediment in order to fabricate porous filter. From XRD analysis, the component of the Joumine reservoir sediment in Tunisia was identified as calcite, quartz and kaolinite mainly. Dissolution test was performed as the safety evaluation of sediment. As a result, fluoride elution from the sediment that were fired in the range of 600°C to 800°C was confirmed. However, fluoride elution from sediments by calcination above 800°C were inhibited. It was inferred that transition of kaolinite that showed at 600°C to 800°C affected to fluoride elution from XRD and TG-DTA analysis. By using gelcasting method with the sediment, wet green body and sintered body were obtained without cracks.

(P024-2016) Effect of calcium salt on reactivity of dicalcium phosphate dihydrate (DCPD) with fluoride ion

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Dicalcium phosphate dihydrate (DCPD) reacts with fluoride ion in an aqueous solution and forms stable fluorapatite (FAp). This reaction is applied to setting and hardening reaction of dental phosphate cement. We have developed novel applications of this reaction to the environmental applications such as water treatment. In this case, release of phosphate ion from the reaction of DCPD is serious problem because phosphate cause to eutrophication of the water environments. In this study, we investigated novel treatment reagent based on DCPD mixed with calcium salts. Release of phosphate is consisting in two steps, dissolving of DCPD and release from reaction of DCPD. We found that release of phosphate from the former step was able to control by addition of soluble calcium salt such as calcium chloride. For the later step, addition of calcium carbonate was applicable because value of pH was controlled to around 8 by dissolution of it.

(P025-2016) The effect of heat exposure on microstructure and mechanical properties of Al_2O_3/Si/SiC coating system

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In the present study, microstructural evolution of Mullite/Si EBC system fabricated by air plasma splay technique was studied. Heat exposure tests were carried out at 1300°C for 1, 5, 10 and 50 hours in air. In-situ observation was done for selected specimen using a high temperature observation system developed by one of the authors. After the test, microstructure was observed using Field-emission scanning electron microscopy (FE-SEM) equipped with an energy-dispersive spectroscopy (EDS). Young's modulus of mullite layer and Si bond coat (BC) layer before and after heat exposure was measured by depth-sensing indentation technique. In-situ observation confirmed that surface cracks nucleated at the transformation temperature of mullite. Nucleation of microcrack originates from volume change during phase transformation of mullite. These cracks propagated along through-the-thick direction, however, were arrested at the interface between mullite EBC and Si BC layer. Reaction-formed product was also observed near the mullite/Si interface at the tip of crack. The reaction-formed product was identified β-cristobalite by Raman micro spectroscopy. In the presentation, the effect of these microstructural changes on Young's modulus of mullite and Si layer will be discussed based on experimental results.

(P026-2016) Thick Aluminum nitride Coatings by Reactive DC Plasma

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Aluminum nitride (AlN) ceramics are of great interest in a diverse range of electrical and electronic applications. It is attributed to their high thermal conductivity, high electric resistivity and chemical stability at high temperatures. Besides that, fabrication of AlN films on the surface of base material had a promising industrial interest. High quality AlN thin films can be fabricated by vapor deposition techniques like CVD and PVD. However, the low deposition rates of these techniques limit its application for thick AlN films. On the other hand, thermal spray is widely used technology for thick ceramic coatings deposition. However, AlN particles decomposition in the high temperature without melting, prevents its deposition by the conventional thermal spray techniques. Using the reactivity of the plasma spray is unique solution to fabricate AlN coatings. Recently we successfully fabricated several AlN based coatings through the reaction between the raw materials and active species in the plasma. This paper will present our effort to fabricate thick AlN coatings through reactive DC plasma spraying of fine particles. Furthermore, investigating the influence of the sintering additives during spray on the coating fabrication and properties.

(P027-2016) Effects of intrinsic defects on electronic structure and optical properties of Boron-doped ZnO using first-principles calculations

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This study adopted first-principles calculations to evaluate the effects of intrinsic defects on the electronic structure and optical properties of Boron-doped ZnO (BZO). Four types of defect were considered: non-defective (B_{Zn}), Zn vacancies (V_{Zn}), O vacancies (V_O), and interstitial Zn (Zn_i). Calculations of formation energy illustrate that O-rich conditions tend to induce V_{Zn}, while O-poor conditions tend to induce V_O and Zn_i. With respect to electric properties, V_{Zn} defects in BZO decrease carrier concentration as well as mobility, which consequently decreases the conductivity of BZO. The existence of V_O or Zn_i defects in BZO leads to n-type conductive characteristics and increases the optical band gap. The existence of Zn_i defects in BZO also increases the effective mass, which decreases the mobility and conductivity of BZO. As for the optical properties, the introduction of V_{Zn} to BZO leads to an increase in transmittance in the visible light region, but a decrease in the UV region. The introduction of intrinsic V_O and Zn_i defects to BZO leads to a significant decrease in transmittance in the visible as well as UV regions.

(P028-2016) The improvement on mechanical and thermal properties of SiC/SiC composites via introducing CNTs into PyC interface

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In order to improve the mechanical and thermal properties, carbon nanotubes (CNTs) were introduced into the interface of SiC/SiC composites via electrophoretic deposition. SiC/SiC composites with pyrocarbon (PyC) and CNTs-PyC interfaces were marked as SiC/SiC-P and SiC/SiC-CP, respectively. The results showed that the flexural strength, fracture energy, interfacial shear strength and thermal conductivity all increased with introduction of CNTs, which of SiC/SiC-CP were 1.174, 1.257, larger than 2, and 2.158 times higher than those of SiC/SiC-P, respectively. It was demonstrated that the meshed CNTs on SiC fibers can strengthen the interface bonding between fiber and matrix and improve the thermal conductivity of interface. The meshed CNTs had positive effects on the mechanical and thermal properties of SiC/SiC composites.

(P029-2016) A feasibility study on SiC_f/SiC composite using SiC fibers with various oxygen contents fabricated by liquid silicon infiltration process

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Liquid silicon infiltration(LSI), which is one of the methods of fabricating fiber reinforced ceramic composites, has many advantages such as low fabrication cost and good shape formability. Consequently, in order to confirm LSI process feasibility of SiC fiber, SiC_f/SiC composites were fabricated using three types of SiC fibers (Tyranno-SA, LoxM and Tyranno-S) which have different crystallinity and oxygen content. Composites that were fabricated with LSI process were well densified by less than 2% of porosity, but showed an obvious difference in 3-point bending strength according to crystallinity and oxygen content. When composites in LSI process was exposed to a high temperature, crystallization and microstructural changes were occurred in amorphous SiOC phase in SiC fiber. Fiber shrinkage also observed during LSI process that caused from reaction in fiber and between fiber and matrix. These were confirmed by with changes of process temperature SEM, XRD and TEM analyses.

(P030-2016) Film Boiling Chemical Vapor Infiltration controled by electrical current

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The densification process of carbon-carbon samples called Film Boiling Chemical Vapor Infiltration, FB-CVI, has as its main control the denfification front temperature. The temperature's fluctuation during the densification of small or thin pieces is difficult to control. Considering a process which should be controlled at 1000°C, sometimes a mean variation of 10% in temperature occurs, which affects the quality of deposition. Electric current is a direct control variable that can be used. A previous study revealed that temperature of a FB-CVI process presents no correlation with the electric current passing through the sample. However, it was shown that samples made at constant temperature, but with different electrical currents had different densities. This project established the conditions of electrical current for better densification of samples obtained using the FB-CVI process. Different samples were densified in different electrical current levels. These results shows that different types of pyrocarbons canbe made with different current values. Rough laminar pyrocarbon were done at current untill 80A and granular pyrocarbon at currents above 100A. It was also shown that the electric current controlled process begining with a current of 70A and increased pedriodically results in a faster process producing samples with the same density.

(P031-2016) High-temperature flexural property of SiC coated PIP-C/SiC composites

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High-temperature flexural property of SiC coated PIP-C/SiC composites was investigated at 1200, and then the effect of SiC coating on PIP-C/SiC composites was researched and compared. The results showed that SiC coating played a key role in of PIP-C/SiC composites. The flexural strength of coated C/SiC composites was 531.2 MPa, while that of uncoated samples was only 330.7 MPa. The long pull-out fibers were observed in coated C/SiC composites, which were thought the reason for higher flexural strength. The reason of keeping a higher strength was thought the better resistance of SiC coating at the oxidation condition.

(P032-2016) The effect of fiber volume fraction of CFRP on liquid silicon infiltration process and properties of C/SiC composite

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Fiber reinforced ceramic matrix composite materials are most promising materials in aerospace and high temperature environment application because of its high thermal and structural stability. The monolithic ceramic materials can be reinforced with carbon, SiC or oxide fibers and these reinforcing fibers increase its toughness and mechanical properties. In this study, LSI (Liquid silicon infiltration) process was applied to fabricate ceramic matrix composite. Generally, porous C/C preform is prepared from FRP material by carbonizing and transversal cracks are formed that acts as a path for liquid silicon infiltration. The infiltration depth and range are significantly affected by crack size and area because the driving force of infiltration is capillary force. In this study, the crack size and area could be controlled by fiber volume fraction of FRP with various fabrication pressures. The change of crack formation was observed and analyzed by SEM and image analysis. The amount of reaction between carbon preform and infiltrated Si was also affected by crack morphology after carbonization. Finally, the optimum fiber volume fraction of FRP was obtained from result of mechanical properties such as flexural and tensile strength test.

(P033-2016) The effect of filament winding angle of C/SiC composite material on mechanical properties fabricated by LSI process

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LSI (Liquid silicon infiltration) is one of the most economic method for fabricating the C/C-SiC composite because of its short process time and low cost. The monolithic ceramic materials can be reinforced with carbon, SiC or oxide fibers and these reinforcement fibers increase its toughness and mechanical properties. In this study, LSI (Liquid silicon infiltration) process was applied to fabricate ceramic matrix composite and the FRP was obtained by filament winding process. Generally, tensile strength test of filament wound composite is difficult because of round shape. The aluminum mandrel of hexagonal type was prepared for plate sample preparation and tensile specimen can be fabricated with various winding angle from 30^{O} to 80^{O}. Tensile test was conducted and modulus, strength according to winding angle result was obtained. The fiber pull-out phenomenon was also analyzed by SEM observation according to winding angle.

(P034-2016) Spark plasma sintering of silicon carbide with carbon and boron as additives

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Silicon carbide powders, with carbon and boron as sintering additives, were sintered by using spark plasma sintering equipment in the temperature range of 1600-2000 ºC. Results showed that with the increasing of the sintering temperature, the density as well as the flexural strength increased.The relative density reached 99.4% and flexural strength was 449±56 MPa for samples sintered at 2000 ºC. Also, short carbon fibers with volume fraction of 10, 20, 30 40% were added in the same matrix and sintered at 2000ºC to improve the fracture strength.

(P035-2016) Improvement on mechanical properties of C/SiC composites via laser machined assisted CVI

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Chemical vapor infiltration (CVI) technique is the most basic and advanced manufacturing technology for continuous fiber reinforced ceramic matrix composites, which has been widely used to fabricate products. However, the CVI process goes along with uneven deposition due to the plugging of the channels, through which reactive gases gets into the deposition region, especially for the large and thick products. Therefore, a new CVI process has been proposed to enhance infiltration rate via the additional the deposition channels through in-situ machining open-hole during CVI process, which means machined assisted CVI (MACVI). In present work, the femtosecond laser was used to open the micro-hole during CVI process, the preferential densification of the composite with 400μm thickness around the micro-hole was clearly observed using micro-computed tomography and scanning electron microscopy. Furthermore, the tensile strength, compressive strength and in plane sheer strength have been increased by 16%, 50%, 30% respectively compared with conventional CVI process. The results show that the laser MACVI is effective and successful for optimizing CVI processes in fabrication of C/SiC composites.

(P036-2016) Preparation and Oxidation Behavior of C/SiC Composites Protected by Varied UHTC Coatings

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Carbon fiber reinforced silicon carbide (C/SiC) composites, due to their outstanding performances, especially at high temperatures, are usually considered as one of the most promising engineering materials. However, owing to their instability in oxidizing environments at elevated temperatures, Antioxidant coating is often needed to improve their oxidation resistance in extreme environments. In this study, C/SiC composites were prepared by polymer impregnation and pyrolysis (PIP). The multi-component ultrahigh temperature coatings were prepared by chemical vapor deposition (CVD) and slurry dip coating method. The structure and composition of the coatings were analyzed by scanning electron microscopy (SEM) and X-ray diffraction (XRD). The oxidation resistances at temperatures below 1700ºC are tested in stagnant air and the oxidation resistances at higher temperature are evaluated using arc jet tests. The mechanical performance tests were conducted before and after oxidation, respectively.

(P037-2016) Rapid concept for the elaboration of C/C composites: the film boiling chemical infiltration

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A work based on the development of a very rapid process for the fabrication of a C/C and C/SiC composites for aeronautic and nuclear industries is presented: the “film boiling” densification. Nowadays C/C composite are mostly elaborated by Chemical Vapour Infiltration. This process is long and restrictive, indeed the elaboration takes several weeks. Using “film boiling process” for the densification of a carbon fiber preform allows a large reducing of the processing time with respect to CVI. The carbon preform is immersed into a carbon precursor and heated up above the precursor decomposition temperature. The precursor in contact with hot surfaces will vaporize and form a “vapor film boiling” at the interface. The preform, heated up above the precursor decomposition temperature, the vapors will decomposed leading to the deposition of C inside the preform. The immersion in a liquid allow the precursor high concentration thus the process is not limited by the diffusion of the species, leading to a rapid densification. Experiments were first carry out with toluene as carbon precursor with the view to expand the precursors to obtain SiC and other carbide matrix / coatings. Several experiments parameters were tuned to estimate their influence on the deposition kinetics and the obtained matrix.

(P038-2016) A new concept for the elaboration of C/C composites: the supercritical fluid chemical infiltration

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In this work, the development of a new process for the fabrication of a C/C composite for aeronautic and aerospace industries is presented. Experiments have shown that using a hydrocarbon fluid in supercritical condition to infiltrate the matrix in a carbon fiber preform allows dramatically reducing of the processing time with respect to conventional processes. The infiltration of a carbon fibrous preform by the mean of a supercritical fluid is done at high temperature in order to get a carbon matrix. The optimization of the experimental parameters linked to the fluid properties (temperature and pressure) is addressed through a thermodynamic approach, while reactor parameters (residence time and shape) are tuned in order to elaborate a carbon matrix. The microstructure of the pyrocarbon coating is characterized by optical microscopy. The best conditions lead to a rapid densification in-depth from the middle of the preform.

(P039-2016) Microwave Heated Chemical Vapour Infiltration of ceramic matrix composites

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Continuous SiC-fiber reinforced ceramic matrix composites are candidate materials for high temperature applications, such as rocket nozzles and turbines blade, requiring good high temperature strength, chemical stability, thermal shock resistance. Chemical vapour infiltration (CVI), a well established technique in the carbon industry, is an attractive technique for introducing matrix materials into fibrous reinforcements due to its relatively low temperature (1100°C). Nevertheless, long processing times (3 - 4 months), high residual porosity and a non uniform density (lower in the middle of the sample) are limiting factors. The use of microwave (MW) radiation to heat substrates during CVI allows these difficulties to be overcome. Microwave heating couples energy directly into the substrate and hence should be more energy efficient. Time processing can be reduced to as little as 3 or 4 days since the sample densifies from inside-out. In this work we use microwave radiation at 2.45 GHz to deposit a silicon carbide matrix, from the thermal decomposition of methyltrichlorosilane in a hydrogen-rich atmosphere, within a fibrous silicon carbide preform. The deposition mechanism and microstructure of the deposit will be discussed with respect to the process conditions used such as temperature, pressure and gas flows.

(P040-2016) C/SiC-ZrC composites and study of its properties

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Reactive melt infiltration is very competitive method for manufacturing UHTCMC, which is simple in technique, low in cost and short in preparation period. ZrC has excellent properties, such as ultrahigh melting point, good anti-ablative performances, and low density. Research has shown that addition of SiC into ZrC will obtain better anti-ablation performance and anti-oxidation performance than single ZrC ceramics. Therefore, it is worth of exploring the RMI method for preparing the C/SiC composites modified matrix by ZrC ceramics and the properties of those composites. In this thesis, C/SiC and C/SiC-ZrC composites were fabricated by using slurry infiltration (SI) method combined with reactive melt infiltration (RMI) method. The properties of the two composites were tested.

(P041-2016) Properties of C/SiC composites fabricated using liquid polycarbosilane as precursor

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C/SiC composites are the mostly applied engineering materials due to their advantages such as low density, high strength and excellent oxidation resistances at high temperatures. These composites are commonly fabricated through polymer infiltration and pyrolysis, chemical vapor infiltration, which are time-consuming. In order to shorten the fabrication cycle of PIP process, liquid polycarbosilane with the ceramic yields rang in 70%-75% are applied to increase the fabrication efficiency. The properties of as-fabricated composites have been studied.

(P042-2016) Ablation behavior of C/SiC composites fabricated through liquid silicon infiltration

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Liquid silicon infiltration (LSI) is low-cost fabrication process for SiC-based composites, which can be applied in a variety of fields for hot-structures. As a result of the existence of free-silicon, which possesses a relatively low melting temperature of ~1410oC, SiC-based composites were mostly applied in brake systems. In this study, the ablation behaviors of SiC-based composites fabricated through LSI were studied through plasma wind tunnel, meanwhile, the mechanical properties and microstructures of composites after high temperature testing were evaluated.

(P043-2016) Evaluation of SiBCN-based composites for re-usable application

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Due to their excellent high thermal stability and oxidation resistance, SiBCN-based composites are candidates for reusable hot-structures. In this study, C/SiBCN composites were fabricated through a modified PIP process, and the oxidation behaviors of composites during temperatures from 1000 oC to 1500 oC for different time were studied. The strength retention after oxidation was evaluated and the microstructures were characterized.

(P044-2016) Influence of addition and holding times on the microstructure and mechanical properties of in-situ Al/TiB_2 composites

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In recent years, TiB_2 reinforced Al metal matrix composite (MMC) has been used in various structural and wear resistance applications. This paper reports the influence of two process parameters, namely holding time and addition time, on the in-situ formation and distribution of TiB_2 particles within Al/TiB_2 composites and their influence on the mechanical properties. The TiB_2 particles were formed by the in-situ reaction of potassium hexafluoro titanate (K_2TIF_6) and potassium tetrafluoroborate (KBF_4) with molten aluminium at various addition and holding times. The microstructure and size of the TiB_2 particles formed are found to be strongly affected by both addition and holding times. The microstructures displayed significantly different degrees of particle agglomeration. Hardness and ultimate tensile strength (UTS) are strongly affected by both addition time and holding time. The variations of hardness and UTS are mostly consistent with that of the microstructure of the composites. The average hardness and UTS of the composites are both higher than those of parent aluminium. In particular, the increase in the maximum average hardness and UTS of the composite are 51% and 44%, respectively, and this was for the composite sample fabricated with 20 minutes of addition time and 30 minutes of holding time.

(P045-2016) Manufacture of SiC/$CoSi_2$ composites: Study of surface properties of Si-Co melts

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Wetting of Si and Si-Me alloys on carbon is known to occur associated to the formation of silicon carbide (SiC) at the triple line and at the liquid/solid interface. This property makes Si-Me alloys suitable candidates to be used in industrial production of SiC/Me_xSi_y composite materials via reactive infiltration. This technique, for SiC production, consists of infiltrating a porous carbon preform, which may or may not contain α-SiC particles, with molten Si, so that it reacts with carbon during infiltration yielding dense SiC. To optimize this kind of processes, it is necessary to measure surface properties of the melts as well as their evolution with temperature. In this work, the wetting behavior of Si-rich Si-Co alloys on carbon materials was studied using the sessile drop technique. Three different stages of spreading controlled by different processes were observed. The influence of temperature, composition and carbon crystallinity was evaluated. As expected for a reaction controlled wetting, a strong dependence of spreading with temperature and a weak influence of alloy composition was found. Carbon crystallinity plays a major role in interface formation, where a higher crystallinity yields a much thicker and constant interface. Surface tension and density of the melts was measured in the temperature range of 1450-1550 C using the pendant drop technique.

(P046-2016) Capability of $TiSi_2$ binary alloy as healing agent for crack-healing in oxide ceramics

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Oxidation induced crack-healing has great advantage for improving structural integrity of oxide ceramic matrix composites. Introduced surface cracks in the composite can be autonomously filled up and bonded by formed oxide resulting from oxidation reaction of 'healing agent ' dispersed in the oxide matrix. Recently a variety of healing agents have been proposed because crack-healing behavior strongly depends on the oxidation property of healing agents. In this paper, we present the capability of $TiSi_2$ as healing agent throughout the strength recovery experiments on the mullite/ 14 vol.%-$TiSi_2$ and alumina /15 vol.%-$TiSi_2$ composite, made by pressureless sintering and spark plasma sintering respectively. The strength recovery behaviors were evaluated by means of three-point bending test at the temperature range from 400 -1200°C for 10 min-300 h. The results were also supported by the in situ observation of crack-disappearance behavior. Experimental studies on the both composite showed the bending strength recovery by annealing even below 1000°C. Those results corresponded to the results of in situ observations. Some excessive oxidation, called 'pest oxidation', were observed in the long-term annealed mullite/ $TiSi_2$ composite. However, we confirmed that the pest oxidation can be easily avoided by controlling microstructure of the composite.

(P047-2016) Tantalum diboride: Obtaining, oxyacetylene torch testing and characterization

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The aim of the study was to determine the behavior of TaB_2 ceramic when exposed to a high temperature heat jet that occurs in thermal protection systems. The materials for studies were obtained from tantalum and boron powders, with the use of the Spark Plasma Reactive Sintering method. The mixture was prepared according to the reaction $Ta+2B \rightarrow TaB_2$. The sintering processes were carried out at the temperature of 2100°C during 30 minutes and at the pressure of 48MPa. During the heating process an exothermic synthesis reaction took place, with a visible decrease in the height of the samples and with temperature increase. The obtained materials have the apparent density of 11.8g/cm^3, the Young's modulus of 500 GPa and the Vickers hardness of 20 GPa. The tests were performed with an oxyacetylene torch at temperatures exceeding 2000°C. The surface temperature of the materials was evaluated during the tests using a pyrometer, an IR thermal camera and thermocouples. In order to study the oxidation mechanisms, the samples were subsequently examined for weight loss, phase composition, as well as for their surface and cross-section microstructure. The studies showed the presence of a tantalum oxide layer Ta_2O_5, which formed at temperatures of above 500°C. The post-test analyses confirm the potential usage of TaB_2 in conditions where temperatures approach or even exceed 2000°C.

(P048-2016) Precursor Synthesis of TaC-SiC Ultrahigh Temperature Ceramic Nanocomposites

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TaC-SiC ultrahigh temperature ceramic nanocomposites were prepared from cross-linking and subsequent pyrolysis of a novel soluble polytantasilane (PTS) precursor in argon atomosphere. PTS was synthesized by blending polycarbosilane (PCS) with polytantaloxane (PT). The prepared ceramic nanomaterials were investigated with respect to their chemical and phase composition, by means of spectroscopy techniques (Raman and variant inductively coupled plasma emission (ICP)), X-ray diffraction (XRD), scanning electron microscopy (SEM) and high-resolution transmission electron microscopy (HR-TEM). Annealing experiments of the TaC-SiC samples at temperatures in the range of 1000–1800 °C showed the conversion into nanostructured ultrahigh temperature ceramic composites. The average grain sizes of the precursor-derived TaC and SiC ceramics were both less than 50 nm with a trace amount of free carbon. Ta, Si and C elements were homogenously distributed in the sample.

(P049-2016) Combustion-mediated synthesis of hollow carbon nanospheres from polymer for high-performance cathode material

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Hollow carbon nanospheres as a potential cathode material for lithium-sulfur batteries was successfully synthesized using a metathesis reaction between sodium azide and halogen polymer. The reaction was driven by thermal heat from the exothermic recombination of Na+ and Cl- (or F-) ions into NaCl (or NaF) salt. The result was an increase of the system overall temperature up to 1320-1750 ºC, and the simultaneous formation of sodium halide-carbon core-shell nanoparticles. Therefore, hollow carbon nanospheres with diameter and shell thickness of 50-500 nm and 10-50nm, respectively, were produced after water washing of the reaction product. The composite cathode was manufactured by "infiltrating" sulfur into hollow core of nanospheres. The electrochemical cycling shows a capacity of 700 mAh/g (after 100 cycles) at 0.5C current rate which is more than 2.4 times larger than that for the sulfur/carbon black nanocomposite prepared by the same technique. This result was achieved due to well-organized and unique 3D structure of hollow carbon, which improved the utilization of sulfur and enhanced the cycle life of the prepared cathodes.

(P050-2016) Enhanced Densification of Polymer Derived SiC Ceramic Powders Using a B precursor

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Manufacturing dense SiC-based components is essential for many applications such as gas turbine components and extreme environment sensors. The pyrolysis of a SiC forming polymer (e.g. SMP-10), milling the obtained ceramic, and subsequent hot pressing of the fine ceramic powder is one of the processing route for making bulk SiC components. However, the relative density of the hot-pressed sample is rather low (~ 87%). Adding only 1 wt.% decaborane into the starting precursor, SMP-10, results in a significant increase in the relative density of the hot-pressed SiC ceramic (~ 95%). In this work the results of our investigations for understanding the underlying cause of the enhanced densification by adding B into the system are presented. For the structural analysis, a combination of the diagnostic techniques including ^{11}B MAS nuclear magnetic resonance spectroscopy, Raman Spectroscopy, and Secondary Ion Mass Spectroscopy were employed. Although the obtained results reveal the existence of B_4C as a major B-containing phase in vicinity of the SiC grains, B seems to develop complex bonding environments with the other elements of the system. In light of our findings, likely scenarios on the role of B in SiC densification are discussed.

(P051-2016) Design and preparation of fiber/matrix interphase in C/SiC composites

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C/SiC composites were fabricated by polymer infiltration and pyrolysis, using C fiber as reinforcement. A layer of pyrocarbon (PyC) and a layer of SiC coatings were first deposited on the fiber surface. The effect of thickness of SiC interphase on microstructure and mechanical properties of the fabricated composites was investigated to extend the application of such C fiber to ceramic matrix composites. As the thickness of deposited SiC increased, the density of the composite gradually increased. Simultaneously, the bending strength and proportional limit stress were also improved. When the thickness of SiC interphase reached about 1 μm, the ultimate bending strength and proportional limit stress of the composites were enhanced sharply. The fracture behavior of the fabricated composites was totally changed after PyC/SiC deposition. Long fiber pullout dominated the fracture surface for composite with PyC/SiC interphase, while for the one without the interphase no fiber pullout was observed.

(P052-2016) Fabrication of hollow/porous SiOC fibers by coaxial electrospinning

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Hollow/porous SiOC fibers were fabricated by coaxial electrospinning and high temperature pyrolysis. The effects of electrospinning parameters, including electrospinning voltage, electrospinning distance and inner electrospinning rate, and the kind of inner electrospinning solution on the SiOC fiber morphology were investigated. Hollow SiOC fibers with the smooth surface could be fabricated by coaxial electrospinning with the mineral oil as the inner electrospinning solution and a slow inner electrospinning rate; while, porous SiOC fibers with porous surface and porous inner structure were fabricated with the 10 wt% PVP-ethanol solution as the inner solution and a high inner electrospinning rate.

(P053-2016) Tubular open-porous polymer-derived ceramic structures with tailored permeability

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Porous ceramics play an important role in highly diverse technological fields, the pore structure having a pronounced effect on the materials performance. In this work, we present free-standing porous ceramic structures based on silicon carbonitride with tailorable pore structures, derived from a preceramic polysilazane precursor. The focus is set on the development of specimens in tubular geometry, thus promoting potential applications as catalyst or membrane supports, which is facilitated by the material's stability in harsh thermal and chemical environments. For this, we developed a straightforward casting process in combination with the use of polymer microbeads as porogens. We show that the obtained structures demonstrate promising performance in terms of gas permeability and mechanical strength, both factors being primarily controllable by porogen structure and content. Using our approach, we are able to generate tubular structures suitable for various interesting applications in energy- and environment-related fields.

(P054-2016) Vibration analysis of higher-order shear deformable functionally graded beams with porosities

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Due to micro-voids and porosities occurring inside functionally graded materials (FGMs) during fabrication, which may lead to the reduction in density and strength of materials, it is therefore necessaryto consider the vibration analysis of beams having porosities in this investigation. Thus, in the present study, the thermal effect on free vibration characteristics of FGM beams made of porous material based on third-order shear deformation beam theory are investigated for the first time. Thermo-mechanical material properties of FGM beam are supposed to vary continuously along the thickness direction according to the power-law form, which is modified to approximate the material properties with the porosity phases. Through Hamilton's principle and third-order shear deformation beam theory, the governing equations are derived and they are solved applying analytical solution.The detailed mathematical derivations are presented and numerical investigations are performed while the emphasis is placed on investigating the effect of the several parameters such as porosity volume fraction, temperature change, power index and slenderness ratio on the natural frequencies of the FG beams in detail. It is explicitly shown that the vibration behavior of porous FGM beams is significantly influenced by these effects.

(P055-2016) First principles study of atomic arrangement of Si, Al and oxygen vacancy and diffusion behavior in mullite

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Mullite, $Al_{4+2x}Si_{2-2x}O_{10-x}$, is an important high-temperature structural material due to low thermal conductivity, low oxygen permeability, and excellent chemical and mechanical stability. In mullite, high-concentration O vacancies are introduced depending on the Si/Al ratio and consequently displaced cation and anion sites are created around the vacancies. However, the three-dimensional atomic structure, such as vacancy position and Si/Al distribution, still remains unclear, and thus knowledge of the structure-property relationship are not fully understood. In this study, first-principles calculations are performed to clarify the precise atomic structure in 3/2-mullite (x=0.25) by varying Si/Al and vacancy positions. In addition, point defect formation properties are examined as a function of point defect site in order to relate the obtained atomic structure to the diffusional property. As a result, our results indicate that the atomic arrangement of Si, Al and oxygen vacancy influences the total energy. The result suggests that a point defect formation and the mechanism behind diffusional property can depend on the local atomic arrangement in mullite.

(P056-2016) Thermal cycling and thermal shock evaluations on environmental barrier coatings fabricated by plasma spray

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Increasing the inlet temperature is one of the key parameters to improve fuel efficiency in the hot gas parts of gas turbine. The elevated temperature requirement causes high temperature oxidation and water vapour corrosion of Si-based materials including fiber reinforced CMC, so environmental barrier coatings (EBCs) are indispensable for protecting the Si-based materials such as SiC and Si_3N_4 from water penetration. In this study we fabricated mullite and rare earth oxide coating by plasma spray on the SiC or SiC fiber reinforced SiC/SiC composite. The SiC/SiC CMC substrate is fabricated by LMI method. Pre-Si bond coating is conducted to increase adhesion between layer and layer. 200μm of EBC coating is finally conducted by controlling power, gun velocity, spraying distance and feed rate. Characterizations on the thermal cycling test at 1200ºC in air are conducted for Mullite, Y_2SiO_5 or Yb_2SiO_5 coatings on SiC or SiC/SiC CMS. Thermal shock tests from 1200ºC to room temperature for 1000 cycles in air are also conducted for evaluating the stability of the coating layer.

(P057-2016) Preparation of $Y_2Si_2O_7$-mullite eutectic structure using glass powder

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A Y2Si2O7-mullite eutectic EBC layer can be prepared by a thermal treatment using a glass with eutectic composition. A glass sample with the eutectic composition is easily obtained for this system. In this paper, the mechanism for the crystallization and formation of eutectic were discussed. The glass transition temperature is 900C, and the crystallization began from 1010C. A large exothermic peak appeared at 1200C. At 1300C, the sample melts down. The primary phase was Y2Si2O7 phase. At 1200C, Y2Si2O7 and mullite phases are crystallized simultaneously. The activation energy for the crystallization was estimated to 329 kJ/mol that value is extremely low compering with the activation energy of mullite phase from the glass state. This glass was heated by the latent heat at the crystallization. By a self heating by the latent heat, the sample was once melted down and a eutectic structure is formed by the cooling step. Hence, a eutectic structure EBC layer can be prepared by dipping method using the glass powder with eutectic composition.

(P058-2016) $TaSi_2$-$MoSi_2$-Borosilicate Glass Double Layer Coating on Fibrous Porous Ceramics for Enhanced Radiation

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A high emissivity double layered coating was deposited on fibrous porous ceramics using a slurry spraying method. The inner layer, in contact with the substrate, is a composite with borosilicate glass as matrix and $MoSi_2$ as dispersion phase; the outer layer is formed by borosilicate glass matrix, $MoSi_2$ and $TaSi_2$ particles. The coating was dense and tightly adhered to the substrate. The infrared radiation property, thermal shock resistance and thermal durability were investigated and compared with those of the $MoSi_2$-glass monolayer coating. The results showed that the coating possessed higher emissivity due to the $TaSi_2$ addition. The thermal shock resistance was comparable with the $MoSi_2$-glass coating, because the inner layer acted as a transition layer and reduced the CTE gradient between the coating and substrate. The isothermal oxidation test indicated that

the thermal durability of the coating was greatly enhanced and the coating was applicable to long-term use at 1775K.

(P059-2016) Development and Property Evaluation of Selected HfO_2-Silicon and Rare Earth-Silicon Based Bond Coat and Environmental Barrier Coating Systems for SiC/SiC Ceramic Matrix Composites

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Advanced EBC systems for SiC/SiC CMC turbine and combustor hot section components are currently being developed to meet future turbine engine emission and performance goals. One of the significant material development challenges for the high temperature CMC components is to develop prime-reliant, high strength and high temperature capable environmental barrier coating bond coat systems, since the current silicon bond coat cannot meet the advanced EBC-CMC temperature and stability requirements. In this paper, advanced NASA HfO_2-Si and rare earth - Si based EBC bond coat - EBC systems for SiC/SiC CMC combustor and turbine airfoil applications are investigated. The coating design approach and stability requirements are emphasized, with the development and implementation focusing on Plasma sprayed and Electron Beam - Physic Vapor Deposited (EB-PVD) coating systems and the composition optimizations. High temperature properties of the advanced EBC systems, including the strength, fracture toughness, creep and oxidation resistance have been studied and summarized. The advanced NASA EBC systems showed some promise to achieve 1500°C temperature capability, helping enable next generation turbine engines with significantly improved engine component temperature capability and durability.

(P060-2016) Mechanical properties and ablation properties of SiCf/SiC-TaC composites

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Continuous SiC fiber reinforced SiC matrix (SiCf/SiC) composites has high strength and stability at high temperature and are the most attractive candidate materials for space-used lightweight components, first wall and blanket components in fusion reactor. SiCf/SiC composites made with indigenous SiC fibre run short of extensive research. In this paper, effects of TaC particle (TaCP) addition on the mechanical properties and ablation properties of SiCf/SiC composites were investigated. The results showed that the mechanical properties of the composites fabricated with TaCP addition decreased because of damage of fibers and pores in the matrix, but the ablation properties were improved greatly. Sample 3D-C fabricated with PCS/Xylene solution as precursors in the first eight infiltration-pyrolysis cycles and PCS/Xylene/TaCp solution as precursors in the later four infiltration-pyrolysis cycles exhibited good mechanical properties and ablation properties. The flexural strength and fracture toughness reached 346.9MPa and 12.61MPa $m^{1/2}$, respectively. Exposed for 60 seconds in a flowing oxyacetylene torch environment, the average mass loss rate and average recession rate were only 0.0067 g s^{-1} and 0.0069 mm s^{-1},respectively.

(P061-2016) Experimental Research on Air Permeability of Fiber Reinforced Aerogel

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Fiber Reinforced Aerogel(FRA) has significant features like low density, low conductivity and high temperature resistance for its application as Thermal Protection System of High Speed Aircraft. It is easy for FRA to absorb moisture because of its high specific surface area, which would cause a drastic inner pressure increment and then break its structure when FRA is undergoing severe aerodynamic heating. Considering this, an experimental Research on air permeability of FRA was firstly conducted. Then, a theoretical model to predict inner pressure change of FRA during rapid temperature rising was established and modified according to results. Research results in this paper should provide significant scientific support when estimating the reliability of FRA using as TPS of aircraft or other forms of application under hygrothermal condition, which could also help significantly to optimize FRA to resolve bottlenecks in its engineering application.

(P062-2016) Strength degradation of carbon fiber in C/SiC composite evaluated through fiber bundle mini composite

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To examine strength degradation in fabrication process of carbon fiber reinforced SiC (C/SiC) made by Si impregnation, a fiber bundle composite, composed by one single carbon fiber bundle and SiC matrix successfully produced through Si infiltration method. Carbon fiber reinforced phenolic resin (CFRP) with single carbon fiber bundle was also made to obtain initial fiber strength. Obtained tensile strength of carbon fiber in a fiber bundle composite (CFRP) were almost same as reported value. Fiber bundle mini composite (C/SiC) with no interface protective coating on the fibers were fabricated to understand strength degradation of carbon fiber by Si infiltration process. C/SiC mini composite were successfully fabricated however, its strength degraded into less than 1/10 of CFRP. Fracture surface observation revealed that carbon fibers in C/SiC composite completely reacted with Si. TO protect carbon fiber from this reaction by infiltrated Si, SiC made by polymer pyrolysis of polycarbosilane were coated onto carbon fiber prior to Si impregnation process. This process protect carbon fiber to react with Si, however, the strength of mini composite was still in same revel. To increase tensile strength, several interface coating system were examined further through these mini composites testing system.

(P063-2016) Electrical Resistance as a Method to Measure Crack Growth in SiC-Based Ceramic Composites

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Electrical resistance holds a great promise for understanding damage in SiC/SiC ceramic matrix composites, because it has been found to be a sensitive measure of internal damage in ceramic matrix composites. A non-visual technique was recently introduced to monitor interlaminar crack growth using electrical resistance, in which monitoring crack growth was achieved by controlling the electrical current path. The proposed method shows that the increase in electrical resistance is directly related to the increase in interlaminar crack length. Thus, the estimated crack length is in great agreement with the measured crack length after taking into consideration a correction factor. This work aims to develop a semi-empirical formula to better estimate the correction factor, and to ultimately improve the accuracy of crack length measurements using electrical resistance, so that method can be implemented in crack monitoring during high temperature interlaminar fracture testing.

(P064-2016) Microstructure and wear behavior of SiC-$FeSi_2$ composites obtained by reactive infiltration

A. Camarano[1]; M. R. Caccia[2]; J. Narciso*[1]; 1. Alicante University, Spain; 2. University of Alicante, Spain

The Si–C covalent bond gives SiC ceramics some advantageous properties like high strength, high thermal stability, good chemical resistance and remarkable tribological properties. Due to this properties SiC is used in mainly technological applications under demanding working conditions, such as brake discs for planes or racing cars, bearings and valves, where friction and wear processes predominate. Nowadays, considerable efforts have been done to improve the tribological performance of SiC materials. The research is focused mainly into find new SiC-based composites materials to enhance these properties. In the present work, SiC-$FeSi_2$ composites were fabricated by infiltrating molten Fe-Si alloys into porous carbon preforms. This process is one of the most attractive manufacturing processes for the SiC production due to the use of low processing temperature and fabrication of near net shape samples.

In the infiltration process carbon react with silicon from the molten Fe-Si alloy during the infiltration forming SiC. This reaction leaves a SiC matrix with $FeSi_2$ continuous reinforcement. The reinforcement is expected to make a considerable improvement of the wear performance, respect to the classic SiC materials. For this purpose four different Si-Fe alloys compositions (5%, 15%, 25%, 35% Fe) were used to corroborate the influence of these reinforcement in the composite.

(P065-2016) Effect of vacuum on microstructure and mechanical properties of silicon carbide produced by reactive infiltration

A. Camarano[2]; M. R. Caccia*[2]; J. Narciso[1]; 1. Alicante University, Spain; 2. University of Alicante, Spain

Reactive infiltration is one of the most attractive manufacturing processes for SiC production. Its main advantages are: low cost, low processing temperature and near net shape capability. Nowadays this technique is highly used to produce materials based on SiC for high temperature applications such as CMC brake discs for planes or racing cars. This process consists in the spontaneous infiltration of liquid silicon into a carbon-containing preform, using inert or vacuum atmosphere, where silicon reacts with carbon to form silicon carbide. Due to the cost, most of the industrial processes are carried out under vacuum in the range of pressure between 10^{-3}-10^{-7} mbar. Reaching these levels of vacuum involves extra productions costs associated to energy waste, requires the improvement of the devices to work under these conditions, and increases production time. In this work, a study to highlight which are the best vacuum conditions for infiltration has been performed. Infiltration of molten Si was conducted on C_f/C porous preforms using three different levels of vacuum. For this purpose three types of devices were used: diaphragm pump (coarse vacuum 5 mbar), rotary pump (medium vacuum 10^{-3} mbar) and turbo molecular pump (high vacuum 10^{-7} mbar).

Wednesday, June 29, 2016

G1. Powder Processing Innovation and Technologies for Advanced Materials and Sustainable Development

Novel Shaping, Forming, Sintering Technology and Nano/microstructure Control

Room: Trinity III
Session Chairs: Di Zhang, Shanghai Jiao Tong University; Junichi Tatami, Yokohama National University

8:30 AM

(G1-027-2016) Bioinspired function materials templates by nature species (Invited)

D. Zhang*[1]; J. Gu[1]; W. Zhang[1]; Q. Liu[1]; H. Su[1]; 1. Shanghai Jiao Tong University, China

Biological materials display an astonishing variety of sophisticated nanostructures that are difficult to obtain even with the most technologically advanced synthetic methodologies. Inspired from their hierarchical structures, many functional materials are developed based on templating synthesis method. This review will introduce the way to fabricate novel functional materials with a great diversity of bio-morphologies, in State Key Lab of Metal Matrix Composites, Shanghai Jiao Tong University in near years. We focused on replicating the morphological characteristics and functionality of biological species (e.g. butterfly wings, plants). We change their original components into our desired materials with original morphologies kept. Based on these results, we discuss the possibility of using these materials in photonic control, solar cells, electromagnetic shielding, energy harvesting, and gas sensitive devices, et al. In addition, the fabrication method could be applied to other nature substrate template and inorganic systems that could eventually lead to the production of optical, magnetic. or electric devices or components as building blocks for nanoelectronic, magnetic, or photonic integrated systems. These bioinspired functional materials with improved performance characteristics are becoming increasing important, which will have great values on the development on structural function materials in the near future.

9:00 AM

(G1-028-2016) Orientation of graphene coating particles using an innovative low magnetic field

T. Takahashi*[1]; N. Sugimoto[2]; M. Sado[2]; J. Tatami[2]; M. Iijima[2]; 1. Kanagawa Academy of Science and Technology, Japan; 2. Yokohama National University, Japan

Particle orientation technique by a magnetic field has been applied to improve markedly properties in various material systems. In the most of materials, superconducting magnet is required to orient particle because of their very small anisotropic diamagnetic susceptibility. In this work, to achieve particle orientation in a low magnetic field like a Nd magnet, graphene-coated on β-Si_3N_4 particle and glass fiber were prepared by using a mechanical treatment technique. FE-SEM and AFM observation showed that the graphene several nanometers thick existed on the particles. In-situ observation of orientation behavior of the graphene coated glass fibers in polyethylene glycol (viscosity is 100-150 Pas) was carried out by an optical microscope. As a result, rotation of the particles with graphene occurred by applying a magnetic field. Resin composites including oriented β-Si_3N_4 particles and glass fibers were prepared in a static magnetic field of 0.5T. The thermal conductivity and mechanical strength were measured.

9:20 AM

(G1-029-2016) Effect of Strain on Photoluminescence Properties of Yttrium Oxide

H. Razavi-Khosroshahi*[1]; K. Edalati[2]; Z. Horita[2]; M. Fuji[1]; 1. Nagoya Institute of Technology, Japan; 2. Kyushu University, Japan

Y_2O_3 with a large bandgap of 5.8 eV is an important host material for rare earth ions in photonics industry. Eu doped Y_2O_3 produces an intense red emission and is widely used in the solid-state lasers. The optical properties of a luminescent ion in a nanoscale host can change due to modifications in the band edge or charge-transfer bands. Recently, strain is considered as a factor that can affect the bandgap and electronic band structure of ceramic materials. High pressure torsion (HPT) is an effective technique that induces strain to material by addition of a plastic shear. In this study, the effect of plastic strain on the phase transformation and photoluminescence (PL) properties of Eu doped Y_2O_3 by using HPT will be studied. Eu doped Y_2O_3 was placed between two Bridgman anvils under a pressure of 6 GPa. XRD, Raman spectroscopy, PL spectroscopy and TEM were used to analyze the microstructure and optical properties of samples. XRD results showed that cubic Y_2O_3 transformed to monoclinic phase. PL spectra confirmed a red shift of peaks at 614 nm as the number of turns increased. Effect of strain on the phase transformation and PL spectra will be discussed on the day of presentation. Further, TEM results will be shown and correlation between microstructure and optical properties will be presented. This work is supported by Advanced Low Carbon Technology Research and Development Program (ALCA), Japan.

9:40 AM

(G1-030-2016) Smart powder processing for advanced materials and sustainable development

M. Naito*[1]; T. Kozawa[1]; A. Kondo[1]; M. Matsuoka[1]; 1. JWRI, Osaka University, Japan

Smart powder processing stands for novel powder processing techniques that create advanced materials with minimal energy consumption and environmental impacts. Particle bonding technology is a typical smart powder processing techniques to bond between particles to make advanced composites. It is achieved by the active surface of particles induced by mechanical energy. This mechanical process can also directly synthesize nanoparticles from starting raw powder materials without extra heat. In this presentation, the applications of this processing for the development of advanced materials such as lithium ion batteries and solid oxide fuel cell which are key materials for our sustainable society.

10:20 AM

(G1-031-2016) Fabrication and Some Properties of Textured Ti_2AlN Ceramics

Y. Sakka*[1]; 1. National Institute for Materials Science (NIMS), Japan

MAX phases are the layered ternary ceramics with the general formula Mn+1AXn (where M is an early transition metal, A is an A group element in the periodic table, X is a C or N, and n = 1, 2, 3). They show unique combination of metallic and ceramic properties, which were derived from their layered hexagonal structure and the anisotropy of the bonding strength. We have demonstrated excellent properties by texturing the MAX phase ceramics. Ti_2AlN single crystal powder was prepared by Ti, Al and TiN. These powders were mixed in molar ratio of 1:1:1 by ball milling with zirconia balls for 24 hours in ethanol, and then heated at 1823 K for 2 h in an Ar atmosphere. After the heating, the powder was grinded by ball milling in order to obtain the single crystals. The powder was dispersed in ethanol with PEI as a dispersant. Textured Ti_2AlN green body was fabricated by a slip casting in a strong magnetic field, where the magnetic field of 12T was applied to the parallel direction of casting. Then the green body after CIPing was sintered at 1673 K for 5 minutes by spark plasma sintering. By XRD results indicate that the c-axis of the Ti_2AlN is oriented parallel direction of the magnetic field. We measured some properties such as the bending strength, fracture toughness, wear resistance, and investigated the influence of textured structure on them.

10:40 AM

(G1-032-2016) A Stochastic Modeling for Ceramic Granule Collapse during Cold Isostatic Pressing

K. Yasuda*[2]; S. Tanaka[3]; M. Naito[1]; 1. JWRI, Osaka University, Japan; 2. Tokyo Institute of Technology, Japan; 3. Nagaoka University of Technology, Japan

This presentation proposes a stochastic modeling for ceramic granule collapse in a spherical powder compact during cold isostatic pressing. To estimate the radial stress distribution in the compact, we newly derive an ordinary differential equation when Young's modulus is given as a function of radial coordinate. This equation is solved numerically, and we obtain the actual radial stress distribution during cold isostatic pressing. By substituting this stress distribution into fracture location theory, we formulate the joint probability density of granule collapse as a function of the radial coordinate and the applied isostatic pressure. For given parameters, we discuss the collapse probability of granules in the powder compact during cold isostatic pressing. This research was partly supported by Grant-in-Aid for Scientific Researches (C) (25420706) and (B)(15H04129) from Japan Society for the Promotion of Science.

11:00 AM

(G1-033-2016) Advanced Sintering of ZnS-$CaLa_2S_4$ Composite Infrared Optical Ceramics

Y. Li*[1]; Y. Wu[1]; 1. Alfred University, USA

Due to their desirable infrared (IR) transmittance, zinc sulfide (ZnS) and calcium lanthanum sulfide ($CaLa_2S_4$) are both attractive candidates for advanced IR optical ceramics. In comparison with ZnS, $CaLa_2S_4$ has a greater hardness, broader wavelength range over which it is IR transparent, and better corrosion resistance to rainwater. In this study, $CaLa_2S_4$ was added as a second phase to ZnS at different concentrations, and the resulting ZnS-$CaLa_2S_4$ composite ceramics were sintered using the Field-Assisted Sintering Technique (FAST). Through XRD and SEM analyses, this research sought to better understand the influence of $CaLa_2S_4$ addition on both the cubic-hexagonal ZnS phase transition, and the mechanism by which the ZnS-$CaLa_2S_4$ composite material is consolidated during FAST. This research also investigated the effects of the addition of $CaLa_2S_4$ on the microstructure and mechanical properties of the ZnS-$CaLa_2S_4$ composite ceramics. Optical characterization of the composite ceramics was performed to investigate the IR optical compatibility of ZnS and $CaLa_2S_4$, as well as the presence of defects within the composite ceramics.

11:20 AM

(G1-034-2016) Porous honeycomb alumina with unidirectional pore fabricated by molding in a magnetic field using a micro resin mold

J. Tatami*[1]; E. Takahashi[1]; S. Mori[1]; 1. Yokohama National University, Japan

Porous ceramics has been used for filters, batteries and so on. In order to improve their properties, control of pore structure and shaping are needed. In this study, porous honeycomb alumina having unidirectional pore was fabricated in combination with a wet molding technique using a small resin mold prepared by stereolithography and an orientation technique of chopped carbon fibers as a pore former by applying a magnetic field. After firing the green body, honeycomb alumina having large and tetragonal holes which maintained the geometry of the small resin mold was obtained without any crack formation and deformation. Inside of the honeycomb was confirmed to be the structure reflecting the resin pillar prepared by streolithography. SEM observation of the wall of the honeycomb showed that there are many pores parallel to the direction of the applied magnetic field as shown in Figure 1. This unidirectional pore structure resulted from orientation of the chopped carbon fiber by the magnetic field in the slurry and the green body. Relative density, open porosity and closed porosity were 53%, 47% and 0%, respectively. This means that the unidirectional pores are communicated in the honeycomb alumina.

G2. Functional Nanomaterials for Sustainable Energy Technologies

Functional Nanomaterials for Sustainable Energy Technologies III

Room: York A

Session Chair: Bruce Koel, Princeton University

9:00 AM

(G2-014-2016) Multifunctional materials for electronics and photonics (Invited)

F. Rosei*[1]; 1. INRS, Canada

The bottom–up approach is considered a potential alternative for low cost manufacturing of nanostructured materials. It is based on the concept of self–assembly of nanostructures on a substrate, and is emerging as an alternative paradigm for traditional top down fabrication used in the semiconductor industry. We demonstrate various strategies to control nanostructure assembly (both organic and inorganic) at the nanoscale. We study, in particular, multifunctional materials, namely materials that exhibit more than one functionality, and structure/property relationships in such systems, including for example: (i) control of size and luminescence properties of semiconductor nanostructures, synthesized by reactive laser ablation; (ii) we developed new experimental tools and comparison with simulations are presented to gain atomic scale insight into the surface processes that govern nucleation, growth and assembly; (iii) we devised new strategies for synthesizing multifunctional nanoscale materials to be used for electronics and photovoltaics.

9:30 AM

(G2-015-2016) Potential and Limitations of Near-Infrared Excited Lanthanide-Doped Nanostructures as Multifunctional Players (Invited)

E. Hemmer*[2]; F. Vetrone[1]; F. Légaré[1]; 1. Institut National de la Recherche Scientifique, Canada; 2. University of Ottawa, Canada

Upconversion emission (emission of UV/visible light under near-infrared (NIR) light) and the emission of longer wavelength NIR light under excitation with shorter wavelength NIR light are well-known for lanthanide (Ln) ions, such as Er^{3+} or Ho^{3+}, doped in a suitable host material. This allows for use of Ln-doped nanoparticles in a plethora of applications including the field of biomedicine, where the use of NIR light is of particular interest due to its ability to penetrate deeper into biological tissue than UV or visible light. Aside from this, Ln^{3+}-doped nanoparticles exhibit temperature-dependent luminescence. This makes them promising candidates for the temperature monitoring of a biosystem, which is expected to open new avenues in medical diagnostics. In this context, the potential of Ln^{3+}:$NaGdF_4$ nanoparticles as building-blocks in novel nanothermometers will be discussed. Beyond the field of biomedicine, upconverting nanoparticles (UCNPs) gained recently interest regarding applications in the energy sector. Yet, a major drawback is the limited efficiency of the UC process (typical quantum yields (QY) <1%). Here, we will present novel insights in the QY on Er^{3+}/Yb^{3+} co-doped UCNPs seeking better understanding of the structure-property relationship in UCNPs, which is a crucial step towards more efficient upconverters.

10:20 AM

(G2-016-2016) Complex metal and oxide materials for renewable energy (Invited)

G. Westin*[1]; 1. Uppsala University, Sweden

Synthesis routes using metal alkoxides and organically coordinated metal salts are described for synthesis of complex oxides, nano-composites and nano-structured metals. Oxide systems of varying complexities were prepared in the forms of thin and ultra-thin films at temperatures typically in the range 270-500ºC. The influence of the precursor, reaction kinetics and thermal treatment in relation to the structures and properties obtained will be discussed. Further the processing using organically coordinated metal salts developed to yield metals and alloys will be described. This route allows for nano-crystalline metals and alloys to be prepared with crystallite sizes below 10 nm, as well as thin- and ultra-thin coatings on nano-structured oxides. Synthesis temperatures in the range 150-500ºC were used. Similar synthesis strategies were used for synthesis of metal-in-ceramic composite films and thin or ultra-thin coatings with a wide range of metal nano-inclusions and oxide matrixes will be described. The metal inclusion sizes were down to a few nm and loadings were up to over 80%. The syntheses and products were studied with a wide array of analytical techniques including. Such simple low cost synthesis routes to highly complex nano-materials are required for practical application in many areas of sustainable energy conversion and storage, catalysis and magneto-electric applications.

10:50 AM

(G2-017-2016) Some fundamentals of catalysis in energy conversion reactions

E. Roduner*[1]; 1. University of Pretoria, South Africa

It is common knowledge that catalysts enhance reaction rates by lowering the activation energy, but it is often obscure *how* catalysts achieve this. High efficiency and selectivity are particularly important in energy conversion reactions. Some fundamental principles of catalysis will be discussed: • Size and shape effects of metallic nanoparticle catalysts • Electronic metal-ceramic support interactions • Fluxionality around the catalytic center • Reversibility of catalytic reactions • Advantages and disadvantages of electrocatalytic reactions Examples will be given mostly for the interconversion between formic acid and H_2/CO_2.

11:10 AM

(G2-018-2016) High-rate CO_2 Photoreduction to CH_4 and CO on Metal-Nitride Nanowires

S. Vanka*[1]; B. AlOtaibi[1]; Z. Mi[1]; 1. McGill University, Canada

Carbon dioxide is one of the major greenhouse gases and at present carbon dioxide emission in the world is at an alarming rate. One of the promising approaches to mitigate this greenhouse gas and transform it into beneficial fuels is to use solar energy. In this study, GaN nanowire arrays were grown on n-type Si substrate by radio-frequency plasma-assisted molecular beam epitaxy under nitrogen rich conditions. Rh/Cr_2O_3 and Pt were photodeposited on the lateral surfaces of GaN nanowires separately to serve as co-catalysts, which are beneficial in CO_2 reduction due to the enhancement in charge separation and the activation of CO_2. By using Rh/Cr_2O_3 core/shell co-catalyst on GaN nanowires, the production of CH_4 is significantly increased, with an average rate of ~3.5 μmol $g_{cat}^{-1}h^{-1}$. Also, the rate of CO_2 to CO conversion is suppressed by nearly an order of magnitude. The rate of photoreduction to CH_4 can be further enhanced and can reach ~14.8 μmol $g_{cat}^{-1}h^{-1}$ by depositing Pt nanoparticles on GaN nanowires. These results, together with the achievement of CO_2 reduction into methane and methanol under visible light illumination will be reported.

11:30 AM

(G2-019-2016) Mesoscopic Modeling of Semiconductor-Liquid Junctions

A. Iqbal*[1]; K. H. Bevan[1]; 1. McGill University, Canada

The rising societal and environmental costs of fossil fuels have driven a resurgence of intense research interest into artificial photosynthesis. However, a comprehensive device model to capture the essence of semiconductor H_2 evolution is immensely challenging as the process involves both atomic scale reaction kinetics at the interface and mesoscale band transport in semiconductor. In this work we attempt to address the phenomena driving water splitting at semiconductor liquid interfaces within the context of a mesoscopic drift-diffusion model. It is shown that a modified Gerischer description can predict the trend of I-V characteristics and Mott-Schottky plot, often observed experimentally. In general, the results of this work are intended to drive the development of comprehensive engineering tools for the optimization of photocatalytic performance.

G4. Ceramics for Sustainable Infrastructure: Geopolymers and Sustainable Composites

Green Building Materials

Room: Trinity IV
Session Chairs: Henry Colorado, Universidad de Antioquia; Waltraud Kriven, University of Illinois at Urbana-Champaign

8:30 AM

(G4-001-2016) Potassium Geopolymer-Bamboo Composite: A Sustainable Construction Material (Invited)

R. A. Sa Ribeiro[2]; M. G. Sa Ribeiro[2]; K. Sankar[1]; W. M. Kriven*[1]; 1. University of Illinois at Urbana-Champaign, USA; 2. National Institute for Amazonian Research, Brazil

Geopolymers are amorphous inorganic polymers that have excellent compressive and flexure strength with a low carbon footprint. However, in their pure form, without reinforcements, they are weak in tension and have low fracture toughness, like conventional ceramics. Bamboo is a fast growing, readily available natural material with a tensile specific strength equivalent to that of steel. Hence, chopped bamboo can be used to reinforce geopolymers in order to make low-cost, sustainable structural material. In this study a potassium polysialate siloxoAgeopolymer matrix was reinforced with randomly aligned bamboo short fibers (Guadua Angustifolia). Four-point flexure testing of bamboo-geopolymer composites were carried out according to ASTM standard C78/C78 M-10. Weibull statistics were used to analyse the flexure test data. Scanning electron microscopy (SEM) and energy dispersive x-ray spectroscopy (EDS) were used to investigate the microstructure as well as the Si/Al ratio in the geopolymer matrix. In addition, X-ray diffraction (XRD) confirmed the formation of geopolymer.

9:00 AM

(G4-002-2016) Wool-geopolymer composite boards with insulating and fireproof properties (Invited)

A. Natali Murri*[1]; V. Medri[1]; E. Landi[1]; 1. National Research Council of Italy, Italy

Thanks to its specific properties, sheep wool is particularly suitable for the design of insulating systems, especially if coupled with other materials that may impart additional mechanical properties. In this regard, if considered as potential replacement of other synthetic fibrous materials, sheep wool has the additional benefit of being completely hazard-free for human health and has lower costs. In this study thermal insulating boards were designed and produced by embedding different amount of wool wastes in a geopolymer matrix. In addition to showing insulating properties, the boards are non-flammable, thanks to the geopolymer binder that prevents the fibers to ignite and, consequently, the composite to degrade in case of fire. In addition, the ceramic nature of the matrix allow the composite to be used also as self-bearing elements, thanks to enhanced mechanical properties. Thermal and fireproof properties of the boards were evaluated by thermogravimetric analysis, thermal conductivity and cone-calorimetry tests, while mechanical properties were determined by 3-points bending tests and compressive strength tests. Obtained results showed that a geopolymer matrix loaded with 10%wt of wool fibers can ensure thermal insulating and fireproof properties (class A2 according to UNI-EN 13501-1) similarly to other synthetic products but with a considerable gain in terms of environmental impact.

9:30 AM

(G4-003-2016) Optimization of Mechanical Properties of Pond Ash Based Geopolymer as Construction Material (Invited)

M. Panigrahi*[1]; P. Rana[1]; R. Dash[1]; R. Ganguly[1]; 1. Gandhi Institute of Engineering and Technology, India

In few decades, researchers were reported the Geopolymer concrete. Geopolymer, it is an inorganic polymer. The matrix phase of Geopolymer is Pond Ash (PA). The mechanism involved of such polymer is that the silicon and the aluminum in the PA reacts with an alkaline solution of sodium silicate, sand and aggregates with water soluble plasticizer to form the Geopolymer concrete that binds the non-reactive materials. The aim of the work is to find compressive strength, structure with property relation and the thermal analysis of the prepared product. The compressive strength is found to be 22 MPa for 1 day cured PA based GP and 36 MPa for 1 day cured PA based GP Motar in the UTM machine. The DSC data's are well supported to the mechanism of the Geopolymer and the water of crystallization is found in the range of 100-250 deg Centigrade. The structural and morphological investigation was made by analytical testing like, SEM/EDX and XRD.

10:20 AM

(G4-004-2016) Effect of Electric Arc Furnace Dust on Phosphate Cement (Invited)

H. Colorado*[1]; 1. Universidad de Antioquia, Colombia

Electric Arc Furnace Dust (EAFD) is classified as a hazardous waste from the steel making industry with high zinc and other oxides contents that can leach in water and soil. Phosphate cements are alternative cement produced upon the reaction of an acid and a base in a process entirely conducted at room temperature in our method. In this paper, different loading contents of EAFD are mixed with wollastonite based phosphate cement in order to analyze the waste effect in microstructure, mechanical behavior, and setting time. For this, scanning electron microscopy, X-ray diffraction, X-ray fluorescence, and thermo-gravimetric analysis characterization were conducted in this research. Compressive strength and density tests were also evaluated.

G5. Advanced Materials, Technologies, and Devices for Electro-optical and Medical Applications

Optical Material II

Room: Trinity V
Session Chairs: Nobuhiro Kodama, Akita University; Romain Gaume, University of Central Florida

8:30 AM

(G5-021-2016) Development of Multi-Component Halides Scintillators (Invited)

E. Bourret*[1]; 1. Lawrence Berkeley National Laboratory, USA

The ability to make new materials is often key to major progress in fundamental physics and numerous applications. The field of scintillation is no exception. Scintillators, materials that emit light due to radiation interactions, find uses in a variety of radiation detection applications that such medical imaging, high energy physics experiments, ore identification/mining and detection of nuclear materials. The pace of discovery of new scintillators has increased dramatically in the last ten years with the realization that most mixed and complex halides have remarkable scintillation properties. However they are often needed in the form of single crystals of large dimensions that is a challenge to achieve. We will present the current state of the growth of single crystals of mixed and complex halides. In particular we will discuss the issues stemming from raw materials purity, the hygroscopic nature of the compounds, the propensity to fracture during cooling and their phase diagrams. Mixed Ba halides are fully miscible and melt congruently. Complex halides exhibit a variety of growth behavior. Results of engineering techniques aimed at improving the quality and performance of the single crystals will be discussed.

9:00 AM

(G5-022-2016) Transparent Ceramic Scintillators (Invited)

N. Cherepy*[1]; Z. M. Seeley[1]; S. A. Payne[1]; P. Beck[1]; E. Swanberg[1]; H. Steven[1]; D. Schneberk[1]; G. Stone[1]; B. Wihl[1]; S. Fisher[1]; P. Thelin[1]; N. Harvey[1]; T. Stefanik[2]; J. Kindem[3]; 1. LLNL, USA; 2. Nanocerox, USA; 3. Cokiya, USA

For lens-coupled radiographic imaging, transparent scintillators without optical scatter are required. Achieving high transparency in a polycrystalline material is challenging and requires innovation in processing. While optical scatter is better tolerated in scintillation counters, attention to process steps in order to optimize the intra-band gap trap state distribution is critical to achieving light yield proportionality, for the best gamma spectroscopy, or to reduce afterglow, for high throughput applications. We report here on our development of two new mechanically rugged, air-stable transparent ceramic scintillators. For radiography, the transparent ceramic bixbyite scintillator, (Gd,Lu,Eu)2O3, or "GLO," offers excellent x-ray stopping, due to its Zeff = 68 and density of 9.1 g/cm3. High transparency in 6-12" diameter plates is achieved by minimizing the formation of secondary phases by adding Gd to the Lu2O3 structure. For gamma spectroscopy, we have demonstrated 5 in3 Ce-doped Gd garnet transparent ceramics, by employing intersubstitutional ions to promote phase stabilization. When pixelated, we obtain R(662 keV) = 3.0%, for GYGAG(Ce) on silicon photodiode readout. This work was performed under the auspices of the U.S. DOE by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344, and has been supported by the US DHS, DNDO, under competitively awarded IAA HSHQDC-12-X-00149, and the US DOE NNSA, ESC.

9:30 AM

(G5-023-2016) Highly-sensitive stoichiometric analysis by Laser-Induced Breakdown Spectroscopy (LIBS): A diagnosis tool for the preparation of advanced optical ceramics (Invited)

R. M. Gaume*[1]; R. Locke[1]; S. J. Pandey[1]; M. Julian[1]; M. Baudelet[1]; V. Motto-Ros[2]; 1. University of Central Florida, USA; 2. Universite de Lyon, France

Transparent ceramics are important optical materials with applications ranging from high-strength windows to high-power lasers and nuclear detectors. Their challenging fabrication however still needs to be perfected to achieve sufficient consistency in optical quality. In particular, a very precise control of the material stoichiometry[1,2], beyond the precision of current analytical techniques, is often required. This work specifically explores the potential of Laser-Induced Breakdown Spectroscopy (LIBS)[3] for measuring the aluminum to yttrium ratio in $Y_3Al_5O_{12}$ (YAG) laser ceramics with a precision of 0.1 mol%. We have designed a compact LIBS system and used the 300 to 500nm spectral region to determine the temperature and composition of the plasma generated on pelletized ceramic samples[4] with varying stoichiometric Al/Y ratios. The simplicity and versatility of the technique will be presented and the achievement of high precision levels on sample compositions through careful instrument design and spectra analysis will be discussed.

10:20 AM

(G5-024-2016) Transparent Ceramics with Tailored Composition

Z. M. Seeley*[1]; N. Cherepy[1]; S. A. Payne[1]; 1. Lawrence Livermore Nat'l Lab, USA

Development of transparent ceramics on both the lab and industrial scale continues to find new uses where polycrystalline ceramics have advantages over other single crystal or glass optical materials. We have developed several new compositions of highly transparent ceramics which offer unique advantages and performance enhancements in the fields of gamma spectroscopy and X-ray CT imaging. In order to demonstrate additional advantages of the ceramic processing route, we are currently working to create transparent ceramics made from a green structure assembled from multiple components. Due to the solid state synthesis route of ceramic processing, maintaining a compositional gradient or structure in a 3-dimensional optic is feasible. The initial application of tailoring the activator concentration gradient to match the pumping profile in laser gain media will improve the laser efficiency. We have successfully fabricated laser rods with a Nd:YAG core and undoped YAG cladding by composite green body fabrication. Exercising this capability of compositionally tailored optical ceramics will likely have advantages in other applications. LLNL-ABS-680737

10:40 AM

(G5-025-2016) Highly transparent polycrystalline ceramics synthesized by full crystallization from glass (Invited)

M. Allix*[1]; E. Véron[1]; C. Genevois[1]; F. Fayon[1]; S. Alahraché[1]; K. Al-Saghir[1]; S. Chenu[1]; M. Suchomel[3]; F. Porcher[4]; C. Dujardin[2]; G. Matzen[1]; 1. CNRS (CEMHTI), France; 2. ILM, France; 3. Argonne National Lab, USA; 4. LLB, France

Transparent polycrystalline ceramics are an emerging class of photonic quality materials competing with single crystal technology for diverse applications. Polycrystalline ceramics offer several advantages, particularly in the fabrication of complex shapes and large-scale materials, and enable greater doping of optically active ions. However, up to date, only a limited number of cubic or nano-crystalline transparent polycrystalline ceramics requiring complex and expensive synthetic approaches has been reported. Our recent work shows the possibility to obtain new transparent polycrystalline ceramics by full and congruent crystallization from glass. This is demonstrated in the case of several new composition, such as $BaAl_4O_7$, $Sr_3Al_2O_6$ and $Sr_3Ga_2O_6$, all showing high transparency in the visible and infra-red ranges. Lately, we have focused our work on large scale and highly transparent strontium aluminosilicate compositions. A crystallographic study coupled to NMR experiments and DFT calculations of the birefringence evidences the role of structural disorder (Al/Si substitution and presence of vacancies on strontium sites) to explain the optical isotropy observed in these hexagonal materials. These results propose an innovative concept, the addition of a controlled structural disorder within crystalline structures, in order to lower the birefringence and to elaborate new transparent ceramics.

11:10 AM

(G5-026-2016) Transparent optical materials for infrared devices (Invited)

M. Prakasam*[1]; A. Largeteau[1]; 1. ICMCB-CNRS, France

Recent applications of Infrared (IR) radiation for various applications for designing optical components ranging from mirrors, lenses, prisms, infrared detectors and CO_2 lasers has increased the search for new materials and its quality. Various transparent materials such as crystals, ceramics and glasses are used for fabrication of IR devices. Conventional transparent materials have a strong absorption in the infrared region making them unsuitable in this spectral range. In the present scenario, crystal though are ideal for applications, primarily in terms of compactness and user friendly, these types of crystals are difficult to be grown due to the high temperature growth issues, which limit size and quality. Though transparent ceramics and glass-ceramics have low transmittance than single crystals has higher mechanical strength and large flexibility to fabricate into complex shapes. Transparent ceramics and glass-ceramics processing with nanosized ceramic powders and advanced densification technology provides an alternative approach to overcome the disadvantages/limits of conventional single-crystal growth methods. A discussion on the fabrication of ceramics, glass-ceramics and crystals for infrared devices and their applications will be presented.

G6: Porous Ceramics for Advanced Applications Through Innovative Processing

Membranes and High SSA Ceramics

Room: Trinity I/II

Session Chairs: Rénal Backov, CRPP UPR CNRS 8641; Dong-pyo Kim, POSTECH

8:30 AM

(G6-029-2016) Grignard functionalization: A new versatile technology to tune surface properties of porous ceramics (Invited)

A. Buekenhoudt*[1]; M. Dorbec[1]; D. Ormerod[1]; K. Wyns[1]; V. Meynen[2]; 1. VITO, Belgium; 2. University of Antwerpen, Belgium

VITO recently developed a novel post-synthesis modification method for ceramic membranes and other porous ceramics. By using Grignard chemistry, a wide variety of organic groups can be grafted on the surface of different ceramic membranes/materials. The technology offers a way to introduce specific functionalities which can significantly alter the surface properties of the ceramics. In contrast to other surface modification methods such as grafting with organosilanes, Grignard grafting results in the creation of a highly stable, direct covalent bond between the transition metal atoms at the ceramic surface and the carbon atom of the organo-magnesium compound. Meanwhile, Grignard modified membranes are in an advanced stage of development and currently 19 to 163-channel ceramic tubes with a length of 120 cm can be reproducibly grafted. This contribution will highlight the versatility and wide application scope of this novel technology. Several case studies covering various fields will be presented. The examples will show that grafting of specific groups on ceramic membranes or other porous ceramics offers a means to alter and tune their surface properties, thereby granting them superior or even unique separation capabilities. Field of applications include waste water filtration with strongly reduced fouling, affinity-based separation in organic solvents and chromatography.

9:00 AM

(G6-030-2016) The preparations and characterizations of the low-cost porous ceramic support layers for microfiltration

J. Ha*[1]; J. Lee[1]; I. Song[1]; 1. Korea Institute of Materials Science, Republic of Korea

Recently porous ceramic membranes have become a subject of special interest due to their outstanding thermal and chemical stability. To alleviate the manufacturing cost issues of porous ceramic membranes, recent research is focused on the utilization of low cost natural materials. In this study, we introduced porous ceramic membranes prepared from diatomite, kaolin, and pyrophyllite which are low-cost natural materials. And we report the results of our efforts to determine whether we could prepare a low-cost ceramic support layer that could control the average pore size, the largest pore size, the flexural strength and the air/water permeability effectively. The pore characteristics of the specimens were studied by scanning electron micrography, mercury porosimetry, capillary flow porosimetry, and a dead-end microfiltration system with particle counters.

9:20 AM

(G6-031-2016) Processing of Frit-Bonded SiC Membrane Supports

Y. Kim*[1]; S. Kim[1]; H. Yeom[1]; J. Ha[2]; I. Song[2]; 1. University of Seoul, Republic of Korea; 2. Korea Institute of Materials Science, Republic of Korea

Interest in SiC membranes has grown continually over the last decade because of their chemical resistance, high temperature stability, low fouling behavior, and high flux compared to polymeric and other ceramic membranes. In this study, porous SiC membrane supports were successfully prepared at a temperature as low as 850°C using SiC and glass frit. The effects of SiC starting particle size and frit content on microstructure, porosity, flexural strength, air flow rate, and maximum pore size were investigated. The porosity decreased with increasing the frit content and decreasing the starting particle size. In contrast, the flexural strength vs frit content curve had a maximum; i.e., there was a small frit content range at which optimum flexural strength was realized. The best results were obtained when the content was ~15 wt%. The specific flow rate increased with increasing the maximum pore size of the membrane supports. By controlling the starting particle size of SiC powders and frit content, the porosity and maximum pore size of membrane supports could be tailored in the ranges of 37-46% and 3-13 μm, respectively. The flexural strength and specific air flow rate of the SiC membrane support prepared from 65 μm-sized SiC and 15 wt% frit were 65 MPa and 63 L/min/cm^2 at an applied pressure of 30 psi, respectively.

9:40 AM

(G6-032-2016) Template-Assisted Polymer-Derived Ceramic Route: From Mesoporous Powders to Monoliths with Hierarchical Porosity

B. Anthony[1]; V. NGuyen[1]; P. Miele[1]; S. Bernard*[1]; 1. CNRS, France

Nowdays, there is a trend toward more flexibility and an increased interest in “smart” and ”adaptive” materials with the objective to meet most industrial specifications. Inherent difficulties to the traditional techniques for the formulation of high performance materials and in particular ceramics can be overcome by the development of novel synthetic paths where chemistry, processing and material science are combined rationally to process multi-scale complex solid state architectures. The relatively recent Polymer-Derived Ceramics (PDCs) concept, which is based on the shaping then pyrolysis of inorganic (= preceramic) polymers into “near net shape” advanced ceramics, is a chemical route which offers original and new preparation opportunities in ceramic science. Here, a template-assisted PDCs route is investigated for preparing materials with tailored porosity from mesoporous powders to monoliths with hierarchical porosity. The strategy is detailed and materials with tailored specific surface areas as well as controlled pore arrangement can be generated. A particular focus will be made on the particular structure of PDC foams made of a relatively large size of cavities and junctions to address easy access toward different types of guest molecular moieties such as MOF crystals to provide CO_2 uptake.

Innovations in Processing Methods of Porous Ceramics

Room: Trinity I/II

Session Chairs: Young-Wook Kim, University of Seoul; Samuel Bernard, CNRS

10:20 AM

(G6-033-2016) Integrative Chemistry: From Bio-inspired Strategies toward Advanced Functional Macrocellular Ceramics (Invited)

R. Backov*[1]; 1. CRPP UPR CNRS 8641, France

Chemical sciences are on continuous evolution offering more and more complex synthetic strategies that rely on emerging inter- and trans-disciplinary vocation. In this vein, we will demonstrate how Integrative Chemistry, through combining soft matter and soft chemistry, allows scissoring matter over all length scales . Therefore, we will focus the talk on biliquid foam oil/water interfaces and sol-gel chemistry toward rational morphosyntheses of advanced functionnal foams. Several nonn-exhaustive applications will be discussed ranging from heterogeneous catalysts enzymatic (foran trans-esterification process) and metallic(Mizoroki-Heck coupling reactions), energy conversion (bio-fuel cells), enegy storage when dealing with Li(BH4)-based confinment storage, as well as

Li-S battery electrodes. Recent results dedicated toward CO2 scavenging within MOF-modified Si/B/C/N macrocellular foams will be discussed.

10:50 AM

(G6-034-2016) Interfacial Synthesis of Metal-Organic Frameworks Structures by Microfluidics and Hollow Mold (Invited)

D. Kim*[1]; 1. POSTECH, Republic of Korea

Metal–organic frameworks (MOFs) are a new crystalline but highly porous materials consisting of metal ions coordinated by organic ligands. Recently, microfluidic strategy for continuous and fast synthesis of MOF nanoparticle and their various hetero-structures rapidly extends into further applications with a variety of functional hollow MOF spheres. In this talk, new single and multi-shell functional MOF hollow spheres were developed by interfacial synthesis in the droplet-microfluidic approach using immiscible two liquid phases. Firstly, the biocompatible MOFs (e.g. iron fumarate MIL-88A) are of crucial interest for enzymatic reaction in a selected and protective manner, it would be beneficial to maintain the reliable bioactivity even under unfriendly conditions. Different types of enzymes were chosen, encapsulated inside hollow MOF spheres and tested in comparison with spheres-free enzymes. This strategy is further exploited for the fabrication of multi-shell MOF structures by automated layer-by-layer synthesis method using immiscible two micro-droplet phase for tandem catalysis. In addition, various MOFs microstructures could be directly prepared by micro-interfacial synthesis methodology with hollow mold, then readily transferred the patterns on various substrates.

11:20 AM

(G6-035-2016) Mesoporous Ce-containing silicon oxycarbonitride nanocomposite membranes for green fuel generation

A. Tamayo*[1]; B. García[2]; 1. Institute of Ceramics and Glass, CSIC, Spain; 2. Universidad Autonoma de Madrid, Spain

Porous ceramic nanocomposite materials have been developed for syngas production through the thermochemical splitting of H_2O and CO_2. After pyrolysis in inert atmosphere of preceramic hybrids, silicon oxycarbonitride nanocomposites containing Ce oxides have been produced as stand-alone membranes. It has been carried out the structural characterization of the obtained materials through spectroscopic techniques and its thermal behavior has been studied as well. The infrared characterization confirms the presence of Si-O, Si-C and Si-N bonds whereas the Raman spectra inform about the presence of a free C phase. The membranes possess a mesoporous structure with pores comprised between 6 and 20 nm size and varies with the amount of Ce. The reactivity of the nanocomposites has been evaluated by injecting the gases CO_2 and H_2O into ceramic tubes coated with the silicon oxycarbinitride nanocomposites. The thermochemical reactions, occurring at temperatures beyond 1000 ^{0}C have been monitored through the analysis of the gases escaping from the tubes. As a result of the reduction of the catalyst, carbon monoxide was produced in presence of CO_2 whereas in a second stage, the production of H_2 could be determined at lower temperature after the injection of H_2O into the ceramic reactor.

G8. Multifunctional Coatings for Sustainable Energy and Environmental Applications

Functional Coatings and Thin Films

Room: York B

Session Chairs: Tetsuo Tsuchiya, National Institute of Advanced Industrial Science and Technology (AIST); Hiroaki Nishikawa, B.O.S.T., Kinki Univ.

8:30 AM

(G8-018-2016) Low temperature growth technique to achieve transparent conductive oxide semiconductors films with high carrier transport (Invited)

T. Yamamoto*[1]; J. Nomoto[1]; H. Makino[1]; 1. Kochi University of Technology, Japan

We demonstrate a new type of thin-film-deposition method that enables us with the film growth with low temperature process. The temperature ranges from a room temperature to 200 degree Celsius. The deposition technique, therefore, provides us with the fabrication of the thin films on flexible polymer substrates with weak heat resistance. We have achieved photovoltaic cells with a conversion efficiency of 24.1% using high Hall mobility cerium oxide and hydrogen co-doped indium oxide electrodes. In addition, we have succeeded in the fabrication of Ga-doped ZnO films with very low optical-loss in the near-infrared spectral range, especially the telecommunication wavelength of 1.5 micron meter. In this talk, we discuss key ingredients in the recipe for the success. Taking into consideration the fact that the oxide films show a polycrystalline textured structure, the first point is to control the evolution of the orientation distribution, and the second point is to improve intra-grain carrier mobility together with the substantial reduction of the contribution of grain boundary scattering to carrier transport. We will clarify the advantage of our deposition technique over the conventional growth technique.

9:00 AM

(G8-019-2016) Room temperature deposition of organic/oxide hybrid gate dielectrics for emergent oxide devices (Invited)

H. Tanaka*[1]; 1. Osaka University, Japan

Electrostatic approach utilizing field-effect transistor (FET) on functional oxides provides an avenue to realize the novel devices and to clarify condensed matter physics. The proposal of hybrid gate dielectrics composed of organic polymer and high-k metal oxide deposited at room temperature enables to develop low-consumption field-effect transistors for functional oxides. We prepared $KTaO_3$ channel FET with hybrid gate dielectrics composed of parylene-C and Y-doped Ta_2O_5 with different ratios of component thicknesses. The conformal coating of organic film and successive deposition of amorphous metal oxides at room temperature lead to well defied interface. The hybrid gate dielectrics could combine advantages of organic film which cover channel surface with less defect and of amorphous metal oxide layer which contribute high dielectric permittivity. The optimized transistor performance was achieved with appropriate Y-doped Ta_2O_5/parylene-C thickness ratio from the point of view on low voltage operation. In addition, Mott-transistors using VO_2 channels employing hybrid gate dielectric triggered carrier transport modulation in VO_2 around phase transition temperature. The hybrid gate dielectrics can be integrated with various channel oxides at low temperature and would be important for the understanding of interface phenomena.

9:30 AM

(G8-020-2016) Development of Functionalized Materials by Surface Chemical Modification (Invited)

T. Nakamura*[1]; 1. National Institute of Advanced Industrial Science and Technology, Japan

Carbon materials, such as diamond powder, films, diamond-like carbon (DLC) films, and single-walled carbon nanotubes (SWNTs), and polymer materials are attractive materials and have been widely investigated because of their various unique electrical, thermal, biological and mechanical properties. Chemical modification of the surface of these materials is expected to lead to an improvement of their original properties while maintaining the bulk properties of carbon and polymer materials. We have developed a simple and useful process for fabricating functional and biocompatible carbon and polymer materials modified with a variety of functionalities by chemical surface modifications. The introduction of the functional moieties on the surface of carbon and polymer materials by using photochemical and organochemical processes showed an improvement of their original properties such as hydrophobicity, hydrophilicity, biomolecular attachment, tribological properties and metal attachment while maintaining the bulk properties of carbon and polymer materials.

10:20 AM

(G8-021-2016) Preparation of fluoroalkyl end-capped oligomers/talc composites – encapsulated cross-linked polystyrene: Application of these composites to the separation of oil and water

H. Sawada*[1]; 1. Hirosaki University, Japan

Fluoroalkyl end-capped vinyltrimethoxysilane oligomer [R_F-(VM)$_n$-R_F; R_F = fluoroalkyl group] can be applicable to the composite reaction with talc particles in the presence of the cross-linked polystyrene particles (PSt) to provide the R_F-(VM-SiO_2)$_n$-R_F/Talc/PSt composites. Interestingly, the modified glass surfaces treated with these composites show a superoleophilic-superhydrophobic characteristic on the modified surface, because the dodecane and water contact angles are 0 and 180°, respectively. Therefore, we tried to apply the R_F-(VM-SiO_2)$_n$-R_F/Talc/Pst composites to the packing material for the column chromatography to separate the fresh W/O (oil: 1,2-dichloroethane) emulsion under reduced pressure to isolate the colorless oil. These results will be demonstrated in this conference.

10:40 AM

(G8-022-2016) Plasmonic thin films structured by Glancing Angle Deposition and their applications to optofluidics (Invited)

K. Namura*[1]; 1. Kyoto University, Japan

Thermoplasmonic effect of gold nanoisland films is attracting much attention for use in local heating at nanometer scale. A focused laser spot on the films can be used as a mobile point heat source for various applications, including biomedicine, chemical reactions, photoacoustics, and optofluidics. The key to efficient heat generation is the shape and size of the gold nanoparticles, to which their optical absorption is sensitive. Glancing angle deposition is one of the physical vapor deposition techniques, which allows us to self-assemble unique nanostructured thin films by tuning the deposition angle. Series of the thin films with various gold nanoparticle sizes are fabricated by using the glancing angle deposition. The local temperature controllability of the fabricated thin films is investigated by photoacoustic measurements. In addition, those thin films are used to demonstrate optofluidic control based on the Marangoni effect, which is found to be useful for mixing, collecting, and sorting particles dispersed in microfluidic chamber filled with water.

11:10 AM

(G8-023-2016) 2D Oxide Nanosheet: A New Platform for High-Temperature electronics (Invited)

M. Osada*[1]; 1. National Institute for Materials Science, Japan

In recent years, the development of new electronic materials for high-temperature applications has been a significant challenge in electronic fields. In automotive industries, for example, cutting-edge technology requires electronic components operable at high temperatures (> 200 °C). However, the lack of reliable high-temperature, high-value capacitors has almost certainly limited growth in these new applications. We now provide a new approach to produce robust high-temperature nanocapacitors using a molecularly-thin high-k material (perovskite nanosheet $Ca_2Nb_3O_{10}$). Through various in-situ characterizations, nanosheet-based capacitors retained both high-e_r characteristic (~200) and high insulation resistance (~10^{-7} A/cm^2) at high temperatures up to 250 °C. Even with an extremely small thickness of ~15 nm, nanosheet-based capacitor shows a small t value (-180 ppm/K), which is almost comparable to the best t value of thin films (+110 ppm/K for $CaBi_4Ti_4O_{15}$). The simultaneous improvement of e_r and thermal stability in high-k nanodielectrics is of critical technological importance, and perovskite nanosheet has great potential for a rational design and construction of high-temperature capacitors.

11:40 AM

(G8-024-2016) Electronic properties of $LaFeO_3$/$SrTiO_3$ heterointerface

H. Nishikawa*[1]; 1. B.O.S.T., Kinki Univ., Japan

Since the discovery of the metallic interface between $LaAlO_3$/$SrTiO_3$ (STO), the oxide hetero-interfaces with novel electronic properties have been very noted which involve the charge reconstruction. As a new stage of the study, we have noted the possibility for the filling control, i.e., the variation of carrier density and the magnetism of the transition metal oxides due to the charge reconstruction at the hetero-interface. Our idea is to utilize difference of band gaps at the hetero-interface between charge-transfer insulator and STO. For example, from the schematic band diagrams at the interface between $LaFeO_3$ (LFO) and STO, doped-electron into Ti3d^1 of STO (3.2 eV from top of the valence band) can be transferred to Fe3d^6 band in LFO (2.2 eV from top of the valence band). This phenomenon can realize the filling control and the magnetism variation of the FeO_2 atomic layer in the LFO. We have grown LFO by pulsed laser deposition on the atomically flat TiO_2-terminated STO (100). During the growth, the surface morphology was monitored by the reflection high-energy electron diffraction (RHEED). The relationship between the resistivity and the temperature of the interface between LFO thin film and STO (100) single crystal shows the metallic conductivity.

H2: Design and Development of Advanced Ceramic Fibers, Interfaces, and Interphases in Composites- A Symposium in Honor of Professor Roger Naslain

Oxide Fibers for Ceramic Matrix Composites

Room: Salon D

Session Chair: Bernd Clauss, DITF

8:30 AM

(H2-018-2016) Novel oxide fibres to reinforce ceramic and metal matrices (Invited)

S. T. Mileiko*[1]; 1. Institute of Solid Physics, Russian Federation

A variety of oxide and metal matrices requires new oxide fibres that should be sufficiently strong and creep resistant at high temperatures and either to provide a possibility to arrest crack in an matrix or to decease oxidation rate of a refractory-metal matric composite to enhance the use temperature of MMCs. The internal crystallization method to obtain oxide fibres i is now using to obtain a family of novel fibres that are characterized by a number of interesting properties. In particular, 1. Fibres containing Al_2O_3-$Y_3Al_5O_{12}$-$CaAl_{12}O_{19}$ are of interest because Al_2O_3-$Y_3Al_5O_{12}$ eutectic is a creep resistant at high temperatures and $CaAl_{12}O_{19}$ inclusions enhances the fracture toughness of composites due to strong anisotropy of calcium hexaaluminate. 2. Fibres containing mullite and zirconia are of interest because of highest creep resistance of mullite among oxides. It occurs that a brittle-matrix composite reinforced with such fibres an evidence of quasi-plastic behavior. 3. Oxide fibres containing either yttrium or lanthanoid elements, examples being $Al_5M_3O_{12}$-Al_2O_3 eutectics where M=Y, Er, Tb…, slow down oxidation of the molybdenum matrix. Fabrication, microstructures, and properties of the fibres mentioned are described in the full-text paper. The results presented have been obtained under support of Russian Science Foundation, Project 16-19-10624, and Russian Foundation for Basic Research, Project 15-03-05415

9:00 AM

(H2-019-2016) Recent developments of oxide ceramic fibers for high performance composites

S. Pfeifer*[1]; B. Clauss[1]; M. R. Buchmeiser[2]; 1. DITF, Germany; 2. University of Stuttgart, Germany

Research at ITCF Denkendorf focuses on the development of continuous oxide ceramic fibers of various composition. Corundum and mullite fibers have achieved a high level of development in the past years. Recent investigations of the fiber properties by others have shown the high potential of these two fiber types. Beyond this, special efforts have been devoted to the development of yttrium aluminum garnet (YAG) and zirconia toughened alumina (ZTA) fibers. Whereas YAG fibers do not yet provide good mechanical stabilities, ZTA fibers can already be produced with good tensile strengths. Spinning dopes containing ceramic precursor materials and polymeric spinning additives can be produced and subsequently be transformed into green fibers via a dry spinning process. Thermal treatment of the green fibers using different temperature profiles results in ceramic fibers of the desired composition. Intensive studies via wide angle X-ray diffraction and thermal analysis (DSC/TGA) coupled with evolved gas analysis as well as structural investigations by SEM were performed to facilitate the understanding of the phase formation and structure-property relationships of the individual oxide ceramic fibers.

9:20 AM

(H2-020-2016) Microstructure evolution and long term performance of a novel mullite fiber at high temperatures

R. S. Almeida*[1]; K. Tushtev[1]; K. Rezwan[1]; 1. University of Bremen, Germany

The objective of this work is to analyze the novel fiber CeraFib 75 in regard to temperature dependent properties. This fully crystalline mullite fiber was developed to overcome the thermal stability of commercially available oxide fibers. Therefore, several tensile and creep tests were used to characterize the fibers under different conditions. As-received CeraFib 75 fibers presented a microstructure of mullite grains with traces of γ- and α-alumina in-between. As a result, the room temperature strength of the new fiber is lower than the well established Nextel 720 fiber. Still, CeraFib 75 showed a higher tensile strength than Nextel 720 when tested at temperatures higher than 1200 °C. The same tendency was seen for the strength retention after heat treatment at temperatures of 1000 - 1400 °C for 25 hours. Creep rates measured were of the same order of magnitude for both fibers, and an increase of the creep resistance was seen after the heat treatments. Further crystal phase and microstructure analysis were used to support each mechanical observations raised. Thus, CeraFib 75 presented an overall superior performance at high temperatures, which was credited to the higher amount of crystalline mullite phase of this fiber.

9:40 AM

(H2-021-2016) Alumina ceramic fibers: Effects on the structure because of exposure to high temperatures

T. Go*[1]; G. Seide[1]; T. Gries[1]; 1. Institute of Textile Technology, RWTH Aachen University, Germany

The motivation for the development of ceramic composite materials is based on the characteristic property of ceramic materials to be very stable at high temperatures and thus maintain their high strength. The central issue that complicates the use of monolithic ceramics is the high brittleness. Under high load two effects are caused by the fibers: On the one hand the fiber pull-out effect and on the other hand, the crack deflection. Both effects can increase the fracture toughness of CMCs compared to a monolithic ceramic significantly. Alumina ceramic fibers show a loss in tensile strength due to creep and grain growth at high temperatures. The crystal growth of commercially available ceramic fibers is detected with different methods. The loss of the strength of the fibers is measured in different stages. Thus, the effects of crystal growth on the strength and therefore the possible applications in CMCs, which are to be used at heights temperatures investigated. The structure of the fibers is not evaluated only at one point but for every fiber at many different measuring points. Characterized statements about the homogeneity of the fibers can be made because of this. This approach not only applies to the study of the structure, but also for the external appearance of the fibers. That is why many points of a fiber are evaluated microscopically and e.g. the fiber cross-section are rated.

H3. Innovative Design, Advanced Processing, and Manufacturing Technologies

Innovative Design IV

Room: Bay

Session Chairs: Laifei Cheng, Northwestern Polytechnical University; Thomas Konegger, TU Wien - Vienna University of Technology

8:30 AM

(H3-024-2016) Crystallization behavior of amorphous Si-B-C-N ceramic sintered at ultra-high pressure and high temperature (Invited)

D. Jia*[1]; Z. Yang[1]; B. Liang[1]; Y. Zhou[1]; X. Duan[1]; 1. Harbin Institute of Technology, China

The high dense amorphous Si-B-C-N bulk ceramic was fabricated at 1000~1600 °C under a pressure of 5 GPa for 30 min where the mechanically alloyed amorphous SiBCN powder was used as raw material. The crystallization and microstructure evolution behaviors of the prepared ceramics were carefully investigated by XRD, TEM and HRTEM. Results show that, at or below 1100°C, the ceramic lies in an amorphous state. With the increasing temperature, the atomic arrangement tends to be well organized, followed by the precipitation and growth of SiC and BN(C) nanocrystals. Above 1400°C, numerous SiC nanocrystals are present in the amorphous ceramic matrix. At 1600°C, the microstructure of Si-B-C-N bulk ceramic is characterized by SiC nanocrystals with an average size of 10~30 nm surrounded by BN(C) phase. The further investigation remains to be done for BN(C) microstructure evolution behavior.

9:00 AM

(H3-025-2016) Infiltration Kinetics and Defect Evolution during 1st Infiltration in Polymer Impregnation and Pyrolysis processing of Ceramic Matrix Composites

N. M. Larson*[1]; F. W. Zok[1]; 1. University of California, Santa Barbara, USA

Current matrix processing methods are ineffective in producing SiC/SiC ceramic matrix composites (CMCs) that can operate for extended periods at 1500°C in engines. To utilize SiC/SiC CMCs at their full potential, processing routes for dense and pure matrices must be developed. The current study investigates defect evolution in polymer impregnation and pyrolysis (PIP) derived CMCs. During polymer infiltration, voids form due to flow speed variations in non-uniformly packed fiber beds. Many studies in the polymer matrix composite community have shown that infiltration kinetics determine the void content in impregnated fiber beds. Thus, understanding fiber bed infiltration kinetics is critical to optimizing CMC processing for denser matrices. In this study, the axial infiltration of unidirectional fiber beds was investigated experimentally. The effects of fiber bed non-uniformity and porosity on infiltration kinetics were determined, enhancing predictive capabilities of fluid flow models. Furthermore, a quantitative measure of fiber bed non-uniformity was developed from cross-sectional image analysis for each infiltrated fiber bed. The effects of infiltration kinetics on the final minicomposite void microstructure are discussed, highlighting opportunities for reducing the void content during the first infiltration in PIP derived CMCs.

9:20 AM

(H3-026-2016) Rapid concepts for the elaboration of carbon or carbide matrix for CMC: The superccritical fluid chemical infiltration and the film boiling chemical vapor infiltration

L. Maillé*[1]; A. Lorriaux[1]; M. Clavel[1]; N. Bertrand[1]; C. Aymonier[2]; Y. Le Petitcorps[3]; 1. University of Bordeaux - Laboratory for Thermostructural Composites (LCTS), France; 2. ICMCB-CNRS, France; 3. University Bordeaux, France

Works are based on the development of two processes for the fabrication of a C_f/C_m or C_f/SiC_m composite or thin films for aeronautic and aerospace industries. The first original process consists in the use of a supercritical hydrocarbon or SiC precursor to infiltrate a matrix in a carbon fiber preform. The second process concerns the film boiling chemical vapor infiltration (so-called Kalamazoo). These two processes allow dramatically reducing the processing time with respect to conventional processes (CVI - chemical vapor infiltration). The experimental parameters (temperatures, precursors, pressures and residence times) are studied in order to perform the carbon matrix. The feasibility of developing a matrix of SiC has been proven. The structure of the coating is characterized by X-Ray Diffraction and the microstructure is observed with an optical microscope.

9:40 AM

(H3-027-2016) Wet-chemical based coatings as interphases of C-fiber preforms

C. Spatz*[1]; W. Freudenberg[1]; N. Langhof[1]; W. Krenkel[1]; 1. University of Bayreuth, Germany

The potential of ceramic matrix composites for industrial applications, especially in the field of high-temperature lightweight design, is still growing. For the optimal utilization of the properties, the fiber-matrix-interface plays an important role. If the bonding is too strong, there is no fiber debonding and the material shows a monolithic fracture behavior. In the case of insufficient bonding, the force-transfer from the matrix to the fiber is prevented. Therefore, fiber coatings can significantly influence the damage tolerance and the failure behavior of ceramic matrix composites. This work presents a wet chemical based dip-coating of fiber preforms in sol-gel solutions to modify the fiber-matrix-interface. Different coating parameters were evaluated. The coatings are based e.g. on a phenolic resin or Si-precursors. The fiber preforms made of high-tensile carbon fibers (Torayca T700, T800) and pitch-based carbon fibers (Granoc XN-15) were manufactured by needling of fiber fleeces. The coating process itself and the microstructure were studied and analyzed. Furthermore, the influence on the mechanical properties of the non-oxide ceramic matrix composites made of these coated preforms is evaluated.

10:20 AM

(H3-028-2016) Thermoplastic Carbon Precursors for Ceramic Matrix Composites (Invited)

W. Krenkel*[1]; N. Langhof[1]; F. Reichert[1]; 1. University of Bayreuth, Germany

Ceramic matrix composites (CMC) draw interest of several industry sectors due to their extraordinary properties. The LSI process is an industrial process for the production of carbon fiber reinforced silicon carbide (C/C-SiC), which is an established material for high performance friction applications. Commonly, non-recyclable phenolic resins are used in this process and transferred to carbon materials. This thermosets are in need of time consuming crosslinking and tempering, which prolongs the process. In contrast to phenolics, two thermoplastic polymers, polyetherimide (PEI) and polyetheretherketone (PEEK), were examined in this study for an application as carbon precursors. Thermoplastics offer several advantages in comparison to thermoset polymers, e.g. reduced processing times and no gaseous reaction products, which occur during the crosslinking of phenolic resins. They offer the possibility to recycle the polymeric material, which is not feasible with thermoset phenolics. Raman and XRD measurements of Carbon/Carbon (C/C) materials reveal, that the derived carbon structure of both thermoplastics exhibit comparable graphitization properties and crystallite sizes than phenolic resin derived C/C. The resulting PEI and PEEK derived C/C-SiC materials with fabric reinforcement can reach a mechanical strength of more than 230 MPa determined via 4-point-bending.

10:50 AM

(H3-029-2016) Development, Manufacturing and Testing of Active Cooled Ceramic Matrix Composites in Propulsion Environment for Hypersonic- or Fast Transportation

S. Schmidt-Wimmer*[1]; S. Beyer[1]; M. Schroeferl[1]; C. Wilhelmi[2]; F. Meistring[2]; 1. Airbus Defence and Space, Germany; 2. Airbus Group Innovations, Germany

During the last years, joint efforts were made in Europe to improve knowledge on hypersonic propulsion, which requires a specific knowhow on component design and dedicated development activities on manufacturing and processing technologies. Active cooled structures were investigated for high speed vehicle applications. Prior to suchlike operation it is mandatory to solve key technology issues of aero-propulsive balance prediction of vehicles flying at high Mach number and the development of high-temperature structures for the propulsion systems, able to withstand very severe environmental conditions generated by the heat release process while ensuring reliability and lightweight construction. Within Airbus Group the development of high temperature ceramic composite materials and structures was strongly pushed. With CMCs a benefit of 30% in weight compared to metallic structures can be gained for particular engine concepts. Innovative technologies for active cooled ceramics based on Airbus CARBOTEX SI® (r-CVI/LSI 3D C/C-SiC) and SICARBON® (PIP 2D C/SiC) material and process techniques to manufacture combustion chamber components with fuel injection- or flame stabilization systems were investigated. Besides this Ultra High Temperature Ceramics (UHTCs) as well as dedicated low cost test facilities were evaluated within Airbus Group.

11:10 AM

(H3-030-2016) Si-C-N ceramics and Si-C-N matrix composites fabricated by CVI/CVD with excellent mechanical and electromagnetic absorbing properties

F. Ye*[1]; X. Yin[1]; L. Zhang[1]; L. Cheng[1]; Y. Liu[1]; 1. Northwestern Polytechical University, China

A novel Si-C-N ternary ceramics were prepared by chemical vapor infiltration/chemical vapor deposition (CVI/CVD) from $SiCl_4$–C_3H_6–NH_3–H_2–Ar precursor system. The as-received Si-C-N ceramics were composed of amorphous Si_3N_4 matrix and crystalline SiC nano-particles (with a homogeneous size of 5 nm) uniformly distributed in the amorphous matrix. This distinctive microstructure made Si-C-N ceramics not only maintain a high mechanical property but realize a low dielectric constant and a high dielectric loss, which led to a minimal electromagnetic reflection coefficient of -42.6 dB, ranking the best level in the already-reported high-temperature structural and wave-absorbing ceramic materials by CVI/CVD. After that, SiC fibers reinforced Si-C-N matrix composites (SiC/Si-C-N composites) were designed and prepared, and their properties were investigated. Also SiC/Si-C-N composites possess a good mechanical property combined with a promising wave-absorbing ability based on the modulus matching and electromagnetic matching between fibers and matrix.

11:30 AM

(H3-031-2016) Coatings and Matrices Improving the Oxidation Resistance of Carbon Fiber Reinforced Composites for Ultra-High Temperature Applications (Invited)

X. Zhang*[1]; S. Dong[1]; L. Gao[1]; H. Zhou[1]; J. Hu[1]; Z. Wang[1]; P. He[1]; Y. Kan[1]; Y. Ding[1]; 1. Shanghai Institute of Ceramics, Chinese Academy of Sciences, China

C/SiC and C/C composites are the prefferred carbon fiber reinforced composites for many high temperature applications because of their outstanding thermomechanical properties. However, owing to their instability in oxidizing environments at elevated temperatures, ultra-high temperature ceramics (UHTCs) coatings need to be developed to improve their oxidation resistance in extreme environments. Besides,introduction of UHTCs to the matrices of the carbon fiber reinforced composites is another potential solution. In this work, multilayered UHTCs coatings with different structures, comprising of SiC,MC and/or MB2 (M=Hf or Zr), are developed. The structures and compositions of the coatings are characterized and the oxidation resistances of the materials at high temperatures are evaluated using static oxidation or are jet tests. The preliminary results obtained will be discussed in detail with the purpose of presenting an understanding of the effects of the coating structures on the oxidation resistance of carbon fiber reinforced composites. Furthermore, carbon fiber reinforced composites with matrices consisting of UHTCs are prepared using various processes.The high temperature resistances of the composites are evaluated using arc jet tesing and the results are compared with that of the composite of which the matrix is not modified using UHTCs.

12:00 PM

(H3-032-2016) Microstructure and properties of Diamond/SiC composites via pouring forming and CVI using large particle size of diamond

Z. Zhao*[1]; Y. Liu[1]; Q. Zhang[1]; W. Feng[1]; L. Zhang[1]; L. Cheng[1]; 1. Northwestern Polytechnical University, China

Diamond/SiC composites using large particle size of diamond were fabricated via pouring forming and chemical vapor infiltration (CVI). The effect of particle size of diamond (ranging from 50 um to 500 um) on microstructure, flexural strength, density, fracture toughness, hardness, coefficient of thermal expansion (CTE) and thermal conductivity (TC) of diamond/SiC composites were discussed. With the increasing of particle size of diamond in composites, the thermal conductivity (TC)and density increased, which the maximum thermal conductivity (TC) and density could reach up to 154 W/(m•k) and 3.18 g/cm^3 respectively. The fracture mechanism of composites was evaluated through analysis of SEM image of fracture surface and residual thermal stress that caused by the mismatch of coefficient of thermal expansion of diamond particles and SiC matrix. Besides, the TC of CVI diamond/SiC composites could be estimated accurately by a modified model, which is Maxwell 2-EMT (effective medium theory).

Thursday, June 30, 2016

G2. Functional Nanomaterials for Sustainable Energy Technologies

Functional Nanomaterials for Sustainable Energy Technologies IV

Room: York A
Session Chair: Gunnar Westin, Uppsala University

8:30 AM

(G2-020-2016) Photo/Electrocatalysis: Mechanistic Insight and Catalyst Design from Density Functional Theory (Invited)

M. Li*[1]; 1. Xi'an Jiaotong University, China

Clean and sustainable energy technologies, such as fuel cells, metal–air batteries and sun-powered water-splitting, are currently under intensive research and development due to their high efficiency, promising large-scale applications, and virtually no pollution emission. Heterogeneous catalysis is at the heart of these technologies. The sluggish rate for the oxygen reduction reaction (ORR) or oxygen evolution reaction (OER) limits the performance of fuel cells and water-splitting devices. A better understanding of how catalysts work at the atomic scale is necessary to fabricate novel highly efficient, earth-abundant and cost-effective materials for ORR and OER. First-principles methods, such as density functional theory (DFT), can be used to determine atomic structures, reaction energies and activation barriers, thus enabling the understanding of elementary electrochemical processes at the solid-liquid interface and the computationally search for novel photo/electrocatalytic materials. In this presentation, we will discuss some results about overpotentials and relevant parameters with regard to ORR and OER at carbon-based catalysts and metal oxides surfaces using DFT. Future directions of our research group at IRCRE include using this fundamental knowledge to develop new design principles for more efficient photo/electrocatalysts as well as finding novel candidate materials.

9:00 AM

(G2-021-2016) Managing photons and carriers for photocatalysis (Invited)

H. Robatjazi[1]; S. Bahauddin[1]; C. Doiron[1]; X. Liu[1]; T. Tumkur[1]; W. Wang[1]; P. Wray[1]; I. Thomann*[1]; 1. Rice University, USA

While small plasmonic nanoparticles efficiently generate energetic hot carriers, light absorption in a monolayer of such particles is inefficient, and practical utilization of the hot carriers in addition requires efficient charge-separation. Here we describe our approach to address both challenges. By designing an optical cavity structure for the plasmonic photoelectrode, light absorption in these particles can be significantly enhanced, resulting in efficient hot electron generation. Rather than utilizing a Schottky barrier to preserve the energy of the carriers, our structure allows for their direct injection into the adjacent electrolyte. On the substrate side, the plasmonic particles are in contact with a wide band gap oxide film that serves as an electron blocking layer but accepts holes and transfers them to the counter electrode. The observed photocurrent spectra follow the plasmon spectrum, and demonstrate that the extracted electrons are energetic enough to drive the hydrogen evolution reaction. A similar structure can be designed to achieve broadband absorption enhancement in monolayer MoS2. Time permitting, I will discuss charge carrier dynamics in hybrid nanoparticles composed of plasmonic / two-dimensional materials, and applications of photo-induced force microscopy to study photocatalytic processes.

9:30 AM

(G2-022-2016) Exploring the optoelectronic properties of Cu-based alloys for solar energy applications (Invited)

C. Persson*[1]; 1. University of Oslo, Norway

The chalcopyrite is today a rather well-established compound for thin film solar cells. New Cu-based materials are explored to benefit from the energetically high-lying Cu d-state in combination with low effective mass of the minority carriers. Nanostructures as well as grain boundaries enhances the optoelectronic effects. Materials with higher functionality open for ultrathin devices and thereby less raw material usage. In this talk, we discuss the details in the optoelectronic properties of emerging Cu-based compounds, like for instance $Cu_2ZnSn(S,Se)_4$, $Cu_2Sn(S,Se)_3$, and $Cu_3(Sb,Bi)(S,Se)_3$, employing a GW approach beyond the density functional theory. We analyze the electronic structure and the optical properties in terms of the absorption coefficients. By modeling the quantum efficiency of the compounds and the device efficiency, we further discuss the optoelectronic response. The results help to understand fundamental physics of the Cu-based materials in order to design and optimize ultrathin solar-energy devices.

10:20 AM

(G2-023-2016) Melanin pigments: en route towards environmentally benign electronics (Invited)

C. Santato*[1]; G. Albano[1]; E. Di Mauro[1]; P. Kumar[1]; 1. Ecole Polytechnque de Montreal, Canada

Melanins are biomacromolecules responsible for the pigmentation of plants and animals. The biological functions of melanins, also present in the inner ear and the substantia nigra of the human brain, go far beyond coloration and include photoprotection, anti-oxidant behavior, and metal chelation. Melanins are also intensively studied for their involvement in melanoma skin cancer and Parkinson's disease. Eumelanins are the form of melanins most studied by material scientists for their photoconductivity and hybrid ionic-electronic transport. We will discuss extended structure properties relationships in eumelanins. Their film forming properties will be introduced considering their notoriously poor solubility in all solvents. The interfaces of eumelanin with metals and electrolytes under electrical bias will be presented, considering the melanins' metal binding properties. The charge transfer and transport properties in different experimental conditions (vacuum vs "wet") and different electrolytes will be reported. The study is relevant to demonstrate biodegradable and biocompatible electrochemical energy storage devices (supercapacitors) and to advance the knowledge on the functional role of melanin in biological systems.

10:50 AM

(G2-024-2016) Quantum Resistive Sensors functionalized by supramolecular assembly of cyclodextrins and graphene to detect ppb of VOC in the atmosphere (Invited)

J. Feller*[1]; S. Nag[1]; M. Castro[1]; P. Guegan[2]; 1. European University of Brittany (UEB), France; 2. Univ. Pierre & Marie Curie, France

A novel electronic nose system comprising functionalized β-cyclodextrin wrapped reduced graphene oxide (RGO) sensors with distinct ability of discrimination of a set of volatile organic compounds (VOC), has been developed. Non-covalent modification of chemically functionalized cyclodextrin with RGO is carried out by using pyrene adamantan as a linker wherever necessary, in order to construct a supra molecular assembly. The chemical functionality on cyclodextrin is varied utilising the principle of selective chemical modification of cyclodextrin. In the present study, the combined benefits of host-guest inclusion complex formation ability and tunable chemical functionality of cyclodextrin, as well as high surface area and electrical conductivity of graphene are utilized for the development of a set of highly selective quantum resistive chemical vapour sensors (QRS), assembled in an electronic nose to detect ppb of VOC in the atmosphere.

11:20 AM

(G2-025-2016) The eSHHA homogeneous platform: Quantitative detection of biomarkers directly in whole blood

S. S. Mahshid*[1]; 1. University of Toronto, Canada

The development of rapid, low cost, easy-to-use approaches for the quantitative detection of multiple biomarkers would drastically impact global health by enabling medical diagnosis at the Point-of-Care. Current multiplexed methods for the quantitative detection of antibodies or other disease markers are complex multiple-step processes reliant on well-trained technicians working in fully-equipped laboratories. As a promising alternative, we describe here eSHHA (electrochemical steric hindrance hybridization assay), as a novel signal transduction mechanism that uses steric-hindrance for the rapid detection of marcromolecules directly in whole blood at clinically relevant concentrations. This homogenous assay takes advantage of the high affinity and specificity of a free signaling DNA strands, carrying a specific recognition element and an electro-active moiety, to hybridize to a complementary capturing DNA strand attached to the surface of a gold electrode and generate electrochemical signal. This assay also takes advantage of the relatively large dimension of macromolecule in comparison to the diameter of double stranded DNA helices, which upon binding to the signaling DNA, inhibits the hybridization. Thus, having the multipelxing ability, this detection platform holds great promise to be well positioned for adaptation as, for example, point-of-care diagnostic.

11:40 AM

(G2-026-2016) Nanostructured WO_3 films for photoelectrochemical applications

F. Quenneville*[2]; X. Meng[2]; E. Di Mauro[2]; C. Santato[1]; 1. Ecole Polytechnque de Montreal, Canada; 2. École Polytechnique de Montréal, Canada

Global energy demand is expectd to increase by 37% from now to 2040 according to the last World Energy Outlook (2014) report from IEA [1]. To advance efficient technologies able to face this energy demand, our group studies metal oxides for the photoelectrochemical generation of fuels (H_2) and energy saving (electrochromic smart windows). Nanostructured mesoporous WO_3 films are among the metal oxides we investigate. Here we focus our attention on the investigation of interfaces between sol-gel deposited WO_3 thin films and electrolytes. Aqueous as well as organic electrolytes, e.g. ionic liquids and ion gels, are considered. For our studies we selected a planar transistor configuration, to easily estimate the charge carrier density that it is possible to achieve in the metal oxide upon application of a certain electrical bias, in dark and light conditions. This estimation is important both for photoelectrochemical and electrochromic applications. In the former case it helps to establish the efficiency of a certain material in extracting the photoproduced charge carriers after light harvesting (through the estimation of the electrical conductivity at different charge carrier density). In the latter case the planar geometry of transistors permits to observe with optical probes how the doping front advances upon application of an electrical bias to extract the ion mobility. [1] http://www.worldenergyoutlook.org/

G3: Novel, Green, and Strategic Processing and Manufacturing Technologies

Novel, Green, and Strategic Processing I

Room: York B

Session Chairs: Surojit Gupta, University of North Dakota; Satoshi Wada, University of Yamanashi

8:30 AM

(G3-001-2016) The Role of Interface Complexions on Processing Ceramic Matrix Nanocomposites (Invited)

W. D. Kaplan*[1]; 1. Technion - Israel Institute of Technology, Israel

The role of dopants in processing ceramics has been an important issue for many years, especially given the contradicting reports of retarded or accelerated grain growth by key dopants and impurities. We have developed a technique to experimentally measure dopant solubility limits at the sintering temperature, such that actual dopant levels can be associated with equilibrium grain boundary (GB) segregation (below the solubility limit) or with enrichment (above the solubility limit). New analysis of the GB mobility of alumina as a function of dopant concentration has shown that some segregating dopants increase the GB mobility, i.e. the opposite of solute-drag. The segregating dopants are associated with 2-D structural and compositional (complexion) transitions at the GBs, and possible changes in the mechanism of GB migration. This presentation will review recent GB mobility measurements and how complexion transitions can be used to control the location of reinforcing particles in the microstructure of ceramic matrix nanocomposites.

9:00 AM

(G3-002-2016) Bio-process Inspired Synthesis and Processing of New Structures and Materials (Invited)

Z. Fu*[1]; 1. Wuhan University of Technology, China

In studying and mimicking the well-defined structures or unique functions of biomaterials, scientists have succeeded in designing and synthesizing bio-inspired materials or bio-inspired functions. Furthermore, the fantastic structure-forming process in biological systems is also evolution results of many billions of years, which efficiently and accurately fabricate biominerals under environmentally benign conditions, in contrast to our present technological world where harsh conditions are commonly prerequisites. Hence, the natural structure-forming process itself is also worth learning by scientists to develop new synthesis and processing techniques for materials, which can be refereed as 'bio-process inspired synthesis and processing'. In this paper we will report our work about natural organism and genetically engineered living organism directed synthesis of nitrogen-doped anatase TiO_2 and its functional properties, organized and confinement controlled intrafibrillar mineralization directed by rationally designed multi-functional proteins, synthesis of vaterite phase directed by rationally designed mmultifunctional proteins. The bio-process inspired approach extends the present engineering methodology to produce materials, especially under environmentally benign conditions.

9:30 AM

(G3-003-2016) Heat-resistant Inorganic Fibers (Invited)

T. Ishikawa*[1]; H. Oda[2]; 1. Tokyo University of Science, Yamaguchi, Japan; 2. UBE Industries, Ltd., Japan

Up to now, many researchers have developed various inorganic fibers for developing composite materials with lightweight and high fracture toughness. Of these, carbon fiber has established a very big market after being adopted in airplane applications. By the practical use in B777 and B787, the consumption of carbon fiber has been remarkably increased. Besides the mechanical properties have been dramatically improved. And presently, SiC-polycrystalline fibers have been also addressed in the field of airplane engines for the severer applications at very high temperatures. Ube Industry (UBE) is one of suppliers of SiC-polycrystalline fiber. UBE's SiC-polycrystalline fiber (Tyranno SA fiber) shows very high heat-resistance up to 2000 degree C and relatively high mechanical properties. And so, some programs on the CMC technology using Tyranno SA fiber have been performed in the field of airplane engines. In these programs, the higher mechanical properties are expected for expanding the application parts. The historical tide is very similar to that of carbon fiber. And also, the control factors on the mechanical strength of these fibers are very similar. Now, the research on the mechanical properties of the SiC-polycrystalline fiber has been actively performed. In this paper, the aforementioned historical viewpoint and the important factors for controlling the mechanical properties of the SiC-polycrystalline fiber will be reported.

10:20 AM

(G3-004-2016) On the Design and Characterization of Novel MRM (MAX Reinforced Metals) (Invited)

F. AlAnazi[1]; S. Ghosh[1]; R. Dunnigan[1]; S. Gupta*[1]; 1. University of North Dakota, USA

It is well known that $M_{n+1}AX_n$ (MAX) phases (over 60+ phases) are thermodynamically stable nanolaminates. These solids display unusual and unique properties. These phases possess a $M_{n+1}AX_n$ chemistry, where n is 1, 2, or 3, M is an early transition metal element, A is an A-group element, and X is C or N. The MAX phases are highly damage tolerant, thermal shock resistant, readily machinable, and with Vickers hardness values of 2–8 GPa, are anomalously soft for transition metal carbides and nitrides.MAX phases display nonlinear, hysteretic, elastic behavior due to kink band formation in the basal planes. The composites of MAX phases with metals (MAXMET) are also important from both fundamental and applied perspective. In this study, recent results on mechanical and tribological behavior of MAX-Metal (Zn, Ag, Al, and Sn) composites will be presented.

10:40 AM

(G3-005-2016) Crystal Structure of In-Ga-Zn Oxide with Composition Shift

K. Dairiki*[1]; Y. Yamada[1]; R. Yamauchi[1]; M. Oota[1]; N. Ishihara[1]; Y. Kurosawa[1]; E. Kikuchi[1]; T. Takasu[1]; M. Tsubuku[1]; S. Yamazaki[1]; 1. Semiconductor Energy Laboratory Inc., Japan

In-Ga-Zn oxide (IGZO) has attracted much attention as a novel material for active layers or transparent electrodes in electronic devices, such as display devices with low power consumption. Kimizuka et al. investigated the crystal structure of In-Ga-Zn-O system, and found that In-Ga-Zn-O forms a homologous series of InGaO3(ZnO)m (m: an integer) which has a layered structure consisting of periodic In-O layers and intervening (Ga, Zn)-O layers. We discovered c-axis aligned crystal (CAAC), a new crystal morphology different from single crystal or polycrystal. CAAC-IGZO has a polycrystal-like structure in a microscopic view, but has no clear grain boundary in the a-b plane. We further investigated the crystal structure of IGZO which has a higher indium or zinc fraction than InGaO3(ZnO)m. The results show that zinc-rich IGZO forms the same crystal structure as InGaO3(ZnO)m, except that ZnO layers are randomly inserted between In-O layers. In addition, indium-rich IGZO is a solid solution of InGaO3(ZnO)m, in which some gallium atoms in (Ga, Zn)-O layers are displaced by surplus indium atoms. Owing to these features, the crystallinity of IGZO films which have a layered crystal structure, such as CAAC-IGZO, is stable even if composition fractions slightly shift from InGaO3(ZnO)m. The wide process margin for fabricating crystalline IGZO thin films facilitates the development of mass-production techniques.

11:00 AM

(G3-006-2016) Novel Structural Ceramics by Microstructure Design

S. Gupta[1]; A. Stoker*[1]; J. Steen[1]; W. Steidl[1]; Q. Tran[1]; T. Gorron[1]; E. Downward[1]; 1. University of North Dakota, USA

It is well known that during the hydraulic fracturing process sands, Ottawa or Brady sands for instance, and/or gravel are used as the proppant material. Drilling at deeper depths and higher pressure can crush sand based proppants, thus reducing well production potential. Different alternative materials have been investigated, for example, sintered ceramic proppant materials - bauxite and kaolinite. There is a huge potential that by using microstructure design, novel proppant materials with high fracture toughness can be fabricated. In this poster, we will present some of the recent research studies on the development of multilayered ceramics based systems.

11:20 AM

(G3-007-2016) Electrical and Mechanical Properties of Pressureless Sintered SiC–Ti_2CN Composites

T. Cho*[1]; Y. Kim[1]; 1. University of Seoul, Republic of Korea

One of the alternative methods for lowering the electrical resistivity of SiC ceramics is to introduce electrically conductive phases such as $MoSi_2$, NbC–Ti, and graphene into SiC. Highly conductive SiC–Ti_2CN composites were fabricated from β–SiC and TiN powders with 10 vol% equimolar Y_2O_3–AlN additives by pressureless sintering. The effects of initial TiN content on the microstructure, electrical, and mechanical properties of the SiC–Ti_2CN composites were investigated. It was found that all specimens could be sintered to ≥ 98% of the theoretical density without an applied pressure. Electrical resistivity of the SiC–Ti_2CN composites decreased with increasing TiN content. The electrical resistivity of the composite fabricated from a mixture containing 25 vol% TiN was 8.6 x 10^{-4} Ω•cm and typical flexural strength value of the composite fabricated from a mixture containing 12 vol% TiN was 494 MPa at room temperature. The low electrical resistivity of the composites was attributed to the in situ-synthesis of an electrically conductive Ti_2CN phase and the growth of N-doped SiC grains during pressureless sintering.

11:40 AM

(G3-008-2016) Surface Modifications of Aluminum and Magnesium alloys by Environment friendly Friction stir processing with addition of ceramic and rare earth materials

K. Singh Sandhu*[1]; H. Singh[2]; G. Singh[1]; 1. Punjabi University, India; 2. Yadavindra College of Engineering, India

Light weight advanced magnesium and aluminum alloys have wide application in aerospace, automobile and other structural industry due to its low density, good corrosion resistance and high strength to weight ratio. These alloys are soft in nature and sometimes due to application surface properties of these alloys are required to be improved. Friction Stir Processing a solid state processing technique is widely used to improve surface properties of these alloys. As processing takes place at solid state refines the microstructure and enhances wear resistance, hardness and tensile properties. Also FSP emerges as a low cost green processing technique as no consumables, fumes and hazardous gases are evolved during processing. Further addition of ceramic particles with FSP changes surface mechanical properties of these alloys. The properties depend upon various processing parameters, size and composition of ceramic particles. However rare earth materials like zirconia and fly ash can also be added. The ceramic particles in conventional liquid processing techniques at elevated temperature have interfacial reaction with metal matrix thus deteriorating mechanical properties.

Novel, Green, and Strategic Processing II

Room: York B

Session Chairs: Yiquan Wu, Alfred University; Young-Wook Kim, University of Seoul

1:30 PM

(G3-009-2016) Deposition Mechanism of Ceramic Layer with Room Temperature Impact Consolidation (RTIC) (Invited)

J. Akedo*[1]; 1. AIST, Japan

The manufacturing of ceramic materials usually requires sintering at high temperatures, which make it difficult to integrate ceramics with low melting point metals, glass or plastics. This is a serious hindrance for upgrading electro-ceramic components and optical components. The aerosol deposition (AD) method is unique coating technology based on collision of solid state fine ceramic powder with a substrate. This coating method has many advantages such as high deposition ratio, low process temperature, high adhesion force with a substrate. During the AD process, submicron ceramics particles are accelerated by gas flow in the nozzle up to a velocity of several hundred m/s and sprayed onto the substrate under vacuuming condition. We found interesting consolidation phenomenon of ceramic in this method over 10 years ago. During collision of fine particles and interaction with substrate, these ceramic particles not only for oxide materials but also for non-oxide materials, formed thick, dense and hard ceramic layers at room temperature. No additional heating for solidification of ceramic powder was required. We named this phenomenon "Room Temperature Impact Consolidation (RTIC)". In this presentation, we explain the densification and the bonding mechanism of ceramic fine particles with RTIC on AD process.

2:00 PM

(G3-010-2016) Preparation of Oxide-based Nano-complex Ceramics by Solvothermal Solidification Method with External-fields and Their Piezoelectric and Dielectric Property (Invited)

S. Wada*[1]; 1. University of Yamanashi, Japan

Recently, a new technique was proposed to prepare nano-structured ceramics with heteroepitaxial interfaces between barium titanate ($BaTiO_3$, BT) and potassium niobate ($KNbO_3$, KN) prepared at low temperatures below 300 deg. C, and their dielectric and piezoelectric properties were enhanced. On the other hand, bismuth ferrite ($BiFeO_3$, BF) had smaller unit cell volume by 1 % than that of BT. Therefore, we expected that the BT unit cell can be compressed and their dielectric properties for the BT-BF nano-structured ceramics were quiet smaller than those for the BT-KN nano-structured ceramics. To confirm the above idea, we prepared BT-KN and BT-BF nano-structured ceramics were prepared by solvothermal method in this study, and their dielectric properties were compared on the view of unit cell volume change of BT. After the reaction, the compacts were washed by ethanol, and dried at 200 deg. C. These nano-complex ceramics prepared in this study were porous with a porosity of around 25 ~ 35 %. The dielectric measurements showed that for the BT-KN nano- structured ceramics with KN/BT ratio of 1, the dielectric constant was 300 at 20 deg. C and 1 MHz, while for the BT-BF nano-complex ceramics with BF/BT ratio of 1, the dielectric constant was 70 at 20 deg. C and 1 MHz.

2:30 PM

(G3-011-2016) Electrical and Thermal Properties of SiC-Nitride (BN, AlN, Si_3N_4, Ti_2CN) Composites (Invited)

Y. Kim*[1]; S. Jang[1]; 1. University of Seoul, Republic of Korea

Electrical and thermal properties of SiC-nitride (BN, AlN, Si_3N_4, Ti_2CN) composites were investigated as a function of nitride content. The results suggested that (1) nitrogen in nitrides could be a source of nitrogen doping in SiC lattice; (2) the addition of a small amount of nitrides (BN, AlN, Si_3N_4) led to a decrease in the thermal conductivity of SiC; (3) a small amount of TiN addition increased the thermal conductivity of SiC, owing to oxygen scavenging of TiN from the SiC lattice; and (4) electrical and thermal properties of SiC ceramics were controllable by adding a small amount of nitrides. Electrical and thermal properties of the SiC-Ti_2CN composites were more deeply investigated as a function of initial TiN content. The SiC-Ti_2CN composites exhibited decreased electrical resistivity with increasing TiN content. The temperature-dependent resistivity of specimens revealed semiconductor-like behavior for TiN content up to 10 vol% and metal-like behavior above 20 vol%. The resistivity of metal-like specimens were as low as 3.5×10^{-4} Ωcm for TiN content of 20 vol%. The addition of a small amount of TiN increased thermal conductivity of SiC ceramics. However, further addition of TiN in excess of 10 vol% deteriorated thermal conductivity of the composites. A thermal conductivity of 224 W/mK was obtained for SiC-2 vol% Ti_2CN composites.

3:20 PM

(G3-012-2016) Fabrication of c-axis oriented AlN by a rotating magnetic field and SPS

T. S. Suzuki*[1]; K. Imai[2]; T. Nishimura[1]; H. Kiyono[2]; Y. Sakka[1]; 1. National Institute for Materials Science (NIMS), Japan; 2. Shibaura Institute of Technology, Japan

The thermal conductivity of AlN is expected to be improved by controlling crystalline orientation, because AlN has hexagonal crystal structure and the thermal conductivity along the c-axis is higher compared with other directions. Crystalline orientation in ceramics can be controlled by using a strong magnetic field. When the ceramics particles dispersed in the solvent are located in the strong magnetic field, the easy magnetization axis of particles rotates to the direction of the magnetic field by a magnetic torque due to the anisotropic magnetic susceptibility of ceramics with asymmetric unit cells. In previous studies, we reported that the a-axis oriented AlN could be prepared by a static magnetic field. On the other hand, sintering additives are needed to obtain dense AlN because of its low sinterability. In this study, we tried to make the c-axis oriented AlN with high thermal conductivity by a rotating magnetic field. Ethyl alcohol slurry was prepared that contained 40 vol% solids; the solids consisted of AlN that included CaF_2 as a sintering additive. Dense AlN was prepared by a slip casting in a rotating 12T magnetic field followed by SPS at 2073K. The thermal conductivity increased with the increasing amount of CaF_2. The thermal conductivity of the c-axis oriented AlN was improved about 10 W/(mK) compared with the random AlN. Translucent AlN can be fabricated with additions of 2 and 3 wt% CaF_2.

3:40 PM

(G3-013-2016) Spark Plasma Sintering of Si_3N_4-Y_2O_3-MgO using nanocomposite particles

J. Tatami*[1]; M. Iijima[1]; K. Jeong[1]; T. Nishimura[2]; 1. Yokohama National University, Japan; 2. National Institute for Material Science, Japan

Si3N4 ceramics have excellent mechanical properties to be applied to many kinds of mechanical components. SPS is a useful technique in order to make dense Si3N4 ceramics. Furthermore, assembled structure of raw materials were also important to make dense ceramics and to control the microstructure. In this study, nanocomposite particles of Si3N4-Y2O3-MgO were prepared by mechanical treatment to obtain dense Si3N4 ceramics by SPS. SEM observation showed that nano-sized Y2O3 and MgO particles were fixed on a submicron-sized Si3N4 particle, and the nanoparticles were uniformly dispersed in the powder mixture. The nanocomposite particles were densified by SPS. Shrinkage of the nanocomposite particles started at lower temperatures than that of the powder mixture prepared by ball-milling, which resulted from uniform formation of liquid phase. It was found that alpha to beta phase transformation of Si3N4 also enhanced by using the nanocomposite particles.

4:00 PM

(G3-014-2016) Field-assisted processing for single crystal by a solid-state conversion

Y. Liu*[1]; Y. Wu[1]; 1. Alfred University, USA

Field-assisted processing has been widely used in ceramics consolidation due to its short processing time and less energy consumption. We herein report a promotional effect of field-assisted processing on single crystal solid-state conversion, in which ceramics were converted into seeded single crystals during solid-state sintering and heat treatment. The DC bias direction exhibited significant influence on converted length due to the anisotropic conductivity at the single-poly crystal interface. Further investigation on isothermal annealing in an electric field showed time-dependent interface migration and grain growth synergically. The role of solute ions was studied in association with grain retardation and cation long-distance diffusion. The experimentally acquired grain boundary energy from isothermal annealing was correlated to the AC impedance spectra, through a space charge derived model. The field-assisted processing in achieving a higher conversion rate might be of potential future interest for fabricating larger size single crystals.

4:20 PM

(G3-015-2016) Corrosion studies of synthesized nano-Al_2O_3 reinforced 6061 metal matrix composite in 3.5% NaCl solution

I. B. Singh*[3]; V. Shrivastava[1]; S. Kale[2]; 1. Academy of Scientific and Innovative Research, India; 2. Barktullah University, India; 3. CSIR-Advanced Materials and Processes Research Institute, India

It is generally observed the strength of the MMCs increases with the decrease of size of micro scaled reinforcement. However, maintaining corrosion resistances of the nano reinforced MMCs solely depends on nanoparticles content in the base alloy. Presence of highly reactive nanoparticles may increase the corrosion reaction after exceeding their optimum level.In the present investigation sol-gel synthesized alpha nanoalumina particles (~ 40nm avearge size) were used in the reinforcement in 6061 alloy. In the next step alloy powder (~ 30 um size) and nanoalumina particles were ball milled and green pellets were made. Finally, the pellets were sintered at 490°C for 2 h. Microstructure examined by FE-SEM indicated the presence of more nanoparticles in the grain boundary regions. Hardness measurement indicated the occurrence of 20-25% higher hardness even after addition of 3 vol% nanoparticles. Electrochemical corrosion measurements of the synthesized MMC pellets in 3.5% NaCl solution indicated that 1 vol % nanoparticles incorporated MMC exhibits a better corrosion resistance. Addition of 2% and above vol% of nano alumina particles was found to becomes detrimental as their corrosion resistance decreases considerably. Present investigation indicates that even 1 vol % incorporation of nanoalumina particles is sufficient to improve hardness with maintaining corrosion resistances.

G5. Advanced Materials, Technologies, and Devices for Electro-optical and Medical Applications

Optical Material III

Room: Trinity V
Session Chairs: Nerine Cherepy, Lawrence Livermore Nat'l Lab; Hanna Dabkowska, McMaster University

8:30 AM

(G5-027-2016) Aggregates of silver nanostructures for SHG enhancement at metal-nonlinear dielectric interfaces (Invited)

L. Sanchez-García[1]; C. Tserkezis[2]; M. Ramirez[1]; P. Molina[1]; J. Carvajal[3]; M. Aguilo[3]; F. Diaz[3]; J. Aizpurua[4]; L. E. Bausa*[1]; 1. Universidad Autonoma de Madrid, Spain; 2. Technical University of Denmark, Denmark; 3. Universitat Rovira i Virgili, Spain; 4. Center for Materials Physics (CSIC-UPV/EHU) and Donostia International Physics Center, Spain

In this work, we demonstrate the enhancement of the blue Second Harmonic Generation (SHG) at metal-nonlinear dielectric interfaces by means of complex Ag nanoaggregates which have been formed on the polar surface of $RbTiOPO_4$ (RTP) by a cost-effective photochemical procedure. The control of the photochemical process allows us to obtain different configurations of Ag nanostructures, whose plasmonic responses can be tuned from the visible to the near infrared region, so as to match either the fundamental beam or the blue SHG one. The possibility of a 60-fold enhancement of the SHG response at the blue electromagnetic region mediated by large complex silver nanoaggregates, is demonstrated. The results point out the role of aggregates of silver nanostructures for enhancing SHG processes at metal-dielectric interfaces and open up alternative paths for the development of efficient nanosized frequency-converter devices in a spectral region of technological interest and with a scalable and low-cost implementation.

9:00 AM

(G5-028-2016) Optical and elctro-optical properties of molybdate and tungstate crystals (Invited)

X. Tao*[1]; 1. Shandong University, China

The search for new polar materials is of current interest owing to their potentially important functional properties including piezoelectricity, pyroelectricity, ferroelectricity, electro-optical and second-harmonic generation activity. In the past few years, our research group has been investigated the suitability of polar oxides containing cations susceptible to second-order Jahn-Teller (SOJT) distortions for nonlinear optical (NLO),electro-optical and piezoelectric application[1-4]. Here we report the synthesis, crystal growth, the phase relationship, linear and nonlinear optical properties, stimulated Raman scatterings, self -Raman frequency doubling and electro-optical properties of a series of new nonlinear optical molybdate and tungstate crystals.

9:30 AM

(G5-029-2016) Glass and polycrystal thin films for monolithic photonic integration (Invited)

J. Hu*[1]; X. Sun[2]; Q. Du[1]; T. Goto[3]; M. Onbasli[1]; C. Ross[1]; L. Li[1]; H. Lin[1]; D. Kita[1]; J. Michon[1]; C. Smith[4]; K. Richardson[4]; 1. MIT, USA; 2. Harbin Institute of Technology, China; 3. Toyohashi University of Technology, Japan; 4. University of Central Florida, USA

Compared to hybrid bonding, monolithic photonic integration promises drastically simplified fabrication processes, reduced cost, and ease of interfacing with other on-chip components. Glass and polycrystal thin film materials are uniquely poised for enabling monolithic photonic integration as they are not limited by lattice and thermal mismatch in epitaxial growth, and can be readily deposited over large substrate areas at reduced temperatures compatible with backend processing thermal budgets. In this talk, we will focus on two types of material systems which exemplify such monolithic photonic integration capabilities: amorphous oxide and chalcogenide glasses, as well as polycrystalline doped garnet films. The former class of materials are known for their broadband transparency and are thus considered ideal material candidates for sensing and imaging applications. We developed a monolithic glass-on-silicon platform for low-loss mid-infrared on-chip transmission and applied it to demonstrate for the first time cavity-enhanced on-chip spectroscopic chemical sensing. We will also discuss a new pulsed laser deposition technique for Ce or Bi substituted yttrium iron garnet thin films with reduced thermal budget, simplified growth protocols as well as improved magneto-optical characteristics, and the demonstration of monolithic nonreciprocal optical isolators with a high figure-of-merit based on garnet materials.

10:20 AM

(G5-030-2016) Chalcogenide glass fibers for mid-infrared sensing: Biomedical applications and CO_2 detection (Invited)

B. Bureau*[1]; C. Boussard[1]; V. Nazabal[1]; J. Troles[1]; 1. University of Rennes 1, France

Chalcogenide glasses are well known material for their mid-infrared transparency which gives access to molecular fundamental vibrational modes, shifted far in the IR. This exceptional transparency, associated with suitable viscosity/temperature dependence is a favorable context to develop innovative optical fibers for mid-infrared sensing. Different kind of optical fibers were designed during the past decades including tapered fibers, doped optical fibers, single mode fibers and microstructured fibers, depending on the targeted applications. Indeed, the optical sensors operating in the mid IR region, where are located the main IR signatures of molecules and biomolecules, are playing an important role in the development of analytical techniques giving in-situ information on metabolic patterns. Such chalcogenide glass fibers are efficient and easy way to record such infrared spectral data that enable in situ and real time studies with no sampling. Numerous pioneer works have been carried out in different domains of application, such as: bacterial contamination in food, bacterial biofilm spreading, identification of tumoral tissues and of biological liquid in biology and medicine, CO_2 detection to strike against the global warming or detection of exo-planet with the European Space agency, for examples.

10:50 AM

(G5-031-2016) Red-emissive Mn-doped tetragermanate phase: Synthesis and spectroscopic study (Invited)

Y. Takahashi*[1]; J. Kunitomo[1]; R. Suzuki[1]; N. Terakado[1]; T. Fujiwara[1]; 1. Tohoku University, Japan

Importance of red-emitting phosphor has recently increased because the phosphor contributes not only to improve a color-rendering of white-LED, but also is enabled to assist a photovoltaic generation and to fabricate the grow light for plant-factory. Basically, in red-phosphor Eu ion is used as a dopant exclusively because of an efficient luminescent center based on the f-f transition. On the other hand, transition-metal ions in d^3-electron system, e.g., Cr^{3+} and Mn^{4+}, are also candidate for the luminescent center, and possess the emissive band based on the d-d transition. Our research group has found the visible red-emission in Mn^{4+}-doped tetragermanate phases having an octahedrally-coordinated Ge unit; ferroelectric $Li(Li,Na)Ge_4O_9$ and benitoite-type $SrGe_4O_9$, and has demonstrated that the latter phase shows an excellent thermal stability of the red emission. In this presentation, our recent studies concerning the red-phosphors free from Eu ion, i.e., rare-earth free phosphor, will be introduced.

11:20 AM

(G5-032-2016) Preparation of Europium-Activated $SrAl_2O_4$ Glass Composites using the Frozen Sorbet Technique (Invited)

T. Nakanishi*[1]; 1. Hokkaido University, Japan

The Frozen sorbet technique is applied to the $SrO-Al_2O_3-B_2O_3$ system to fabricate novel glass ceramics including Eu^{2+}, Dy^{3+}: $SrAl_2O_4$ (SA) microcrystals. The transparent glass composites with aluminoborate glass phase and SA single crystals (ave. 20~40 μm) have been successfully prepared. The glass composites show remarkable light-storage ability (e.g., charge-carrier trapping phenomenon) based on the natural properties of SA-crystals, and this provide various photo-functionalities, such as long-persistent luminescence, photo-induced conductivity, and mechano-luminescence. The preparation of transparent SA glass composites using the Frozen sorbet technique and their unique optical properties are presented as novel light-storage materials for energy applications.

Optical Material IV

Room: Trinity V

Session Chair: Xutang Tao, Shandong University

1:30 PM

(G5-033-2016) Morphology of surface nanostructures in oxide crystals and glasses fabricated by femtosecond laser ablation or focused ion beam etching (Invited)

N. Kodama*[1]; 1. Akita University, Japan

We report here the fabrication of periodic surface ripples and nanohole arrays in oxide single crystals and glassesl by femtosecond laser ablation or focused ion beam etching toward realizing 2D photonic crystals. First, self-organized nanostructures (ripples) are observed on the surface of a Ti^{3+}:Al_2O_3 crystal irradiated by femtosecond laser radiation. The subwavelength ripples are aligned perpendicular to the polarization direction of the laser radiation. The observed spacing of the subwavelength ripples increases from ~λ/5 to 2λ/5 (λ: laser wavelength) with increasing laser pulse energy. In addition, we observe screw-shaped nanostructures in the focal spot of circularly polarized beam irradiation. Second, nanoholes were fabricated in borate crystals and borate glasses with the same composition ratio by femtosecond laser ablation. The SEM images reveal the formation of cylindrical nanoholes with beam spot diameter or less on the borate glasses, whereas almost quadrangular nanoholes with subwavelength edges were formed on the borate crystals. Further, naonohole arrays were also fabricated in a borate glass by focused ion beam etching. The holes on the borate glasse varied from cone shape, to elliptic cone shape depending on the amount of ion dose. The photonic band structures and electromagnetic wave propagating of the arrays were calculated.

2:00 PM

(G5-034-2016) Silicon nitride and Indium Tin Oxide Nanostructures for dielectrophoretic manipulation of DNA

S. Mahshid*[1]; M. Ahamed[2]; W. Resiner[3]; R. Sladek[3]; 1. University of Toronto, Canada; 2. university of Windsor, Canada; 3. McGill University, Canada

Classical nanochannel-based confinement have gained worldwide acceptance for the manipulation of single DNA molecules. Despite their widespread use for genomic and physical studies, these methods continue to limit the potential for dynamic manipulation and trapping of DNA molecules. They are limited either by sensing resolution or by low concentration of molecules at the nanofeatures. We propose and demonstrate a novel technological approach, one that utilizes reversible, tunable nanofluidic confinement to immobilize and linearize DNA molecules for single molecule optical analysis– a design based on di-electrophoresis force and ITO patterned electrodes. In this study, the device of design contains a nano-patterned dielectric layer on silicon nitride that sits on top of an indium tin oxide. The second surface contains a uniform transparent conductor. An alternating electric field is then applied between the two surfaces. On the patterned surface, the field is concentrated in the conductive nano-features, leading to an enhanced local electric field magnitude. The DEP-force will gently drive the macromolecules into the nanofeatures and then confine them in the features, forcing the molecules to adopt a conformation determined by the local geometry of the patterning, including stretched conformations and concentrated trapped conformations.

2:20 PM

(G5-035-2016) Color centers in $Y_3Al_5O_{12}$ single crystals grown by the EFG technique

T. Tokairin*[1]; H. Junichi[3]; V. Garcia[4]; K. Shimamura[2]; 1. Ibaraki University, Japan; 2. National Institute for Materials Science, Japan; 3. Shinko Manufacturing, Japan; 4. National Institute for Materials Science (NIMS), Japan

The Y3Al5O12 (YAG) crystals grown by the edge-defined film-fed growth (EFG) technique have three absorption bands of color centers. The absorption bands at 235nm,300nm and 370nm are F and F- type color centers. The excitation spectrum of the colored YAG crystals was measured for 398nm emission by 370nm excitation. The 630nm emission by 370nm excitation was obtained only for the colored YAG crystals grown by the EFG technique using carbon heater. The carbon concentrations in these YAG crystals was determined to be10 ppm by a GDSM analyzer. In this work, the application of carbon heater for the growth of YAG crystals by the EFG technique is attempted, and the availability of red phosphor by excitation of ultraviolet rays is examined.

Ferro/Piezo I

Room: Trinity V

Session Chairs: Qiang Li, Tsinghua University; Anilkumar Gopinathan Nair, Noritake Co., Ltd

3:20 PM

(G5-036-2016) Reliability Design for Multilayer Ceramic Capacitors with Ni electrodes (Invited)

H. Kishi*[1]; 1. Taiyo Yuden Co., Ltd., Japan

Progressive technological innovations in multilayer ceramic capacitors with Ni electrodes (Ni-MLCCs) play a remarkably important role in downsizing and improving performances in a wide variety of electric equipments, especially in mobile electronic equipment such as smart phones and personal computers. Recently, the use of Ni-MLCCs are being expand for several applications, such as the automotive electronic components, medical equipment, communication infrastructure equipment, industrial equipment, and so on. In response to the continual demand for improvement of the properties of Ni-MLCCs, namely, higher capacitive volumetric efficiency, higher reliability under high temperature and high DC rated voltage, smaller case-size, extensive efforts have been made in processing technologies and material designs, including powder handling technologies and co-firing technologies. One of the key technologies for Ni-MLCCs is decreasing the thickness of the dielectric active layers. Therefore controlling the composition and microstructure of dielectrics is very important because the insulation degradation is strongly correlated with the microstructure and resulting oxygen vacancies. In this paper, the recent progress in material design and processing technology for realizing high-reliability Ni-MLCCs are presented.

3:50 PM

(G5-037-2016) Crystal Structure of Nanostructured Electroceramic Film using Aerosol-type Nanoparticle Deposition for Microelectronics and Energy Application (Invited)

Y. Imanaka*[1]; 1. Fujitsu Laboratories Ltd., Japan

Nanoparticle deposition, which enable to deposit dense, nanoparticulated film with high crystallinity at room temperature and its integration and multilayer process are the promising ceramic technology for microelectronics and energy application. For example, in the flexible electronics, the thin electrical element modules are needed to achieve the miniaturization and multi-function capabilities of next-generation mobile terminals. The capacitors consisting of the ceramics such as BaTiO3 for multi-layer capacitor application, should be incorporated on a polymer sheet. Originally, the crystal structure of BaTiO3 at room temperature is tetragonal, and the Curie point from tetragonal to cubic is around 130 degree. However, many reports explain that the Curie point is shifted to room temperature, when the grain size of BaTiO3 becomes smaller. In this study, the crystal structure of the BaTiO3 film consisting of the grain with nano-level size with nanoparticle deposition was investigated using XRD with high energy power, XANES (X-ray Absorption near Edge Structure), XAFS (Extended X-ray Absorption Fine Structure) and HAXPES (Hard X-ray PhotoElectron Spectroscopy). We examined the correlation between dielectric properties and the crystal structure of the nanoparticle deposition film.

4:20 PM

(G5-038-2016) Texture Engineering of Lead-Free Piezoelectric Ceramics (Invited)

J. Jeon*[1]; H. Cha[1]; 1. Korea Institute of Materials Science, Republic of Korea

$Bi_{0.5}Na_{0.5}TiO_3$ and $(K,Na)NbO_3$ based lead-free ceramics have been receiving especial attentions as promising piezoelectric materials to replace $Pb(Zr,Ti)O_3$. Although BNT- and KNN-based ceramics are reported to be promising for piezoelectric applications, their piezoelectric properties must be further improved before they can replace PZT. The piezoelectric properties of BNT- and KNN-based ceramics can be improved through compositional modification by preparing solid solutions. Further improvement in the piezoelectric properties can be achieved by controlling the grain orientation through texture engineering using anisotropic templates with plate-like shapes. Through the growth of aligned anisotropic templates, texture engineering can produce samples containing grains aligned along certain crystallographic orientations instead of randomly distributed matrix grains. One of the most important parameters in texture engineering is the role of the template. BiT, BNT15, and BNT plates are generally used as templates for texturing of BNT and $NaNbO_3$ plates are used for texturing of KNN. These templates can be prepared by molten-salt synthesis through chemical reactions between the raw materials in NaCl (or NaCl+KCl) flux. In this study, we investigated the synthesis mechanism of plate-like templates during molten-salt synthesis and their role in texture engineering of BNT- and KNN-based lead-free piezoelectric ceramics.

4:50 PM

(G5-039-2016) Interests of high pressure in materials science (Invited)

A. Largeteau*[1]; 1. ICMCB-CNRS, France

High pressure has been applied mainly in Physics to study the geology of earth for example and Chemistry to develop diamond and quartz for example in industrial applications. The development of high pressure in different scientific domains was strongly dependent on the knowledge of the associated technologies. At the beginning, high pressure was mainly used in synthesis of minerals from extraction of metals from ores and for crystal growth of α-quartz called as hydrothermal crystal growth. In the case of ceramics, application of very high pressure has been reported to have yielded nanostructured materials. Hydrothermal crystal growth offers a complementary alternative to many of the classical techniques of crystal growth used to synthesize new materials and grow bulk crystals for specific applications. This specialized technique is often capable of growing crystals at temperatures well below their melting points and thus potentially offers routes to new phases or the growth of bulk crystals with less thermal strain. The hydrothermal process is utilized for growing a wide variety of crystals. In the present talk, hydrothermal growth of Ge doped SiO_2 crystals for piezoelectric applications and the general principle of high hydrostatic pressure and their role in phase transition with their diverse applications in various fields will be discussed.

G7: Advanced Functional Materials, Devices, and Systems for Environmental Conservation and Pollution Control

Advanced Functional Materials, Devices, and Systems for Environmental Conservation and Pollution Control I

Room: Trinity III
Session Chairs: Nobuhito Imanaka, Osaka University; Shinobu Fujihara, Keio University

9:00 AM

(G7-001-2016) Magnetic field-assisted fabrication of oriented K_2NiF_4-type nickelate cathode for SOFC (Invited)

M. Matsuda*[1]; A. Murata[1]; T. Uchikoshi[2]; T. S. Suzuki[2]; Y. Sakka[2]; 1. Kumamoto University, Japan; 2. National Institute for Materials Science, Japan

In the present work with the aim of fabricating oriented cathode of mixed ionic and electronic conducing layered Ln_2NiO_4 (Ln =La, Pr and Nd) for low-temperature operating solid oxide fuel cell, a magnetic field has been applied for orientation control of Nd_2NiO_4 (NNO). Textured bulks of NNO were fabricated by slip-casting in magnetic field. X-ray diffraction analyses revealed that the c-axis of NNO was aligned parallel to the magnetic field applied. Anisotropic electric conductivity and thermal expansion coefficient were observed for the textured bulks with the c-axis orientation: higher conductivity and lower thermal expansion were obtained along the a-b plane perpendicular to the c-axis. Based on the results obtained, fabrication of the a-b plane perpendicular-oriented NNO cathode on an electrolyte was attempted in magnetic field. Application of a rotating magnetic field was effective for the fabrication. The rotation of magnetic field in the horizontal plane made the random orientation of the c-axis while retaining the a-b plane orientation against the electrolyte. From performance tests for single-cells constructed with the oriented NNO cathode, it was obvious that the cathode performance of NNO was improved by the preferential orientation of a-b plane to electrolyte.

9:30 AM

(G7-002-2016) Atomic-scale characterization of ion conduction, structure and stability of ceria-based catalysts and related materials: Present status and problems (Invited)

M. Yashima*[1]; K. Fujii[1]; E. Niwa[1]; 1. Tokyo Institute of Technology, Japan

Ceria-based materials are utilized as automotive exhaust catalysts for the removal of noxious compounds, as catalysts for reforming ethanol and methane to produce hydrogen in fuel cells, and as materials for solar-energy-to-fuel conversion and solid oxide fuel cells (SOFCs). This paper is a critical review on the atomic-scale characterization of oxide-ion diffusion pathway, the existing phases, the phase transformations, stable and “metastable” phase diagrams, and oxygen storage capacity (OSC) of ceria-based materials [M. Yashima, Catal. Today, 253, 3-19 (2015)]. The spatial distributions of neutron scattering length density, bond valence sum (BVS), and bond-valence-based energy (BVE) in the unit cell of tetragonal ceria-zirconia, cubic fluorite-type ceria-based materials, and other fluorite-type compounds as $Ce_{0.5}Zr_{0.5}O_2$, CeO_2, $Ce_{0.97}Y_{0.07}O_{1.96}$, δ-$Bi_{1.4}Yb_{0.6}O_3$, and α-CuI indicate three-dimensional network of curved $<100>_F$ ion diffusion paths and anisotropic $<111>_F$ thermal vibration of mobile ions, which are responsible for ion conduction. BVE distributions of $Ce_{0.5}Zr_{0.5}O_2$ and CeO_2 indicate lower activation energy and higher mobility of oxide ions in $Ce_{0.5}Zr_{0.5}O_2$ compared with CeO_2. This work has shown that BVS map and BVE landscape are useful to study ion diffusion pathways in ceria-based catalysts and in other ionic conductors.

10:20 AM

(G7-003-2016) Bio-inspired intellgient and self-healing materials for clean water production

P. Wang*[1]; 1. King Abdullah University of Science and Technology, Saudi Arabia

The presentation consists of two parts: (1) a bio-inspired method for direct preparation of stable superhydrophilic micropatterns onto superhydrophobic surface based on a facile inkjet printing technology will be discussed. By directly inkjet printing a bio-inspired ink of dopamine solution with delicately optimized solution composition, stable Wenzel's microdroplets of dopamine solution with well-defined micropatterns were obtained onto the superhydrophobic surfaces, and after the following formation of polydopamine via the in-situ polymerization of dopamine, superhydrophilic micropatterns can be readily achieved. The produced patterned surfaces showed high efficiency in fog harvesting. (2) Water evaporation driven by the solar irradiation plays a critical role in the global water cycle as well as in many industrial processes. However, the conventional solar evaporation experiences high energy loss and thus low evaporation rate due to its bulk water heating nature. With an aim at enhancing solar driven evaporation, herein, we propose and demonstrate a novel interfacial heating membrane. The membrane is designed so that it spontaneously stays at the water-air interface and collects, self-heals its hydrophobocity once lost, converts solar light into heat energy, and locally heats only the water at the air water interface.

10:40 AM

(G7-004-2016) Mesocrystal Nanowire Comprised of Oriented Nanoparticles for Cathode Material of Na-ion batteries

E. Hosono*[1]; S. Kajiyama[1]; M. Okubo[1]; J. Kikkawa[2]; 1. National Institute of Advanced Industrial Science and Technology (AIST), Japan; 2. National Institute for Materials Science (NIMS), Japan

For the low carbon society, the development of electric vehicles and plug-in hybrid vehicles by using Li-ion batteries with high performances has attracted researchers of industrial and academic fields. The investigation for high power performances of Li-ion batteries is an important task for automotive batteries in addition to the study for high energy density. Research and development of nanostructural control for electrodes have been reported by many researches because the short diffusion length of lithium ions in nanomaterials is suitable for high power density. We have studied the nanostructural control of electrodes, too. Especially, we focus single crystalline nanowires and mesocrystal nanowires by electrospinning methods for secondary batteries. Single crystalline nanowires of $LiMn_xFe_{1-x}PO_4$ and mesocrystal nanowires of $LiMn_{0.4}Fe_{0.6}PO_4$ with carbon sheath are reported. In addition to Li-ion batteries, we have studied Na-ion batteries, which are expected as low cost secondary batteries because sodium is a ubiquitous element. In this presentation, fabrication of mesocrystal nanowires comprised of $Na_3V_2(PO_4)_3$ oriented nanoparticles by electrospinning method and the performances of Na-ion batteries are reported.

11:00 AM

(G7-005-2016) Low-temperature Crystallization of Ion-conductive Cubic $Li_7La_3Zr_2O_{12}$ Nanoparticles (Invited)

H. Suzuki[1]; P. J. Kumar[1]; M. Senna[1]; K. Nishimura[1]; N. Sakamoto[1]; N. Wakiya*[1]; 1. Shizuoka University, Japan

In this study, ion-conductive cubic $Li_7La_3Zr_2O_{12}$ (LLZO) nanoparticles with garnet structure were successfully prepared from reactive precursor at low temperature. The crystalline phases and the crystallization temperatures for the powders derived from different precursors were also prepared by the solid-liquid reaction and sol-gel method, respectively. In addition, we designed the molecular structure of the alkoxide-derived precursors in the sol-gel method. As a result, homogeneity of the precursors was different depending on the processing method. In the solid-liquid reaction method, zirconia powders were reacted with the La source to form homogeneous La-Zr precursor to decrease the crystallization temperatures. In this case, we need Al addition to obtain cubic LLZO nanoparticles at above 700 oC. On the other hand, homogeneity of the precursor should be high enough to obtain cubic LLZO nanoparticles without addition of Al at 700 oC for the case of sol-gel derived precursor. Compared with the above two method, homogeneous precursors at molecular-level could be prepared by the sol-gel method if the partial hydrolysis condition of the zirconium alkoxide were optimized for the low-temperature crystallization. As a result, we successfully prepared cubic LLZO nanoparticles to sinter into high density, showing the higher enough conductivity for all-solid type Li-ion batteries

11:30 AM

(G7-006-2016) Thin-film type Protonic Electrochemical Capacitors with Metal-oxide Nanosheet Electrodes (Invited)

M. Miyayama*[1]; S. Suzuki[1]; 1. The University of Tokyo, Japan

To solve the recent energy-related problems, it is an important subject to develop energy storage devices composed of naturally abundant elements, secure and bending-durable for portable/ wearable conditions, and provided with high energy/power densities. The protonic electrochemical capacitor using oxide electrodes and aqueous electrolyte is a promising candidate. We used metal-oxide nanosheets with thickness of only a few nanometer as the component material. In the present talk, preparation and properties of nanosheet-derived electrodes and their applications to thin-film capacitor devices are described. The electrode of $H_x(Ni,Co,Mn)O_2$ nanosheet-derived particles exhibited a large capacity of about 200 mAh g^{-1} in KOH solution, and a capacitor using a $H_x(Ni,Co,Mn)O_2$ cathode and an AQ (anthraquinon)-based anode showed a high energy density reaching 40 Wh kg^{-1}. Electrical conductivities were examined on nanosheet-restacked RuO_2 thin films (thickness ~ 300 nm) under bending deformation. Above 80% of original conductivity was maintained even under bending with a curvature radius of 3 mm. All-nanosheet electrochemical capacitors consisting of RuO_2 film electrodes and LDH (layered Mg-Al double hydroxide) film electrolyte worked reversibly with a capacity close to that in aqueous electrolyte. The results suggest the possibility of all-solid thin-film, flexible storage devices.

Advanced Functional Materials, Devices, and Systems for Environmental Conservation and Pollution Control II

Room: Trinity III

Session Chairs: Nobuhito Imanaka, Osaka University; Shinobu Fujihara, Keio University

1:40 PM

(G7-007-2016) Functional mixed anion compounds for environmental challenges (Invited)

H. Kageyama*[1]; 1. Kyoto University, Japan

Mixed anion compounds are an emerging class of materials that can show novel or improved functionalities. In this contribution, I will mainly show two mixed anion systems, (1) a layered phosphide-telluride with highly selective metal capturing and (2) oxyhydride with low temperature exchange and catalytic properties. (1) $BaTiO_{3-x}H_x$ ($x \le 0.6$) can be prepared by topochemical reaction using a pristine oxide $BaTiO_3$. The lability of H^- in $BaTiO_{3-x}H_x$ allows H^-/N^{3-} exchange to occur, yielding a room-temperature ferroelectric $BaTiO_{3-x}N_{2x/3}$. The hydride lability also leads to novel anion-derived functions. It is revealed this oxynitride is extremely active catalyst for ammonia synthesis. The metal supported on the oxyhydride shows much better performance than well-known catalysts. (2) Layered oxides etc embrace rich intercalation reactions to find a variety of applications spanning from energy storage to secondary batteries. An evolving area is to capture metals selectively which is of environmental significance but rather unexplored. We find that some layered telluride displays exclusive insertion of transition metals as opposed to alkali cations. Interestingly, the intercalation reactions proceed in solid state and at surprisingly low temperatures (e.g. 80 °C for Cd). The new method of controlling selectivity provides opportunities in the search for new materials for various applications.

2:10 PM

(G7-008-2016) A facile process for the bulk synthesis of $LiMn_2O_4$ nanorods using pre-synthesized γ-MnOOH nanowires

I. B. Singh*[1]; 1. CSIR-Advanced Materials and Pprocesses Research Institute, India

Lithium manganese oxide particularly $LiMn_2O_4$ is well known cathode material of Li ion batteries because of its higher charge storage capacity. A variety of synthetic approaches like combustion, sol-gel, solution phases, templeting, etc have been developed for the synthesis of nanostructured $LiMn_2O_4$. However, most of the developed process are costly because of low yield. In the present approach $LiMn_2O_4$ was synthesized by using the pre-synthesized nanowires of gamma manganese oxyhydroxide (γ-MnOOH) as manganese precursor. Firstly γ-MnOOH nanowires were synthesized in bulk using 8 mM $MnSO_4$ and 8 mM $(NH4)_2S_2O_8$ at pH 10 using hydrothermal treatment at 130^0C for 10 h in KOH medium. The synthesized γ-MnOOH was transferred to β-MnO_2 after calcinations at 280^0C. Finally nanorods of $LiMn_2O_4$ was prepared after heating homogenized mixture of LiOH and β-MnO_2 in their 0.014 and 0.028 molar ratio ratio at 750^0C for 10 h. After carrying characterization using X-ray diffraction (XRD), field emission scanning electron microscopy (FE-SEM), transmission electron microscopy (TEM) and inductively coupled plasma mass spectrometry (ICP-MS), it was confirmed that the spinel formed is pure $LiMn_2O_4$ nanorods of average 1μm length and 80nm dia of tetrahedral symmetry.

2:30 PM

(G7-009-2016) Catalytic Combustion-type Carbon Monoxide Novel Gas Sensor with Oxide Ion Conducting Solid (Invited)

N. Imanaka*[1]; 1. Osaka University, Japan

Carbon monoxide (CO) is one of toxic gas species which can cause as a severe health hazard if inhaled, even at relatively low content level. Since the CO binding ability to hemoglobin is approximately 250 times as high as that of oxygen, exposure to elevated levels of CO gas (especially higher than 0.15%) would be considerably fatal. Unfortunately, a critical disadvantage with conventional catalytic combustion-type CO gas sensors is that the catalysts such as Pt/Al_2O_3 or Pd/Al_2O_3 etc, need to be elevated at the operating temperature such as 400 degree C for the complete CO oxidation. At such elevated temperatures, other gases such as methane and also volatile organic compounds (VOCs) burn out. Therefore, this type of sensors always lacks the selective CO detection. Recently, we have succeeded in developing a low-temperature operating sensors with the catalytic combustion-type, by the application of Pt loaded oxide ion conduxcting solid, some of them can operate at 70 degree C, which temperature is more than 300 degree C lower compared with conventional ones. Details will be addressed at the presentation.

3:20 PM

(G7-010-2016) Dielectric Enhancement of Nanostructured Composite Capacitors Prepared by Wet Chemical Method

S. Ueno*[1]; Y. Sakamoto[1]; K. Nakashima[1]; S. Wada[1]; 1. University of Yamanashi, Japan

From the point of view of energy conservation, it is significantly important to develop ceramic capacitors with high-energy density. We have attempted to develop high-performance conductor/insulator composite ceramic capacitors with boundary-layer (BL) structure as seen in BL capacitors exhibiting high capacitance. We tried to replace semiconductor grains in common BL capacitors with conductor grains to prepare frequency dependence-free capacitors. We proposed a novel solution-based processes to prepare metal (or conductive oxide)/insulator composite capacitors. For example, Ti/$BaTiO_3$ (BT) composite compacts consisting of Ti metal grains and BT boundary nanolayers were successfully prepared from pressed Ti-BT core-shell-particle compacts by hydrothermal treatment. We reveal that the thickness of the resultant BT boundary nanolayers can be controlled by the hydrothermal conditions, and the effective dielectric constant depends largely on the thickness of these BT nanolayers. The resultant Ti/BT composite capacitors with the BL structure exhibited high effective dielectric constants of over 10^4 and relatively lower loss tangent at 10 kHz at room temperature.

3:40 PM

(G7-011-2016) Mesoporous titania-based electrodes by hydrothermal processes for dye-sensitized solar cells (Invited)

J. Hojo*[1]; M. Inada[1]; 1. Kyushu University, Japan

Dye-sensitized solar cells have been receiving a great attention because of expectant high photoenergy conversion, facile preparation and low cost. Metal oxide semiconducting electrode is a key component and titania has been typically used. The photoelectrode requires large surface area for dye adsorption, high crystallinity for electron transfer and large pore for electrolyte diffusion. Mesoporous microspheres consisting of anatase nanoparticles were synthesized by hydrolysis of titanium butoxide. Titania aggregates with irregular shape were formed by hydrothermal treatment of microspheres, leading to the increase in crystallite size, pore size and photovoltaic efficiency, but the surface area decreased. Mesoporous titania-silica composites were prepared by hydrolysis of titanium oxychloride and silicon ethoxide. Rutile phase formed without silica addition, whereas anatase phase was stabilized by silica addition, crystallite size decreased, and surface area increased. The photovoltaic efficiency increased by silica addition because of the phase change from rutile to anatase and the increase of surface area. However, the cell efficiency decreased at large silica contents. The optimal electrode structure will be totally discussed.

4:10 PM

(G7-012-2016) Materials Tuning of Titania Nanotubes for Enhancing Physical-photochemical Multifunctions (Invited)

K. Fujii[1]; H. Nishida[1]; T. Goto[1]; S. Chou[1]; S. Lee[2]; T. Sekino*[1]; 1. Osaka University, Japan; 2. Sun Moon University, Republic of Korea

Titania (TiO_2) nanotube (TNT) has excellent physico- and photo-chemical properties due to the synergy of its semiconductor properties, unique nano- and crystalline structures. However, it has large bandgap energy so that development of visible-light responsible TNTs is required. In this research, we have modified the TNT to realize high performance visible light responsible photocatalyst coupled with excellent molecular adsorption capability. Our strategy lies in doping elements to TNT. Metal (Cr, Sm, Nb, V and Ru) -doped TNTs have been synthesized by a simple solution chemical route based on the treatment of TiO_2 powders in alkaline solution. Obtained M-doped TNTs exhibited optical adsorption in the visible light region, and the bandgap energy decreased depending on the doped elements. Methylene blue (MB) and rhodamine-B (RhB) dyes removal test revealed that the small amount of metal ion doping enhanced the MB adsorption capacity. In addition, visible light responsibility was confirmed in photocatalytic performances. On the other hand, we have recently succeeded in synthesis of visible light responsible nanostructured titania by simple chemical treatment of TNT. Obtained materials have exhibited excellent visible light responsibility. Relations between processing, nanostructures, surface chemistry and photochemical properties of these modified TNTs will be discussed in detail.

4:40 PM

(G7-013-2016) Precursor-derived Porous ZnO Materials and Their DSSC Applications (Invited)

S. Fujihara*[1]; H. Kajihara[1]; E. Tanaka[1]; T. Enomoto[1]; H. Ohashi[1]; M. Hagiwara[1]; 1. Keio University, Japan

In the chemical solution process, ZnO shows the preferential growth in one direction based on its hexagonal wurtzite-type structure. The deposition of ZnO films therefore leads to morphologies such as densely packed columns or well-arrayed nanorods. For electrochemical applications, multiscale porous ZnO materials are often required to increase the reaction sites and promote the diffusion of external reactants. Here we introduce our recent approaches to fabricating porous ZnO materials through synthesis and morphological control of precursors and their transformation to ZnO. We have paid particular attention to layered basic zinc salts (LBZS) and metal-organic frameworks (MOFs) as precursors because of their excellent controllability of morphologies. LBZS films could be deposited through control over kinetics of hydrolysis reactions of zinc salts and heterogeneous nucleation of zinc hydroxides. The resultant films had unique morphologies with assemblies of sheet-like or flake-like particles and could be converted to ZnO without morphological deformation. In contrast, submicron MOF particles, which were grown in the chemical solution, could be converted into aggregate particles consisting of nanometer-scale ZnO primary particles. The above ZnO materials were applied in dye-sensitized solar cells (DSSCs), which showed relatively high light-to-electricity conversion efficiencies.

H1. Computational Modelling and Design of New Materials and Processes

Atom-scale Modeling I

Room: Bay

Session Chair: Jingyang Wang, Institute of Metal Research

1:50 PM

(H1-001-2016) Ab initio Molecular Dynamics Simulations of the Irradiation Response of Ceramics (Invited)

W. J. Weber*[1]; B. Liu[2]; B. Petersen[1]; J. Wang[3]; H. Xiao[4]; Y. Zhang[1]; 1. University of Tennessee, USA; 2. Shanghai University, China; 3. Institute of Metal Research, China; 4. University of Electronic Science and Technology of China, China

Ab initio molecular dynamics (AIMD) methods have been used to investigate low-energy atomic recoil events in 3C-SiC and Ti_3SiC_2, which are key materials for refractory coatings and composites proposed for nuclear applications and extreme environments. In 3C–SiC, the minimum displacement energies for C and Si atoms are found along the [1 0 0] direction, with values of 20 and 49 eV, respectively. The results demonstrate that significant charge transfer occurs during the dynamics process, and defects can enhance charge transfer to surrounding atoms, which provides important insights into the formation of charged defects. It is found that the C vacancy is a positively charged defect, whereas the Si vacancy is in its neutral state. In Ti_3SiC_2, the threshold displacement energies are shown to be strongly dependent on recoil direction and layer of origin. For Ti and Si atoms in the Ti-Si layer, which exhibit weak mixed bonding, the threshold displacement energies for recoils perpendicular to the basal planes are larger than those parallel to the basal planes, which is obviously related to the layered-structure. In contrast, the threshold displacements energies for the strong covalently-bonded Ti and C atoms in the Ti-C layer are less dependent on recoil direction. Work supported by the U.S. Department of Energy, Basic Energy Sciences, Materials Science and Engineering Division.

2:20 PM

(H1-002-2016) DFTFIT: Potential Generation for Molecular Dynamics Calculations

C. N. Ostrouchov*[1]; F. Yuan[1]; Y. Zhang[2]; W. J. Weber[1]; 1. University of Tennessee, USA; 2. Oak Ridge National Lab, USA

We present a Python package DFTFIT that is used to create interatomic potentials for molecular dynamics (MD) from density functional theory (DFT). DFTFIT will facilitate the design of new and advanced materials. It implements a popular variation of the Force-Matching algorithm, which is based on least square optimization. Our software is novel because of how it tightly integrates with mainstream DFT and MD packages, such as VASP, Quantum Espresso, and LAMMPS. One key benefit of this approach is that DFTFIT improves as more potentials become available in MD packages. Our package also allows for easy quantification of the quality of a potential by automating calculations of the equilibrium and non-equilibrium properties. We demonstrate the software on two model ceramic systems of interest for ceramic matrix composites: MgO and SiC. The potentials for both systems show improvement, which validates the effectiveness of the software by fitting two-body and three-body potentials.

2:40 PM

(H1-003-2016) Mechanical properties of pyrocarbons – from molecular to macroscopic scale

J. Leyssale[1]; A. Gamboa[2]; B. Farbos[2]; S. Jouannigot[1]; G. Couégnat[1]; A. P. Gillard[2]; M. Charron[2]; G. L. Vignoles*[2]; 1. CNRS, France; 2. University Bordeaux, France

Laminar pyrocarbons are employed in carbon/carbon and other ceramic-matrix composites for aerospace and energy applications, due to their outstanding thermal and mechanical properties at extreme temperatures. The design of pyrocarbon-containing materials requires a good knowledge of these properties. Unfortunately, they are strongly varying with their structure and texture at various scales, themselves a function of the processing conditions. Moreover, they are difficult to measure experimentally, because bulk pyrocarbon sample are difficult to prepare. Modeling is therefore a precious help to address these issues. Virtual mechanical tests have been carried out by Molecular Dynamics on a series of pyrocarbon models recently obtained by the IGAR (Image-Guided Atomistic Reconstruction) technique. These nanoscale mechanical properties will be discussed in front of the actual properties as determined by specific experiments.

Atom-scale modeling II

Room: Bay

Session Chair: William Weber, University of Tennessee

3:20 PM

(H1-004-2016) Giant phonon anharmonicity and anomalous pressure dependence of lattice thermal conductivity in Yttrium silicates (Invited)

J. Wang*[1]; 1. Institute of Metal Research, Chinese Academy of Sciences, China

Modification of lattice thermal conductivity (κ_L) of a solid by means of hydrostatic pressure (P) has been a crucially interesting approach that targets a broad range of advanced materials from thermoelectrics and thermal insulators to minerals in mantle. The universal knowledge stands with a positive relationship, $d\kappa_L/dP>0$. Recently we predicted an abnormally negative trend, $d\kappa_L/dP<0$, in Yttrium silicates under hydrostatic pressure using density functional theoretical calculations. For the first time, a novel mechanism is proposed as a combined effect of suppressed group velocity and enhanced anharmonicity of heat-carrying acoustic phonons in pressured lattice, which is originated from pressure-induced intensification of the anharmonic coupling between acoustic phonons and a bunch of low-lying "rattling-like" optic phonons. The present results bring new insights for engineering thermal conductivity of complex solids with diverging structural flexibility, enormous bonding heterogeneity, and giant phonon anharmonicity.

3:50 PM

(H1-005-2016) Computational high throughput exploring advanced structural-functional integrated materials

Q. Zeng*[1]; L. Zhang[1]; L. Cheng[1]; 1. Northwestern Polytechical University, China

To shorten the time-to-market of advanced materials, the high throughput concept has been introduced into the recent Materials Genome Initiative (MGI) project. This paper reviewed our recent work on exploring advanced structural-functional materials through hybrid evolutionary algorithms together with first-principle calculations. With these approaches, many novel compounds were discovered each in cost of around one month of computation time using about 100 CPU cores. Examples include ultra-high temperature ceramics, dielectric ceramics, and battery materials and so on. The structure-property relationship of these materials can be easily constructed by such systematic screening. Consequently, the structural-functional properties can be tuned by varying the stoichiometry and/or topology of these compounds.

4:10 PM

(H1-006-2016) Study of Core/Shell Synthesis of ZrC/SiC nanocomposites using DFT and Atomistic Thermodynamic Modelling

E. Osei-Agyemang*[1]; S. Cristol[1]; R. Lucas[2]; 1. Universite Lille 1, France; 2. Centre Européen de la Céramique, France

A major task for the nuclear and aerospace industries lies in the making of highly refractory ceramics with properties compatible with harsh working conditions. Zirconium Carbide (ZrC), a non-oxide ultrahigh temperature ceramic with a melting point of 3430ºC has excellent mechanical properties and hence can be used in such applications. However, introduction of O_2 forms low refractory oxides leading to deterioration of the mechanical properties.Coating the surface of ZrC with another ceramic material such as Silicon Carbide (SiC) that is resistant to O_2 and maintains its physical properties, is a promising solution. In order to achieve such coatings, the ZrC low index surfaces need to be functionalized with small molecules before grafting a SiC precursor like a polycarbosilane.In this study, DFT and atomistic thermodynamic modelling is used to study the stabilities of ZrC surfaces. The stable facets are subsequently reacted with O_2 in order to gain detailed understanding of the surface oxidation process. Molecular dynamics simulation was then used to model the oxidized layer and the interface between the ZrC and ZrO_2. TEM, XPS and TOF-SIMMS experiments were performed to confirm the nature of the oxidized layers on the surface. The exposed ZrO_2 surfaces were modified with H_2O and functional OH groups are observed, on which grafting of polycarbosilane precursors are modelled.

4:30 PM

(H1-007-2016) Thermodynamic calculations in the Y-Si-C-O-H system for yttrium silicate based EBCs

I. J. Markel*[1]; D. M. Cupid[1]; M. Steinbrück[1]; H. J. Seifert[1]; 1. Karlsruhe Institute of Technology, Germany, Germany

Si-based Ceramic Matrix Composites (CMCs) are promising structural materials for the hot sections of next generation gas turbines. Since the presence of water vapor in the combustion gas may lead to the formation of gaseous hydroxides which cause the volatilization of the protective SiO_2 scale, environmental barrier coatings (EBC) are required. Combinations of yttrium silicates with Y_2O_3 or SiO_2 are one of the most promising EBC materials, and it is necessary to understand their behavior at high-temperature and in O_2/H_2O containing combustion atmospheres. In this work, the CALPHAD method was used to develop a thermodynamic dataset of the multi-component Y-Si-C-O-H system to be able to simulate heterogeneous reactions between the EBC and various gas atmospheres. An existing thermodynamic description of the Y-Si-C-O system was therefore refined by updating the description of the Y_2O_3-SiO_2 pseudo-binary system and including descriptions of the Gibbs free energies of the Si-O-H and Y-O-H gas species. The newly developed dataset was used to calculate the thermochemical reactions between the yttrium silicate coating and the SiC base material as well as with the O_2/H_2O containing combustion atmosphere. The stabilities of yttrium mono- and disilicate against erosion was also evaluated as a function of coating and gas composition, temperature and pressure.

H3. Innovative Design, Advanced Processing, and Manufacturing Technologies

Innovative Design V

Room: Bay

Session Chairs: Shaoming Dong, Shanghai Institute of Ceramics, Chinese Academy of Sciences; Hagen Klemm, FhG IKTS Dresden

8:30 AM

(H3-033-2016) Liquid silicon infiltration of carbon-based preforms embedded in powder field modifiers heated by microwaves (Invited)

A. Ortona*[1]; P. Vavassori[2]; M. Mallah[3]; S. Gianella[4]; M. Nagliati[5]; 1. SUPSI, Switzerland; 2. Petroceramics, Italy; 3. Fricke und Mallah Microwave Technology GmbH, Germany; 4. Erbicol, Switzerland; 5. Brembo SGL Carbon Ceramic Brakes, Italy

Liquid silicon infiltration (LSI) is a process to produce silicon carbide matrix composites by infiltrating porous carbon preforms. Even if LSI is considered one of the fastest manufacturing techniques for the production of CMCs, long processing time is required to heat and cool the relevant furnaces. In this work, we show the benefits of applying microwave power to perform LSI. A set up in which preforms are embedded in powder field modifiers is presented. The use of SiC/BN powder as field modifiers has the twofold function of being an efficient way to heat up the components uniformly and of being impermeable to molten silicon. Si-SiC bulk, composite and porous ceramic parts were successfully infiltrated in minutes. Due to plasma formation, vacuum could not be applied. Infiltrations were thus performed at ambient pressure. The different microstructures produced by microwave heating were compared with the ones produced with conventional heating. A dedicated set up needs to be designed for every component since microwaves heating is strongly depending on part's shape and mass, even with powder field modifiers.

9:00 AM

(H3-034-2016) Microstructure Analysis and Properties Evaluation of SiBCN-based Composites fabricated through high-efficient PIP process

Z. Wang*[1]; S. Dong[1]; Y. Ding[1]; 1. Shanghai Institute of Ceramics, Chinese Academy of Sciences, China

With the application of new precursor for SiBCN with high ceramic yields and low viscosity, novel PIP processes with the curing of precursors at low temperatures have been developed to fabricate SiBCN-based composites. The microstructure evolution behaviors accompanied in the fabrication process have been analysized, the properties such as oxidation resistance and high temperature stability have been evaluated as well.

9:20 AM

(H3-035-2016) The effect of ZrC matrix geometry on ablation properties of C/SiC-ZrC composites

H. Zhou*[1]; 1. Shanghai Institute of Ceramics, Chinese Academy of Sciences, China

Impregnating carbon fiber and SiC based systems with UHTCs phase to form C/SiC-UHTCs are becoming more and more attractive because their ablation resistance and oxidation resistance properties under ultra-high temperature environment will be greatly enhanced. The UHTCs matrix geometry is the key factor for their ultra-high temperature performance. In order to get clear guideline for design of the UHTCs matrix, 3D C/SiC-ZrC composites were prepared by PIP process in this paper in which the polymer-derived ZrC matrix geometry were designed on purpose. The ablation-resistive properties of C/SiC-ZrC composites were measured by the arc-heated wind tunnel ablation tests. Effects of ZrC matrix geometry on ablation properties of C/SiC-ZrC composites were discussed.

9:40 AM

(H3-036-2016) Microstructure and mechanical properties of ZrC-modified C/SiC composites

J. Dai*[2]; J. Shao[1]; J. Sha[1]; W. Krenkel[3]; 1. Dalian University of Technology, China; 2. Dalian University of technology, China; 3. University of Bayreuth, Germany

C/SiC composites have been considered as promising materials for a variety of high-temperature applications, such as propulsion systems and thermal protection system. However, the thermal stability in oxidative environment is strongly depends on the microstructure and phase composition of the matrix. Ultra-high temperature ceramics, presented excellent oxidation resistance under severe environment. Therefore, for improving the thermal stability of C/SiC composites under harsh environments, this work introduced the ultra-high temperature ceramic particles, ZrC, into the matrix of C/SiC composites by slurry infiltration technique. The influence of volume fraction of ZrC on microstructure, mechanical properties and oxidation resistance was investigated. To some extent, results found that homogeneously dispersed ZrC particles could strengthen the mechanical properties and oxidation resistance of composites.

10:20 AM

(H3-037-2016) Computational Study of Various Heating Methods in Thermal Gradient CVI Process (Invited)

A. Kulik*[2]; V. Kulik[1]; M. Ramm[2]; M. Bogdanov[2]; 1. Baltic State Technical University "VOENMEH", Russian Federation; 2. STR Group, Inc., Russian Federation

Chemical Vapour Infiltration (CVI) is one of the most promising methods for production of high-quality composite materials with ceramic matrices. The principal advantage of the CVI method is ability to produce composites without thermal, chemical, or mechanical damaging the fibres. Thermal gradient CVI (TG-CVI) is a modification of CVI process utilizing temperature drop over the bulk of the sample to be infiltrated, which allows production of a material with low residual porosity. There are three principal methods of heating of TG-CVI reactors: resistive, inductive or Radio-Frequency (RF), and microwave (MW). The resistive method leads to heat release in a heater only, RF – to heat release in a heater and partially in the sample, and MW normally results in heat release mostly in the sample. Thus, these methods produce different temperature distributions inside the sample and have different efficiency. In this work, numerical simulation is used to study and compare these heating methods. The efficiency of each method is estimated basing on quality of produced material, duration of the process, and electricity costs. Advantages and drawbacks of each method are analysed.

10:50 AM

(H3-038-2016) Optical design, preparation and thermal insulation performance of multi-layer coatings on a CMC (Invited)

Y. Liu*[1]; X. Zhang[1]; Q. Shao[1]; H. Zhang[1]; 1. Southeast University, China

Reflective multilayer films consisting of dielectric materials of SiCx, SiNy and SiOz, where subscripts x, y and z indicate nonstoichiometry, and metallic-like TiN were designed optically and deposited on carbon fibers-reinforced silicon carbide composites (C/SiC) substrates by magnetron sputtering. The morphology and crystalline structures of the films were analyzed by scanning electron microscopy and X-ray diffractometer. Optical constants were characterized by ellipsometer and the reflectance in near-infrared range measured by ultraviolet and visible spectrophotometer. The heat-insulating performance and oxidation behavior at a maximum temperature of 1100 degrees C in ambient air were investigated. It was found that TiN/(SiOz, SiNy)n multilayers possessed the highest reflectance ~72.43% when n was 3, where n represents repetition number of the layers combination, and showed the best thermal-insulating performance during initial one-hour heating, but the insulation deteriorated after thermal exposure up to tens of hours. In comparison, SiC/(SiNySiCx)n, where n=2 or 3, multilayer coatings were more stable. Oxidation processes were analyzed and correlated to thermal insulation effects.

11:20 AM

(H3-039-2016) Manufacturing of Oxide Fiber Composites with Water-based Slurries

T. Wamser*[1]; S. Scheler[1]; B. Martin[1]; G. Puchas[1]; W. Krenkel[1]; 1. University of Bayreuth, Germany

In recent years, oxide fiber composites are more and more used in components for metallurgy, burners or in turbines. Advantages are their thermo-mechanical characteristics or the corrosion resistance. The presentation is focussed on manufacturing routes of oxide fiber composites with water-based slurries. One possibility is the vacuum-assisted slurry-infiltration of near-net-shape fiber preforms. Suitable preforms are braids or weaves with an adapted three dimensional fiber-architecture to enhance the interlaminar shear strength. Another option is the preparation of prepregs, which can be laminated to process fabric-reinforced composites. Both manufacturing techniques are shown and advantages of the different manufacturing techniques will be discussed on the basis of complexity of the processing and fabricable geometries. Finally microstructural analysis and some mechanical characteristics are compared to disclose the potential of each manufacturing technique

H4. Materials for Extreme Environments: Ultrahigh Temperature Ceramics (UHTCs) and Nano-laminated Ternary Carbides and Nitrides (MAX Phases)

New Precursors for Powders, Coatings, and Matrix or Fibers of Composites

Room: Salon C
Session Chair: Dhavanesan Kothanda Ramachandran, University of Birmingham

8:30 AM

(H4-001-2016) Single-Source-Precursor Synthesis and Properties of Hf-Containing Ultrahigh-Temperature Ceramic Nanocomposites (UHTC-NCs) (Invited)

E. Ionescu*[1]; 1. Technical University Darmstadt, Germany

Polymer-derived ceramic nanocomposites (PDC-NCs) can be synthesized via thermal conversion of suitable single-source precursors, leading in a first step to amorphous single-phase ceramics, which subsequently undergo phase separation processes to furnish bi- or multiphase ceramic nanocomposites. PDC-NCs have been shown to be excellent candidate materials suitable for applications at ultrahigh-temperatures and under harsh environments. In the present work, amorphous SiHfCN- and SiHfBCN-based materials were synthesized via cross-linking and ceramization of tailor-made single-source precursors. High-temperature annealing of the obtained amorphous ceramics led to UHTC-NCs with promising compositions, such as SiC/HfC, HfN/Si_3N_4/SiBCN or HfC/HfB_2/SiC. The presented results emphasize a convenient preparative approach to nano-structured ultrahigh-temperature stable materials starting from greatly compliant single-source precursors. Additionally, recent results concerning the stability of the prepared UHTC-NCs in ultraharsh environments (i.e., oxidative atmosphere, combustion atmosphere, hydrothermal environment) will be presented and discussed.

9:00 AM

(H4-002-2016) "Ductile" and "Soft" YB_6 and YB_4 Ceramics with Heterogeneous Strong σ Bond and Weak τ Bond for Ultrahigh-Temperature Applications

Y. Zhou*[1]; 1. Aerospace Research Institute of Materials & Processing Technology, China

Transition metal borides have contributed to the success of ultra-high-temperature materials (UHTM) development. Current ZrB_2 and HfB_2-based UHTMs exhibit high-temperature environmental stability, high strength and modulus but inevitable brittleness. In the ZrB_2 and HfB_2 scenarios, the high Young's modulus is underpinned by the strong covalent bonding in the crystal structure. It is well established that, in addition to composition, chemical bonding plays a pivotal role in dictating the structure and properties of a material. Therefore, comparing to the composition modification, changing the nature of chemical bonding in transition metal borides is more effective in overcoming the intrinsic brittleness, poor thermal shock resistance (due to high Young's modulus) and machinability (due to high hardness). Especially, if weak bonds co-exist with strong covalent bonds in transition metal borides, tailoring the properties will become feasible. Interestingly, YB_6 and YB_4 are predicted as 'ductile' and soft ceramics for ultrahigh-temperature applications through density functional theory investigations on the electronic structure and bonding properties. The 'ductility' is under pinned by chemical bonding anisotropy, i.e., a strong σ bond connecting the B_6 octahedra and a weak τ bond formed by overlapping the lobes of two perpendicular p orbitals.

9:20 AM

(H4-003-2016) Preparation of TiC, TiB_2 and TiC-TiB_2 powders from a novel carbon coated precursors method and their sintering properties with high entropy alloy

Z. Fu*[1]; R. Koc[1]; 1. Southern Illinois University Carbondale, USA

High quality TiC, TiB_2, and TiC-TiB_2 powders were prepared by carbo/borothermal reduction from carbon coated titanium dioxide (TiO_2) precursors. Reactions were conducted at 1500°C for 2 hours with argon flowing at 0.1L/min. Phases, microstructures and surface areas were characterized by X-ray diffraction (XRD), transmission electron microscope (TEM) and Brunauer-Emmett-Teller (BET) surface area analyzer respectively. Powders synthesized from carbon coated precursors featured with high purity, fine particle size, narrow size distribution, spherical shape, loose agglomeration and high surface area. With 10 wt. % TiNiAlFeCoCr high entropy alloy(HEA) powders as sintering additive, synthesized powders were sintered at 1550°C through pressureless sintering. Traditional additive Ni were also sintered with synthesized powders as comparison. Owing to excellent sintering properties of synthesized powders, all samples reached densities of above 95% theoretical density. Scanning electron microscope (SEM) micrographs of polished surfaces showed that samples with HEA additive have much finer grain size comparing with traditional Ni additive. Samples with HEA additives have better mechanical properties including hardness and fracture toughness comparing with Ni additive.

Methods for Improving Damage Tolerance, Oxidation and Thermal Shock Resistance

Room: Salon C

Session Chair: Emanuel Ionescu, Technical University Darmstadt

10:20 AM

(H4-004-2016) Creating ultra-high temperature ceramic matrix composites

J. Binner[1]; D. Kothanda Ramachandran*[1]; 1. University of Birmingham, United Kingdom

There is an increasing demand for advanced materials with a temperature capability of well over 2000°C, in highly corrosive environments and whilst subject to intense heat fluxes and mechanical stress associated with vibration, for aerospace and other applications. The interaction of environmental conditions together with the requirement that dimensional stability is maintained makes the selection of suitable materials extremely challenging. This paper discusses the design, development, manufacture and testing of a new class of Ultra High Temperature Ceramic Matrix Composites (UHTCMCs) based on C fibre preforms enriched with ultra-high temperature ceramics (UHTC) suitable for application in severe aerospace environments.

10:40 AM

(H4-005-2016) Processing and Testing of Ultrahigh Temperature Fiber-reinforced Ceramics

J. Stiglich*[1]; B. Williams[1]; V. Arrieta[1]; 1. Ultramet, USA

Ultramet has developed innovative processing for ultrahigh temperature fiber-reinforced ceramics. Using a rapid melt infiltration process, Ultramet fabricates high strength fiber-reinforced ceramic matrix composite structures that can operate in various hot-gas environments at temperatures in excess of 2800°C. A low temperature process has also been developed to apply fiber interface coatings to protect the fibers during processing and to maximize composite mechanical properties during use. The processing is applicable to ceramic matrixes with extremely high melting points including zirconium carbide, hafnium carbide, tantalum carbide, and ceramic alloys. Hot-gas testing of melt infiltrated ceramic matrix composite structures in oxidizing environments has been performed at various facilities, and the components survived with low or no erosion. Processing and testing of ceramic composite materials will be discussed.

11:00 AM

(H4-006-2016) Oxidation of HfB_2 and HfB_2-20 vol% SiC at 1500°C in Air: Effect of Compressive Stress

A. DeGregoria[1]; M. Ruggles-Wrenn*[1]; 1. Air Force Institute of Technology, USA

The oxidation behaviors of HfB_2 and of HfB_2-20 vol% SiC were studied. Test samples of each material were oxidized at 1500°C in air using a box furnace. The exposure times were 0, 0.5, 1, 2, 3, 6, 9, 12, 15, 30, 45, and 90 h. Weight gain and the evolution of oxide scale with exposure time were characterized for both materials. Experimental results were compared to predictions of a mechanistic model by Parthasarathy et al. For HfB_2-20 vol% SiC, predictions agreed well with experiment. For HfB_2, the model significantly underpredicted the scale thickness, but accounted for weight gain reasonably well except for the longest exposure time of 90 h. The effects of compressive stress on oxidation were also examined. Samples of HfB_2 and of HfB_2-20 vol% SiC were subjected to compressive stress of 50 MPa for up to 12 h at 1500°C in air. For both materials, compressive stress had little effect on the growth of oxide scale with time.

11:20 AM

(H4-007-2016) Thermodynamic Predictions for the Oxidation of Entropy-Stabilized UHTCs

L. Backman*[1]; E. Opila[1]; 1. University of Virginia, USA

Applications such as thermal protection and propulsion systems for hypersonic vehicles require materials that can perform at and exhibit oxidation resistance at temperatures above 2000ºC. Entropy stabilized quinary refractory metal carbides, nitrides, and borides are currently being investigated for these applications. The design of such materials requires as input the oxidation behavior of each of the components. A thermodynamic approach was used to investigate the relative stability of the oxides of Hf, Mo, Nb, Ta, Ti, V, W, and Zr. FactSage free energy minimization software and databases were used to calculate the equilibrium oxide phases and free energies of formation for the oxides of these refractory metals. The results are summarized in Ellingham diagrams. HfO_2 was found to be the most thermodynamically stable oxide with the highest melting temperature (T_m) among the oxides reviewed. Periodic trends were also noted, wherein Group IV elements form the most stable oxides with the highest melting points, Group V elements form oxides with low T_m, and Group VI elements form stable gaseous oxide species. The results are utilized to identify strategies for optimizing oxidation resistance of UHTCs at temperatures above 2000ºC. This thermodynamic approach will be applied to refractory carbides, nitrides and borides as well.

11:40 AM

(H4-008-2016) Preparation and characterization of carbon reinforced ZrC composites via combined slurry impregnation and volumetrically heated RF-CVI processing

D. Kothanda Ramachandran*[1]; A. D'Angio[1]; J. Binner[1]; 1. University of Birmingham, United Kingdom

Carbon fibre reinforced ZrC composites have the potential to offer improved toughness and thermal shock resistance for ultra-high temperature applications. The production of such composites is not straightforward however, either in with respect to material processing challenges or their subsequent high temperature characterization. Whilst a range of different approaches to making fibre-reinforced ceramic composites have been investigated in the past, the combination of slurry impregnation and RF-CVI (RF heated chemical vapour infiltration) routes offer the possibility of achieving the desired densification and also good control over the matrix structure and degree of bonding with the fibres, precise control of which is essential to obtain the maximum toughness values. The primary focus of the current work was to optimize the process parameters in the RF-CVI process in order to achieve uniform infiltration and hence densities. The extent of infiltration of the composite by both the initial impregnation of the fibre preform with particulates and then the subsequent RF-CVI process was determined using micro-CT whilst microstructural characterisation was achieved by a combination of observation of sections with FEG-SEM and X-ray diffraction. Determination of the thermal-oxidative ablation resistance involved oxyacetylene torch testing.

Novel Processing Methods (Bulk, Coatings and Thin Films)

Room: Salon C

Session Chair: Hui Gu, Shanghai University

1:30 PM

(H4-009-2016) Carbide Based Ultra High Temperature Ceramics: Preparation and Properties (Invited)

G. Zhang*[1]; 1. Donghua University, China

Refractory carbides such as ZrC, HfC and TaC demonstrate high melting point and are important ultra high temperature ceramics. They are potential candidates for the applications in the next-generation rocket engines and hypersonic spacecrafts working at 2200-3000ºC. On the other hand, ZrC has low neutron absorption cross-section and a good resistance to strong radiation and corrosion of nuclear fission products. For example in the frame work of the Gen-IV project, ZrC is one of the inert matrix materials to be used for fuel components. In this case, low temperature densification of ZrC ceramics is essential. In this presentation, we will report our recent results on the sintering and properties of ZrC, HfC and TaC ceramics especially for ZrC ceramics with different additives. (1) Hot pressing of ZrC ceramics with the addition of Zr and C. (2) Hot pressing of ZrC ceramics with the addition of MC (M=V, Nb, Ta). (3) Reactive hot pressing of ZrC_{1-x}-SiC and ZrC_{1-x}-$Zr_3Al_3C_5$ ceramics with the addition of silicon or aluminum at low temperatures.

2:00 PM

(H4-010-2016) Core-rim structure in diboride-based ultra-high temperature ceramics

D. Hu*[1]; H. Gu[1]; 1. Shanghai University, China

To improve the sintering and performance like mechanical properties and oxidation resistance, transition metal disilicides and carbides are used as sintering additives and reaction agents in the diboride-based ultra-high temperature ceramics (UHTCs). Solid solution in the diboride phases is an important result of doping, and the core-rim structure, a special type of solid solution, plays multiple roles in the relationship of sintering – solid solution – microstructure – property. Indeed, the solute composition of core-rim structure could be used to analyze the diffusion and solute-precipitation process and the role of liquid phase; and by the combination of cell parameters and solute composition, as well as the thermal expansion coefficient of core-rim structure, the stress and strain state of such structure could be qualitative or semi-quantitative analyzed. The indispensable foundation for all of these analyses is the integrated quantitative characterization of the core-rim structure, by combined using XRD (including the structure refinement, Vegard's law and K-value method), SEM and TEM methods. By using such quantitative analysis for the core-rim structures from the hot pressing and reactive hot pressing, the relationship of sintering – microstructure – property was analyzed, which contribute to design the sintering process and optimize the properties.

2:20 PM

(H4-011-2016) Temperature Dependences of the Elastic Moduli of Single-crystal and Polycrystalline SiC to 1273 K

M. Manghnani*[1]; 1. University of Hawaii, USA

Knowledge of in-situ high-temperature (HT) elastic properties of ceramics plays important role in assessment of their stability in various structural and technological applications. Using high precision ultrasonic interferometry technique, we have investigated the temperature dependences of compressional and shear elastic wave velocities (V_P, V_S), bulk modulus K_S and shear modulus G, Young's modulus E, and Poisson's ratio σ in dense polycrystalline samples of α- hexagonal and β- cubic SiC (CVD) sample to 1000 K. The elastic moduli (K, G, and E) of β- cubic SiC are higher than those for α- SiC. In both cases, the moduli decrease with T, whereas Poisson's ratio increases with temperature. In addition, we report the single-crystal elastic constants Cij of 2H (α-hexagonal) SiC to 1273 K, using Brillouin scattering and compare the results with previous Brillouin studies of 4H and 6H SiC and theoretical calculations. Comparison of the results for the bulk and single-crystal data shows that the single-crystal elastic moduli vary linearly with temperature as compared to slightly curvilinear temperature dependences observed in the case of bulk SiC samples. In both cases, the HT structural stability of SiC is displayed. Implications for the above results are discussed in terms of micro-structure and thermal stability.

Structure-property Relationships of Existing Systems

Room: Salon C

Session Chair: Marina Ruggles-Wrenn, Air Force Institute of Technology

3:20 PM

(H4-012-2016) Abnormal Thermal Shock Behavior of a Cr_2AlC ceramic in Different Quenching Media (Invited)

S. Li*[1]; 1. Beijing Jiaotong University, China

The nonsusceptibility to thermal shock is an essential property for ceramics used in high-temperature environments. However, most ceramics are sensitive to thermal shock due to their intrinsic brittleness and low thermal diffusivity. Recently, some MAX phases (M denotes an early transition metal, A is a mostly IIIA or IVA group element, and X is either C or N) such as Ti_3SiC_2, Ti_3AlC_2,Ta_4AlC_3 and Cr_2AlC, have been demonstrated to exhibit abnormal thermal shock behavior as quenched in water. The main mechanism is due to crack healing, namely, thermal shock-induced cracks are instantly healed by the formation of Al_2O_3 well adhering to the crack faces during quenching in water. However, the abnormal thermal shock behavior of the MAX ceramics was mainly demonstrated during quenching in water. It is not clear that the unique thermal shock behavior remains valid during quenching in other quenching media. This work reports on the thermal shock behavior of Cr_2AlC, as a representative of MAX phase ceramics, during quenching in water, oil and molten salt. The mechanisms for the thermal shock behavior in different quenching media have been discussed.

3:50 PM

(H4-013-2016) Oxidation of SiC_f/SiC graded composites under Laser Heating

C. Carney*[1]; D. King[2]; M. Cinibulk[1]; 1. Air Force Research Lab, USA; 2. UES, Inc., USA

Ceramic matrix composites with BN/SiC coated Hi Nicalon S™ SiC fibers and matrices derived from a combination of polymer-derived SiC ceramic and powder particulate slurries were prepared. Two CMCs were processed using a wet layup of slurry infiltrated 8HS fabric. The first panel was prepared with only SiC loaded preceramic polymer while the second panel had a SiC loaded base and an outer layer with HfB_2 loaded preceramic polymer. Processing development will be discussed in terms of increasing matrix density and grading of the HfB_2 content. The panels were tested for oxidation resistance by laser heating at 2 and 3 MW/m^2 to achieve temperatures between 1600°C and 2500°C. SEM/TEM analysis are discussed to compare the samples. Oxidation resistance was compared between graded and ungraded composites to show that the addition of HfB_2 to the matrix reduced the impact of oxidation on the fibers and fiber coatings.

4:10 PM

(H4-014-2016) Solid-solution as monitor for phase and microstructure evolution in multi-phased ultra-high-temperature ceramics

H. Gu*[1]; D. Hu[1]; 1. Shanghai University, China

For diboride-based ultra-high temperature ceramics (UHTC), carbide phases are needed as reaction agents, sintering aides as well as performance modifiers. Such multiple roles makes the carbide a key issue in the design of multi-phased ceramics, affecting nearly every aspects of processing and performance. Indeed, the multi-tasking carbides could stay within the microstructure as intermediate reactants, final minor phases, intergranular remnents, and the last but not the least, solid-solutions. Indeed, solid-solution may contain information not only for phase relationship, but also on the earlier stages of sintering process and microstructure evolution. However, its measurements were dominated by XRD method, which takers only average and quite insensitive to low level solutions, hence solid-solutions were larged ignored. By a quantitative analysis of solute composition and phase components involving a combination of XRD, SEM and TEM methods, formation mechanism and relationship between successive phases during sintering and densification could be revealed and established. By such an integrated analysis of solid-solutions for several sintering routes, multi-phase relationships and multi-leveled microstructures are intermixed with each other, which provide a new perspective to design UHTC sintering.

4:30 PM

(H4-015-2016) Fabrication and densification of highly concentrated HfC-SiC slurries for the preparation of an ultra-high temperature ceramic matrix composites

L. Feng*[1]; S. Lee[1]; 1. Korea Institute of Materials Science, Republic of Korea

Nano HfC powder having the average particle size of 125 nm was synthesized through the optimization of processing conditions and the application of spark plasma sintering (SPS) apparatus. The metal basis purity (except Zr) and maximum synthesis capacity of the nano HfC powder were 99.92% and 175g/day, respectively. By using ethanol and polyethylenimine (PEI) as the dispersoid and dispersant, respectively, a concentrated slurry with 40vol% solid loading was prepared using the nano-HfC powder. In order to prepare HfC slurries containing the sintering additives, HfC, $HfSi_2$ and C powders were mixed by high energy ball mill. Highly concentrated slurry up to 55vol% solid loading was successfully fabricated using the powder mixture. Dense (98%) and nano-structured HfC-SiC composites were fabricated after reactive spark plasma sintering (R-SPS) at 1750 - 1850°C under 40MPa pressure. Ultra-fine (200 – 300 nm) and homogeneously distributed HfC and SiC grains were observed in the dense composites due to the high energy milling of raw powders, molecular-level homogeneity of Si and Hf in $HfSi_2$, and low sintering temperature by R-SPS. The Vickers hardness, Young’s modulus and fracture toughness of the nano composites were about 23 GPa, 315 GPa and 3.7 $MPa \times m^{1/2}$, respectively.

4:50 PM

(H4-016-2016) Strengthening and Tribological Surface Self-Adaptability of Ti_3AlC_2 by Incorporation of Sn to Form $Ti_3Al(Sn)C_2$ Solid Solutions

Z. Huang*[1]; 1. Beijing Jiaotong University, China

Ti_3AlC_2 is one of the most fascinating members of the MAX phases. It exhibits an unusual combination of properties, such as excellent oxidation resistance, good electrical and thermal conductivity. It also demonstrates good tribological properties. To attain a set of desired tribological properties over a wide range of conditions, the authors try to induce tribological surface self-adaptability after incorporating Sn to form $Ti_3Al(Sn)C_2$ solid solutions. Three $Ti_3Al(Sn)_xC_2$ compounds (x=0, 0.2, 0.4) were synthesized using a two-time hot-pressing sintering method. Significant strengthening was observed after incorporation of 0.2Sn and 0.4Sn to form $Ti_3Al(Sn)C_2$. The flexural strengths of these compounds were measured to be 560 MPa and 620 MPa, respectively; these values are 51% and 67% higher, respectively, compared with the strength of Ti_3AlC_2. Tribological surface self-adaptability after the incorporation of Sn was also investigated at a sliding speed of 30 m/s and normal loads of 20~80 N. The results showed that the friction coefficient could be adapted to fall within the range of 0.13~0.33 after incorporation of different amounts of Sn. Tribological surface self-adaptability mechanisms were also discussed.

5:10 PM

(H4-017-2016) Synthesis of textured MAX bulk ceramics by pressure assisted sintering

X. Duan*[1]; D. Jia[1]; Y. Zhou[1]; L. Shen[2]; S. Wim[2]; S. V. Zwaag[2]; 1. Harbin Institute of Technology, China; 2. Delft University of Technology, Netherlands

The synthesis of a high purity MAX phase ceramics (Cr_2AlC, Ti_3AlC_2) involving pressure-less sintering (PLS) of elemental powders followed by pressure assisted sintering of the crushed reaction product of the PLS product is described. Depending on the ball milling conditions either intermediate coarse equiaxed MAX phase particles or intermediate small flake like MAX phase powdwes were obtained. Then these powders were sintered by spark plasma sintering or hot-press sintering. The textured microstructures that the (0001) planes are perpendicular to the compression direction were appeared. The mechanical properties of textured MAX phase ceramics, such as elastic modulus, flexural strength, fracture toughness and Vicker's hardness, all showed the anisotropic characteristics.

H6. Advanced Thermal and Environmental Barrier Coatings: Processing, Properties, and Applications

Environmental Barrier Coating Processing and Development

Room: Trinity IV

Session Chairs: Dongming Zhu, NASA Glenn Research; Satoshi Kitaoka, Japan Fine Ceramics Center

8:30 AM

(H6-001-2016) Mechanics of Polymer Derived Composite Ceramic Coatings and Joints (Invited)

R. Bordia*[1]; 1. Clemson University, USA

The pyrolysis of Si-based polymeric precursors to make composite ceramics offers many advantages over conventional ceramic processing. This is especially true for ceramic coatings and for joining and bonding ceramics. Advantages include ease of green state processing, ability to form a ceramic material at low temperatures, and form high purity, tailorable composites. We have investigated the mechanics of constrained pyrolysis for ceramic coatings. It is shown that the stresses generated in the coating due to the constraint from the substrate can lead to cracking in the coating. A critical thickness below which cracking does not occur has been calculated. It has been shown that this depends on the free (unconstrained) shrinkage of the coating. The predictions of this analysis have been experimentally verified. We have also modified the Landau-Levich analysis to make coatings of controllable thickness using dip-coating process. We use these calculations and analysis to develop robust processes to make high performance composite ceramic coatings on both ceramics and metals and for joining of ceramics and ceramic matrix composites. The mechanical properties of joints and coatings, including the fracture toughness of the interface and high temperature strength of the joints, will be presented.

9:00 AM

(H6-002-2016) Multifunctional High Temperature Coatings for Gas Turbine Components via Directed Vapor Deposition (Invited)

B. Gogia*[1]; D. Hass[1]; 1. Directed Vapor Technologies Intl, USA

Silicon based ceramic materials are the leading candidates to replace nickel-based turbine components in next generation gas turbine engines for high temperature applications. Thermal/Environmental Barrier Coatings (T/EBCs) are coating systems that are applied to the surface of these ceramics to protect against moisture-assisted oxidation-induced ceramic recession. However, several key coating challenges remain including higher temperature capability and prime reliance (especially in the presence of impact/erosion/corrosion conditions). As a result, advanced T/EBC systems are sought which both retain or improve the environmental protection afforded at elevated temperatures and also significantly improve the impact and erosion resistance. Due to the multifunctional requirements, next generation T/EBC systems are anticipated to be more complex than current systems and also would require the cost effective processing approach in which the required coating composition, microstructure and architecture is achieved. Here, a novel affordable Directed Vapor Deposition approach that results in the highly efficient deposition of advanced coating structures and compositions is used to deposit multifunctional T/EBC barrier coatings. Results indicate that the novel coatings created using the DVD technique can be effectively employed to improve component performance.

9:30 AM

(H6-003-2016) Self-healing EBC material for gas turbine applications

W. Kunz*[1]; H. Klemm[1]; A. Michaelis[1]; 1. Fraunhofer IKTS, Germany

Ceramic matrix composites are near-future materials for high temperature applications in gas turbines for energy production and aviation. However, corrosive attack by water vapour is still a reliability- and lifetime-limiting factor, especially for non-oxide CMC. For this reason environmental barrier coatings (EBC) have been developed to provide environmental protection in harsh gas turbine environments. Nevertheless, cracks and other defects lead to local loss of protection in almost every known EBC, especially under thermal and mechanical cycling. Therefore, self-healing abilities are substantial for durable EBCs. A new type of environmental barrier materials was investigated in order to provide self-healing abilities. First, the multi-phase materials were tested regarding their self-healing mechanisms at elevated temperatures in oxidizing atmospheres. The water vapour corrosion resistance and self-healing abilities of the materials in gas turbine atmospheres were evaluated in a high temperature burner rig up to 1400°C. The functionality of potential EBC materials with self-healing abilities was strong dependent on both, the oxidation and corrosion processes taking place during serve in hot gas environments.

9:50 AM

(H6-004-2016) Mass-transfer Mechanisms in Yb-silicate under Oxygen Potential Gradients at High Temperatures

S. Kitaoka*[1]; M. Wada[1]; T. Matsudaira[1]; N. Kawashima[1]; D. Yokoe[1]; M. Takata[1]; 1. Japan Fine Ceramics Center, Japan

EBCs can play a key role in allowing SiC_f/SiC_m to be applied to hot-section components in advanced airplane engines for better environmental stability and durability. Because a Yb-silicate such as $Yb_2Si_2O_7$ offers excellent resistance to water vapor volatilization, and its thermal expansion coefficient is close to that of SiC_f/SiC_m, it is a strong candidate for use in EBCs, which are exposed to a steep oxygen potential gradient ($d\mu_O$) at high temperatures. However, the mass transfer mechanism in $Yb_2Si_2O_7$ layer in such environments is not well understood. In this study, $Yb_2Si_2O_7$ wafers containing a tiny amount of SiO_2 or Yb_2SiO_5, were used as model EBC layers. The oxygen permeability of the wafers was evaluated at temperatures above 1473 K under a $d\mu_O$, which was produced by exposing the upper and lower surfaces of the wafer to atmospheres with a different oxygen partial pressure (P_{O2}). Oxygen permeation occurred via grain boundary (GB) diffusion of oxygen from the high-P_{O2} surface to the low-P_{O2} surface, and simultaneous GB diffusion of Yb in the opposite direction, resulting in decomposition of $Yb_2Si_2O_7$ near the low-P_{O2} surface. The microstructure stability of the wafers depended strongly on the coexistence of the SiO_2 or Yb_2SiO_5 that was initially present in the wafers.

10:30 AM

(H6-005-2016) Ytterbium silicate environmental barrier coatings by laser chemical vapor deposition (Invited)

A. Ito*[1]; M. Sekiyama[1]; T. Goto[1]; 1. Tohoku University, Japan

Rare-earth silicates exhibit excellent stability against high-temperature atmosphere, and thus they are promising as environmental barrier coating (EBC) materials for high-temperature structural materials such as turbine blades. EBC with a columnar microstructure can reduce thermal conductivity and improve thermal shock resistance, while that with a dense microstructure can be a corrosion and oxidization resistant coating. Thus far, electron-beam physical vapor deposition (EB-PVD) and plasma spraying have been used for preparing EBC. Chemical vapor deposition (CVD) is an alternative technique for EBC. CVD can produce conformal coatings with controlled microstructures by changing deposition conditions. However, CVD has not been used for EBC because of a relatively low deposition rate. We have developed laser-assisted CVD (laser CVD) to enhance chemical reactions in CVD process, resulting in a high deposition rate greater than hundred μm per hour. Ytterbium silicate coatings were prepared by laser CVD to investigate effects of deposition conditions on the phase composition, orientation and microstructure of the coatings. (110)-oriented β-$Yb_2Si_2O_7$ coatings had a dense cross section, and deposition rate was 260 μm h^{-1}. X2-Yb_2SiO_5 coatings showed a columnar structure and deposition rate reached 480 μm h^{-1}.

11:00 AM

(H6-006-2016) Combined Thermomechanical and Environmental Durability of Environmental Barrier Coating Systems on SiC/SiC Ceramic Matrix Composites

D. Zhu*[1]; B. J. Harder[1]; R. Bhatt[2]; 1. NASA Glenn Research, USA; 2. Ohio Aerospace Institute, USA

Environmental barrier coatings (EBCs) and SiC/SiC ceramic matrix composites (CMCs) will play a crucial role in next generation turbine engines for hot-section component applications. The development of prime-reliant environmental barrier coatings is essential to the EBC-CMC system durability, ensuring the successful implementations of the high temperature and lightweight engine component technologies for engine applications. This paper will emphasize recent NASA environmental barrier coating and CMC developments for SiC/SiC turbine airfoil components, utilizing advanced coating compositions and processing methods. The emphasis has been particularly placed on thermomechanical and environment durability evaluations of EBC-CMC systems. We have also addressed the integration of the EBCs with advanced SiC/SiC CMCs, and studied the effects of combustion environments and Calcium-Magnesium-Alumino-Silicate (CMAS) deposits on the durability of the EBC-CMC systems under thermal gradient and mechanical loading conditions. Advanced environmental barrier coating systems, including multicomponent rare earth silicate EBCs and HfO_2-Si based bond coats, will be discussed for the performance improvements to achieve better temperature capability and CMAS resistance for future engine operating conditions.

11:20 AM

(H6-007-2016) Calcium-magnesium aluminosilicate (CMAS) interactions with ytterbium disilicate ($Yb_2Si_2O_7$) environmental barrier coating material

V. L. Wiesner*[1]; D. Scales[2]; N. Johnson[3]; B. J. Harder[1]; N. P. Bansal[1]; 1. NASA Glenn Research Center, USA; 2. University of Washington, USA; 3. College of Wooster, USA

Particulates, including sand and runway dust, are regularly ingested by air-breathing engines and melt at target operating temperatures of next-generation aircraft engines (>1200°C). Upon melting, these particulates become glassy deposits with compositions loosely corresponding to calcium-magnesium aluminosilicate (CMAS) with other trace elements. Exposure to molten CMAS can limit the durability of environmental barrier coatings (EBCs) used to protect next-generation silicon-based ceramic matrix composite engine components by adhering to and thermo-chemically interacting with underlying coatings (EBCs) leading to premature failure of the component. In this study, a synthetic sand glass was prepared to evaluate the high-temperature interactions between CMAS and ytterbium disilicate ($Yb_2Si_2O_7$), a candidate EBC material. Synthesized CMAS glass was added to the surface of hot-pressed $Yb_2Si_2O_7$ substrates, which were then heated in air at temperatures ranging from 1200°C to 1500°C. Pellets of mixed CMAS glass and $Yb_2Si_2O_7$ powders were also prepared and heated in air at 1200°C to 1500°C. Materials characterization techniques, including X-ray diffraction with Rietveld analysis, scanning electron microscopy and X-ray energy-dispersive spectroscopy, were used to evaluate the resulting phase compositions and microstructure of reacted CMAS/EBC specimens.

11:40 AM

(H6-008-2016) Resistance of Yttrium Di-Silicate Environmental Barrier Coatings to Calcium-Magnesium-Aluminum-Silicate Attack

J. H. Shaw*[1]; N. Verma[1]; C. G. Levi[1]; F. W. Zok[1]; 1. UC Santa Barbara, USA

Silicon-carbide (SiC) based ceramic matrix composites (CMCs) are susceptible to rapid surface recession in combustion environments due to thermochemical attack by water vapor. Rare earth mono- and di-silicate coatings are of great interest for environmental barrier coatings (EBCs) in water vapor environments due to their low silica activity and their themomechanical compatibility with SiC/SiC CMCs, respectively. However, when used in aerospace applications, these coatings are also subject to thermochemical attack by calcium-magnesium-aluminum-silicate (CMAS) that may be ingested by the engine. This talk addresses the resistance of a yttrium di-silicate EBC to CMAS attack. A model air plasma sprayed coating is subjected to CMAS at fixed concentration and temperature to determine (i) the kinetics of surface recession and (ii) the reaction products formed. The effect of the chemical composition of the CMAS is addressed, and a contrast is made between the relative performance of mono- and di-silicate coatings. Finally, two special cases are examined: the effect of a through-thickness temperature gradient on surface recession; and the performance of the as-deposited coating relative to that of a nominally-dense specimen.

Environmental Barrier Coating Processing, Characterizaton and Modeling

Room: Trinity IV

Session Chairs: Peter Mechnich, DLR - German Aerospace Center; Valerie Wiesner, NASA Glenn Research Center

1:30 PM

(H6-009-2016) Comparison of Different Environmental Barrier Coating Systems (Invited)

R. Vassen*[1]; E. Bakan[1]; C. Gatzen[1]; D. E. Mack[1]; O. Guillon[1];
1. Forschungszentrum Juelich, Germany

Ceramic matrix composites (CMCs) are attracting increasingly high attention for applications in gas turbine due to their excellent high temperature capabilities and high strength to mass ratios. Due to the water vapor rich, high velocity combustion gas in a gas turbine CMCs, high recession rates even for oxide/oxide composites are observed. Hence, protective coatings called environmental barrier coatings (EBCs) are needed. The talk will give an overview on literature results on EBC systems for both non-oxide and oxide CMCs and will also try to point out major challenges and further needs with respect to this kind of coatings. Within this overview also our own results on different types of EBC systems as RE silicates for non-oxide or spinels for oxide CMCs CMCs manufactured by thermal spray methods will be presented.

2:00 PM

(H6-010-2016) Environmental barrier coatings for SiC/SiC-CMCs: Manufacturing and behaviour under cyclic oxidation and flowing water vapour

V. Leisner*[1]; U. Schulz[1]; P. Mechnich[1]; 1. DLR - German Aerospace Center, Germany

Silicon carbide ceramic matrix composites (SiC/SiC-CMCs) are promising materials for application in the hot section of gas turbines. SiC forms a protective SiO_2 scale (TGO) which sufficiently protects the underlying material from oxidation at high temperatures in dry air. However, if rapidly flowing water vapour in a combustion environment is present, the TGO is subjected to severe volatilization by formation of silicon hydroxide. Thus, an environmental barrier coating (EBC) system is required which needs to have thermochemically compatible interfaces and a coefficient of thermal expansion (CTE) matching the SiC/SiC-CMC. In this study, CMCs were coated by magnetron sputtering and EB-PVD with silicon-based bond coats, $Y_2Si_2O_7$ and Y_2SiO_5 or combinations thereof. The coating architecture was designed namely to minimize chemical interactions among different layers and with a strain tolerant micro structure. The samples were cyclically tested up to 1250°C in air with and without thermal gradient, respectively. Their degradation behaviour in flowing water vapour was additionally investigated. Emphasis was put on both interfacial chemical reactions, and phase evolution. While the uncoated SiC/SiC-CMC suffered from severe degradation under water vapour, the EBC system proved to be stable and provides good protection of the SiC/SiC-CMC.

2:20 PM

(H6-011-2016) Preparation of Yb silicate layers by dual electron beam PVD

N. Yamaguchi*[1]; T. Yokoi[1]; T. Matsuda[1]; S. Kitaoka[1]; M. Takata[1]; 1. Japan Fine Ceramics Center, Japan

Novel environmental barrier coatings (EBCs) for SiC/SiC composite is being developed in this study: a multilayered system, including a Si based bond layer on the SiC/SiC substrate, followed by a mullite oxygen shielding layer and an Yb silicate (Yb_2SiO_5 and $Yb_2Si_2O_7$) gradient water vapor shielding/volatilization barrier layer. This EBC system will be applicable at 1400ºC, temperature limit of SiC fiber. In order to control structure and composition of Yb silicates having large vapor pressure differences between components, the electron beam PVD was chosen. Dual electron beams and multiple evaporation sources enable the formation of complex oxides and compositional and structural gradient layers. In this study, Yb silicate layers prepared by the dual electron beam PVD were investigated, focused on the effect of Yb/Si ratio in vapor flux and heat treatment at 1400ºC. Yb silicates were deposited on mullite which is underlying to Yb silicate in the developing EBC. Yb/Si ratio was changed by controlling the electron beam power applied to Yb_2O_3 and SiO_2 evaporation sources. Almost single phase Yb_2SiO_5 and $Yb_2Si_2O_7$ layers were obtained at Yb/Si ratio of 2/1 and 2/2, respectively. Both layer showed coned columnar structure with intercolumnar gaps. Effect of heat treatment on densification behavior of the layers during and/or after was also mentioned, in relation to substrate heating during deposition.

2:40 PM

(H6-012-2016) Silica Depletion in Rare Earth Silicate Environmental Barrier Coatings in High-Temperature High-Velocity Water Vapor

C. G. Parker*[1]; E. Opila[1]; 1. University of Virginia, USA

Air plasma sprayed (APS) Yb2Si2O7 environmental barrier coatings (EBCs) have been exposed to water vapor between 1200 and 1400°C at nominal gas velocities of ~165 m/s for 125 hours. The Yb2Si2O7 EBC reacts with water vapor, depleting SiO2 from the coating to form Si(OH)4(g) and porous Yb2SiO5. The depth of this SiO2 depletion from the coating has been measured and, surprisingly, an inverse relationship between temperature and average depletion depth has been observed. The average depletion depth observed after 125 hour exposures at 1200°C is approximately 15 μm compared with 8 μm at 1300°C and minimal depletion at 1400°C. The depletion zone width was also observed to decrease significantly with temperature, with depletion zone widths approximately 3 times wider at water vapor impingement temperatures of 1200°C compared to 1300°C. Possible mechanisms for the experimentally observed temperature dependence of silica depletion will be discussed.

3:20 PM

(H6-013-2016) ab initio Calculations of Rare Earth Silicates for Environmental Barrier Coatings (Invited)

M. Yoshiya*[1]; A. Ioki[1]; Y. Akada[1]; T. Yokoi[1]; 1. Osaka University, Japan

Rare earth silicates and their sister compounds have attracted attention as candidates for environmental barrier coating (EBC) materials due to their excellent high temperature mechanical properties as well as low thermal conductivity, high chemical stability against oxygen and moisture at elevated temperature. Intensive studies have done for these rare earth silicates, by experiments, to examine their potential for possible use for EBC. However, understanding for these silicate are still limited primarily due to its complicated microstructures depending on sintering conditions and deposition techniques and conditions, which would vary obtained results from experiment to experiment. Thus, in this study, ab initio calculations in conjunction with lattice dynamics have been performed for those silicates in a systematic manner to reveal essential mechanical properties as well as thermodynamic properties by intentionally excluding the impact of the microstructures and deviation from stoichiometry. Uniaxial tensile test has also been carried out to understand which atomic plane or crystallographic direction crack would be initiated in operating environments at elevated temperatures.

3:50 PM

(H6-014-2016) Theoretical Prediction and Experimental Investigation on the Thermal and Mechanical Properties of Yb_2SiO_5 and β-$Yb_2Si_2O_7$

Y. Zhou*[1]; 1. Aerospace Research Institute of Materials & Processing Technology, China

Recent works demonstrate that rare-earth silicates, especially Yb_2SiO_5 and $Yb_2Si_2O_7$, are promising candidates for EBCs due to their superior high-temperature stability, outstanding durability in water vapor, and desirable chemical and mechanical compatibility with silicon-based matrix. However, the mechanical and thermal properties of Yb_2SiO_5 and $Yb_2Si_2O_7$ have been barely investigated. In this presentation, structural, mechanical, and thermal properties of Yb_2SiO_5 and β-$Yb_2Si_2O_7$ investigated using a combination of first-principles calculations and experimental investigations will be presented. Theoretically, anisotropic chemical bonding and elastic properties, damage tolerance and low thermal conductivity are predicted. Experimentally, bulk Yb_2SiO_5 and β-$Yb_2Si_2O_7$ are prepared, superior mechanical properties, damage tolerant behavior and low thermal conductivity are approved. Anisotropic thermal expansion coefficients (CTEs) were determined based on high-temperature X-ray diffraction analysis, and are correlated to the structural characteristics of the two compounds. The unique combination of the thermal and mechanical properties endows Yb_2SiO_5 and β-$Yb_2Si_2O_7$ potential candidates for TBC/EBC of silicon-based ceramics.

4:10 PM

(H6-015-2016) Evaluation of interface adhesion in multilayer environmental barrier coating for SiC/SiC composites

H. Kakisawa*[1]; T. Nishimura[1]; 1. National Institute for Materials Science (NIMS), Japan

Multilayer environmental barrier coatings composed of bond coat and top coat were fabricated by air plasma spray technique. Interface adhesion between the layers and between the coating and substrate was evaluated: cross-sectional observation of the coating by SEM, XRD analysis, and interface fracture test were done. SEM observation revealed that all interfaces were adhered with each other. Transverse cracks were observed in the top coat and the cracking became significant after the heating at 1573 K for 2 hours. XRD analysis showed the formation of amorphous oxide layers as fabricated and the crystallization of the layers after the heating. A notch and initial crack was introduced at the interface and a blade was inserted to the cracked interface. Interface adhesion strength and interface toughness was discussed from load-displacement curve during the inserting.

4:30 PM

(H6-016-2016) Thermal Behavior and Mechanical Properties of Y_2SiO_5 Coatings after Isothermal Heat Treatment

B. Jang*[1]; F. Feng[1]; K. Lee[2]; E. Garcia[3]; S. Kim[4]; Y. Oh[4]; H. Kim[4]; 1. National Institute for Materials Science (NIMS), Japan; 2. Kookmin University, Republic of Korea; 3. Institute of Ceramics and Glass, CSIC, Spain; 4. Korea Institute of Ceramic Engineering and Technology (KICET), Republic of Korea

Due to the excellent high temperature mechanical properties, e.g. high temperature strength and toughness, non-oxygen silicon-based ceramics such as silicon nitride (Si_3N_4) and silicon carbide (SiC) are of interest as candidate materials for hot parts of gas turbines. However, since it is prone to hot-corrosion in combustion environments, the development of environmental barrier coatings (EBCs) is mandatory. Y_2SiO_5coatings have been deposited by flame spray technique as protection layer of SiC substrate from oxidation and steam corrosion. In this work, Y_2SiO_5 coatings are heat treated by different temperature and different exposed times in air environment condition. The thermal behaviors such as phase transformation, microstructure change and TGO growth has been examined by XRD, SEM, and EDS analysis. In addition, the mechanical properties are evaluated by nano-indentation test. The result shows that the change of microstructure and composition is not too critical, but high temperature and long exposed times are more easily to lead the phase transformation to Y_2SiO_5crystalline phases, thus can improve the mechanical properties of Y_2SiO_5 coatings in terms of hardness and young's modulus.

4:50 PM

(H6-017-2016) EBC Development for Al_2O_3/Al_2O_3 CMC Combustor Liners

P. Mechnich*[1]; 1. DLR - German Aerospace Center, Germany

Environmental barrier coatings (EBC) are considered mandatory for the application of ceramic matrix composites (CMC) in hot sections turbine engines such as combustors. Low thermal mismatch, good adherence, microstructural stability and resistance against hot corrosion are key material properties. Y_2O_3-stabilized ZrO_2 (YSZ), Yttrium-Aluminum Garnet $Y_3Al_5O_{12}$ (YAG) as well as Y_2O_3 are considered attractive EBC materials for all-oxide CMCs consisting of Al2O3 fibers and matrices. In order to identify the most promising EBC material, Al_2O_3/Al_2O_3-CMCs were coated by means of air plasma spraying (APS). EBC-coated CMC coupons were subjected to relevant thermochemical loads such as burner-rig tests and CMAS-type corrosion. It turned out that Y_2O_3 offers the most favorable combination of corrosion resistance and compatibility to Al_2O_3/Al_2O_3 CMC. Two full scale CMC combustor liners were coated with 0.5 and 1 mm thick APS Y_2O_3 EBCs, respectively. An additional array of effusion cooling holes was manufactured by means of Laser-drilling. Tests in a high pressure combustor rig revealed a good coating performance. Specific aspects of laser-drilling of similar CMC components are discussed.

5:10 PM

(H6-018-2016) Characterization of protection efficiency of silicate environmental barrier coating (EBC)

S. Arnal*[1]; F. Rebillat[2]; F. Mauvy[3]; 1. LCTS - CNRS, France; 2. University Bordeaux, France; 3. ICMCB-CNRS, France

Future generations of parts of turbines will be replaced by Ceramic Matrix Composites (CMCs). Generally these CMCs consist of ceramic matrices reinforced with silicon carbide fibers. However, at elevated temperatures and under severe atmospheres, silicon carbide present in the matrix reacts with oxygen and water vapour present in the atmosphere to form silica not always stable. To protect CMCs, EBCs are put in place. The most stable EBCs are often rare-earth. To deposit EBCs, various processes are being used. These techniques generate different microstructures by varying the duration of sintering for example. These differences in microstructure will have an important influence on the ionic conductivity inside the coating and the recession rate of EBC by volatilization. The challenge of this investigation is to characterize the ionic conductivity in the selected materials. Ionic conductivity has been revealed by employing complex impedance spectroscopy. The use of this technique allows determining the ionic conductivity of the ceramic at different temperatures in various environments dry or wet. These microstructures will differ by the grain surface and grain boundaries surface, inducing changes in the ionic conductivity also. The comparison between the values of ionic conductivity and of diffusion coefficient is then interesting to validate the method.

H7. Thermomechanical Behavior and Performance of Composites

Creep, Rupture, and Fatigue of CMCs

Room: Salon D

Session Chair: Triplicane Parthasarathy, UES

8:30 AM

(H7-001-2016) Influence of Constituents on Creep Properties of SiC/SiC Composites

R. Bhatt*[1]; 1. Ohio Aerospace Institute, USA

SiC/SiC composites are being considered as potential candidate materials for next generation turbine components such as combustor liners, nozzle vanes and blades because of their low density, high temperature capability, and tailorable mechanical properties. These composites are essentially fabricated by infiltrating matrix into a stacked array of fibers or fiber preform by one or combination of manufacturing methods such as, Melt Infiltration (MI) of molten silicon metal, Chemical Vapor Infiltration (CVI), Polymer Infiltration and Pyrolysis (PIP). To understand the influence of constituents, the SiC/SiC composites fabricated by MI, CVI, PIP, and (CVI+PIP) were creep tested in air between 1200^0 and 1482^0C for up to 500 hrs. The failed specimens were analyzed for under a scanning electron microscope to assess damage mechanisms. Also, knowing the creep deformation parameters of the fiber and the matrix under the testing conditions, the creep behavior of the composites was modeled and compared with the measured data. The implications of the results on the long term durability of these composites will be discussed.

8:50 AM

(H7-002-2016) Fatigue behavior of an advanced SiC/SiC ceramic composite at 1300°C in air and in steam

M. Lee[1]; M. Ruggles-Wrenn*[1]; 1. Air Force Institute of Technology, USA

The fatigue behavior of a non-oxide ceramic composite with a multi-layered matrix was investigated at 1300°C in laboratory air and in steam environment. The composite was produced via chemical vapor infiltration (CVI). The composite had an oxidation inhibited matrix, which consisted of alternating layers of silicon carbide and boron carbide and was reinforced with laminated woven Hi-Nicalon™ fibers. Fiber preforms had pyrolytic carbon fiber coating with boron carbon overlay applied. Tensile stress-strain behavior and tensile properties were evaluated at 1300°C. Tension-tension fatigue behavior was studied for fatigue stresses ranging from 70 to 160 MPa in air and in steam. The fatigue limit (based on a run-out condition of 2 x 10^5 cycles) was between 80 and 100 MPa. Presence of steam had little influence on fatigue performance. The retained properties of all specimens that achieved fatigue run-out were characterized. Composite microstructure, as well as damage and failure mechanisms were investigated.

9:10 AM

(H7-003-2016) Creep and Stressed Oxidation Testing and Modelling of Different Fiber Type and Content SiC/SiC Minicomposites

A. S. Almansour*[1]; G. N. Morscher[1]; 1. University of Akron, USA

Non-Oxide based Ceramic Matrix Composites (CMCs) are promising candidates for high-temperature applications in aerospace and nuclear industries. Therefore, the tensile creep behavior of different fiber content pristine and precracked Hi Nicalon, Hi Nicalon Type S and Tyranno ZMI reinforced minicomposites with BN interphases and Chemical vapor infiltrated Silicon Carbide matrix (CVI-SiC) were determined. Precracking stresses were determined from room temperature monotonic tensile tests with the use of Acoustic Emission (AE) monitoring. Creep tests were performed in air at 1200 C. Very low fiber volume fraction samples were tested to characterize the behavior and properties of CVI-SiC matrix. Equations for axial stress rate change and redistribution between fibers and matrix in creep were derived from single constituent creep equation. Minicomposites creep strain model was then constructed based on the derived load sharing equations. Finally, experimental and modelling results were compared to previous high temperature fiber testing data and the effects of load-sharing and matrix cracking on CMC creep behavior will be discussed.

9:30 AM

(H7-004-2016) Variability in the Stress Rupture Behavior of N720/AS

J. Pierce*[2]; L. Zawada[1]; C. P. Przybyla[1]; R. John[1]; K. Davidson[1]; 1. Air Force Research Laboratory, USA; 2. University of Dayton Research Institute, USA

A major impediment to certification of high temperature ceramic matrix composites (CMCs) for turbine engine and hypersonic applications is a lack in understanding processing-microstructure-property relationships and durability behavior under relevant service conditions. CMCs exhibit variability in behavior due to their complex microstructures and processing techniques. Specifically, these materials can have woven or laminate fiber architectures, fiber coatings, localized and distributed porosity, and other features that directly impact operant damage modes, making their behavior complicated to model. In addition, iterative and multi-step processing techniques continue to present challenges in control of processing variability. The objective of this project was to characterize variability in the stress rupture life of an oxide-oxide CMC, Nextel720/Aluminosilicate. Thirty high-temperature sustained load tests were conducted to establish the repeatability in the rupture life comparing specimens from three different material plates. The results showed significant variability, which was unexpected given the maturity of the processing route and lack of complexity for this particular CMC. Sources of variability including microstructure, test environment, and specimen geometry were explored. Findings from this and similar studies will be presented along with lessons learned for conducting variability studies in CMCs.

Environmental Effects at Elevated Temperatures

Room: Salon D

Session Chair: Craig Smith, Ohio Aerospace Institute

10:30 AM

(H7-005-2016) Thermal oxidation of SiC/BN/SiC CMCs during dry and wet oxygen exposures to explore crack-sealing

M. Wilson*[1]; E. Opila[1]; 1. University of Virginia, USA

The oxidation of Ceramic Matrix Composites (CMC) is a complex process due to the combined oxidation of ceramic fibers, matrix, and an interphase. In this work, the oxidation of CVD SiC coated SiC/BN/SiC CMCs with a single uncoated face exposing the fibers, matrix and interphase were studied. The thermal oxidation of the exposed face was characterized as a model to understand crack-sealing in CMCs during use. The sealing of the exposed face of the CMC by thermal oxidation varies with time, temperature, and environment. CMC oxidation experiments were conducted using thermogravimetric analysis for times of 1, 50, and 100 hours, at temperatures of 800, 1200, and 1300°C, in both dry (O_2) and wet (50 v% H_2O/50 v% O_2) environments. The influence of these parameters on thermal oxidation of the exposed face was explored. Scanning Electron Microscopy (SEM) and Energy-Dispersive Spectroscopy (EDS) were used to characterize the morphology and composition of the oxide products. Relative kinetics of exposed face-sealing was determined. Results were interpreted in terms of constituent oxidation and volatilization reactions in the dry and wet environments.

10:50 AM

(H7-006-2016) Strength recovery and crack-filling behaviour of alumina/ TiC self-healing ceramics

S. Yoshioka*[1]; W. Nakao[1]; 1. Yokohama National University, Japan

Extrinsic self-healing is one of the most attractive function to ensure the structural integrity of ceramic matrix composite on the use of high temperature material. The autonomous healing of surface cracks is induced by the oxidation of embedded non-oxide particles called 'healing agents'. The crack-filling resulting from the oxides formation enables to recover the tensile strength of the composite. In this paper, we report on the use of TiC particles as high temperature healing agent in alumina based composites. The capability of TiC was discussed based on a theoretical analysis of its high temperature stability, its volumetric expansion upon oxidation and the adhesion between the reaction product with Al_2O_3. Fully dense alumina/TiC composites were made by Spark Plasma Sintering. The strength recovery behaviour was determined for temperatures between 400 and 1000 °C by means of three-point bending test. The strength recovery due to crack-filling was complemented by direct observation of the crack-healed part using Focused Ion Beam (FIB/SEM) and Electron Probe Micro Analyser (EPMA). Experimental studies on the alumina/ TiC composite showed complete tensile strength recovery by annealing for 1 hour at 800 °C. The nature of the healing reactions was studied experimentally and found to be in accordance with the predicted complete filling of the indentation induced cracks via rutile formation.

Modeling Thermo/mechanical/environmental Behavior of CMCs

Room: Salon D
Session Chair: Marina Ruggles-Wrenn, Air Force Institute of Technology

1:30 PM

(H7-007-2016) Toward Understanding Microstructure-Sensitive Damage Initiation and Progression in SiC-SIC Ceramic Matrix Composites in Service Environments (Invited)

C. P. Przybyla*[1]; S. E. Bricker[3]; J. P. Simmons[1]; N. A. Engel[4]; K. N. Kollins[4]; R. Krishnamurthy[2]; T. A. Parthasarathy[2]; P. Mogilevsky[2]; M. V. Braginsky[3]; T. L. Whitlow[3]; E. L. Jones[1]; M. D. Uchic[1]; 1. Air Force Research Laboratory, USA; 2. UES, USA; 3. University of Dayton Research Institute, USA; 4. Southwest Ohio Council for Higher Education, USA

As SiC continuous fiber reinforced SiC ceramic matrix composites (CMC) near insertion into commercial turbine engine applications, much attention has shifted from processing refinement to better understanding the fundamental physics of damage initiation and progression in these materials for more accurate behavior and life prediction. Here a multi-disciplinary approach has been taken to quantify the stochastic microstructure and identify anomalous attributes hypothesized to influence damage progression, develop experimental techniques to physically characterize the fundamental structure-property relationships and develop physics based models to predict damage response in service environments. Specifically, 3D high resolution datasets were obtained via automated serial sectioning and algorithms were developed to quantify the nominal and anomalous microstructure attributes. Information rich experiments have been designed using AE and DIC to determine locations of damage initiation and progression for later high resolution micrographic inspection. Physics based environmental degradation models are developed for coupling with discrete damage models to investigate coupled enviro-mechanical damage. This work is enriching current understand of the influence of local microstructure on damage response for SiC-SiC CMCs.

2:00 PM

(H7-008-2016) Modeling Environmental Degradation of SiC-Fiber Reinforced CMCs

T. A. Parthasarathy*[2]; Q. Yang[3]; B. Cox[4]; D. B. Marshall[5]; C. P. Przybyla[1]; M. Cinibulk[1]; 1. Air Force Research Laboratory, USA; 2. UES, Inc., USA; 3. University of Miami, USA; 4. Consultant, USA; 5. Teledyne Scientific, USA

A methodology to predict the spatio-temporal evolution of fiber degradation within a composite as a function of environmental variables, fiber architecture, and mechanical loading is presented. We have explored the possibility of integrating an environmental degradation micromodel with an Augmented FEM model to accomplish this. The main focus of this presentation will be on the fiber degradation micromodel. The various mechanisms that are involved in environmental degradation of SiC fiber reinforced ceramics are catalogued and modeled. The key mechanisms that were analytically modeled include oxygen depletion from matrix crack face oxidation, recession of BN interphase from oxidation and volatilization in the presence of moist air, the oxidation of the fibers, the loss of strength from fiber oxidation, and the closure in the matrix crack opening from scale formation. The details of the models are presented along with parametric studies. Preliminary results from integration of this model with an A-FEM model will be presented.

2:20 PM

(H7-009-2016) Micromechanical modeling for fatigue hysteresis loops of fiber-reinforced ceramic-matrix composites under arbitrary loading stress levels

L. Li*[1]; 1. Nanjing University of Aeronautics and Astronautics, China

Under fatigue loading of fiber-reinforced CMCs, the fatigue hysteresis loops can reveal the composite's internal damage. The fatigue hysteresis loops of fiber-reinforced CMCs under arbitrary loading stress levels have been investigated using the micromechanical approach. Based on the fatigue damage mechanism of fiber slipping relative to matrix upon unloading and subsequent reloading and considering the difference existed in the new and original interface debonded region, the interface debonded length, unloading interface counter-slip length and reloading interface new-slip length are determined by fracture mechanics approach. The fatigue hysteresis loops models under arbitrary loading stress levels have been developed. The effects of fatigue peak stress, fiber volume fraction, matrix crack spacing, interface debonding and interface wear, and arbitrary loading stress levels on interface frictional slip and fatigue hysteresis loops have been analyzed.

2:40 PM

(H7-010-2016) Analysis of Delamination Growth in Ceramic Matrix Composites

R. S. Kumar*[1]; G. Ojard[1]; R. Kevin[2]; 1. United Technologies Research Center, USA; 2. Pratt & Whitney, USA

Delamination growth in 2D woven ceramic matrix composite materials is studied using experiments and associated numerical modeling. Double cantilever beam and end notch flexure tests were conducted on a 2D woven ceramic matrix composite to measure, respectively, mode I and mode II fracture energies. The tests revealed significant increase in load carrying capacity with the growth of crack, especially under mode I conditions, whereas, this effect was not significant under mode II loading. Cohesive-zone finite element analysis was conducted on both the test geometries to predict the corresponding load-displacement and crack-growth responses. It was found that the behavior under mode I loading can only be explained by incorporating cohesive traction-separation relationship with a long tail, which is interpreted and modeled as a superposition of two traction-separation relationships representing mechanisms associated with crack-tip and fiber-bridging in the crack-wake, respectively.

Elevated Temperature Test Techniques

Room: Salon D
Session Chair: Longbiao Li, Nanjing University of Aeronautics and Astronautics

3:20 PM

(H7-011-2016) LCF and TMF Behaviour of a Ceramic Matrix Composite

J. P. Jones*[1]; M. R. Bache[1]; M. Whittaker[1]; P. J. Doorbar[2]; P. Jones[1]; 1. Swansea University, United Kingdom; 2. Rolls-Royce plc, United Kingdom

The high temperature development of nickel base superalloys has plateaued in recent years. As a result, researchers have turned to ceramic matrix composites (CMC), capable of enduring extreme temperature and loading conditions whilst delivering substantial weight savings. The structural integrity of CMC material, when employed in a gas turbine engine, is intimately controlled by the evolution of damage through the combination of thermo-mechanical loading and environmental degradation. Simulating these representative operating conditions in the laboratory can pose significant technical challenges. An advanced facility has been developed, incorporating an innovative radiant lamp furnace with non-invasive thermography temperature control. The load controlled system is capable of delivering thermal ramp rates up to 25°C/s^{-1} whilst

accurately controlling temperature of the entire gauge section and monitoring strain through extensometery. Thermomechanical fatigue properties of a CMC material have been evaluated and compared to conventional, isothermal low cycle fatigue data generated at the extreme temperatures of the TMF cycle. A detailed assessment of the specimen was undertaken using computed tomography and scanning electron microscopy, allowing correlations between inherent processing artefacts within the composite architecture and subsequent crack initiation sites and crack growth paths to be realised.

3:40 PM

(H7-012-2016) Electrical resistance changes of melt infiltrated SiC/SiC subject to long-term tensile loading at elevated temperatures

C. Smith*[1]; G. N. Morscher[2]; 1. NASA Glenn Research Center, USA; 2. University of Akron, USA

Melt infiltrated (MI) SiC/SiC ceramic matrix composites (CMCs) are slowly replacing metals in the hot section components of turbine engines. The increasing application of these composites requires structural health monitoring techniques that are sensitive to transverse matrix cracks which form at elevated temperatures. Previous research has demonstrated a large increase in electrical resistance in response to transverse matrix cracks that formed in MI SiC/SiC during room temperature tensile loading. This study investigates the electrical resistance response of slurry cast MI SiC/SiC CMCs at elevated temperatures (815°C and 1315°C), under a wide range of applied stress. The post-test resistance of the composites at room temperature will also be discussed. Resistance data will be compared with observed matrix crack densities.

H9. Component Testing and Evaluation of Composites

Characterization of Ceramic Matrix Composites

Room: Trinity I/II

Session Chairs: Xingang Luan, Northwestern Polytechical University; Tatsuya Hinoki, Kyoto University

8:30 AM

(H9-001-2016) Monitoring Damage of MI CMCs with Stress Concentrations Utilizing Acoustic Emission and Electrical Resistance (Invited)

G. N. Morscher*[1]; R. Maxwell[1]; 1. University of Akron, USA

Ceramic matrix composites (CMCs) containing Hi-Nicalon Type S fibers, with a boron-nitride (BN) interphase in a prepreg melt-infiltrated siliconized silicon-carbide (SiC) matrix have been examined at room-temperature. Balanced, symmetric laminate composites were tested in tension for specimens with different sources of stress concentration. These included specimens with a center-hole, a single edge notch, and double edge notches. Monotonic uniaxial tensile tests, hysteretic uniaxial tensile tests and uniaxial fatigue tests were performed while being monitored with acoustic emission (AE) and electrical resistance (ER) health monitoring techniques. The mechanical, acoustic, and electrical measurements were studied to gain insight into the effect of stress concentrations on CMC systems and to better understand damage accumulation in these architectures. The relationships between the health monitoring techniques and the sources of damage will be discussed.

9:00 AM

(H9-002-2016) Mechanical behavior of a wound all-oxide ceramic matrix composite

S. Hackemann*[1]; 1. DLR - German Aerospace Center, Germany

The winding technique of the investigated all-oxide CMC enables variable fiber architecture, but makes the experimental investigations of the mechanical behavior and modeling of the material rather complex. The transformation of elastic constants from unidirectional material to wound material with deviating fiber orientations cannot be performed straightforward, as the influences of shrinking cracks and the cross-over lines from the winding process have to be taken into account. Unidirectional material was tested to determine the failure envelope of the lamina and to discuss appropriate failure criteria with focus on failure mode concept-based or physically based criteria. The choice of these criteria enables the determination of fiber dominated failure and matrix dominated failure but causes comparably high numerical effort. The cross-over lines and their vicinity revealed exceptional high strains at the failure in comparison to the layer-like material sections. Optical deformation measurements during mechanical testing were conducted on laminates with stacked cross-over lines, since the cross-over lines turned out to be a main source of failure when fiber bundle dominated failure occurs. The experimental results are the basis for the modification of the model. Apart from the first material law, which was derived from unidirectional material data, a second material law is introduced for the cross-over lines.

9:20 AM

(H9-003-2016) In-situ SEM Investigation of Microstructural Damage Evolution in a Melt Infiltrated SiC/SiC Composite

K. M. Sevener*[2]; J. Tracy[3]; Z. Chen[2]; S. Daly[2]; J. D. Kiser[1]; 1. NASA Glenn Research Center, USA; 2. University of Michigan, USA; 3. Stanford University, USA

Many efforts within the CMC community are focused on modeling the mechanical and environmental degradation of CMCs. Direct observations of damage evolution are needed to support these modeling efforts and provide quantitative measures of damage parameters used in the various models. This study was performed to characterize the damage evolution during tensile loading of a melt infiltrated (MI) silicon carbide reinforced silicon carbide (SiC/SiC) composite. A SiC/SiC tensile coupon was loaded in a tensile fixture within an SEM while observations were made at prescribed stress increments. Both traditional image analysis and DIC (digital image correlation) were used to quantify damage evolution. With the DIC analysis, microscale damage was observed at the fiber/matrix interfaces at stresses as low as 5 ksi. First matrix cracking took place between 20 and 25 ksi, accompanied by an observable relaxation in strain near matrix cracks. Matrix crack opening measurements at the maximum load ranged from 200 nm to 1.5 mm. Crack opening along the fiber/matrix interface was also characterized as a function of load and angular position relative to the loading axis. This characterization was performed to support NASA GRC modeling of SiC/SiC environmental degradation.

9:40 AM

(H9-004-2016) Damage Evolution and Fracture in SiC_f/SiC Specimens

C. D. Newton*[1]; Z. Quiney[1]; M. R. Bache[1]; A. L. Chamberlain[2]; 1. Swansea University, United Kingdom; 2. Rolls-Royce Corporation, USA

Previous mechanical assessments of CMC's have concentrated on standard bulk material properties and from such studies the SiC_f/SiC system has shown the most promise. However, before such materials can be selected for engineering service, more sophisticated mechanical characterisation is vital in support of a "damage tolerant"design. SiC_f/SiC processing introduces porosity between the individual reinforcing fibres and between woven fibre bundles. Subsequent mechanical loading (static or cyclic) may initiate cracking from these stress concentrations in addition to fibre/matrix decohesion and delamination. The localised coalescence of such damage ultimately leads to rapid failure. During our ongoing research, proven techniques for the monitoring of damage in structural metallics, i.e. optical microscopy, potential drop systems and digital image correlation (DIC), have been adapted for the characterisation of CMC's tested at room temperature. As processed SiC_f/

SiC materials were subjected to detailed computed tomography (CT) inspections prior to specimen extraction and subsequent static and cyclic mechanical testing. DIC strain measurements were performed to identify the earliest stages of damage initiation followed by interruptions to loading and further CT inspection to identify evolving damage forms and locations. The potential employment of DIC and associated monitoring techniques at elevated temperatures will be discussed.

10:20 AM

(H9-005-2016) Damage analysis in 3D woven SiC/SiC ceramic matrix composites

B. Legin*[1]; Z. Aboura[1]; J. Marteau[1]; F. Bouillon[2]; 1. University of Technology of Compiègne, France; 2. Safran Herakles, France

The aim of this study is to investigate the damage process in a SiC/SiC composite with a 3D woven reinforcement under tensile loading. 3D woven structures exhibit more complex and specific damage process than the typical catastrophic failure behaviour of laminated structures. Furthermore, ceramic matrix composites are characterized by brittle components involving relatively low strain to failure. Consequently, investigating 3D woven CMC requires special techniques. An experimental procedure is implemented to accurately study damage phenomena. Material testing is instrumented with digital image correlation (DIC), acoustic emission and microscopic observation. These specialized techniques are coupled to identify areas where damage initiates and then to monitor damage progress. Experimental data show progressive damage in 3D SiC/SiC composites. DIC captures shear strain concentration. In order to further understanding of this non classic strain field under tensile test, experiments are completed by voxel-based FE modelling which implements real paths of weaving and specificity of material. Bridge between experiments and modelling highlights weaving dependency on damage initiation and then on damage progress. All various techniques used in this study lead to a proposal for a damage scenario from initiation to failure which is an indispensable step to develop damage model.

10:40 AM

(H9-006-2016) Asymmetric Four Point Bending Test Method for Interlaminar Shear Strength in Ceramic Matrix Composites

S. C. Zunjarrao*[1]; D. Patro[1]; M. Kashfuddoja[1]; P. Jadhav[1]; S. Nagarajan[1]; K. Sriram[1]; S. Subramanian[1]; B. Zhou[2]; D. Carper[2]; 1. GE Global Research, India; 2. GE Aviation, USA

A new test method for measurement of interlaminar shear strength in continuous fiber reinforced ceramic composites is proposed. The current standard ASTM test method (ASTM C1425) for interlaminar shear strength for such composites uses a double edge notched (DEN) compression coupon. Large variation in measured strength was observed with the standard ASTM test method, possibly due to machining variability and damage at the notches. The proposed test method for ILSS is an asymmetric four point bending test method (AFPB) adapted from ASTM C1469 Standard Test Method for Shear Strength of Joints of Advanced Ceramics. This test method does not require any machining of notches and the sample size requirement is much smaller than the ASTM test method. The shear loading in this method is similar to the standard short beam shear test (ASTM D2344) with higher shear to tensile ratio compared to SBS with AFBP. Using finite element analysis, coupon geometry and the distance between the loading and support pins was optimized to maximize shear and minimize tensile and compressive stresses on the specimen. It was found that the variability in the measured ILSS strength was lower with this method compared to the ASTM standard method using the DEN compression specimen. The value of ILSS measured using AFPB method was found to be consistently higher than that measured using DEN coupons.

11:00 AM

(H9-007-2016) The Wedge-Loaded Double Cantilever Beam Test: A Friction Based Method for Measuring Interlaminar Fracture Properties in Ceramic Matrix Composites

R. Mansour*[1]; M. Kannan[1]; G. N. Morscher[1]; F. Abdi[2]; C. Godines[2]; S. DorMohammadi[2]; 1. University of Akron, USA; 2. AlphaSTAR Corporation, USA

Interlaminar fracture properties play an important role in predicting failure for fiber-reinforced ceramic matrix composites. Elevated temperature induces more severe conditions for interlaminar properties, resulting in a weaker interlaminar toughness. One of the main challenges in evaluating interlaminar fracture toughness at room and high temperature is the development of an experimental setup that provides ease for testing and allows for in-situ monitoring of the crack growth. Hence, a wedge-loaded double cantilever beam method is introduced as a potential technique for measuring Mode I interlaminar fracture energy. In this work, the effect of friction on the wedge-loaded double cantilever beam method is being investigated, using wedges made from different materials. It has been found, however, that the load required to initiate and propagate an interlaminar crack is independent of the wedge material, as long as the appropriate coefficient of friction is taken into consideration. Preliminary estimates of Mode I energy release rate at room and high temperature were also provided.

CMC Properties under Severe Conditions

Room: Trinity I/II

Session Chairs: Hagen Klemm, FhG IKTS Dresden; Christian Wilhelmi, Airbus Group Innovations

1:30 PM

(H9-008-2016) Long duration testing of cooled CMC micro combustion chambers by using the ERBURIG^{K} test facility in the European Program ATLLAS2 (Invited)

C. Wilhelmi*[1]; K. Bubenheim[1]; M. Bouchez[2]; S. Schmidt-Wimmer[3]; S. Beyer[3]; R. Behr[3]; J. Goergen[3]; 1. Airbus Group Innovations, Germany; 2. MBDA, France; 3. Airbus Defence and Space, Germany

Hypersonic airliner would be exposed to temperatures that are beyond the limits of classical aircraft materials. In order to handle this challenge the latest developments of new materials and composite structures suitable for high temperature application need to be taken into account. Different materials such as CMC materials and different cooling techniques can fulfill these demands. This scope led to the European research program ATLLAS2 with focus on advanced light-weight high-temperature material development strongly linked to high-speed passenger aircraft. In this context, the aim of the particular work presented here was a long duration (several hours instead of minutes) investigation of cooled CARBOTEX-SI® composite structures (Rapid-CVI based 3D C/C composite coated with SiC) in PTAH-SOCAR technology on micro combustion chamber scale in relevant environment. The manufacture and long duration testing of GN2-cooled CMC micro combustion chambers using the ERBURIG^{K} (Environmental Relevant Burner Rig–Kerosene) test facility are presented. The results of the long duration testing (several hours were obtained without failure) of such cooled CMC structures at small scale but in strong oxidative environment is given in the present paper. The study concludes with post-test material analysis on the tested parts, in particular on the inner hot gas wall.

2:00 PM

(H9-009-2016) Improved method for assessing erosion of ceramic materials under high speed water vapor jet

O. Sudre*[1]; M. Calabrese[1]; Y. Chen[1]; D. B. Marshall[1]; S. Lucato[1]; A. L. Chamberlain[2]; 1. Teledyne Scientific Company, USA; 2. Rolls-Royce, USA

A simple method is described for investigating the effect of water vapor environment on ceramics and composites under high speed flow conditions. The test conditions are relevant to those experienced in gas turbine engines. A water vapor jet is formed by feeding water at a controlled rate into a capillary inside a tube furnace, where the large expansion of vaporization within the confines of the capillary accelerates the jet. With modest flow rates of liquid water, steam jets with temperatures up to 1400°C and velocities in the range 100–300 m/s have been achieved. Although significant erosion rates can be measured, the quantitative analysis is impeded by the limited size of the interaction region. Several approaches are being developed to improve the technique through modeling and by increasing the interaction zone while keeping the technique at a benchtop scale. The approach is demonstrated on matrix, coatings and composite materials provided by Rolls-Royce Corporation.

2:20 PM

(H9-010-2016) Effect of curvature on foreign object damage of SiC/SiC composites

M. J. Presby*[1]; R. Mansour[1]; M. Kannan[1]; G. N. Morscher[1]; F. Abdi[2]; C. Godines[2]; S. R. Choi[3]; 1. University of Akron, USA; 2. Alpha Star Corporation, USA; 3. NAVAIR, USA

As ceramic matrix composites (CMCs) are implemented in aerospace engines, a major concern arises over the damage caused by foreign object impact. Due to the brittle nature of ceramics, they are vulnerable to localized surface damage and crack nucleation and propagation arising from foreign object damage (FOD). Therefore, it is critical to study and understand the effect of localized surface damage on the life of the material due to FOD. In this work, several c-coupons and straight specimens of liquid silicon infiltrated, fiber reinforced SiC/SiC composites were each impacted by a steel ball projectile at ~340 m/s at room temperature and pressure. The damage morphology of the impacted surfaces was determined using non-destructive evaluation (NDE) techniques. The change in electrical resistance, pre- and post-impact, was compared to the damage volume quantified by optical images and micro-CT scanning, and to the energy absorbed by the samples. It was found that the damage mechanism differs significantly depending on curvature and thickness, where the presence of curvature improves the ability of the material to absorb and dissipate impact energy.

2:40 PM

(H9-011-2016) Mechanical properties and thermal stability of TiC/Ni (TiC. 60 Vol. %) composites by liquid infiltration

M. Braulio*[1]; C. A. Leon Patiño[1]; E. A. Aguilar[1]; 1. Universidad Michocana de San Nicolas de Hidalgo, Mexico

The composite TiC/Ni is an attractive and novel material, its excellent physical and chemical properties, good wear and corrosion resistance and good performance even at high temperature, make it an attractive material for structural design and mechanical systems. The composite TiC/Ni was fabricated by liquid infiltration of electrolyte nickel in a porous ceramic preform. The composite obtained was characterized through scanning electron microscopy and X-ray diffraction. SEM examination showed a homogeneously distribution of the reinforcing phases and perfect bonding to the metal matrix. X-ray diffraction analysis showed a material free of reaction products however, a thermodynamic study performed with FactSage 7.0 software indicated the possibility to form a small amount of a Ni-Ti solid solution and graphite precipitates. Results of the mechanical characterization indicate average values of elastic modulus of 384 GPa and hardness of 786 HV. The composite has a coefficient of thermal expansion (CTE) of $9.58X10^{-6}$ $°C^{-1}$. Flexural strength test the TiC-Ni by three point showed that the strength was 1161 MPa. The oxidation behavior of TiC particle reinforced nickel matrix composites was studied in air for up to 24 hours in a temperature range 900-1000°C. The oxide layer of long-term oxidation behavior was examined by scanning electron microscopy and X-ray diffraction.

3:20 PM

(H9-012-2016) Hot gas stability of various ceramic matrix composites (Invited)

H. Klemm*[1]; T. Wamser[3]; W. Kunz[1]; A. Rüdinger[4]; R. Weiss[5]; A. Lauer[5]; C. Wilhelmi[6]; S. Hofmann[7]; D. Koch[2]; T. Machry[6]; 1. FhG IKTS Dresden, Germany; 2. Institute of Structures and Design, Germany; 3. Uni Bayreuth, Germany; 4. FhG ISC Würzbirg, Germany; 5. Schunk Kohlenstofftechnik GmbH, Germany; 6. Airbus Group Innovations, Germany; 7. DLR - German Aerospace Center, Germany

In the framework of various scientific activities of the "Ceramic Composites e.V.", several companies and institutes in Germany collaborate in the development of ceramic matrix (CMC) for high-temperature applications. In a special test program, the hot gas stability of various oxide and non-oxide CMC with and without surface coating fabricated in different institutions of the CC e.V. was investigated in the hot gas test equipment of IKTS Dresden. The test conditions varied at temperatures from 1250 to 1400 °C, gas speed of 100 m/s and water vapor pressure between 0,2 and 0,25 bar. After testing, the microstructure of surface and bulk material was analyzed. The hot gas corrosion of the materials was found to be in the range of comparable materials reported in literature. Various oxide materials fabricated with matrices with high hot gas resistance exhibited a superior hot gas stability. Information about the influence of the hot gas atmosphere to the mechanical behavior was obtained by comparison of the failure behavior in tension strength tests on samples prior and after the hot gas test. Embrittlement of the CMC caused by grain coarsening of the ceramic fibers was observed with increasing test temperature.

3:50 PM

(H9-013-2016) Thermomechanical Evaluation of Hybrid Composite for High Temperature Applications

M. Y. Chen*[1]; R. A. Brockman[2]; T. J. Whitney[2]; G. P. Tandon[2]; C. Tseng[3]; R. Ko[2]; 1. Air Force Research Lab, USA; 2. University of Dayton Research Institute, USA; 3. UES, Inc., USA

Structurally Integrated Thermal Protection Systems (SITPS) hold the promise of reduced aerospace vehicle weight by eliminating conventional "parasitic" heat-shields. Replacing the traditional TPS, load-bearing high temperature-capable materials are used to construct a graded structure that transitions from ceramic- to polymer matrix composite. Novel SITPS configurations are investigated with capability of withstanding 2000°F "hot-side" surface temperature for 30 minutes, while maintaining a "cool-side" surface temperature below 550°F. This presentation will discuss the design, analysis, thermal exposure testing, and NDE analysis of prototype TPS panels. The primary focus of the presentation is a series of 6" x 6" "scale-up" samples of representative SITPS cross-sections, developed to screen material choices (including several foam materials and stiffeners), validate analytical models, and refine fabrication techniques. Material property data are essential input for modeling analysis. In this effort, thermal properties obtained from laser based tests and modulus obtained from novel NDE technique coupled with experimental validation will be presented. Design drivers, analysis results, comparison of experimental and analytical temperature data, and structural observations will be discussed.

4:10 PM

(H9-014-2016) Fracture and Hydrothermal Corrosion Behavior of Silicon Carbide and Its Composite

D. Kim*[1]; H. Lee[1]; J. Park[1]; W. Kim[1]; 1. Korea Atomic Energy Research Institute, Republic of Korea

As nuclear energy systems require better safety, reliability, sustainability, and economics, and structural materials expose to severe environments such as higher temperature, higher neutron dose and extremely corrosive environment. After the Fukushima nuclear accident, there is an effort to replace the current fuel cladding material by accident-tolerant materials to improve safety. Silicon carbide, SiC, is one of the accident-tolerant fuel cladding materials due to its superior performance under design-basis and severe-accident conditions. A multi-layered SiC composite design concept consists of monolith SiC and SiC_f/SiC composite to provide hermeticity and structural integrity, respectively. However, a use in LWR core materials is limited by its brittle property and corrosion problems under normal operating conditions. Therefore, in this study, fracture behavior of constituent layers and statistical mechanical properties of the multi-layered SiC composite was evaluated. Also, corrosion behavior was investigated under normal operating conditions of a pressurized light water reactor.

4:30 PM

(H9-015-2016) Compact, Lightweight, Ceramic Matrix Composite Based Acoustic Liners for Reducing Subsonic Jet Aircraft Engine Noise

J. D. Kiser*[1]; C. J. Miller[1]; L. S. Hultgren[1]; J. E. Grady[1]; M. G. Jones[2]; 1. NASA Glenn Research Center, USA; 2. NASA Langley Research Center, USA

Recent developments have reduced fan and jet noise contributions to overall subsonic aircraft jet-engine noise. Now, aircraft designers are turning their attention toward reducing engine core noise. The NASA Glenn Research Center and NASA Langley Research Center have teamed to investigate the development of a compact, lightweight acoustic liner based on oxide/oxide ceramic matrix composite (CMC) materials. The NASA team has built upon an existing oxide/oxide CMC sandwich structure concept that provides mono-tonal noise reduction. Oxide/oxide composites have good high temperature strength and oxidation resistance, which could allow them to perform as core liners at temperatures up to 1000°C (1832°F), and even higher depending on the selection of the composite constituents. NASA has initiated the evaluation of CMC-based liners that use cells of different lengths (variable-depth channels) or effective lengths to achieve broadband noise reduction. Reducing the overall liner thickness is also a major goal, to minimize the volume occupied by the liner. As a first step toward demonstrating the feasibility of our concepts, an oxide/oxide CMC acoustic testing article with different channel lengths was tested. Our approach, summary of test results, current status, and goals for the future are reported.

4:50 PM

(H9-016-2016) Effect of Interphase on the high-temperature mechanical properties of single tow SiC mini-composite

K. Kawanishi*[1]; S. Muto[1]; T. Nakamura[1]; 1. IHI Corporation, Japan

Mechanical properties of single tow mini-composite infiltrated by SiC matrix is mainly effected by the type and property of interphase. The main type of interphase is carbon and BN(Boron Nitride).High temperature tensile tests of mini-composite of each type interphase are performed in order to determine the influence to the tensile properties.Also, the fractography of mini-composite after the test is performed in order to determine the mechanism of the fracture.The effect of interphase may be more noticeable in the time-dependent properties like fatigue or creep rupture tests than monotonic loading test like tensile.The fatigue and creep rupture tests are performed in high temperature.Finally, the SiC matrix could affect the mechanical properties of mini-composites.The SiC matrix is infiltrated by CVI. The several conditions of SiC matrix thickness or volume of each mini-composite are tested in order to determine the dependence of SiC matrix properties on the mechanical behavior.

Friday, July 1, 2016

G3: Novel, Green, and Strategic Processing and Manufacturing Technologies

Novel, Green, and Strategic Processing III

Room: York B

Session Chairs: Tohru Suzuki, National Institute for Materials Science; Junichi Tatami, Yokohama National University

8:30 AM

(G3-017-2016) Paper-Derived Ceramics (Invited)

N. Travitzky*[1]; P. Greil[1]; 1. University of Erlangen-Nuremberg, Germany

Preceramic papers which offer excellent shaping properties were proposed over 10 years ago as feedstock material for the fabrication of lightweight ceramic products, generally denoted as paper-derived ceramics. In this talk, the formation, microstructure and properties of preceramic papers and their conversion into bio-templated ceramic materials will be presented. Oxide as well nonoxide ceramics were processed into single sheet, corrugated structures, multilayer and complex-shaped ceramics. A high filler loading and uniform distribution of ceramic fillers could be achieved by optimized control of paper formation mechanisms. Sintering of oxide loaded preceramic paper in air resulted in porous products with the porosity shape and distribution templated by the pulp fiber used in paper making. In the case of non-oxide loaded paper, dense composite materials were obtained by reactive infiltration. Due to the versatility of compositions and the flexibility in shaping and stacking (including laminated object manufacturing - LOM), the preceramic paper technology offers an economical approach to process lightweight ceramics with tailored microstructures and properties for a broad field of applications.

9:00 AM

(G3-018-2016) Stereolithographic Additive Manufacturing of Functional Ceramic Components (Invited)

S. Kirihara*[1]; 1. Osaka University, Japan

In stereolithographic additive manufacturing, two dimensional (2D) cross sectional patterns were created through photo polymerization by ultra violet laser drawing on spread resin paste including ceramic nanoparticles, and three dimensional (3D) composite models were sterically printed by layer lamination though chemical bonding. An automatic collimeter was equipped with the laser scanner to adjust beam diameter. Fine or coarse beams could realize high resolution or wide area drawings, respectively. As row material of the 3D printing, nanometer sized ceramic particles were dispersed in to photo sensitive liquid resins from 40 to 60 % in volume fraction. The resin paste was spread on a glass substrate at 10μm in layer thickness by a mechanically moved knife edge. An ultraviolet laser beam of 355 nm in wavelength was adjusted from 10 to 300 μm in variable diameter and scanned on the pasted resin surface. Irradiation power was changed automatically from 10 to 200 mW for enough solidification depth for 2D layer bonding. The created 3D composite precursor was dewaxed and sintered in an air atmosphere to obtain full ceramic components. Through the computer aided design, manufacturing and evaluation, porous electrode of yttria stabilized zirconia for solid oxide fuel cell, alumina photonic crystals to control electromagnetic waves and artificial bones of calcium phosphate scaffolds were created successfully.

9:30 AM

(G3-019-2016) Development of Novel Microstructures and Improvement of Materials Properties through Reactive Processes in Advanced Non-Oxide Ceramics (Invited)

G. Zhang*[1]; 1. Donghua University, China

Reactive synthesis is an important approach to produce non-oxide ceramics with novel microstructures and properties. In this presentation, recent developments of employing reactive synthesis to produce typical boride and carbide based ceramics will be summarized. Reactive hot pressing of Zr, Si, Mo and B was used to produce platelet reinforced ZrB_2-$MoSi_2$ ceramics, and textured materials were obtained by hot forging subsequently. The obtained materials demonstrated obviously improved mechanical properties and oxidation resistance. A superhard B_4C-ZrB_2 ceramics has been prepared by a so-called "carbide boronizing" approach. This method utilized a conversion reaction between boride and carbide. Reactive spark plasma sintering was applied to prepare dense and fine-grained ZrC and HfC ceramics using ZrO_2 or HfO_2 and C as starting materials. This technique can effectively avoid the fast grain growth of carbide ceramics at the final stage of the sintering process. Different kind of ZrC based ceramic composites including nano-sized ZrC1-x-SiC and ZrC1-x-Zr3Al3C5 composites were reactively hot pressed by the addition of silicon or aluminum to ZrC. The reaction mechanisms and microstructure evolution processes will be discussed.

10:20 AM

(G3-020-2016) Processing of Re:YAG transparent ceramics from synthesized nanopowder

X. Chen*[1]; T. Lu[2]; Y. Wu[1]; J. Qi[2]; 1. Alfred University, USA; 2. Sichuan University, China

Transparent YAG ceramics have become an attractive alternative for high-power and high efficiency solid-state lasers. Due to the sophisticated fabrication techniques and equipment currently employed to fabricate transparent ceramics, in addition to the fact that many of the basic scientific issues surrounding transparent ceramics are not yet well understood, there are still some problems to be solved in the fabrication, characterization, and application of this class of materials. We have systematically investigated various aspects surrounding the synthesis of nanopowders, including the parameters of the calcination, granulation and sintering processes, as well as the effects of powder morphology. We have addressed some of the key scientific problems in the transparent ceramic field, and have generated a number of innovative research results. Re:YAG samples with high in-line transparency were fabricated from synthesized YAG nanopowder. Pure, well-dispersed YAG nanopowders were employed to synthesize using an alcohol-water co-precipitation method. The nanopowder was then consolidated into a bulk Yb:YAG ceramic through vacuum sintering.

10:40 AM

(G3-021-2016) Recent Developments in the Design of MAX-Polymer (MAXPOL) Multifunctional Composites

S. Ghosh[1]; R. Dunnigan[1]; F. AlAnazi[1]; S. Gupta*[1]; 1. University of North Dakota, USA

$M_{n+1}AX_n$ (MAX) phases (over 60+ phases) are thermodynamically stable nanolaminates displaying unusual, and sometimes unique, properties. These phases possess a $M_{n+1}AX_n$ chemistry, where n is 1, 2, or 3, M is an early transition metal element, A is an A-group element, and X is C or N. The MAX phases are highly damage tolerant, thermal shock resistant, readily machinable, and with Vickers hardness values of 2–8 GPa, are anomalously soft for transition metal carbides and nitrides. In this paper, we report the synthesis and characterization of novel MAX-Polymer composites. It is expected that these novel composites can be used for multifunctional applications.

11:00 AM

(G3-022-2016) Advanced processing of optical ceramic materials (Invited)

Y. Wu*[1]; 1. Alfred University, USA

Typical methods for fabricating transparent ceramics include both dry and wet forming techniques. Gel-casting is a near-net shape ceramic forming process for both simple and complex part geometries which employs a high volume fraction of organic materials for the purposes of dispersion and gelling. Conventional casting processes have some disadvantages associated with toxicity issues, rigid processing conditions, and the problems associated with a high concentration of organic additives. In this work, a new system was studied to investigate a green, more robust process for fabricating transparent optical ceramics. The process is very convenient, nontoxic, and low-cost, and can be conducted at room temperature in air with a comparatively small volume fraction of organic additives.

11:20 AM

(G3-023-2016) Macro-porous ceramics: Freezing process and properties

M. Fukushima*[1]; H. Hyuga[1]; C. Matsunaga[1]; Y. Yoshizawa[1]; 1. National Institute of Advanced Industrial Science and Technology (AIST), Japan

The macroporous ceramics through freezing route will be shown in terms of an advanced methodology. This method can produce micrometer-sized pore channel in honeycomb shape, and with various orientations. Three main technological features have been discussed: (1) unique microstructures comprised of honeycomb shape with various orientations; (2) relationship between strategically modulated freezing parameters and cellular properties; (3) the engineering applications such as strength, thermal conductivity, electrochemical responses, air permeability and piezoelectric properties. This method has several advantages of very high porosities up to 98%, controllable cell size in the range of micrometer and various cell configurations from 1D to 2D orientation, which was depending on the process parameters such as an initial solid loading of slurry and sintering temperature as well as freezing conditions. The method proposed is very simple, ecofriendly, and versatile approach that can tailor pore configurations with engineered porosity and yield near-net shaped cellular components with distinctive characteristics suitable for a variety of industrial applications.

G5. Advanced Materials, Technologies, and Devices for Electro-optical and Medical Applications

Ferro/Piezo II

Room: Trinity V
Session Chair: Yoshihiko Imanaka, Fujitsu Laboratories Ltd.

8:30 AM

(G5-040-2016) Material Design in Piezoelectric Ceramics Including Lead-Free by Elastic Constants (Invited)

T. Ogawa*[1]; 1. Shizuoka Institute of Science and Technology, Japan

R & D on piezoelectric ceramics including lead-free was mentioned from viewpoints of relationships between piezoelectricity and elastic constants such as Young's modulus (Y) and Poisson's ratio (σ). Recently, we had developed a method to measure sound velocities for disk samples (10-15$^{\phi}$×1.0-1.5^{T} mm) by an ultrasonic precision thickness gauge (Olympus Model 35DL) with high-frequency (30 MHz and 20 MHz) pulse generation. The relationships between a planar coupling factor of disk (k_p) vs. changes in longitudinal (V_L) and transverse wave velocities (V_S) [$\Delta V_L/\Delta V_S$], and changes in rigidity (G) and bulk modulus (K) [$\Delta G/\Delta K$] before and after DC poling in soft and hard PZT, $PbTiO_3$, alkali niobate and alkali bismuth titanate were investigated. The k_p increased with increasing $+\Delta V_L$ and $+\Delta K$. There were thresholds regarding k_p vs. ΔV_S and ΔG around -5% and -10%. Larger changes in $-\Delta V_S$ and $-\Delta G$ correspond to larger changes in $-\Delta Y$. These phenomena mean that high piezoelectricity is due to the mechanical softness of the materials. It was confirmed while higher k_p values appeared at lower Y and higher σ values, the G decreases and K increases after DC poling because of domain alignment. In addition, the ceramic bulk density was focused on to improve piezoelectricity in lead-free ceramics, as a result, the candidates of lead-free ceramic compositions with high piezoelectricity were proposed.

9:00 AM

(G5-041-2016) Elastic Constants Evaluated by Sound Velocities in Relaxor Single-Crystal Plates Applying to Ultrasonic Probe for Medical Uses (Invited)

T. Ogawa*[1]; 1. Shizuoka Institute of Science and Technology, Japan

Sound velocities were measured by an ultrasonic precision thickness gauge (Olympus Model 35DL) with high-frequency (longitudinal wave: 30 MHz, transvers wave: 20 MHz) pulse generation in relaxor single-crystal plates ($20.7^L \times 4.0^W \times 0.39^T$ mm) of (100) $0.70Pb(Mg_{1/3}Nb_{2/3})TiO_3$-$0.30PbTiO_3$ (PMNT70/30) applying to an ultrasonic probe for medical uses. The directions of DC poling field and sound wave propagation are in thickness. The elastic constants in PMNT70/30 single-crystal plates were compared with the ones in PMNT70/30 ceramic disks ($20.0^{\Phi} \times 1.00^T$ mm). PMNT70/30 single-crystal plates possessed relatively small σ (Poisson's ratio) [0.0 before and 0.16 after DC poling] and K (bulk modulus) [3.7 and 7.8×10^{10} N/m^2] in comparison with the σ [0.364 before and 0.395 after DC poling] and K [10.1 and 12.1×10^{10} N/m^2] in PMNT70/30 ceramics. The decrease in domain boundaries in the single-crystal plates caused increasing Y (Young's modulus), G (rigidity), σ and K through the domain alignment by DC poling. The existence of grain boundaries in PMNT70/30 ceramics caused decreasing Y and G, and increasing σ and K. The effects of introducing domain and grain boundaries on elastic constants act like same for Y and G. It was though that domain and grain boundaries function as absorption of mechanical stress because of introducing defects accompanied with the boundaries.

9:30 AM

(G5-042-2016) Polarization Rotation and Temperature-induced Mc-C Phase Transition in PMN-PT Single Crystal near MPB (Invited)

C. Xu[1]; Q. Li*[1]; Q. Yan[1]; N. Luo[1]; Y. Zhang[1]; X. Chu[1]; 1. Tsinghua University, China

Relaxor-based (1-x)$Pb(Mg_{1/3}Nb_{2/3})O_3$-x$PbTiO_3$ (PMN-PT) ferroelectric crystal was one of the most promising smart materials, which undergoes a phase transition from rhombohedral (R) to tetragonal (T) phase with increasing of PT content. Its phase structure, which varied with temperature and biased electric field, were believed complicated. Especially in the vicinity of the R-T phase boundary, the microstructure was still unclear, viewing from the initial R/T phase coexistence theory to the discovery of monoclinic structure. It was generally accepted now that the apparent continuous-phase transitions through MPB region from rhombohedral to tetragonal are mediated by intermediate phases of monoclinic symmetry, and that the excellent electromechanical response in this region is related to these phase transitions according to the symmetry-allowed polarization rotation. Temperature dependent domain structures in as-grown PMN-0.36PT single crystal were investigated by a polarizing light microscopy (PLM). Room temperature phase was proved a M_C-type monoclinic phase by domain extinction position and micro-Raman study. Temperature-induced polarization rotation and a M_C to cubic (C) phase transition were found, consistent with the temperature dependent dielectric response. The observed M_C phase was metastable and also believed as a result of the long-range internal stress.

10:20 AM

(G5-043-2016) Electrocaloric Properties of PZT- and $BaTiO_3$ based ceramics and KTN Crystals (Invited)

H. Maiwa*[1]; 1. Shonan Institute of Technology, Japan

The electrocaloric effect (ECE) is a phenomenon in which a material shows a reversible temperature change under an applied electric field. In order to create ECE cooling devices, materials with large ECEs are required. In this study, The electrocaloric properties of $Pb(Zr,Ti)O_3$(PZT)-based and $Ba(Zr,Ti)O_3$ ceramics, $KTa_{1-x}Nb_xO_3$(KTN) and $Pb(Mg,Nb)O_3$-$PbTiO_3$ (PMN-PT) crystals were investigated by the indirect estimation and direct measurement of temperature–electric field (T–E) hysteresis loops. The measured T-E loops showed a similar shape to strain–electric field (s–E) loops. The adiabatic temperature change △T due to electrocaloric effects was estimated from the polarization change of these samples. △Ts of 0.48 and 0.66 K were estimated for the $(Pb,La)(Zr,Ti)O_3$ (PLZT)(9.1/65/35) ceramics and PMN-PT crystals under a field of 30 kV/cm, respectively. The measured temperature changes △Ts in these samples upon the release of the electric field from 30 kV/cm to zero were 0.39 and 0.36 K, respectively. KTN crystal exhibited △T of 0.42 K upon the release of the electric field from 20 kV/cm to zero. The mechanism governing ECE will be also discussed. This study is partly supported by grant from KAKENHI #26420684, GRENE(Green Network of Excellence) project from The Ministry of Education, Culture, Sports, Science and Technology, Japan.

10:50 AM

(G5-044-2016) Advanced materials development for energy application (Invited)

A. M. Gopinathan Nair*[1]; 1. Noritake Co., Ltd, Japan

Fuel cells for stationary power generation and automotive applications have the potential to significantly reduce our dependence on fossil fuels. In this presentation we will describe the development of selected advanced materials necessary for solving some of the prevailing technical issues of Proton Exchange Membrane Fuel Cells (PEM FC) and Alkaline Fuel Cells (AFC). The R&D center of Noritake Company Ltd. is actively involved in the development of component materials for FC application (PEMFC, SOFC and AFC) with advanced properties. High performance anion conducting layered double hydroxide (Mg-Al LDH) electrolyte materials and electro catalyst materials for AFC and PEM FC are being developed by the rational selection of conditions leading to morphology control of the catalyst and the substrate material. The substrate materials for catalyst play an important role in deciding the final properties such as activity and durability of the electro catalyst. Pt nanoparticles of 3-4nm were deposited on modified porous/hollow carbon spheres and also on tin oxide nano fibers. In addition to this, various types of alumina based porous ceramic substrates are also being developed for dehydration and energy related application.

11:20 AM

(G5-045-2016) Single Crystal Phosphors for High-Brightness White LEDs and LDs (Invited)

K. Shimamura*[1]; E. García Víllora[1]; S. Arjoca[1]; D. Inomata[2]; K. Iizuka[2]; 1. National Institute for Materials Science, Japan; 2. Tamura Corporation, Japan

White light-emitting diodes (WLEDs) are demanded for general lighting applications. The most economical WLED consists of a blue-LED and the yellow-phosphor Ce^{3+}:$Y_3Al_5O_{12}$ (Ce:YAG) ceramic powders. However, in applications that require high-brightness (HB), a conventional packaging possesses several drawbacks. That is why, a new concept of high-brightness white LEDs based on Ce:YAG single crystal phosphor plates (SCPPs), which can overcome the conventional temperature- and photo-degradation problems, is proposed. SCPPs demonstrated excellent thermal stability with no temperature quenching, high values of luminous efficacy and increased quantum efficiency. Two inch Ce:YAG single crystals were grown with different compositions by standard Czochralski technique. SCPPs prepared by the grown single crystals exhibited a very high internal quantum efficiency (QE_{int}) (over 95%), with an outstanding temperature stability in the temperature range 25-300ºC. In contrast with powder and ceramic phosphors, we found that the Ce^{3+} emission of Ce:YAG SCPPs practically does not depend on the Ce concentration.

G7: Advanced Functional Materials, Devices, and Systems for Environmental Conservation and Pollution Control

Advanced Functional Materials, Devices, and Systems for Environmental Conservation and Pollution Control III

Room: Trinity III
Session Chairs: Nobuhito Imanaka, Osaka University; Shinobu Fujihara, Keio University

8:40 AM

(G7-014-2016) New Design Concept of Long Wavelength-emitting LED Phosphors

K. Toda*[1]; S. Kim[1]; K. Uematsu[1]; M. Sato[1]; 1. Niigata University, Japan

Recent years, Eu^{2+} or Ce^{3+}-activated nitride phosphors have been usually used in the white LEDs as commercial phosphors. The excitation and emission band of Eu^{2+} or Ce^{3+}-activated phosphors are due to the energy transitions between the 4f ground state and 5d excited state. The short bonding length between activator and anions increases the crystal field splitting of the 5d band, which leads to decrease the energy gap between the 4f ground state and the lowest level of the 5d excited state. On the other hand, the Eu^{2+} or Ce^{3+}-activated oxide phosphors are also expected to be obtained the excitation and emission band in the longer wavelength region, if the oxide host materials have compactible site for substitution of activator ions. Therefore, we focused on oxide materials including the low coordination number site. As a result, we could successfully synthesize the novel long wavelength-emitting Eu^{2+} or Ce^{3+}-activated phosphors such as $NaMgPO_4:Eu^{2+}$ and $Sr_3Sc_4O_9:Ce^{3+}$. In this study, we present the luminescence properties of the novel oxide phosphors developed.

9:00 AM

(G7-015-2016) Multiplet Energy Map of MnO_6^{8-} Cluster with D_{3d} Symmetry for Theoretical Design of Novel Red Phosphor Materials (Invited)

K. Ogasawara*[1]; 1. Kwansei Gakuin University, Japan

Recently demand of white LED is rapidly increasing for its use in energy-saving, environmentally-friendly lighting systems. However, since standard white LED is constructed with blue LED and yellow phosphor, red phosphor is required to improve the color rendering property. Among candidates of red phosphors, Mn^{4+}-doped oxides are drawing attention as cheaper alternative for the currently used Eu-doped nitride phosphor. Although multiplet energies of transition metal ions in crystals are generally analysed based on the well-known Tanabe-Sugano diagrams, they are based on empirical parameters and they cannot associate the multiplet energy with the actual local structure. Therefore, for the theoretical search of novel red phosphors, diagrams based on the actual local structure are desired. For this purpose, we recently created the multiplet energy diagrams in terms of the bond length for CrO_6^{9-} and MnO_6^{8-} clusters with O_h symmetry based on first-principles calculations. In this work, in order to clarify the relationship between the local structure and the multiplet energy in lower symmetry environment, multiplet energy maps in terms of the bond length and the elevation angle were created based on first-principles calculations. The effects of electron correlation and covalency were also investigated quantitatively.

9:30 AM

(G7-016-2016) Functional materials and systems for prevention of soil pollution by recycled waste plasterboard (Invited)

M. Tafu*[1]; 1. National Institute of Technology, Toyama College, Japan

Plasterboard is widely used in inner wall of building and disposed after lifetime of the building. Recycle usages and/or systems of waste plasterboard are required because of lack of landfill capacity. Ground stabilization is one of the useful application of the gypsum collected from waste plasterboard. Plasterboard made from chemical gypsums from various industrial byproduct, and contain various chemicals such as fluoride. Therefore, application of the waste gypsum has serious problem of soil pollution by fluoride in the waste gypsum. We have developed novel functional materials based on calcium phosphate that stabilize fluoride in the waste gypsum, and recycling system by various industrial sites. In this presentation, we introduce our achievements concerning functional materials and recycling system of waste plasterboard.

10:20 AM

(G7-017-2016) Magnetic Functionalities of Iron Oxide-based Thin Films (Invited)

K. Tanaka*[1]; K. Fujita[1]; 1. Kyoto University, Japan

Iron and oxygen are one of the elements that are abundant on the Earth. Iron oxide-based compounds including ferrites have been practically utilized as magnetic materials such as a permanent magnet, a recording medium, a magnetic core, an optical isolator, and so forth. In the present work, we present iron oxide-based thin films which may be promising in the fields of magneto-optics in a short wavelength region as well as spintronics. The former compound is zinc ferrite with random spinel structure, in which trivalent iron ion heavily replaces zinc ion in the tetrahedral site, leading to large magnetization, high magnetic transition temperature, and large Faraday effect in the UV-visible range. The structure of the zinc ferrite thin film, from which the magnetic functionalities stem, is clarified by using the X-ray absorption spectroscopy and first-principles calculations. The other compounds, relevant to the spintronics, are solid-solutions between ilumenite and hematite. We have synthesized thin films with high quality of the solid-solutions. The resultant thin films are p-type or n-type semiconductors depending on the composition of the solid-solutions. They are also ferrimagnets with high Curie temperature. These facts suggest that the ilumenite-hematite solid-solution thin films may find spintronics applications.

10:50 AM

(G7-018-2016) Piezoelectric silicate single crystals for combustion pressure sensor applications

M. Hagiwara*[1]; T. Hoshina[2]; H. Takeda[2]; T. Tsurumi[2]; S. Fujihara[1]; 1. Keio University, Japan; 2. Tokyo Institute of Technology, Japan

Development of high-temperature sensors utilizing the direct piezoelectric effect of crystals has attracted increasing research interest. Combustion pressure sensors for automobile engines enable the optimization of timing and amount of fuel injection so as to improve the performance and efficiency of the engines. Piezoelectric crystals for combustion pressure sensor applications are required to possess superior electrical properties such as thermally-stable piezoelectric properties and high insulation resistance. Here we report calcium aluminate silicate $Ca_2Al_2SiO_7$ (CAS) single crystals as a candidate material for combustion pressure sensors. Bulk single crystals of CAS were the Czochralski method. It was found that CAS has sufficiently high electrical resistivity in a wide temperature range up to 800 °C and thermally insensitive piezoelectric properties. We also demonstrated that a pseudo-combustion pressure change of an automobile engine at 700 °C could be detected using the CAS single crystal.

11:10 AM

(G7-019-2016) Effect of Iron Doping on the Spontaneous Spinodal Phase Separation of Binary Oxide Composites and Their Semiconducting Properties

W. Jiang*[1]; T. Goto[1]; T. Sekino[1]; 1. Osaka University, Japan

It is well known that SnO_2-TiO_2 binary system exhibits complete solid solubility above 1430°C, while after sintering and appropriate annealing below 1430°C spinodal decomposition in this system takes place and results in a characteristic lamellar structure. Such a modulated structure is expected to form coherent and clean interface exhibiting strong anisotropic features between different phases. In this study, Fe^{3+} was doped to this system to control the phase separation during sintering process and electrical properties of different phases simultaneously. Through experimental work, it was demonstrated that self-organized phase separation with typical lamellar structure could be successfully obtained by the one-step sintering due to the doping of Fe^{3+} to SnO_2-TiO_2 binary system. Meanwhile, electrical resistivity decreased with the amount of Fe^{3+} doping increased and semiconductive property was shown simultaneously. The details of electrical properties such as Hall coefficient, p/n type of different phases and so on for the samples with different Fe^{3+} concentrations will be discussed in relation to the microstructural development. It was thus considered that the fabrication of new-type ceramic composite with nano-scaled hetero-structure via spontaneous phase separation and different electrical properties between different phases can be expected.

H1. Computational Modelling and Design of New Materials and Processes

Large-scale Modeling I

Room: Bay
Session Chair: Alexey Kulik, STR Group, Inc.

8:30 AM

(H1-008-2016) Different scales of oxidation modeling inside ceramic matrix composites (Invited)

F. Rebillat[1]; G. L. Vignoles*[2]; 1. University Bordeaux, France; 2. University of Bordeaux 1, France

Ceramic matrix composites (CMCs) encounter many applications in the aeronautic and aerospace fields. Matrix cracks are always present, opening paths to oxidizing gases across the full composite section up to the interphase and fibers. To improve reliability and lifetime at high temperature in an oxidizing environment, some constituents can produce enough condensed oxides to fill matrix cracks and to ensure self-healing. For example, boron compounds may be introduced in an SiC matrix to produce sealing fluid phases based on B_2O_3. To predict CMC lifetime, models are needed to give the sealing rate of a matrix crack and the amount of oxygen reaching the fibers and interphase. Due the complex architecture of CMCs, the oxidation modeling is generally addressed at different scales. A certain degree of accuracy is allowed at each scale but cannot be found in all superior scales. A broad view across these length scales is proposed, starting from the pure constituents: interphase, self-healing matrix, fibers, the latter being degraded by a synergetic effect in presence of liquid oxide and oxygen supply. Then, numerical simulation of composite evolution in an oxidizing environment may be proposed by extension of these models, introducing a more or less complex description of constituent arrangements. Interesting interpretations of volume phenomena in 1 to 3D geometries are obtained.

9:00 AM

(H1-009-2016) Simulation and Experimental Validation of Cyclic Thermal Shock Damage in Ceramic Laminated Composites

S. E. van Kempen[1]; N. Giang[1]; U. A. Özden[1]; A. Bezold[1]; C. Broeckmann[1]; R. Hammerbacher[2]; A. Roosen[2]; C. Nikasch[3]; F. Lange*[3]; 1. RWTH Aachen University, Germany; 2. Friedrich-Alexander-University Erlangen-Neurnberg, Germany; 3. Siemens A.G., Germany

Ceramic laminated composites (CLCs) offer a high thermal shock resistance since critically loaded component regions can be equipped with suitable materials. The deliberate use of weak layers for crack absorption and deflection offers particularly beneficial capabilities. In this work, a differential strain based damage model was implemented in an FE environment to predict damage in heterogeneous CLCs under the influence of cyclic thermal loads. The phenomenological model was used to simulate subcritical and macroscopic crack growth, as well as laminate failure. In the model, damage in response to thermal shock yields a reduction of a material's stiffness moduli and residual strength, both of which have been validated experimentally using impulse excitation and 4-point-bending tests. To validate the model, CLCs were subjected to cyclic thermal shock using an air shower with which single sided surface cool down rates up to 50 K/s were achieved. The simulations are in good agreement with experiments. This work forms a basis for the implementation of microstructural damage models for monolithic materials and CLCs under the influence of cyclic thermal loads.

9:20 AM

(H1-010-2016) A Simulation Approach to Predict Deformation and Stochastic Failure Behavior of Components made of an Oxide/Oxide CMC with Porous Matrix

T. Becker*[1]; C. Dresbach[1]; S. Reh[1]; 1. DLR - German Aerospace Center, Germany

CMCs show high thermal resistance combined with damage tolerance and non-brittle failure. They are suitable for mechanically loaded components under high temperatures. For dimensioning of components, the adaption of existing simulation and calculation methods for CMC materials is required. This includes the development of a failure criterion ensuring high reliability of components against fracture under consideration of the scatter in material strength. The material investigated in this work is WHIPOX, a wound oxide/oxide CMC with a defined fiber orientation and a highly porous matrix. For the prediction of the mechanical behavior a simulation approach was set up, based on commercial finite element software. It takes into account the composition of the CMC to calculate the elastic properties. The progressive fracture of the matrix phase is modeled by a load-dependent decrease of elastic constants. The composite failure probability is calculated with a stochastic failure criterion which evaluates stresses or strains from fiber and matrix. The final model shows anisotropic, non-linear and temperature-dependent behavior of deformation and failure. The results obtained from simulation demonstrate good agreement to experimental data. The simulation approach is applied on the component scale to demonstrate its applicability in industrial context.

9:40 AM

(H1-011-2016) Modeling of failure strength and strain of an all oxide ceramic composite material

Y. Shi*[1]; J. Neraj[1]; S. Hackemann[2]; S. Hofmann[1]; D. Koch[1]; 1. DLR - German Aerospace Center, Institute of Structures and Design, Germany; 2. DLR - German Aerospace Center, Institute of Materials Research, Germany

Prediction of maximum applicable loads is especially required for the newly developed Ceramic Matrix Composites (CMCs), as they show a sound potential for a variety of highly demanding applications. However, modeling of failure strength and strain of CMCs have not been investigated widely yet. The paper presents results on the definition of failure criteria with focus on an oxide CMC

WHIPOX (wound highly porous oxide ceramic matrix composite). A failure model was created by adaption and modification of an existing model, the Tsai-Wu failure criterion. Using an inverse approach based on the Classical Laminate Theory, the engineering properties of an equivalent UD-layer of WHIPOX have been calculated in earlier works, which are now used to validate the analytical failure model in this paper. The modified Tsai-Wu criterion in stress- and strain-space has been developed with consideration of different matrix microstructure. In case of the non-linear elastic behavior up to failure, an empirical modeling approach with an inelastic deformation gradient Δ is presented to allow the calculation of failures strain. The Δ value depends on the fiber orientation and is coupled with stiffness matrix of WHIPOX. A good correlation between experimental and analytically calculated results is shown. This analytical approach shows a high potential for the prediction of the failure properties of other CMCs.

Large-scale Modeling II

Room: Bay
Session Chair: Thomas Becker, DLR - German Aerospace Center

10:20 AM

(H1-012-2016) Influence of Image Processing Parameters on the Computed Elastic Properties in X-Ray μ-CT Scans of C/C Composites

M. Charron[1]; O. Caty[2]; G. Couégnat[1]; G. L. Vignoles*[2]; 1. LCTS - CNRS, France; 2. University of Bordeaux 1, France

The rapid developments of X-ray μ-CT methods give access to 3D images providing a very accurate description of the composition of materials, from which property computations can be performed. The purpose of this study is to obtain the effective elastic properties of a complex and tangled material, a 3D carbon/carbon composite with needle-stitched woven textile reinforcement. The needling process induces an intricate geometry with many random fiber orientations. The first part of this work is to present the algorithm used to extract the directions; the influence of several processing parameters is studied. The second part addresses the computation of effective thermo-elastic properties based on the orientations results. The influence of the image definition – from very coarse to very fine – on the results is discussed.

10:40 AM

(H1-013-2016) Numerical Simulation of CVI Process for Complex Shaped Preforms

A. Kulik*[2]; V. Kulik[1]; M. Ramm[2]; M. Bogdanov[2]; 1. Baltic State Technical University "VOENMEH", Russian Federation; 2. STR Group, Inc., Russian Federation

Chemical Vapour Infiltration (CVI) is one of the most promising methods for production of high-quality composite materials with ceramic matrices. The principal advantage of the CVI method is ability to produce composites without thermal, chemical, or mechanical damaging the fibres. The crucial problem of CVI process development is finding optimal reactor design and operating conditions providing high densification degree on the one hand and short process duration on the other hand. This problem is of special importance in case of fabrication of complex shaped products, where significantly nonuniform densification of the preform is expected. In recent years, numerical simulation proved to be an efficient tool assisting in development and improvement of CVI technology. In this work, simulation is used to study densification process of complex shaped preforms. We analyse details of gas mixture flow and species transport in the reaction chamber and in the porous medium of the preform, chemical deposition of the matrix material inside the pores, and evolution of structure of densified preform material. Effect of the reactor design and operating conditions on densification uniformity and the process duration is studied.

11:00 AM

(H1-014-2016) Analysis and modeling of the surface state of porous ablators for atmospheric reentry

P. Blaineau[1]; C. Levet[2]; F. Panerai[3]; A. Turchi[4]; G. L. Vignoles*[1]; 1. University of Bordeaux 1, France; 2. University Bordeaux & CEA, France; 3. University of Kentucky, USA; 4. von Karman Insitute for Fluid Dynamics, Belgium

A class of heat shields for atmospheric entry of space objects make use of insulating refractories like carbon fiber preforms consolidated by a small amount of pyrolyzed phenolic resin. These ~80% porous ablators display exceptional thermal and chemical properties. In order to improve their design, we propose a modelling approach to describe their behavior during operation. The structural details of the porous medium are acquired by X-ray Computerized MicroTomography (CMT) ; then, image-based numerical simulations allow the evaluation of heat and mass transfer properties. Simulations of ablation by an oxidizing species give acces to quantification of the reaction rates, from the knowledge of the overall recession velocity and of the depth of the affected zone. A simple analytical model is derived to interpret these results.

H4. Materials for Extreme Environments: Ultrahigh Temperature Ceramics (UHTCs) and Nano-laminated Ternary Carbides and Nitrides (MAX Phases)

Novel Characterization Methods and Lifetime Assessment; Other High Temperature Material and Properties

Room: Salon C
Session Chairs: Alexandre Allemand, CEA; Zhezhen Fu, Southern Illinois University Carbondale

8:30 AM

(H4-018-2016) Oxidation Resistant Mechanism of TiAlSiCN and TiCrSiCN Compositions made by Plasma Spark Sintering at 1200

A. Manulyk*[1]; 1. National Technical University Kyiv Polytechnical Institute, Canada

Thermal stability and oxidation resistance properties become critical factors for design of protective coatings, which are used in higher temperatures. An additional improvement of these properties in multi-component coatings could be achived by selecting of proper alloying elements, such as: Aluminium and Chromium. It is known that these elements have a positive effect on the thermal stability and oxidation resistance of titanium carbides, borides, and nitrides and improve their wear resistance properties, especially, in high temperatures.

8:50 AM

(H4-019-2016) Synthesis of high quality TiB_2 from novel carbon coated precursors method and its hot press properties

Z. Fu*[1]; R. Koc[1]; 1. Southern Illinois University Carbondale, USA

High quality TiB_2 powders were prepared by borothermal reduction from carbon coated titanium dioxide (TiO_2) precursors mixing with B_4C. Mixtures were then reacted at 1500°C for 2 hours with argon flowing at 0.1L/min. Phases, microstructures and surface areas were characterized by X-ray diffraction (XRD), transmission electron microscope (TEM) and Brunauer-Emmett-Teller (BET) surface area analyzer respectively. TiB_2 powders synthesized from carbon coated precursors featured with high purity, fine particle size, narrow size distribution, spherical shape, loose agglomeration and high surface area. Synthesized powders were then hot pressed at temperature range between 1500 and 1800°C for holding time from 0.5 hour to 1 hour. Influence of sintering temperature and time on relative densities, microstructures, and mechanical properties were evaluated and tested. Results show a temperature of 1700°C could help lead a nearly full relative density along with outstanding hardness and fracture toughness.

9:10 AM

(H4-020-2016) Synthesis by spark plasma sintering (SPS) of a composite of barium aluminosilicate ($BaAl_2Si_2O_8$) reinforced by oxide fibers

A. Allemand*[1]; Y. Le Petitcorps[2]; R. Billard[2]; 1. CEA, France; 2. LCTS - CNRS, France

The aerospace industry needs refractory and resistant to oxidation materials at high temperatures between 1200 and 1700 °C. The $BaAl_2Si_2O_8$ (BAS) partially meets its criteria. BAS is usually synthesized by conventional ceramic routes. $BaCO_3$, SiO_2 and Al_2O_3 powders are the starting precursors. The obtained BAS is in the metastable hexagonal phase. The low reactivity of the system leads to the persistence of the initial or intermediate products. Higher durations and / or temperatures may complete the reaction. However, the hexagonal metastable structure could be transformed in the monoclinic stable phase. A new innovative way, combining another aluminous precursor and the SPS synthesis technique enables to get BAS in a single step. This new synthesis will be presented in detail. SPS technique proved to be effective in reducing the processing time, reduce the level of residues and densify the material. After obtaining the BAS, it may be mixed with oxide fibers as reinforcement and compacted again with SPS to obtain a composite. A patent has been filed on this process. Initial tests also suggest that the composite can be formed in the same step as the synthesis of BAS. Tests of rapid rise to very high temperature (2200 °C/min up to 1700 °C) exhibit no craks inside the BAS sample. The crystalline structure is still hexagonal.

9:30 AM

(H4-021-2016) Wettability and interfacial interactions between TiB_2 ceramic and Ni-Al melts

I. Kaban*[1]; L. Xi[1]; R. Nowak[2]; G. Bruzda[2]; N. Sobczak[2]; J. Eckert[3]; 1. IFW Dresden, Germany; 2. Foundry Research Institute, Poland; 3. Erich Schmid Institute of Materials Science, Austria

Investigations of the high-temperature wettability and interfacial interactions in the Ni-Al/TiB_2 system are particularly interesting for the development of high-quality light-weight composites and reliable joining of the ultrahigh-temperature ceramic. In this work, the wettability of TiB_2 ceramic by Ni-Al melts is observed using the sessile drop method and applying the contact heating and capillary purification techniques. The interfacial interactions and phase-formation are studied by the X-ray diffraction and microstructural analysis of the cross-sections in the solidified Ni-Al/TiB_2 couples. TiB_2 ceramic is found to be well wetted by the liquid Al-rich alloys. No reaction product in the (near-)interfacial area is revealed by XRD or scanning electron microscopy. The ceramic/metal interface remains macroscopically smooth and planar. The Ni-Al melts of equiatomic or near-equiatomic composition instantaneously spread over ceramic surface and diffuse along the grain boundaries into TiB_2. In the case of pure Ni and Ni-rich melts, the dissolutive wetting and formation of new phases at the metal/ceramic interface as well as inside the solidified alloy drops is observed. In summary, the behavior of liquid Ni-Al alloys on TiB_2 ceramics changes from a non-reactive wetting on the Al-rich side to a dissolutive, reactive wetting on the Ni-rich side.

9:50 AM

(H4-022-2016) Tribological Behavior of TiCN Based Cermets Processed via Conventional Sintering against Cemented Carbide in sliding wear

V. Verma*[1]; 1. Indian Institute of Technology Roorkee, India

The present work investigates in designing new generation TiCN-WC-Ni/Co cermet system with or without TaC for further improvement in sliding wear resistance against cemented carbide at varying loads (5, 10 or 20 N). Powder mixtures of Ti(CN)-5WC-20Ni, Ti(CN)-5WC-20Ni-5TaC, Ti(CN)-5WC-10Ni-10Co, Ti(CN)-5WC-10Ni-10Co-5TaC compositions were sintered to high density (>97%) by conventional sintering in argon atmosphere. Hardness increased from 14 to 16 GPa and fracture toughness from 8.75 to 9.25 MPa $m^{1/2}$ with variation in cermet composition. Sintered cermets reveal Ti(CN) core and (Ti,W)(CN)/(Ti,W,Ta)(CN) rim solid solution. SEM (BSE) images of all cermets primarily reveal three major microstructural phases of core-rim-binder with distinct difference in their contrast. Addition of TaC in TiCN-WC-Ni/Co cermets led to the refined carbide size having lowest contiguity of ceramic phase. This attributed to high mechanical properties and reduced wear. The steady state coefficient of friction (COF) varied from 0.25 to 1.17 and wear rate of cermets changed from 2.21×10^{-6} to 7.34×10^{-6} mm^3/Nm. Hard debris oxides are responsible for higher COF at low load of 5 N and their compaction leads to the formation of tribolayer at high load of 20 N. Material transfer from tungsten carbide ball onto the cermet disc enhanced at high load due to increased flash temperature.

H6. Advanced Thermal and Environmental Barrier Coatings: Processing, Properties, and Applications

Advanced Thermal and Environmental Barrier Coatings

Room: Trinity IV

Session Chairs: Makoto Hasegawa, Yokohama National University; Byung-Koog Jang, National Institute for Materials Science (NIMS)

8:40 AM

(H6-019-2016) Fabrication and environmental barrier performance of the coatings with thermal energy reflection formed by aerosol deposition technique

M. Tanaka*[1]; S. Hori[2]; S. Kitaoka[1]; O. Sakurada[2]; N. Shishido[3]; S. Kamiya[3]; K. Nishioka[4]; Y. Kagawa[4]; 1. Japan Fine Ceramics Center, Japan; 2. Gifu University, Japan; 3. Nagoya Institute of Technology, Japan; 4. University of Tokyo, Japan

EBCs for SiC/SiC composites play a critical role in hot-section components such as next-generation gas-turbine engines. We have previously proposed a new concept for advanced EBCs that can effectively reflect thermal energy in addition to preventing oxidation of the underling SiC/SiC. Such thermal reflectivity can arise from the formation of periodic layered structure consisting of two kinds of oxide materials with a large difference in refractive index. The combination of Al doped $Y_2Ti_2O_7$ (AYT) and alumina is expected to be candidate for satisfying the above conditions. It is essential for the expression of both functions of thermal energy reflection and environmental barrier to form the fully dense layers without the shrinkage during sintering of the layers at high temperature. Aerosol deposition (AD) technique will be expected to form such dense layers by impacting raw particles on a substrate at room temperature. In this study, microstructure development of the layers formed by the AD method with either AYT or alumina particles was discussed from the viewpoint of compression fracture of the raw particles controlled their microstructures in addition to evaluation of the environmental barrier performance of the layers.

9:00 AM

(H6-020-2016) Effect of Heat Treatment on Aerosol Deposited Mullite Coating for EBCs

M. Hasegawa*[1]; T. Mizuno[1]; A. Iuchi[1]; 1. Yokohama National University, Japan

Environmental barrier coatings (EBCs) are necessary to protect SiC fiber reinforced SiC ceramic matrix composites which may oxidize under water vapor condition. In order to prevent the vertical cracking of EBCs, the coatings are required to be dense from the as-deposit state. Aerosol deposition (AD) method is known to fabricate a dense and uniform ceramic coating without oxidation at room temperature by impacting fine ceramics particles directly on the substrate. In this study, mullite which is one of the component materials for EBCs is deposited on several substrates such as alumina and silicon by AD method. Change of microstructure on mullite coating under heat treatment in a vacuum and heat exposure in an air is investigated. In as-deposited state, mullite coating is composed of fine crystal grains with slight tiny pores. The grains and pores on the coatings increase with increasing heat treatment time and temperature. Oxides in between coating and Si substrate are not visible in as-deposit state and heat treated state. After heat exposure in air, oxides appear. Under same heat exposure condition, the thickness of oxides seems to become thinner when the heat treatment time and temperature become longer. This indicates that the heat treatment of the mullite coatings in a vacuum is effective to protect the silicon substrate from the oxidation.

9:20 AM

(H6-021-2016) Defect formation and migration in $Y_2Ti_2O_7$ pyrochlore

T. Ogawa*[1]; A. Kuwabara[1]; C. Fisher[1]; H. Moriwake[1]; S. Kitaoka[1]; 1. Japan Fine Ceramics Center, Japan

Environmental barrier coatings (EBCs) protecting Si-based materials in the hot section of aircraft engines have been developed in order to improve fuel efficiency and decrease CO_2 emissions. To suppress the temperature increase by thermal radiation at high temperature, multilayer EBCs composed of Al_2O_3 and $Y_2Ti_2O_7$ have been designed and developed. Although oxygen permeability (diffusion) in $Y_2Ti_2O_7$ is one of the key factors affecting the oxidation resistivity of the coatings, defect creation and migration mechanisms in the material are still not well understood. In this study, we investigated point defect formation in $Y_2Ti_2O_7$ pyrochlore crystal. The defect formation energies of various types of point defects including complex defects were calculated using density functional theory. By determining the Fermi level according to the charge neutrality condition with electronic carriers, defect concentrations under different environmental conditions have been evaluated. We find that the stable defect types are oxygen vacancies and self-trapped electrons at Ti sites under reduced conditions. The obtained results are compared with the indication from the recent oxygen permeation experiments.

9:40 AM

(H6-022-2016) Vacuum Plasma Sprayed Ultra High Temperature Ceramic Coatings on Ceramic Matrix Composites

Y. Yoo*[1]; E. Byon[1]; U. Nam[1]; M. Jeon[1]; 1. Korea Institute of Materials Science, Republic of Korea

Ultra high temperature ceramics (UHTCs) are promising candidate materials for extremely high temperature applications such as re-entry aerospace shuttle or supersonic aircrafts because of their excellent mechanical properties and high melting temperatures. However, the densities of UHTCs are so high that there are difficulties to apply to aerospace applications as a monolith. Previous researches have introduced about ceramic matrix composites (CMCs) with infiltrated UHTCs for reducing the weights. UHTC infiltrated CMCs show better ablation resistance than normal CMCs when carbon fibers are not exposed. When the carbon fibers are exposed on the surface during ablation, however, rapid oxidation of carbon fibers occurs. UHTC coatings on CMC surfaces can protect carbon fibers in CMCs from the ablation, as well as reducing the weights. Present study introduces UHTC coatings deposited on CMCs by vacuum plasma spraying (VPS). From submicron to tens of microns sized UHTC powders were injected into plasma flame composed of mixture of Ar and H_2 gas. SiC with carbon fiber composites were used as substrates. Thickness and microstructure of UHTC coatings were examined by scanning electron microscopy (SEM). Crystalline structures of deposited UHTC coatings were examined by X-ray diffraction (XRD). A little amount of oxide was formed during spraying even though coatings were deposited in vacuum.

10:20 AM

(H6-023-2016) Vacuum Plasma Spray Processes for TBC Coating System Applications

R. V. Gansert*[1]; R. Herber[2]; L. Guggenheim[2]; S. Keller[2]; 1. Advanced Materials & Technology Services, Inc., USA; 2. AMT AG, Switzerland

Increasing demands on aerospace and space engine (turbine, rocket) performance has necessitated continued development in Thermal Barrier Coating (TBC) systems. These systems involve a ceramic top coating and superalloy bond coating. AMT AG and its USA partner Advanced Materials & Technology Services, Inc. design & build low pressure, vacuum plasma, and hybrid systems for producing TBC systems. Superalloy and refractory metal (niobium, tantalum) coatings are produced with less oxides and porosity, and higher density (99%) in a low pressure and vacuum as compared to ambient air pressure. Nickel-based bond coatings have shown enhanced oxidation protection and increased resistance to spallation. TBC's are produced ranging from vacuum (VPS) batch operations to- continuous low pressure plasma coating (LPCS) systems. LPCS processes may be operated at high power levels (e.g., 120 kW) using 03C plasma guns, whereas VPS processes are conducted at lower power (55 kW) with F4 plasma guns. Hybrid systems will be shown consisting of combination of these systems. Process and configuration differences between VPS, LPCS and hybrid systems will be examined. Superalloys and refractory metals will investigated between vacuum and air plasma spray (APS). TBC coatings systems will be examined between vacuum, low pressure and APS systems.

10:40 AM

(H6-024-2016) The toughening effects in the yttrium-doped lanthanum zirconate pyrochlore/fluorite solid solutions

Y. Wang*[1]; R. Liu[1]; Y. Cao[1]; P. Xiao[2]; 1. National University of Defense Technology, China; 2. University of Manchester, United Kingdom

The poor fracture toughness of cubic pyrochlores or fluorites is the largest obstacle to block their wide application as the next-generation thermal barrier coatings (TBCs). A series of yttrium dopants have been introduced to the lanthanum zirconate and their structure evolution and fracture toughness have been thoroughly investigated. With yttrium continuously introduced, the single pyrochlores gradually transform to the single fluorites, with a pyrochlore/fluorite coexisting domain as a transit region. It is found that the heavy doping of smaller guest ions, or the light doping of bigger gues ions are beneficial to the toughening of the host lattice, clarifying that the effects of dopants on fracture toughness are dependent not only on their relative size compared to their host but also on their concentration. Strikingly, the pyrochlore/fluorite double phase region exhibits dramatically increased fracture toughness, which is attributed to the greatly reduced grain sizes in this region and to the greatly extended crack propagation routes following the transgranular crack pattern. This study suggests a new strategy to overcome the brittleness of cubic pyrochlore/fluorite TBC topcoat materials and pave the way for their practical application.

11:00 AM

(H6-025-2016) Influence of topcoat-bondcoat interface on lifetime in suspension sprayed thermal barrier coatings

M. Gupta*[1]; N. Markocsan[1]; X. Li[2]; 1. University West, Sweden; 2. Siemens Industrial Turbomachinery AB, Sweden

A Thermal Barrier Coating (TBC) system is designed to protect gas turbines from high temperatures and harsh environments. Development of TBCs allowing higher combustion temperatures is of high interest since it results in higher fuel efficiency and lower emissions. It is well known that nano-structured TBCs produced by Suspension Plasma Spraying (SPS) have significantly lower thermal conductivity as compared to conventional systems due to their very fine porous microstructure. However they have not yet been commercialised due to low reliability and life expectancy of the coatings. Lifetime of a TBC system is highly dependent on topcoat-bondcoat interface topography and chemistry. To enhance functional performance, fundamental understanding of relationships between interface characteristics, microstructure formation, and functional performance is essential. The objective of this work was to study the effect of topcoat-bondcoat interface in SPS TBC systems by changing bondcoat topography and chemistry through grit blasting, shot peening and heat treatments. The effect of changing interface on topcoat microstructure was also investigated. High velocity air fuel spraying was used for bondcoat deposition while axial-SPS was used for topcoat deposition. Lifetime was examined by thermal cyclic fatigue and thermal shock testing. The failure mechanism in each case will be discussed.

11:20 AM

(H6-026-2016) Thermal barrier coatings: Effective characterization of mechanical and thermal properties

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Thermal Barrier Coatings (TBC) are advanced materials used to prevent damage on metallic parts - like blades - exposed to high temperatures in aircraft engines or gas turbines. They consist of a thermally insulating ceramic upper layer (top coat), an Al-rich metal coating (the bond coat), the superalloy substrate meant to be protected, and a thermally grown oxide (TGO) layer which is formed between the bond coat and the top coat during the operation of the engine or turbine. Thermogravimetry is used to compare the oxidation stability of different superalloy and bond coat systems. Differential Scanning Calorimetry is critical for the understanding and improving the synthesis procedure. A cause of TBC failure during thermal cycling is the thermo-mechanical stress on the top coat during the growth of the TGO layer and a stress from the sintering and shrinkage of the top coat layer. Thermomechanical analysis with a three-point bending setup was used to determine the mechanical properties of the coatings (e.g. Young's modulus). The sintering temperatures of several new candidates for a top layer coat (zirconate and cerate based materials) was measured. Selection of an appropriate thermal conductivity analysis technique is critical to obtaining meaningful and accurate thermal transport property data.

11:40 AM

(H6-027-2016) Effect of Hafnium Concentration on Microstructural and Oxidation Resistance of βNiAl Compounds

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In this study, hafnium metal as a dopant was incorporated into βNiAl model alloys by arc melting method. Unlike coating-substrate interdiffusion problems, these alloys offer nearly absence of such interdiffusion events which facilitates the study of dopant effect alone. The Hf doped alloys were oxidised at 1150°C for 50 hours in air. The main aim of this study was to understand the effect of Hf concentrations on microstructural evolution and oxidation resistance of βNiAl alloys, since βNiAl-based compounds are widely used in thermal barrier coating (TBC) applications. Results demonstrated an improved oxidation resistance of βNiAl alloys upon an appropriate Hf addition (≤ 0.5 at. %). In contrast, overdoping (of Hf) resulted in poor oxidation resistance and allowed formation of Hf and Ni rich phases. In addition, severe internal oxidation was observed in overdoped alloys.

12:00 PM

(H6-028-2016) The factors influencing solid solubility in metallic bond coat alloys of Thermal barrier coating systems

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TBC's are employed to protect hot section components in industrial and aerospace gas turbine engines. In general, a typical TBC's consist of two deposit layers, the metallic bond coat and the top coat and one that is evolved during processing and operation the thermal grown oxide. This paper presents the influences of various factors, such as dimensional factor of atoms and types of crystal lattices on formation of solid solutions. In addition for accuracy was studied the influence the electronegativity, electron structure and the Darken-Gurry method in metallic bond coats. Those factors are discussed separately and then are integrated in one method. Non-compliance with one of these conditions leads to these solid solutions between components are formed only in limited ranges of concentration or are not formed in general. The implemented studies show that main failures of coats used on TBC's are related to not fully taking the physical-chemical features of elements into consideration during the determination of the composition of alloys. Therefore, at a choice of coating structure is necessary to proceed from the principle "structure-property", to choose and substantiation methods of an assessment of properties of the coating alloys of hot section components. This method has been applied to several types of metallic alloys and good results have been obtained.

Author Index

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Author Index

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Author Index

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