



# ACTSEA2021

**7th International Symposium on Advanced Ceramics  
and Technology for Sustainable Energy Applications  
toward a Low Carbon Society**

**NOV. 15 – NOV. 17, 2021  
Virtual Conference**

**National Taipei University of Technology, Taipei, Taiwan**

**Organized by:**



**Endorsed by:**

**Materials Research Society-Taiwan (MRS-T)  
The American Ceramic Society  
The European Ceramic Society  
The Ceramic Society of Japan  
The Korean Ceramic Society  
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特殊分析 ▶▶ 圓二色光譜儀、葉綠素螢光儀、多功能酶標儀

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- 1993 在台灣證券交易所掛牌上市
- 2000 併購飛利浦被動元件事業群
- 2018 併購Pulse普思電子、Brightking君耀電子
- 2020 併購KEMET基美電子

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德國製超音波洗淨器  
箱型高溫爐  
新世代管型爐  
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搖篩篩網配件  
元素分析儀  
OES分光儀

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- 水平式、垂直式、光學式、相變儀

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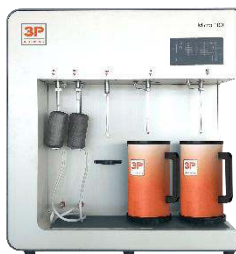
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- 表面積 (STSA)
- DR、DA、MP 方法
- HK/SF 孔徑分析；
- NLDFT 孔徑分佈；
- 平均孔徑、總孔體積；
- 吸附曲線、吸附熱計算

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Email: [info@fstintl.com.tw](mailto:info@fstintl.com.tw) 聯絡人: 郭文龍先生/0919-138-108

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# Preface

Welcome to the Seventh International Symposium on Advanced Ceramics and Technology for Sustainable Energy Applications toward a Low Carbon Society (ACTSEA 2021) held from Nov. 15-17, 2021 at the National Taipei University of Technology, Taipei, Taiwan.

Based on the success of the last 6 ACTSEA International Symposium: 1st (Ping Tung, 2007) 、 2nd (Taipei, 2009) 、 3rd (Ping Tung, 2011) 、 4th (Taipei, 2013) 、 5th (Tainan, 2015) and 6th (Kaohsiung, 2017) held for every other year since 2007 by Prof. Jow-Lay Huang (National Cheng Kung University, Taiwan), Prof. Kuan-Zong Fung (National Cheng Kung University, Taiwan), Prof. Wei-Hsing Tuan (National Taiwan University, Taiwan), Prof. Hua-Tay Lin (Guangdong University of Technology, China), Prof. Tatsuki Ohji (National Institute of Advanced Industrial Science and Technology, Japan), and Prof. Sanjay Mathur (University of Cologne, Germany). On behalf of the organizing committee of ACTSEA 2021, it is our great honor and pleasure to welcome all of your participation and contribution in this conference.



The purpose of this symposium is to provide an international scientific forum for discussion and exchange of ideas on the up-to-date R&D of advanced ceramics for sustainable energy and energy efficiency applications. The experts and scholars from industries, universities, and research laboratories will discuss recent advances, development, field applications, and future challenges for creating ceramics with unusual properties as well as bringing these ceramics to the marketplace. The presentation and discussion will focus on both basic science and technology aspects.

Since the aim and vision of ACTSEA Symposium series has been well recognized, ACTSEA 2021 is endorsed by several materials-related societies including the American Ceramic Society (ACerS), European Ceramic Society (ECerS), the Ceramic Society of Japan (CerSJ), the Korean Ceramic Society (KCerS), World Academy of Ceramics (WAC) and Taiwan Ceramic Society (TCerS).

Due to an uncertain COVID-19 situation that resulted in a very difficult travel restriction for most countries and researchers, this conference is only offering on-line participation to the event with Virtual Video Presentation. With strong support and contribution from ACTSEA 2021 participants, there are more than 115 attendees from 11 countries. The presentations include 4 keynote speeches, 25 invited talks, 18 oral talks and 71 poster presentations covering the following topics: “Alternative energies”, “Battery and energy storage”, “Energy efficiency technologies and applications”, “Fuel cells”, “High performance materials under extreme conditions”, “LED”, “Materials and technologies for low carbon,



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sustainable society”, “Nuclear”, “Photovoltaic/Solar power”, and “Thermoelectric”. We would like to express our sincere thanks to all of the speakers and attendees who have arranged to join this conference from their extremely busy schedule. We sincerely appreciate the financial supports from the Ministry of Science and Technology of Taiwan, Ministry of Education and National Taipei University of Technology. With their generous support, ACTSEA 2021 will be more successful. We hope you all enjoy the conference and good health.

Sincerely,

A handwritten signature in black ink that reads "Eric Yeh" followed by a long horizontal flourish.

Eric YEH  
ACTSEA 2021 Conference Chair  
President of TCers  
Vice President of Holy Stone

## Founders of ACTSEA



**Prof. Jow-Lay Huang**  
National Cheng Kung  
University, Tainan, Taiwan



**Prof. Kuan-Zong Fung**  
National Cheng Kung  
University, Tainan, Taiwan



**Prof. Hua-Tay Lin**  
Guangdong University of  
Technology, China



**Prof. Wei-Hsing Tuan**  
National Taiwan University,  
Taipei, Taiwan



**Prof. Tatsuki Ohji**  
National Institute of Advanced  
Industrial Science and  
Technology (AIST), Japan



**Prof. Sanjay Mathur**  
University of Cologne,  
Germany

# Organization Institutions of ACTSEA2021



**Eric YEH**

- **President of Taiwan Ceramic Society**
- **ACTSEA 2021 Conference Chair**



**Sea-Fue WANG**

- **President of NTUT, Taiwan**
- **ACTSEA 2021 Honorary Conference Chair**



**Wei-Hsing TUAN**

- **Chair of ACerS-Taiwan Chapter**
- **ACTSEA 2021 Conference Co-Chair**

# Organization Committee Members

## Organizer

Prof. Jow-Lay Huang, National Cheng Kung University, Taiwan  
Dr. Eric Yeh, Taiwan Ceramic Society  
Prof. Sea-Fue Wang, National Taipei University of Technology  
Prof. Wei-Hsing Tuan, National Taiwan University, Taiwan  
Prof. Hua-Tay Lin, Guangdong University of Technology, China  
Prof. Tatsuki Ohji, National Institute of Advanced Industrial Science and Technology (AIST), Japan  
Prof. Kuan-Zong Fung, National Cheng Kung University  
Prof. Sanjay Mathur, University of Cologne, Germany  
Prof. I-Ming Hung, Yuan Ze University

## Committee member

Prof. Chien-Te Hsieh, Yuan Ze University  
Prof. Kuen-Song Lin, Yuan Ze University  
Prof. Chien-Ming Lei, Chinese Culture University  
Prof. Yen-Yu Chen, Chinese Culture University  
Prof. Yung-Chin Yang, National Taipei University of Technology  
Prof. Yu-Chuan Wu, National Taipei University of Technology  
Prof. Te-Wei Chiu, National Taipei University of Technology  
Prof. Chuan-Ming Tseng, Ming-Chi University of Technology  
Prof. Yu-Ching Huang, Ming-Chi University of Technology  
Prof. Cheng-Ying Chen, Ming-Chi University of Technology  
Prof. Ying-Chieh Lee, National Pingtung University of Science and Technology  
Prof. Chien-Chih Chiang, Lunghwa University of Science and Technology  
Prof. Jeng-Kuei Chang, National Yang Ming Chiao Tung University  
Dr. Chun-An Lu, Industrial Technology Research Institute  
Prof. Shu-Yi Tsai, National Cheng Kung University  
Prof. Chung-Jen Tseng, National Central University  
Prof. Sheng-Wei Lee, National Central University  
Prof. Ching-Yuan Su, National Central University  
Prof. Tai-Nan Lin, Institute of Nuclear Energy Research  
Prof. Horng-Show Koo, Taipei University of Marine Technology



# Acknowledgment

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# ACTSEA 2021 Program Overview

Time	Date	Nov. 15, 2021 (Mon)	Nov. 16, 2021 (Tue)	Nov. 17, 2021 (Wed)
09:00 ~ 12:00		-Registration	-Registration	-Registration
		-ACTSEA Review	-Keynote Speech	-Keynote Speech
			-Oral Sessions	-Oral Sessions
12:00 ~ 13:30	Lunch			
13:30 ~ 17:00		-Opening	-Oral Sessions	- Oral Sessions
		-Post Sessions		-Students Award (Post)
				- Closing Ceremony

# ACTSEA 2021 Program

Nov. 15 - Nov. 17, 2021 (UTC+8)

<b>Monday</b> <b>Nov. 15, 2021</b>	➤ 09:00 – 12:00 ➤ 13:30 – 13:40 ➤ 13:40 – 17:19	Registration Opening Ceremony / ACTSEA Review Poster Session		
<b>Post</b>	<b>Room 1; Chairman: Chuan-Ming Tseng</b>			
13:40 – 17:19 (3min for each post) post ID order	<b>A_P01</b>	<b>Hairus Abdullah</b> Impressive OER Performance on Micro-Tree-Like Ni <sub>3</sub> S <sub>2</sub> in Alkaline Solution	<b>B_P11</b>	<b>Yi-Hung Wang</b> Effect of concentration on performance of ZrO <sub>2</sub> nanoparticle electrochemical in Vanadium Redox Flow Batteries
	<b>A_P02</b>	<b>Chi Yuan Lee</b> Integration of High Pressure Resistant Flexible 6-in-1 Microsensor and High Pressure Proton Exchange Membrane Water Electrolyzer	<b>B_P12</b>	<b>Debabrata Mohanty</b> Synthesis and Properties of Li <sub>2</sub> MnO <sub>3</sub> -LiMn <sub>1/3</sub> Co <sub>1/3</sub> Ni <sub>1/3</sub> O <sub>2</sub> Cathode Materials for Lithium-Ion Battery
	<b>A_P03</b>	<b>Chi Yuan Lee</b> PEMWEs MEA Anode Internal Sensing Technology Development	<b>B_P13</b>	<b>Jing-Yu Lai</b> Synthesis and Material Characteristic of Li <sub>1.3</sub> Al <sub>0.3</sub> Ti <sub>1.7</sub> (PO <sub>4</sub> ) <sub>3</sub> Solid Electrolytes for Lithium-ion Battery
	<b>A_P04</b>	<b>Jui-Teng Lee</b> Incorporation of Au@CuSCu <sub>2</sub> S nanoparticles on ZnO nanosheets for efficient photodark responsive degradation of organic pollutants	<b>B_P14</b>	<b>Jing-Yu Lai</b> Synthesis and Properties of double-layered Li <sub>2</sub> MnO <sub>3</sub> LiMn <sub>1/3</sub> Co <sub>1/3</sub> Ni <sub>1/3</sub> O <sub>2</sub> material for Lithium-Ion Battery
	<b>B_P01</b>	<b>Tai-Feng Hung</b> Polymer-derived Nitrogen-doped Carbon Materials with Hierarchically Porous Architectures toward Capacitive Performances for Lithium-ion Capacitors	<b>E_P01</b>	<b>Enzhu Lin</b> The effects of selectively and randomly deposited Ag nanoparticles on the piezocatalytic activity of BaTiO <sub>3</sub> nanocubes/cuboids
	<b>B_P02</b>	<b>Dhanapal Vasu</b> Excellent Electrochemical active CuFe <sub>2</sub> O <sub>4</sub> 3D-rGO based Supercapacitor Electrodes with an Ultrahigh Specific Capacitance	<b>E_P02</b>	<b>Tung-Wei Chang</b> Development of nano-sized Fe-based powder for Inductance
	<b>B_P03</b>	<b>Arjunan Karthi Keyan</b> High energetic supercapacitor electrode of CuCoO <sub>2</sub> -rGO nanocomposite with ultrahigh specific capacitance	<b>E_P03</b>	<b>Chang-Chun Zheng</b> Preparation of Nitrogen-doped BaTiO <sub>3</sub> Thin Films on TiNSi by Plasma Electrolytic Oxidation
	<b>B_P04</b>	<b>Zhen Chong</b> Performance of Molybdenum-Modified Titanium Oxide as anode for lithium-ion Battery	<b>E_P04</b>	<b>Heng-Jyun Lei</b> Preparation of CeO=CuCrO <sub>2</sub> composite by electrospinning method
	<b>B_P05</b>	<b>Chi Yuan Lee</b> Development of Instant Diagnostic Technology for Hydrogenvanadium Flow Battery	<b>E_P05</b>	<b>Bing-Zhen Hsu</b> Porous Structure ZnO-ZnFe <sub>2</sub> O <sub>4</sub> Catalyst Applied by Hydrogen from Methanol Steam Reforming
	<b>B_P06</b>	<b>Jen Hao Yang</b> Effect of Synthesis Routes on Nickel rich and Cobalt-free Layered Oxides Cathode for Li Ion Batteries	<b>F_P01</b>	<b>Chi Yuan Lee</b> Flexible Integrated Microsensor for In-situ Monitoring of Proton Battery
<b>B_P07</b>	<b>Xiejing Luo</b> Computational simulation and efficient evaluation on corrosion inhibitors for electrochemical etching on aluminum foil	<b>F_P02</b>	<b>Wei-Cheng Chin</b> Correlation between NiFe <sub>2</sub> O <sub>4</sub> Cathode Thickness and Hydrogen Production Efficiency for Solid Oxide Electrolyzer Cells	
<b>B_P08</b>	<b>Jia-Hong Du</b> Polarization Reduction of Surface-Modified Garnet Solid Electrolytes for Solid State Li-ion Battery Applications	<b>F_P03</b>	<b>Kuan-Lin Chen</b> Hydrogen Storage Alloy Tanks for Fuel Cell Assisted Bicycles	
<b>B_P09</b>	<b>Yu-Hsuan Su</b> Synthesis and Electrochemical Properties of Single-Crystal LiNi <sub>0.5</sub> Co <sub>0.2</sub> Mn <sub>0.3</sub> O <sub>2</sub> Cathode for Lithium-Ion Batteries	<b>F_P04</b>	<b>Yen-Yu Chen</b> Preparation of Porous Zirconia by Ceramic Photopolymerization Process	
<b>B_P10</b>	<b>Zih-Heng Hsieh</b> Characterization of spinel cathode material for advanced lithium-ion batteries	<b>F_P05</b>	<b>Jhieh-Yu Tang</b> Effect of Dual Phases on Ionic Conduction of Consisting of Doped Ceria and Carbonates	

13:40 – 17:19  
(3min for  
each post)  
post ID order

F_P06	<b>Yuan-Jie Tsai</b> A Modified Solid-State Reaction Method to Synthesize Proton-Conducting $\text{BaCe}_{0.5}\text{Zr}_{0.3}\text{Y}_{0.2}\text{O}_{3-\delta}$ Electrolyte with Improved Sinterability	F_P20	<b>Ayano Iizuka</b> Computer simulation via phase-field method to consider the effect of magnetic field on the formation process of spontaneous superlattice structure using dynamic auroral PLD
F_P07	<b>Sheng-Wei Lee</b> Nd-doped LSCF nano-fibrous cathode for proton-conducting solid oxide fuel cells	F_P21	<b>Yi-Chu Han</b> The study of 8YSZ electrolyte fabrication of the tubular solid oxide fuel cells by the dip-coating method
F_P08	<b>Chia-Chieh Shen</b> Small Fuel Cell Powered Vehicle	F_P22	<b>Yi-Le Liao</b> The Research of the Mechanism of in-situ Sintering Solid Oxide Fuel Cell
F_P09	<b>Liangdong Fan</b> Intermediate temperature solid oxide fuel cell with nanoscale electrodes fabricated by one-step sintering technology	H_P01	<b>Yi Hsiang Lai</b> Processing and performance of oxidation-resistant layers on graphite
F_P10	<b>Liangdong Fan</b> Enhancement of Oxygen Reduction Reaction activity of Cobalt Based Cathode in Solid Oxide Fuel Cell	H_P02	<b>Chien-Chih Chiang</b> Influence of Unipolar Pulsed Two-Stage Rise Voltage on Wear Resistance of Carbon Steel Surface Using MAO method
F_P11	<b>Azam Khan</b> Preparation and Characterization of $\text{YxBa}_{2-x}\text{Co}_2\text{O}_{5+\delta}$ Cathode Material for Solid Oxide Fuel Cell	H_P03	<b>Kai-Yo Huang</b> Analysis of the microstructure and dielectric properties on $\text{CaCu}_3\text{Ti}_4\text{O}_{12}$ -based dielectric ceramic materials
F_P12	<b>Ko-Yun Chao</b> Preparation and Properties of $\text{Y}_x\text{Sr}_{1-x}\text{TiO}_{3-\delta}$ anode for Solid Oxide Fuel Cells	H_P04	<b>Ming-Zhe Lu</b> High temperature stability $\text{BaTiO}_3\text{-Bi}_{0.5}\text{Na}_{0.5}\text{TiO}_3$ -based dielectric ceramics of formulation improvement and material properties analysis
F_P13	<b>Ko-Yun Chao</b> Preparation and Characterization of High Temperature Mixed Proton-electron Conductors	H_P05	<b>Gourav Mundhra</b> Use of a composition-graded solid electrolyte for determination of Gibbs energy of formation of lanthanum hafnate A prospective TBC material for turbine applications
F_P14	<b>Takeshi Kawai</b> Spontaneous formation of superlattice thin film with perovskite $\text{A}^{3+}\text{B}^{3+}\text{O}_3$ structure using dynamic aurora PLD and its effect on physical properties	H_P06	<b>Tsung-Yang Ho</b> High Performance Solid State $\text{SO}_2$ sensor using Nano-structured Oxides
F_P15	<b>Haruki Zayasu</b> Preparation and characterization of epitaxially grown YSZ thin films on porous silicon substrates for SOFC applications	H_P07	<b>Chien-Chih Chiang</b> Effects of MAO Coating on the Hardness and Corrosion Resistance of 6032 Aluminium Alloy
F_P16	<b>Kaoru Ogata</b> Spontaneous formation of superlattice thin films on substrates having heterogenous structure using dynamic aurora PLD	H_P08	<b>Bo-Cheng Lai</b> Dielectric properties of $\text{CaO-B}_2\text{O}_3\text{-SiO}_2$ glass-ceramics in the millimeter-wave range of 20–60 GHz frequency
F_P17	<b>Kazuto Yoshida</b> Low temperature synthesis of PZT thin films with giant piezoelectric displacement on glass substrate by domain engineering from molecular-designed	L_P01	<b>Mu-Tsun Tsai</b> Luminescence Investigation of Chromium-doped Forsterite Phosphor Thin Films
F_P18	<b>Ryoya Nishimura</b> The effect of starting materials on low-temperature preparation of $\text{Li}_{6.5}\text{La}_3\text{Zr}_{1.5}\text{Ta}_{0.5}\text{O}_{12}$ single crystal using the flux method	L_P02	<b>Mu-Tsun Tsai</b> Luminescence Investigation of Blue-emitting Cordierite Phosphor Thin Films
F_P19	<b>Seiji Sogen</b> Synthesis of PZT thin film with single crystal-like ferroelectricity on SUS substrate	L_P03	<b>Chien-Chih Chiang</b> Structures and Photoluminescence Properties of $(\text{Ba/Sr})_{1-x}\text{MgAl}_{10}\text{O}_{17}\text{Eu}_x/2$ Phosphors



13:40 – 17:19  
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each post)  
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M_P01	<b>Chung-Lun Yu</b> ZnO-ZnCr <sub>2</sub> O <sub>4</sub> Catalyst Fabricated by Glycine Nitrate Process and Used for Hydrogen Generation with the Steam Reforming of Methanol	P_P01	<b>Chien-Chih Chiang</b> Synthesis and Characteristic of III-VI Metal Chalcogenide semiconductor nanoparticle
M_P02	<b>Zhen-Yu Sun</b> CuCrO <sub>2</sub> -TiO <sub>2</sub> Nanocomposites Prepared by Glycine Nitrate Process and Photodegradation the Organic Dye with Ultraviolet Light	P_P02	<b>Gu-Yan Liao</b> Characteristics of La <sup>3+</sup> dopants in CeO <sub>2</sub> thin films for resistance random access memory application
M_P03	<b>Yung-Fu Wu</b> Nickel Recovery from Spent Plating Solution by Chemical Precipitation		
M_P04	<b>Yung-Fu Wu</b> Anticorrosion for 304 Stainless Steel by Using TiO <sub>2</sub> Ag <sub>2</sub> O Protection Layer		
M_P05	<b>Chin-Wei Hung</b> Fabrication of CuYO <sub>2</sub> Nanofibers by Electrospinning		
M_P06	<b>Yu-Feng You</b> Preparation of Janus Structure ZnOCuO Composite Oxide Particle		
M_P07	<b>Shu-Yi Tsai</b> Effect of adding mesoporous silica KIT-6 of V <sub>2</sub> O <sub>5</sub> WO <sub>3</sub> TiO <sub>2</sub> catalyst for selective catalytic reduction		
M_P08	<b>Qiaofeng Han</b> Synthesis of Bi <sub>4</sub> O <sub>5</sub> I <sub>2</sub> BiOI heterojunction with improved visible-light photocatalytic activity		
M_P09	<b>Min Ao</b> The effect of La <sub>2</sub> O <sub>3</sub> addition on intermetallic-free aluminium matrix composites reinforced with TiC and Al <sub>2</sub> O <sub>3</sub> ceramic particles		
M_P10	<b>Ying-Chieh Lee</b> A Study of Low-Temperature Sintering of Al <sub>2</sub> O <sub>3</sub> Ceramics with TiO <sub>2</sub> and Nb <sub>2</sub> O <sub>5</sub> addition		
M_P11	<b>Li-En Chen</b> Electrostatic separation for recycling silicon from the crushed photovoltaic modules		
M_P12	<b>Zihan Kang</b> Novel Bi <sub>2</sub> WO <sub>6</sub> /g-C <sub>3</sub> N <sub>4</sub> /ZnO Z-scheme heterojunctions with g-C <sub>3</sub> N <sub>4</sub> interlayer modulated by piezoelectric polarization for efficient piezo-photocatalytic decomposition of harmful organic pollutants		
M_P13	<b>Mi Chen</b> Characerization of Graphene/CNTs Hybrid Conductive Film by Screen Printing		
M_P14	<b>Wan-Chien Wu</b> Developments of Calcium Sulfate Coating on Ti <sub>6</sub> Al <sub>4</sub> V Substrate by Flame Spray		
M_P15	<b>Ti Hsin</b> High entropy piezo-catalyst oxide for dye-degradation		

<b>Tuesday</b> <b>Nov. 16, 2021</b>	➤ ➤	09:00 – 16:00 09:30 – 16:50	Registration Conference Sessions
		<b>Room 1</b>	<b>Room 2</b>
		Session Chair: Kuan-Zong Fung	
09:30 – 10:10	<b>Keynote Session I</b>	<b>K_1 Chun-Hway Hsueh</b> Enhanced Luminous Transmittance and Solar Modulation by Subwavelength VO <sub>2</sub> Nanoparticle Film for Smart Window Applications	
10:10 – 10:50	<b>Keynote Session II</b>	<b>K_3 Yasser Ashraf Gandomi</b> Novel Reactor Design and Experimental Diagnostics for Redox Flow Batteries	
10:50 – 11:10	<b>Coffee Break</b>		
		Session Chair: Chien-Ming Lei	Session Chair: Yen-Yu Chen
11:10 – 11:30	Invited Speaker	<b>H_I01 Kungen Teii</b> Plasma Deposition of High-Quality Cubic Boron Nitride Films for Applications to Ultrahard Coatings and Electronic Devices	Invited Speaker <b>F_I01 Naoki Wakiya</b> In-situ observation of spontaneous phase separation via spinodal decomposition in Sr excess SrTiO <sub>3</sub> thin film
11:30 – 11:50	Invited Speaker	<b>P_I01 Ngoc Duy Pham</b> Novel P-dopant for Spiro-OMeTAD-based Hole-Transporting Materials towards Efficient and Stable Perovskite Solar Cells	Invited Speaker <b>B_I04 Van-Duong Dao</b> Environmental energy harvesting based on nanogenerator
11:50 – 12:10	Invited Speaker	<b>P_I02 Al Jumlat Ahmed</b> Thermoelectric Performance of Nano-engineered Perovskite Oxide Materials Sr <sub>1-x</sub> La <sub>x</sub> TiO <sub>3</sub> and Ba <sub>1-x</sub> La <sub>x</sub> TiO <sub>3</sub>	Invited Speaker <b>F_I03 Yen-Yu Chen</b> Microstructures and Electrical Properties of BaCeZrYYbO <sub>3-δ</sub> YSZ composites prepared by Solid-State Sintering for Sustainable Energy Application
12:10 – 13:10	<b>Lunch Break</b>		
		Session Chair: Horng Show Koo	Session Chair: Shu-Yi Tsai
13:10 – 13:30	Invited Speaker	<b>P_I03 Hong-Xia Wang</b> Towards Cost-Effective, Stable and Greener Perovskite based Solar Cells and Light Emitting Diode	Invited Speaker <b>F_I04 Francesco Ciucci</b> High Performance Protonic Ceramic Fuel Cells
13:30 – 13:50	Invited Speaker	<b>E_I01 Horng-Show Koo</b> Recent Progress on Gallium Oxide Ceramic Materials and Thin Films for High-efficiency and Energy-saving Applications	Oral <b>F_O01 Azam Khan</b> Study of BaCO <sub>3</sub> and Samarium-doped Ceria Carbonate Composite Electrolyte for Low-Temperature Solid Oxide Fuel Cells
13:50 – 14:10	Invited Speaker	<b>A_I01 Subramanian Sakthinathan</b> Efficient Electrocatalyst for Hydrogen Evolution Reaction based on Delafossite Materials supported Carbon composite	Invited Speaker <b>B_I01 Nghia Van Nguyen</b> Carbon coated Sodium Manganese oxide as a cathode material for Sodium-Ion battery
14:10 – 14:30	Invited Speaker	<b>M_I01 Shan-Tao Zhang</b> Ferroelectric and pyroelectric property in antiferroelectric-based composites	Invited Speaker <b>B_I02 Manas Ranjan Panda</b> Probing the Li/Na/Storage Mechanism of 2D Transition Metal Dichalcogenides Using Synchrotron-Based X-ray Techniques
14:30 – 14:50	Invited Speaker	<b>M_I02 Nobuhiro Matsushita</b> "Spin-Spray Method" A Novel Solution Process for Preparing Semiconductor Oxide Films with Low Environmental Load	Invited Speaker <b>B_I03 Debasmitta Dwibedi</b> Insights into Stabilization of α-Na <sub>2</sub> Fe(SO <sub>4</sub> ) <sub>2</sub> and Structure/ Polymorphism/ and Electrochemistry Thereof

14:50 – 15:10		Coffee Break			
		Session Chair: Alex Chinghuan Lee		Session Chair: Tai-Nan Lin	
15:10 – 15:30	Oral	M_O01 Chia-Wei Huang Chemical Looping Gasification of Spent Coffee Ground Using Iron ore as Oxygen Carrier	Invited Speaker	F_I02 Kuan-Ting Wu The Role of Self-exsolved Heterogeneous Composite Nanoparticles towards Highly Active Fuel Electrode for CO <sub>2</sub> H <sub>2</sub> O Co-electrolysis	
15:30 – 15:50	Oral	M_O02 Asit Kumar Panda A Non-Enzymatic/Biocompatible Electrochemical Sensor based on N-doped Graphene Quantum Dot-incorporated SnS <sub>2</sub> Nanosheets for In Situ Monitoring of Hydrogen Peroxide in Breast Cancer Cells	Invited Speaker	B_I05 Tungabidya Moharana Development of Paper-Based Flexible Supercapacitor Fabricated Using Polypyrrole	
15:50 – 16:10	Oral	M_O03 Lien-Hui Kan Investigation on Luminescent Layer of Alkaline-earth Aluminates on Aluminum Alloy	Invited Speaker	B_I06 Prabeer Barpanda Perovskite Lead-based anodes for secondary batteries	
16:10 – 16:30	Invited Speaker	L_I01 Sakhivel Gandhi Nanoporous Silica Materials: A Versatile Supporting Material for the Development of 'Phosphor in Glass'	Invited Speaker	B_I07 Tran V. Thu Graphene-MnFe <sub>2</sub> O <sub>4</sub> -polypyrrole ternary hybrids with synergistic effect for supercapacitor electrode	
16:30 – 16:50	Oral	L_O01 Pei-Tzu Cheng Optical Properties of Europium doped Calcium Sulfide Prepared by Carbon	Invited Speaker	H_I02 Masahiro YOSHIMURA Continuous(Successive) Fabrication of Nano-Structured Ceramic Materials via Soft, Solution Processing without Firing	

<b>Wednesday</b> <b>Nov. 17,</b> <b>2021</b>	➤ ➤	08:30 – 16:00 09:30 – 16:10	Registration Conference Sessions
	<b>Room 1</b>		<b>Room 2</b>
	<b>Session Chair: I-Ming Hung</b>		
09:30 – 10:10	<b>Keynote Session I</b>	<b>K_2 Tatsumi Ishihara</b> Tubular Type Solid Oxide Reversible Cell Using LaGaO <sub>3</sub> Electrolyte Film Prepared by Dip-coating Method	
10:10 – 10:50	<b>Keynote Session II</b>	<b>K_4 Hong Wang</b> High Performance Dielectrics for Passive integration and Energy Storage	
10:50 – 11:10	<b>Coffee Break</b>		
	<b>Session Chair: I-Ming Hung</b>		<b>Session Chair: Yen-Yu Chen</b>
11:10 – 11:30	Invited Speaker	<b>B_I09 Prasant Kumar Nayak</b> High-capacity layered oxide cathode materials for rechargeable Li-ion batteries	Invited Speaker <b>E_I03 Meng-Fang Lin</b> Nanofiber for triboelectric nanogenerator
11:30 – 11:50	Oral	<b>B_O01 Debabrata Mohanty</b> Effect of different LiTFSI content on Composite Solid Electrolyte with NASICON-type LATP and PVDF-HFP for Solid-State Lithium-ion	Oral <b>E_O03 Feng Sheng Chao</b> Supercapacitive Properties of Bi-doped ZnCo <sub>2</sub> O <sub>4</sub> Nanostructure Synthesized by In-situ Hydrothermal Method
11:50 – 12:10	Oral	<b>P_O01 Chia-Yu Chang</b> Development of Visible Light Responsive TiO <sub>2</sub> Photoelectrodes by Metal Nanoparticle Loading	
12:10 – 13:10	<b>Lunch Break</b>		
	<b>Session Chair: Te-Wei Chiu</b>		<b>Session Chair: Subramanian Sakthnathan</b>
13:10 – 13:30	Oral	<b>B_O03 Bruce Chen</b> Roles of Binders on Self-Discharge for Porous Carbon Supercapacitor Electrodes	Invited Speaker <b>B_I08 P. Muhammed Shafi</b> Three Dimensional NiO Nanonetwork Electrode for Efficient Ultra-fast Electrochemical Energy Storage Application
13:30 – 13:50	Oral	<b>B_O04 Chinghuan Lee</b> Structure evolution and operando analysis methods of fast-charging lithium titanate materials developed in HiGEM research center	Oral <b>B_O06 Ngoc Thanh Thuy Tran</b> Insight into the degradation mechanism of the Ni-rich NMC cathode materials
13:50 – 14:10	Oral	<b>B_O05 Yu-Si Chen</b> Fe-Cu-Schiff base complexes as Electrocatalysts for Zn-Air Batteries	Oral <b>F_O02 Liangdong Fan</b> High-performance in-situ Ni nanoparticle exsolved LSTN/LNSDC composites for low-temperature solid oxide fuel cells
14:10 – 14:30	Oral	<b>E_O01 Chih-Heng Lee</b> A DFT Study of the Effect of Degrees of Inversion on the Electronic Structure of Spinel NiCo <sub>2</sub> O <sub>4</sub>	Oral <b>E_O02 Pao-Wen Shao</b> Flexo-phototronic Effect in Centrosymmetric BiVO <sub>4</sub> Epitaxial Films
14:30 – 14:50	Oral	<b>B_O02 Rahmandhika Firdauzha Hary Hernandha</b> SiO <sub>x</sub> Carbon Multilayer Coating on Silicon Nanoparticles Synthesized via Supercritical CO <sub>2</sub>	




14:40 – 15:00	<b>Coffee Break</b>	
	Session Chair: Hwai-En Lin	
15:00 – 15:20	Invited Speaker	E_I02 Alice EH Lee Sie Robust tristate reversible electrochemical mirror electrochromic devices
15:20 – 15:40	Oral	L_O02 Henni Setia Ningsih Synthesis and characterization of Tb-doped Y <sub>4</sub> SiAlO <sub>8</sub> N powder by spray pyrolysis
15:40 – 16:00	Oral	E_O04 Deng-Li Ko High-stability transparent flexible energy storage based on PbZrO <sub>3</sub> / muscovite heterostructure
16:00 – 16:20	-Students Award (Post) -Closing Ceremony	

## Keynote Lectures

Paper ID	Corresponding Author	All Authors	Title	Institution	Department
K_1	Chun-Hway Hsueh	Ying-Chou Lu, Chun-Hway Hsueh	Enhanced Luminous Transmittance and Solar Modulation by Subwavelength VO <sub>2</sub> Nanoparticle Film for Smart Window Applications	National Taiwan University	Department of Materials Science and Engineering
K_2	Tatsumi Ishihara	Tatsumi Ishihara and Tan Zhe	Tubular Type Solid Oxide Reversible Cell Using LaGaO <sub>3</sub> Electrolyte Film Prepared by Dip-coating Method	Kyushu University	Department of Applied Chemistry
K_3	Yasser Ashraf Gandomi	Yasser Ashraf Gandomi, Matthew M. Mench	Novel Reactor Design and Experimental Diagnostics for Redox Flow Batteries	Massachusetts Institute of Technology	Chemical Engineering
K_4	Hong Wang	Hong Wang	High Performance Dielectrics for Passive Integration and Energy Storage	Southern University of Science and Technology	College of Science

## K\_1. Enhanced Luminous Transmittance and Solar Modulation by Subwavelength VO<sub>2</sub> Nanoparticle Film for Smart Window Applications (Chun-Hway Hsueh)

<b><u>Prof. Chun-Hway Hsueh</u></b>	
<p><b>Affiliation:</b> Department of Materials Science and Engineering, National Taiwan University</p> <p><b>Position:</b> Distinguished Professor</p> <p><b>Email:</b> hsuehc@ntu.edu.tw</p>	

<b>Education</b>	<ul style="list-style-type: none"> <li>● PhD, Department of Materials Science and Engineering, University of California, Berkeley, USA</li> <li>● MS, Department of Materials Science and Engineering, National Tsing Hua University, Taiwan</li> <li>● BS, Department of Physics, National Taiwan University, Taiwan</li> </ul>
<b>Experience</b>	<ul style="list-style-type: none"> <li>● Distinguish Professor, Department of Materials Science and Engineering, National Taiwan University (2010–present)</li> <li>● Visiting Research Professor, Department of Physics, University of Tennessee, Knoxville (2008–2013)</li> <li>● Visiting Professor, Department of Materials Science and Engineering, National Taiwan University (2008–2010)</li> <li>● Distinguished R&amp;D Staff, Oak Ridge National Laboratory (1986–2010)</li> <li>● Research Engineer, Department of Materials Science and Engineering, University of California, Berkeley (1982–1986)</li> </ul>
<b>Honors and Awards</b>	<ul style="list-style-type: none"> <li>● The World's Top 2% Scientists (list published by Stanford University)</li> <li>● Fellow of Materials Research Society, Taiwan (MRS-T)</li> <li>● Academician of Asia Pacific Academy of Materials (APAM)</li> <li>● Ceramic Medal, Taiwan Ceramic Society</li> <li>● 2017 Breakthrough of Future Technology Award, Ministry of Science and Technology (MOST), Taiwan</li> <li>● Fellow of American Society for Metals (ASM) International</li> <li>● Fellow of the American Ceramic Society (ACerS)</li> <li>● Fellow of the World Innovation Foundation (WIF)</li> <li>● ISI Highly Cited Researcher in Materials Science</li> <li>● The Ross Coffin Purdy (Best Paper) Award, The American Ceramic Society (ACerS)</li> </ul>

K\_1

## Enhanced Luminous Transmittance and Solar Modulation by Subwavelength VO<sub>2</sub> Nanoparticle Film for Smart Window Applications

Ying-Chou Lu, Chun-Hway Hsueh\*

Department of Materials Science and Engineering, National Taiwan University, Taiwan


\*Corresponding Author: [hsuehc@ntu.edu.tw](mailto:hsuehc@ntu.edu.tw)

### Abstract

The VO<sub>2</sub> nanoparticle (NP) films were prepared by self-template syntheses, including sputtering of V films and post-annealing. Compared to the VO<sub>2</sub> thin film with a refractive index of  $\sim 2.8$  at 550 nm wavelength, the subwavelength VO<sub>2</sub> NP films with the lower effective refractive index (less than 2) exhibited the higher luminous transmittance ( $T_{lum}$ ) due to the decreased reflectance differences at the air/VO<sub>2</sub> and VO<sub>2</sub>/glass interfaces. Also, the subwavelength rutile VO<sub>2</sub> NPs provided the localized surface plasmon resonance excited at  $\sim 1250$  nm wavelength to enhance the solar modulation ( $\Delta T_{sol}$ ). Using finite-difference time-domain simulations, the optimal NP size and porosity of NP film were designed to obtain the optimum balance between  $\Delta T_{sol}$  and  $T_{lum}$  and the results were confirmed by experimental measurements. The single-sided VO<sub>2</sub> NP film with an ultrahigh  $T_{lum}$  of 93.3% exhibited a transparent vision with  $\Delta T_{sol}$  of 6.1%, and the double-sided VO<sub>2</sub> NP film provided an improved  $\Delta T_{sol}$  of 14% while  $T_{lum}$  was kept at  $\sim 70\%$ . With the increasing layer number of VO<sub>2</sub> NP films, excellent  $\Delta T_{sol}$  of 19% could be achieved for quadra-layered VO<sub>2</sub> NP film while  $T_{lum}$  remained at 69.5%. The outstanding performances of the VO<sub>2</sub> NP films exceeded the reported results for porous films, multilayer and nanostructures. Thus, we believe that the VO<sub>2</sub> NP film is a promising nanostructure to lead VO<sub>2</sub>-based coatings to a new method for smart window applications, including the building glazing and windshield of vehicle.

**Keywords:** Vanadium dioxide, Nanoparticle, Luminous transmittance, Solar modulation, Localized surface plasmon resonance, Finite-difference time-domain simulation

## K\_2. Tubular Type Solid Oxide Reversible Cell Using LaGaO<sub>3</sub> Electrolyte Film Prepared by Dip-coating Method (Tatsumi Ishihara)

<b><u>Prof. Tatsumi Ishihara</u></b>	
<b>Affiliation:</b> International Institute for Carbon Neutral Energy Research (WPI-I2CNER), Kyushu University <b>Position:</b> Professor <b>Email:</b> ishihara@cstf.kyushu-u.ac.jp	

<b>Education</b>	<ul style="list-style-type: none"> <li>● 1984 Kyushu University B.Sc (Department of Applied Chemistry)</li> <li>● 1986 Kyushu University M.Sc. (Department of Materials Science and Technology)</li> <li>● 1992 Dr. of Engineering (Kyushu University)</li> </ul>
<b>Experience</b>	<ul style="list-style-type: none"> <li>● 1986 Research Associate, Kyushu University</li> <li>● 1989-2003 Research Associate, Lecture, Associate Professor, Oita University</li> <li>● 2003 Professor, Kyushu University</li> <li>● 2012 Associate Director, International Institute for Carbon Neutral Energy, Kyushu University</li> <li>● 2012 Distinguished Professor, Kyushu University</li> </ul>
<b>Honors and Awards</b>	<ul style="list-style-type: none"> <li>● 2012 Somiya Award from IUMRS</li> <li>● 2013 Catalyst Society of Japan Award (Industrial) Academic Award from Ceramic Society of Japan</li> <li>● 2016 Daiwa Adrian Prize</li> <li>● 2020 Catalyst Society of Japan Award (Academic)</li> </ul>

K\_2

## Tubular Type Solid Oxide Reversible Cell Using LaGaO<sub>3</sub> Electrolyte Film Prepared by Dip-coating Method

Tatsumi Ishihara<sup>1\*</sup>, Tan Zhe<sup>1</sup>

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### Abstract

Reversible operation of Solid Oxide Fuel Cells is now important subject from energy storage of renewable electric power such as solar or wind power [1]. At present, planer type cell design is widely studied for this purpose, however, because of tight gas sealing, tubular type cell design is more desirable from gas sealing. In this study, micro tubular solid oxide cell using La<sub>0.9</sub>Sr<sub>0.1</sub>Ga<sub>0.8</sub>Mg<sub>0.2</sub>O<sub>3-δ</sub> (LSGM) thin electrolyte film was prepared by dip-coating and co-sintering process on NiO-YSZ substrate [2,3].

NiO-YSZ porous substrate with 10 mm diameter and 30 mm length was used for preparation of the cell. For preventing reaction between LSGM and NiO, TiO<sub>2</sub>-Ce<sub>0.6</sub>La<sub>0.4</sub>O<sub>2</sub>/Ce<sub>0.6</sub>Mn<sub>0.3</sub>Fe<sub>0.1</sub>O<sub>2</sub> was used for buffer layer. Ni-Fe layer was also deposited on the surface of NiO-YSZ substrate.

It was found that the infiltration of Ce(NO<sub>3</sub>)<sub>3</sub> solution into NiO-YSZ substrate was effective for increasing the maximum power density, because both IR loss and overpotential were significantly decreased. The maximum power density of the cell was 0.95 and 0.42 W cm<sup>-2</sup> at 873 and 773 K, respectively at 3 M Ce nitrate infiltrated. The long-term stability of the cell was also measured by using the cell infiltrated with 1.5 M Ce, the stable power generation performance was demonstrated up to 100 h. The steam electrolysis performance of the cell using Ce infiltration was further studied and it was found that Ce infiltrated was also effective to higher current density in SOEC operation and 1.07 A cm<sup>-2</sup> at 1.6 V was achieved at 873 K using 2 M Ce(NO<sub>3</sub>)<sub>3</sub> infiltration. In order to further increase in power density and redox stability, effect of co-infiltration with Ce is further studied and co-infiltration of Ni with Ce is further effective for increasing initial performance of the cell, in particular, lower temperature around 773 K and cycle stability of SORC over 100 cycles. Therefore, in this presentation, infiltration effects on NiO-YSZ fuel electrode substrate will be introduced.


**Keywords:** Tubular type SOFC, LSGM electrolyte film, Ce infiltration, reversible operation.

### References

- [1] S. Yesid, and G. D. Hotza, *Renewable and Sustainable Energy Reviews*, 61 (2016) 155-174
- [2] Z. Tan and T. Ishihara, *J. Electrochem. Soc.* 164 (2017) F1690- F1696
- [3] Z. Tan, J.T. Song, A. Takagaki and T. Ishihara, *J. Mater. Chem. A*, 9 (2021) 1530-1540



K\_3. Novel Reactor Design and Experimental Diagnostics for Redox Flow Batteries (Yasser Ashraf Gandomi)

<b><u>Dr. Yasser Ashraf Gandomi</u></b>	
<b>Affiliation:</b> Massachusetts Institute of Technology (MIT)	
<b>Position :</b> Postdoctoral Associate <b>Email:</b> ygandomi@mit.edu	

<b>Education</b>	<ul style="list-style-type: none"> <li>● Post-Doctoral Fellowship in Chemical Engineering, Massachusetts Institute of Technology (MIT)</li> <li>● Doctor of Philosophy (PhD) in Mechanical Engineering, University of Tennessee</li> <li>● Master of Science in Mechanical Engineering, University of Tennessee</li> </ul>
<b>Experience</b>	<ul style="list-style-type: none"> <li>● Flow batteries</li> <li>● Fuel cells</li> <li>● Li-ion batteries</li> <li>● Membranes</li> <li>● Capacitive deionization</li> </ul>
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K\_3

## Novel Reactor Design and Experimental Diagnostics for Redox Flow Batteries

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### Abstract


Redox flow batteries (RFBs) are scalable energy storage devices that can be integrated with renewable energy sources (e.g., wind and solar energy) to enhance the reliability of renewables-based electricity systems [1]. Despite being very promising, further improvements in the performance and durability of RFBs is needed for widespread adoption of this technology. One of the major issues yet to be addressed for RFBs is relatively fast capacity decline because of electroactive species crossover through the membrane throughout charge/discharge cycling [2]. In this talk, we will discuss advanced experimental diagnostics to assess the sources of lost efficiency and performance limitations in RFBs. Also, we will elaborate on novel reactor architecture design for enhanced localized performance and reduced crossover for redox flow batteries. These enhanced features can be tailored to reduce the self-discharge through the separator while maintaining higher capacity utilization during extended cycling.

**Keywords:** Energy storage, Redox flow batteries, Experimental diagnostics, Crossover, Membranes.

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K\_4.High Performance Dielectrics for Passive Integration and Energy Storage (Hong Wang)

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<b>Experience</b>	<ul style="list-style-type: none"> <li>● 2017-Present Chair Professor, Southern University of Science and Technology</li> <li>● 1995–2017 Assistant Professor(1995-1998), Associate Professor(1998-2002), Professor(2002-07), Xi'an Jiaotong University,</li> </ul>
<b>Honors and Awards</b>	<ul style="list-style-type: none"> <li>● IEEE Fellow (2020)</li> <li>● Chang Jiang Scholar Chair Professor, The Ministry of Education of China (2011)</li> <li>● Distinguished Young Scholar, National Science Foundation of China (2010)</li> </ul>

K\_4

## High Performance Dielectrics for Passive Integration and Energy Storage

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### Abstract

With the development of electronic and information system towards miniaturization and high density integration, especially the speedy applications of wireless network and internet of things, it is required that the electronic materials and components should have the matching properties such as high performance, multifunctional, high frequency enabling and low energy consumption. The highlights of recent advances on the novel LTCC dielectric ceramics for passive integration, dielectric nanocomposites for electronic packaging and energy storage applications will be presented, while the remaining challenges and the promising opportunities of the development will be discussed as well.

**Keywords:** Dielectric, Passive integration, Energy storage, Composite

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# Technical Symposia

## Invited Speaker

Paper ID	Corresponding Author	All Authors	Title	Institution	Department
A_I01	Subramanian Sakthinathan, Te-Wei Chiu	Subramanian Sakthinathan, Karthikeyan Arjunan, Dhanapal Vasu, Te-Wei Chiu	Efficient Electrocatalyst for Hydrogen Evolution Reaction based on Delafossite Materials supported Carbon composite	National Taipei University of Technology	Department of Materials and Mineral Resources Engineering
B_I01	Van-Nghia Nguyen	Van-Nghia Nguyen, Van-Nguyen To, Van-Ky Nguyen, Quy-Quy Nguyen, Trung-Son Luong, Manh-Thao Pham, Manh-Ha Hoang, Thi-Thu-Hoa Nguyen	Carbon coated sodium manganese oxide as a cathode material for sodium-ion battery	Hanoi Architectural University	Open training Institute
B_I02	Manas Ranjan Panda	Manas Ranjan Panda, Qiaoliang Bao, Mainak Majumder, and Sagar Mitra	Probing the Li/Na Storage Mechanism of 2D Transition Metal Dichalcogenides Using Synchrotron-Based X-ray Techniques	Monash University	Department of Chemical Engineering
B_I03	Debasmita Dwibedi	Debasmita Dwibedi, Shini-ichi Nishimura, Prabeer Barpanda, Atsuo Yamada	Insights into Stabilization of $\alpha$ - $\text{Na}_2\text{Fe}(\text{SO}_4)_2$ and Structure/Polymorphism/ and Electrochemistry Thereof	Tokyo University	Department of Chemical System Engineering, School of Engineering
B_I04	Van-Duong Dao	Van-Duong Dao	Environmental energy harvesting based on nanogenerator	Phenikaa University	Faculty of Biotechnology, Chemistry and Environmental Engineering
B_I05	Tungabidya Maharana	Rama Devi, Kavita Tapadia, Alekha Kumar Sutar, Tungabidya Maharana	Development of Paper-Based Flexible Supercapacitor Fabricated Using Polypyrrole	National Institute of Technology, Raipur, India	Department of Chemistry
B_I06	Prabeer Barpanda	Anshuman Chaupatnaik, Prabeer	Perovskite lead-based anodes for secondary batteries	Indian Institute of Science (IISc), India	Materials Research Centre, Faraday

		Barpanda			Materials Laboratory (FaMaL)
B_I07	Tran V. Thu	Tran V. Thu, To V. Nguyen, Le X. Duong, Le T. Son, Vu V. Thuy	Graphene-MnFe <sub>2</sub> O <sub>4</sub> -polypyrrole ternary hybrids with synergistic effect for supercapacitor electrode	Le Quy Don Technical University	Department of Chemical Engineering
B_I08	P Muhammed Shafi, A Chandra Bose, Jae-Jin. Shim	Nikhitha Joseph, P Muhammed Shafi, J. S. Sethulakshmi, Raj Karthik, A Chandra Bose and Jae-Jin. Shim	Three Dimensional NiO Nanonetwork Electrode for Efficient Ultra-fast Electrochemical Energy Storage Application	Yeungnam University	School of Chemical Engineering
B_I09	Prasant Kumar Nayak	Prasant Kumar Nayak	High-capacity layered oxide cathode materials for rechargeable Li-ion batteries	SRM Institute of Science and Technology, India	Department of Chemistry
E_I01	Horng-Show Koo	Horng-Show Koo and Mi Chen	Recent Progress on Gallium Oxide Ceramic Materials and Thin Films for High-efficiency and Energy-saving Applications	Taipei University of Marine Technology	College of Innovative Design and Department of Visual Communication Design
E_I02	Alice EH Lee Sie	Alice EH Lee Sie	Robust tristate reversible electrochemical mirror electrochromic devices	Nanyang Technological University	School of Materials Science and Engineering
E_I03	Meng-Fang Lin	Meng-Fang Lin	Nanofiber for triboelectric nanogenerator	Ming Chi University of Technology	
F_I01	Naoki Wakiya	Naoki Wakiya, Mayu Yoshida, Takahiko Kawaguchi, Naoniri Sakamoto, Kazuo Shinozaki, Hisao Suzuki	In-situ observation of spontaneous phase separation via spinodal decomposition in Sr-excess SrTiO <sub>3</sub> thin film	Shizuoka University	Department of Electronics and Material Science
F_I02	Kuan-Ting Wu	Kuan-Ting Wu, Tatsumi Ishihara	The Role of Self-exsolved Heterogeneous Composite Nanoparticles towards Highly Active Fuel Electrode for CO <sub>2</sub> H <sub>2</sub> O Co-electrolysis	Kyushu University	Department of Applied Chemistry
F_I03	Yen-Yu Chen	Yen-Yu Chen, Pin-Lun Huang, Chia-Yu Liu, An-Chang Lin, Hsuan-Yun Lin, Chien-Ming Lei	Microstructures and Electrical Properties of BaCeZrYYbO <sub>3-δ</sub> YSZ composites prepared by Solid-State Sintering for Sustainable Energy Application	Chinese Culture University	Chemical and Materials Engineering



F_I04	Francesco Ciucci	Francesco Ciucci	High Performance Protonic Ceramic Fuel Cells	The Hong Kong University of Science and Technology	Department of Mechanical and Aerospace Engineering
H_I01	Kungen Teii	Kungen Teii, Jason H. C. Yang, Seiichiro Matsumoto	Plasma Deposition of High-Quality Cubic Boron Nitride Films for Applications to Ultrahard Coatings and Electronic Devices	Kyushu University	Department of Advanced Energy Science and Engineering
H_I02	Masahiro YOSHIMURA	Masahiro YOSHIMURA	Continuous(Successive) Fabrication of Nano-Structured Ceramic Materials via Soft, Solution Processing without Firing	National Cheng Kung University	Department of Materials Science and Engineering
L_I01	Sakthivel Gandhi	Abinaya Mayavan, Sakthivel Gandhi	Nanoporous Silica Materials: A Versatile Supporting Material for the Development of 'Phosphor in Glass'	SASTRA University	School of Chemical and Biotechnology
M_I01	Shan-Tao Zhang	Shan-Tao Zhang	Ferroelectric and pyroelectric property in antiferroelectric-based composites	Nanjing University	College of Engineering and Applied Sciences
M_I02	Nobuhiro Matsushita	Ryosuke Nitta, Yuta Kubota, Lin Hwai En, Masahiro Yoshimura, Nobuhiro Matsushita	"Spin-Spray Method" A Novel Solution Process for Preparing Semiconductor Oxide Films with Low Environmental Load	Tokyo Institute of Technology	Dept. of Materials Science and Engineering
P_I01	Ngoc Duy Pham	Ngoc Duy Pham, Shujuan Huang, Weijian Chen, Hongxia Wang, Baohua Jia, and Xiaoming Wen	Novel p-dopant for Spiro-OMeTAD-based Hole-Transporting Materials towards Efficient and Stable Perovskite Solar Cells	Macquarie University	School of Engineering
P_I02	Al Jumlat Ahmed	Al Jumlat Ahmed	Thermoelectric Performance of Nano-engineered Perovskite Oxide Materials $Sr_{1-x}LaxTiO_3$ and $Ba_{1-x}LaxTiO_3$	University of Wollongong	Institute for Superconducting and Electronic Materials
P_I03	Hongxia Wang	Hongxia Wang	Towards Cost-Effective, Stable and Greener Perovskite based Solar Cells and Light Emitting Diode	Queensland University of Technology (QU T)	Centre for Materials Science

## A. Alternative energies

A\_I01

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<b>Experience</b>	<ul style="list-style-type: none"> <li>● Project Associate-“Synthesis of Higher Number Carbon Alcohols” National Centre for Catalysis Research (NCCR), Indian Institute of Technology (IIT), Chennai, India- 600036.</li> <li>● Summer Research Project-“Synthesis and Spectroscopic Properties of Few Metalloporphyrin Complexes” Bioinorganic Laboratory, Indian Institute of Technology (IIT) Kanpur-620024, Uttar Pradesh, India.</li> </ul>
<b>Honors and Awards</b>	<ul style="list-style-type: none"> <li>● Visiting Researcher at the department of physical chemistry, University of Madras, November 2019.</li> <li>● Certificate of the excellence award-Winning 2016 sunshine scholarship in the faculty and student research category.</li> <li>● Awarded Taipei Tech International Graduate School Student Scholarship for Academy Year 2014-2017.</li> </ul>

	<ul style="list-style-type: none"><li>● Awarded with Summer Research Fellowship for the year 2011-2012 by Indian Academy of Science (IAS), India for meritorious postgraduate students.</li><li>● First Rank student in Under Graduate, A.V.V.M. Sri Pushpam College, Tamilnadu, (2008 to 2011 Batch)</li><li>● Proficiency Prize Winner in Chemistry A.V.V.M. Sri Pushpam College, Tamilnadu, (2010&amp;2011)</li><li>● Best Paper Presentation Award at International Symposium On Smart Sensing Technology &amp; 20th Symposium of Association for Chemical Sensor in Taiwan (2015)</li><li>● Distinguished paper award from an association of chemical sensor Taiwan.</li><li>● Received travel grant from Ministry of Science and Technology (MOST) Taiwan for Third International Conference on 2D Materials and Technology (ICON-2DMAT), Nanyang Technological University, December 11-15th 2017 Singapore.</li><li>● Received travel grant from Ministry of Science and Technology (MOST)-Taiwan for ISAF-FMA-AMF-AMEC-PFM joint conference (IFAAP) to be held during May-27- June 1, 2018, at the International Convention Center, Hiroshima, Japan.</li><li>● Visiting post-doctoral fellow at the department of physical chemistry, University of Madras, 2018.</li></ul>
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A\_I01

## Efficient Electrocatalyst for Hydrogen Evolution Reaction based on Delafossite Materials supported Carbon composite

Subramanian Sakthinathan<sup>1\*</sup>, Karthi keyan Arjunan<sup>1</sup>, Dhanapal Vasu<sup>1</sup>, Te-Wei Chiu<sup>1\*</sup>

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### Abstract

Fossil fuels are used to fulfill the world's energy needs as high energy sources, but they also cause excessive environmental pollution. Hence, alternative energy sources are being explored at the moment to generate more energy while polluting the environment less. For all the renewable energy sources, hydrogen is a very important, environmentally friendly alternative energy source. Hydrogen production can be achieved by low-cost electrochemical water electrolysis. Delafossite materials have low electrical resistivity and great potential as a new class of catalysts for applications in electrochemical water splitting. Especially, copper-based delafossite materials have a wide variety of interesting electronic properties such as good electrical conductivity and optical properties. Moreover, Cu-based delafossite materials such as  $\text{CuCrO}_2$ ,  $\text{CuAlO}_2$ , and  $\text{CuFeO}_2$  have good catalytic activity in water splitting. The  $\text{CuCrO}_2$ ,  $\text{CuAlO}_2$ , and  $\text{CuFeO}_2$  delafossite complex were incorporated with nitrogen and boron-doped reduced graphene oxide (N-rGO, B-rGO) and multiwalled carbon nanotubes (MWCNT) based nanocomposite (N-rGO-MWCNT) for the hydrogen evolution reaction (HER). The  $\text{CuCrO}_2$ ,  $\text{CuAlO}_2$ , and  $\text{CuFeO}_2$  delafossite complex were made by self-combustion glycine nitrate process (GNP), and the N-rGO-MWCNT and B-rGO-MWCNT composite was prepared by the hydrothermal method. The morphology was characterized by spectroscopy and microscopy techniques. The materials were structurally well ordered with a porous structure and high surface area. The GCE/N-rGO-MWCNT/ $\text{CuAlO}_2$ , GCE/B-rGO-MWCNT/ $\text{CuFeO}_2$ , and GCE/N-rGO-MWCNT/ $\text{CuCrO}_2$  electrode exhibited an electrocatalytic activity for the HER under strongly acidic conditions with a low over-potential, increasing reduction current, and a small Tafel slope of  $48 \text{ mV dec}^{-1}$ ,  $54 \text{ mV dec}^{-1}$ ,  $62 \text{ mV dec}^{-1}$ , respectively at  $10 \text{ mA cm}^{-1}$  with long-term stability. Furthermore, the aforementioned electrodes were correlated with Pt/C and exhibited superior electrocatalytic performance towards the HER in acidic media. Therefore, the electrode appears to be an excellent catalyst for the electrocatalytic reaction of HER.

**Keywords:** Hydrogen evolution reaction, MWCNT, Graphene oxide, Delafossite complex, Acidic media

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B. Battery and energy storage

B\_I01

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<b>Education</b>	<ul style="list-style-type: none"><li>● Hanoi 2 Pedagogical University, Bachelor Degree of Physics (2004)</li><li>● Hanoi 2 Pedagogical University, Master Degree of Condensed Matter Physics (2010)</li><li>● YuanZe University ,Doctor Degree of Material Sciences (2015)</li></ul>
<b>Experience</b>	<ul style="list-style-type: none"><li>● Sodium-ion battery</li><li>● Lithium-ion battery</li></ul>
<b>Honors and Awards</b>	<ul style="list-style-type: none"><li>● Doctor Programe Vietnam Government Scholarship (VEST 500) (2011)</li><li>● Excellent in Research Award, Hanoi Architectural University (2019)</li></ul>

B\_I01

## Carbon coated sodium manganese oxide as a cathode material for sodium-ion battery

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### Abstract

Sodium-ion battery (SIB) is a candidate for large scale energy storage devices. P2-type layered structure materials have been known as high capacity cathode materials for SIB. However, the low rate capability of the materials has restricted the practical applications of SIB. In this study, we enhanced the performance of a P2-type layered structure sodium-manganese oxide (NMO) by coating carbon on the material surface. X-ray diffraction (XRD), Raman spectra, thermal gravimetric (TGA), scanning electron microscopy, energy-dispersive X-ray spectroscopy (SEM-EDS), transmission electron microscopy (TEM), and selected area electron diffraction (SAED) analyses were used to investigate structure and morphology of pristine NMO and carbon-coated sodium-manganese oxide (NMO@C). The electrochemical test results showed that the performance of NMO@C material is higher than that of pristine NMO. The specific capacity of NMO@C is 160 mAh g<sup>-1</sup> at 0.1 C, which is 33% higher than that of pristine NMO material; The capacity of NMO@C material at high charged/discharged rate of 1 C is 115 mAh g<sup>-1</sup> meanwhile the capacity of NMO material at 1 C is negligible. The Electrochemical Impedance Spectrum (EIS) shows that lower Ohmic resistance, charge transfer resistance ( $R_p$ ), and Warburg impedance of NMO@C material compared to those of NMO material had improved the electrochemical performance of NMO@C.

**Keywords:** Layered structure, Carbon coating, Cathode, Sodium-ion Battery



B\_I02

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<b>Education</b>	<ul style="list-style-type: none"> <li>● Ph.D. from IITB-Monash Research Academy (A joint research collaboration between Indian Institute of Technology Bombay, India and Monash University, Australia)</li> <li>● Master of Science in Physics from Pondicherry Central University, Pondicherry, India</li> </ul>
<b>Experience</b>	<ul style="list-style-type: none"> <li>● Postdoctoral Research Fellow, Faculty of Engineering, Monash University, Australia from Jan 2021.</li> <li>● Ph.D. Researcher, IIT Bombay, India &amp; Monash University, Australia, 2016-2020.</li> <li>● Junior Research Fellow, Department of Physics, Pondicherry Central University, India, 2013-2015.</li> </ul>
<b>Honors and Awards</b>	<ul style="list-style-type: none"> <li>● IIT Bombay, India &amp; Monash University, Australia Graduate Fellowship, 2016-2020.</li> <li>● Tata Chemicals Best Journal Paper Award by the IITB-Monash Research Academy for the year 2019-2020.</li> <li>● Thermo Fisher Scientific Best Collaborations award by the IITB-Monash Research Academy for the year 2018–2019.</li> </ul>

B\_I02

## Probing the Li<sup>+</sup>/Na<sup>+</sup> Storage Mechanism of 2D Transition Metal Dichalcogenides Using Synchrotron-Based X-ray Techniques

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### Abstract


Transition metal dichalcogenides (MX<sub>2</sub>, M = Mo or W and X = S, Se or Te) recently gained research attention as electrode materials for rechargeable lithium/sodium-ion batteries. These materials are promising candidates to realize the demands for superior rate performance, long cycle life, and higher power and energy density requirements. So far, the unclear structural and electrochemical reaction mechanisms are the major challenges for implementing these materials as potential electrodes. As a part of this objective, we have studied a new class of bulk semiconducting transition metal dichalcogenides, specifically, the 2D layered structure of molybdenum ditelluride (MoTe<sub>2</sub>). MoTe<sub>2</sub>'s relatively high interlayer spacing of about 0.70 nm (graphite (0.335 nm) and MoS<sub>2</sub> (0.615 nm)) and its higher electronic conductivity make it an efficient anode material for both lithium/sodium-ion batteries. We have explored the lithium/sodium storage mechanism in the 2H phase of MoTe<sub>2</sub> using Synchrotron-based experimental techniques alongside theoretical studies.

**Keywords:** Transition metal dichalcogenides, Molybdenum ditellurides, Anode materials, Lithium/sodium-storage mechanisms, Synchrotron-based in situ/ex-situ experimental techniques

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B\_I03

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<b>Education</b>	<ul style="list-style-type: none"> <li>● <b>Doctor of Philosophy (Ph. D.)</b> (2013-2018), Materials Research Centre, Indian Institute of Science (IISc), Bangalore, India.</li> <li>● <b>Master of Science (M. Sc.)</b> (2010-2012), School of Physical Sciences, Pondicherry University, Puducherry, Tamilnadu, India</li> <li>● <b>Bachelor of Science (B. Sc.)</b> (2007-2010), Department of Physics Ravenshaw University, Cuttack, Odisha, India.</li> </ul>
<b>Experience</b>	<ul style="list-style-type: none"> <li>● Postdoctoral Researcher at Yamada-Okubo laboratory, Chemical System Engineering, The University of Tokyo, Japan.(2019 Jan-present)</li> <li>● Research Associate at Materials Research Centre, Indian Institute of Science</li> <li>● Project Intern at Computational Chemistry Unit, Shell Technology Centre Bangalore, Karnataka, India. (2018 Jul- 2018 Dec)</li> </ul>
<b>Honors and Awards</b>	<ul style="list-style-type: none"> <li>● JSPS Post-doctoral Fellow Awarding Body: Japan Society for the Promotion of Science Description: A highly competitive international fellowship with the purpose to award excellent young researchers, (2020)</li> <li>● IUCr Young Scientists Award Awarding Body: International Union of Crystallography (IUCr), England. Description: Awarded to young scientists worldwide involved in crystallography research. (2019)</li> <li>● Sudborough Medal Awarding Body: Material Research Centre, Indian Institute of Science Bengaluru, India. Description: Awarded to best thesis award from Material Research Centre of the academic year (2019)</li> <li>● MRS-S Graduate Student Award -2017 Awarding Body: Materials Research Society of Singapore (MRS-S),</li> </ul>

	<p>Singapore. Description: Awarded to 5 students worldwide involved in materials science (2017)</p> <ul style="list-style-type: none"><li>● ECS Herbert H. Uhlig Summer Fellowship -2017 Awarding Body: The Electrochemical Society (ECS), USA. Description: Awarded to 4 students worldwide involved in electrochemical science. (2017)</li><li>● Ludo Frevel Crystallography Scholarship Award -2017 Awarding Body: International Centre for Diffraction Data (ICDD), USA. Description: Awarded to 10 Ph.D. students worldwide involved in crystallography research. (2017)</li></ul>
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B\_I03

## Insights into Stabilization of $\alpha$ - $\text{Na}_2\text{Fe}(\text{SO}_4)_2$ and Structure, Polymorphism and Electrochemistry Thereof

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### Abstract


To enhance the safety, cost, and energy density of new generation Na-ion batteries, significant research efforts have been devoted to the search for new positive electrode materials or optimisation of promising materials that exhibit high redox potentials and are composed of low-cost and environmentally benign earth-abundant elements. Among various reported positive electrode materials, sulfate chemistry has yielded promising results for iron-based polyanionic materials using the  $\text{Fe}^{\text{III+}}/\text{Fe}^{\text{II+}}$  redox couple invoking the highly electronegative attributes of sulfates via inductive effect. Additionally, sulfur and sulfate-based compounds are very economic, being the by-products of fuel combustion, coal power plants and oil/petrochemical industries. Hence, Na-Fe-S-O quaternary system renders promising scope to design sustainable high-voltage cathodes for sodium-ion batteries, including the discovery of monoclinic alluaudites  $\text{Na}_2\text{Fe}_2(\text{SO}_4)_3$  phase with the highest ever  $\text{Fe}^{3+}/\text{Fe}^{2+}$  redox potential at 3.8 V (vs. Na).<sup>[1, 2]</sup> In present work, we thoroughly investigated another promising cathode  $\alpha$ - $\text{Na}_2\text{Fe}(\text{SO}_4)_2$  of Na-Fe-S-O quaternary sulphates. Although the titled compound has previously been studied, there are no successful synthesis reported so far, thus referring the same as highly metastable phase.<sup>[3]</sup> With an insight from gravimetric analysis and controlled Pechini based aqueous synthesis route we successfully stabilised the  $\alpha$ - $\text{Na}_2\text{Fe}(\text{SO}_4)_2$ . The as-synthesized material delivers a decent reversible discharge capacity approaching 90 mAh/g, involving  $\text{Fe}^{3+}/\text{Fe}^{2+}$  redox activity centered at 3.5 V. Further, we report the ball-milling synthesis and electrochemical properties of its alluaudite polymorph of  $\text{Na}_2\text{Fe}(\text{SO}_4)_2$ , with 3.6 redox activity (vs. Na) and an overall sustained capacity of about 90 mAh/g. Using similar synthesis conditions, the cobalt-, manganese, and nickel-based Na-Fe-S-O analogues have also been studied. Overall, our results will demonstrate that polymorphism can play a crucial role in the search for new battery electrode materials and emphasize the need to understand and master synthetic control. A detailed study on the Na-M-S-O quaternary systems showing phase transformation, compositional and structural flexibility relating to their electrochemical performances has been the focus of this investigation.

**Keywords:** Cathode, Sodium-ion battery, alluaudites

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B\_I04

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B\_I04

## Environmental energy harvesting based on nanogenerator

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### Abstract


With the fast development of Internet of Things (IoT), the energy supply for all the electronics and sensors has become a critical challenge. The energy harvesting from the environment has a great potential to demand energy due to its easy fabrication and operation. In this talk, we first present next-generation solar cells, which were fabricated with different counter electrodes fabricated by dry plasma reduction method. Note that the dry plasma reduction can work under atmospheric pressure, low temperature (70oC), and short reduction time (15 min). Then we concentrate on advances in the recent development of nanogenerators based on solar to water evaporation-induced electricity generation systems for possible application in the IoT, resistive switching memory, supports big data and in the future of the generated electricity as power sources for some small electronic devices like a liquid crystal display, a blue light-emitting diode, an electric fan, and light-emitting diodes; for energy storage such as a capacitor, for electrochemical deposition and electrochemical cells. Lastly, future opportunities and difficulties to develop nanogenerator for environment energy harvesting.

**Keywords:** dry plasma reduction; nanogenerator; water evaporation-induced electricity; solar to steam; energy harvesting.

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B\_I05

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<b>Honors and Awards</b>	<ul style="list-style-type: none"> <li>● Completed seven Sponsored projects by DST, CSIR, UGC, BRNS and TEQIP</li> <li>● Young Scientist Award by DST in 2014</li> <li>● “National Doctoral Fellowship” offered by AICTE India for pursuing Ph.D. at IIT Roorkee</li> <li>● Awarded 325 USD for my publication in Progress in Polymer Science</li> <li>● Qualified <b>National Eligible Test for LECTURESHIP</b> conducted by <b>CSIR-UGC</b></li> <li>● Qualified All India Graduate Aptitude Test in Engineering (<b>GATE</b>)</li> <li>● Best Oral presentation at International Conference APCBEES Taipei Taiwan in Nov 2016</li> </ul>

B\_I05

## Development of Paper-Based Flexible Supercapacitor Fabricated Using Polypyrrole

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### Abstract


Paper-based supercapacitors have attracted more attention for their high electrochemical performance. However, most of them adopt sandwiched structure. In the present investigation, a simple approach has been followed for fabrication of paper-based flexible symmetrical supercapacitor, an energy saving device with composite functional material of nickel nanoparticles (Ni NPs) and polypyrrole (PPy). PPy has been chosen owing to its facile synthetic route and low cost. Ni@PPy nanocomposite is synthesized through two-step process involving the growth of Ni NPs followed by pyrrole polymerization on the paper substrate. The paper-based supercapacitor fabricated with Ni@PPy has shown electrical conductivity of  $105 \text{ Scm}^{-1}$ . The paper-based flexible supercapacitor device configured with Ni@PPy/electrolyte/Ni@PPy is evaluated for its electrochemical performance which showed a good specific capacitance of  $544 \text{ Fg}^{-1}$  at  $1 \text{ Ag}^{-1}$ . The better specific energy of  $48 \text{ Whkg}^{-1}$ , specific power of  $400 \text{ Wkg}^{-1}$ , good cycling stability (68.3% capacitance retention after 3000 cycles at  $5 \text{ Ag}^{-1}$ ) are obtained for paper-based flexible supercapacitor compared to other reported polymer based nanocomposite materials. The paper-based supercapacitor is highly efficient, portable and flexible for variety of electronic applications.

**Keywords:** Paper-based supercapacitor, Energy storage, Nickel nanoparticles, Polypyrrole, Nanocomposites

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B\_I06

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<b>Experience</b>	<ul style="list-style-type: none"> <li>● CNRS Postdoctoral Fellow, Universite de Picardie Jules Verne, France (2009-2010)</li> <li>● JSPS Postdoctoral Fellow, The University of Tokyo, Japan (2010-2013)</li> <li>● Assistant Professor, Indian Institute of Science, Bangalore, India (2013-2019)</li> <li>● Associate Professor, Indian Institute of Science, Bangalore, India (2019-present)</li> </ul>
<b>Honors and Awards</b>	<ul style="list-style-type: none"> <li>● Humboldt Research Fellowship for Experienced Researchers, Alexander von Humboldt Foundation, Germany. (2021)</li> <li>● Emerging Investigators of Journal of Materials Chemistry, Royal Society of Chemistry (RSC), UK. (2019)</li> <li>● Ross Coffin Purdy Award, The American Ceramic Society (ACerS), USA. (2016)</li> <li>● Energy Technology Division S. Srinivasan Young Investigator Award, The Electrochemical Society (ECS), USA. (2016)</li> <li>● ISE Prize for Applied Electrochemistry, International Society of Electrochemistry (ISE), Switzerland. (2015)</li> <li>● JSPS Postdoctoral Fellowship, Japan Society for the Promotion of Science (JSPS), Japan. (2010)</li> </ul>

	<ul style="list-style-type: none"><li>● H.H. Dow Student Achievement Award, The Electrochemical Society (ECS), USA. (2008)</li><li>● C.G. Fink Summer Fellowship, The Electrochemical Society (ECS), USA. (2007)</li><li>● Shell Centenary Chevening Fellowship, The British Council, UK. (2003)</li></ul>
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B\_I06

## Perovskite lead-based anodes for secondary batteries

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### Abstract

In the quest to find new anode materials, various insertion, conversion and alloying based compounds have been reported. Here, putting perovskite frameworks on anvil, lead-based perovskites ( $\text{PbTiO}_3$  and  $\text{PbZrO}_3$ ) are introduced as novel anode materials for non-aqueous M-ion rechargeable batteries ( $M = \text{Li}, \text{Na}, \text{K}$ ). These compounds were scalably prepared by conventional solid-state and combustion routes. Charge storage in these perovskites involves a standard conversion ( $\text{Pb}^{\text{II}} \rightarrow \text{Pb}^0$ ) followed by reversible Li-Pb/Na-Pb/K-Pb (de)alloying reaction. The oxide matrix ( $\text{M}_2\text{O}$ ,  $\text{TiO}_2$  etc.) phase is crucial for reversibility of Pb alloying reaction, as pristine PbO fails fast. The conversion-alloying reaction mechanism has been verified by ex situ electron microscopy (TEM) study.  $\text{PbTiO}_3$  delivered 410 mAh/g capacity in the first charge (vs.  $\text{Li}/\text{Li}^+$ ,  $\text{Na}/\text{Na}^+$ ), while around 180 mAh/g capacity (vs.  $\text{K}/\text{K}^+$ ). Particularly,  $\text{PbTiO}_3$  forms a robust anode for sodium-ion batteries with maximum charge extracted under low voltage (below 0.8 V vs.  $\text{Na}/\text{Na}^+$ , 275 mAh/g). Similar electrochemical activity was also noticed for other perovskites like  $\text{PbZrO}_3$  that confirms Pb-based (simple and mixed) perovskites can form a potential class of battery anode materials.

**Keywords:** Battery; Anode materials; Perovskite;  $\text{PbTiO}_3$

B\_I07

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<b>Experience</b>	<ul style="list-style-type: none"> <li>● 2015-, Lecturer, Le Quy Don Technical University, Vietnam</li> <li>● 2012-2014, Specially-appointed Assistant Professor, Toyohashi University of Technology, Japan</li> <li>● 2008-2011, Research Assistant, Japan Advanced Institute of Science and Technology, Japan</li> <li>● 2002-2008, Instructor, Le Quy Don Technical University, Vietnam</li> </ul>
<b>Honors and Awards</b>	



B\_I07

## Graphene-MnFe<sub>2</sub>O<sub>4</sub>-polypyrrole ternary hybrids with synergistic effect for supercapacitor electrode

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### Abstract


Hybridization of dissimilar materials is a promising solution to improve desired properties in various applications. Herein, we chemically grew a conductive polymer (polypyrrole, PPy) on graphene-supported manganese ferrite microspheres (MG, ~344 nm in size) to form PPy/MG hybrids at various PPy contents (20, 33.3, and 42.9 wt%). PPy, MG binary, and PPy/MG ternary hybrids were comprehensively characterized to correlate their structure, morphology, and properties. Electrochemical measurements revealed a significantly enhancement of capacitive performances of PPy/MG as comparison to those of each component. Consequently, the combination of PPy and MG resulted in maximum specific capacitance of 147.2 F/g at scan rate of 10 mV/s or 66.1 F/g at current density of 0.5 A/g. These synergistic and cooperative effects are attributed to reduced diffusion resistance in the PPy/MG hybrids. This work thus suggests an efficient strategy to develop high-performance material for supercapacitor electrode [1].

**Keywords:** Graphene oxide, MnFe<sub>2</sub>O<sub>4</sub>, Polypyrrole, Ternary hybrids, Supercapacitor, Synergistic effect

### References

[1] TV Thu, *Electrochim. Acta* 314, 151-160 (2019).

B\_I08

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<b>Honors and Awards</b>	<ul style="list-style-type: none"> <li>● Qualified all India GATE 2013 (among the top 7.3%).</li> <li>● <b>Junior Research Fellowship</b> from Ministry of Human Resource, Govt. of India (July 2013-June 2015).</li> <li>● <b>Senior Research Fellowship</b> from Ministry of Human Resource, Govt. of India (June 2015-October 2018).</li> <li>● <b>SPIE International Travel support</b> to attend SPIE optics and Photonics conference Aug 28 – Sep 1, 2016 at San Diego, California, USA.</li> </ul>

B\_I08

### Three Dimensional NiO Nanonetwork Electrode for Efficient Ultra-fast Electrochemical Energy Storage Application

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#### Abstract

Electrochemical capacitors have achieved prodigious attention among energy storage devices due to their simple and efficient storage mechanism, moderate specific energy and power densities which bridge the gap between Li-ion batteries and physical capacitors. The performance of active material plays a foremost role in the energy storage mechanism of such storage devices. Here, we have developed a porous Nickel oxide (NiO) nest-like particle with a large surface area and used as cathode material for supercapacitor application. The porous NiO electrode exhibits an excellent electrochemical performance with a specific capacity of 422 C g<sup>-1</sup> at 1 A g<sup>-1</sup> specific current. Moreover, the NiO//AC asymmetric device exhibited higher specific energy of 25 Wh kg<sup>-1</sup> at a specific power of 1280 W kg<sup>-1</sup> and could maintain more than 50% of specific energy at an extra-high specific power of 19.2 kW kg<sup>-1</sup>. Surprisingly, the device exhibits an ultra-fast power delivery performance with a considerably lower response time (13 ms). The porous NiO nanonetwork-based electrode manifests a great potential to be an ultra-fast efficient next-generation electrode candidate for electrochemical energy storage devices.

**Keywords:** Nickel Oxide, Energy storage, Supercapacitor, Battery-type.

#### References

- [1] Conway, B.E., 2013. Electrochemical supercapacitors: scientific fundamentals and technological applications. Springer Science & Business Media.

B\_I09

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<b>Honors and Awards</b>	

B\_I09

## High-capacity layered oxide cathode materials for rechargeable Li-ion batteries

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### Abstract


Owing to the increasing energy demand, depletion of fossil fuels and environmental pollution, there is growing interest on renewable energy storage and conversion. Electrochemical energy storage devices such as batteries play an important role in the renewable energy storage, which can be used on demand. Among various battery technologies, rechargeable Li-ion batteries possess high energy density and long cycle-life and hence dominating as the power source for the portable electronic devices such as smartphones, laptops etc. The 2019 Nobel Prize in Chemistry was awarded to three eminent scientists, namely, Prof. Goodenough, Whittingham and Yoshino for the development of Li-ion batteries that has created a rechargeable world. These Li-ion batteries are going to be implemented soon to drive the electric vehicles. However, their energy density is limited by the specific capacity as well as the potential of electrode materials, especially that of cathode materials. There are three types of cathode materials, i.e., layered oxides, spinel oxides and polyanionic compounds, already explored till to date. Among them, layered oxides are known to exhibit high specific capacities while spinels such as  $\text{LiMn}_2\text{O}_4$  and  $\text{LiNi}_{0.5}\text{Mn}_{1.5}\text{O}_4$  are known to exhibit high voltage, but low specific capacity.

Commercialized cathode materials such as  $\text{LiCoO}_2$ ,  $\text{LiNi}_{1/3}\text{Mn}_{1/3}\text{Co}_{1/3}\text{O}_2$  and  $\text{LiMn}_2\text{O}_4$ , etc., can provide specific capacities  $\leq 170 \text{ mAh g}^{-1}$ . However, the energy density of Li-ion batteries should be increased in order to make the related applications more versatile. Layered Li and Mn-rich oxide cathodes with  $x\text{Li}[\text{Li}_{1/3}\text{Mn}_{2/3}]\text{O}_2 \cdot (1-x)\text{LiMO}_2$  (M=Ni, Mn, Co) are shown to exhibit capacities  $\geq 250 \text{ mAh g}^{-1}$ . However, they suffer from capacity fading and average discharge voltage decay on cycling, leading to decrease in the energy density. Hence it is essential to improve the performance of these cathode materials by adopting various approaches such as fine tuning the composition and using additives to the electrolyte, which I would be reflecting in this presentation.

**Keywords:** Li-ion battery, Li and Mn-rich, high-capacity cathodes

## E. Energy efficiency technologies and applications

E\_I01

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<b>Honors and Awards</b>	
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E\_I01

## Recent Progress on Gallium Oxide Ceramic Materials and Thin Films for High-efficiency and Energy-saving Applications

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### Abstract

Gallium oxide (Ga<sub>2</sub>O<sub>3</sub>) have been considered as the next generation and the most promising semiconductor material for the applications of high-efficiency and energy-saving power electronics [1-3]. Among various semiconductor materials and devices, Si-based technology plays critical role in the early-stage electronic industry, but followed by the concerned subjects of novel requirements and the related applications in the high-efficiency and high-performance devices and systems for energy-saving issues become necessary. Under this background, novel materials such as SiC and GaN having unique properties are used to fabricate high-performance devices for the development of energy-saving systems. However, the bandgap values of SiC/ GaN are usually greater than 3.3–3.4 eV, and will suffer different technical challenges in manufacturing.

Although gallium oxide (Ga<sub>2</sub>O<sub>3</sub>) is by no means a novel material, the discovery of Ga<sub>2</sub>O<sub>3</sub> semiconductor material, i.e. the fourth generation semiconductor, has recently attracted great attention, for device design engineers, due to some of unique material features and substrate availability, which is consistent with the requirements of applications in the field of energy-saving and green electricity. There are five kinds of polymorphic phases with  $\alpha$ ,  $\beta$ ,  $\gamma$ ,  $\delta$ , and  $\epsilon$  in gallium oxide, since the monoclinic  $\beta$ -Ga<sub>2</sub>O<sub>3</sub> is the most explored crystal structure due to its ease of heteroepitaxial / homoepitaxial growth, its thermal stability, its incredibly large bandgap of 4.5–4.9 eV, which lead to be the most readily available.

In this article, we focus on the Ga<sub>2</sub>O<sub>3</sub> semiconductor material, the related material properties of bulk/thin film, accessible process technologies and physical characteristics of basic devices are reviewed and demonstrated.


**Keywords:** Gallium oxide, Semiconductor, Power devices, Crystal growth, Thin film

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E\_I02

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E\_I02

## Robust tristate reversible electrochemical mirror electrochromic devices

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### Abstract

Electrochromics, which offer dynamic control of lighting and solar heat, are progressively being installed in architectural buildings, aircraft, and automobiles. Such aesthetic glazing technology improves the energy efficiency by managing the external solar irradiation into buildings, which enables lighting, heating, ventilation and air-conditioning (HVAC) energy savings when installed as the smart glass.

Reversible electrochemical mirror (REM) electrochromic devices with merits of various optical states (clear, colored, and mirror states), facile device assembly, and cost effectiveness are attractive alternatives to conventional electrochromic devices. Current REM works are dominated by Ag metal, which is highly costly, poor cycling stability in the reflectance mode, and slower switching speed. By judiciously selecting the electrolyte components and understanding the electrochemistry of Cu, REM can be realized, which functions based on the mechanism of Cu electrodeposition and dissolution. As an electrochemically active material, Cu can be electrochemically tuned to achieve different redox states with controlled electrical bias.

The current bottleneck in REM is the poor durability in the reflectance mode. With the incorporation of an alloying element, it could assist in the electrochemical deposition and dissolution of Cu and hence, promote reversibility. From the kinetics study, the electrochemical deposition of CuSn film is relatively fast. Sn serves to provide a nucleation layer during electrodeposition as validated using Johnson–Mehl–Avrami–Kolmogorov (JMAK) analysis. Furthermore, a hybridization approach, with its well-tailored electrolyte combination and optimization, has been designed for development of high-performance and safe REM electrolyte. The established hybrid electrolyte delivers superior electrochemical behavior, stability, faster coloration time, and the ability to tailor the redox behavior of Cu in addition to the energy storage capability.

Our investigations on Cu-based REMs have shown promising outcomes for electrochromic, thermal control, and energy storage applications. These tunable mirrors are also highly attractive for dynamic displays, privacy glass, and camouflage applications.


**Keywords:** Reversible electrochemical mirror devices, electrochromics, polymer electrolytes, smart windows, and energy storage.

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E\_I03

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E\_I03

## Nanofiber for triboelectric nanogenerator

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### Abstract


Triboelectric nanogenerator (TENG) is an energy harvesting device which can convert the dynamic mechanical energy into electricity by a conjunction of triboelectric effect and electrostatic induction. In this study, core-shell nanofibers of PDMS ion gel /PVDF-HFP were successfully prepared by incorporating cross-linking agent during electrospinning. The electrospun nanofiber mats were used to fabricate pressure sensors to detect the static and dynamic pressures by harnessing the capacitance changes and triboelectric effects judiciously. The core-shell PDMS ion gel/PVDF-HFP nanofiber sensor functions as a capacitive pressure sensor, which offers high sensitivity of  $0.43 \text{ kPa}^{-1}$  in the low pressure ranges from 0.01 kPa to 1.5 kPa. The sensitivity, flexibility, and robustness of our capacitive pressure sensor allows it to be utilized as a wrist-based pulse wave detector for heart-rate monitoring. In addition, the core-shell PDMS ion gel/PVDF-HFP nanofiber mat made a good triboelectric based pressure sensor in the high pressure range with a linear pressure sensitivity  $0.068 \text{ V kPa}^{-1}$  from 100 kPa to 700 kPa, one of the best reported at present. The increase in inductive charges and the enhanced dielectric capacitance of the core-shell nanofiber layer compared to the pure PVDF-HFP nanofiber layer allows it to function in the triboelectric nanogenerator (TENG) with the maximum power density reaching  $0.9 \text{ W/m}^2$ , which is sufficient to light up several hundred light emitting diodes (LEDs) instantaneously.

**Keywords:** Triboelectric nanogenerator, Electrospun, Core-shell nanofiber, Tactile pressure sensor

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F. Fuel cells  
F\_I01

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F\_I01

## In-situ observation of spontaneous phase separation via spinodal decomposition in Sr-excess SrTiO<sub>3</sub> thin film

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### Abstract

Though no spinodal decomposition (SD) is reported in Sr-Ti-O phase diagram, we have found that the SD to bring out spontaneous superlattice is observed in epitaxial SrTiO<sub>3</sub> (ST) thin film having Sr-excess composition. This SD is observed for thin film deposited using PLD under magnetic field application<sup>1</sup>. However, the dynamics of SD was not clarified yet. To clarify this, we developed new PLD in which an electromagnet and RHEED is attached. The purpose of this work is to examine the evolution of surface structure of Sr-excess ST thin film as *in-situ* observation. The thin film was deposited on ST(001) single crystal at 700°C under O<sub>2</sub> pressure of 1.0x10<sup>-4</sup> torr under 1,200 G of magnetic field. The deposition under magnetic field was repeated with an interval. During the interval, magnetic field was not applied to avoid deflection of electron beam of RHEED. The RHEED observation was carried out during each the interval. Figure 1 shows RHEED images of ST thin film just after deposition and after aging for 3 min. The RHEED observation was carried out from two azimuth of ST[110] and [100]. This figure indicates that drastic change of RHEED pattern is observed. On the surface of ST thin film after aging, 30 nm-thick ST thin film was deposited and RHEED observation was carried out (Fig. 2). This figure depicts that the original RHEED pattern is observed. We repeated this cycle for 4 times, and found that the reproducibility is high. These results indicate that SD in epitaxial ST thin film occurs during deposition and aging. The driving force of the SD was considered to be excess energy at the surface of thin film by impingement of ions that are enhanced by application of magnetic field during deposition.

**Keywords:** Spinodal decomposition, Epitaxial, Thin film, RHEED

**References:** [1] N. Wakiya, *et al.*, *NPG Asia Mater.*, **8** (2016) e279.

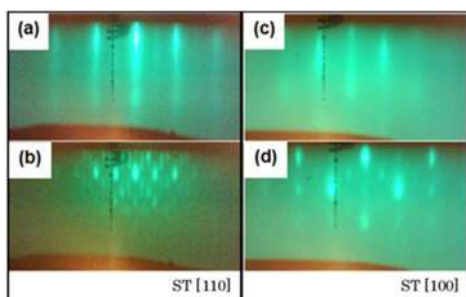


Fig. 1 RHEED images of ST thin film (a) (c) just after deposition and (b) (d) after aging for 3 min

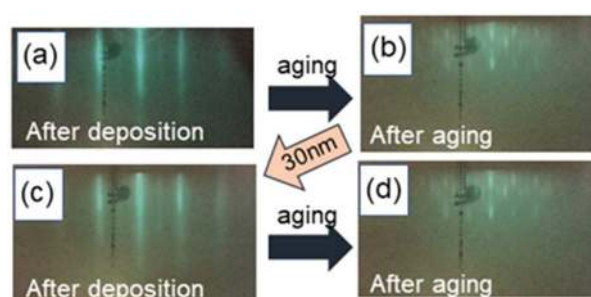



Fig. 2 RHEED images of ST thin film in the film formation process (a)(c) just after deposition of 30 nm-thick ST thin film (b) (d) just after aging

F\_I02

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F\_I02

## The Role of Self-exsolved Heterogeneous Composite Nanoparticles towards Highly Active Fuel Electrode for CO<sub>2</sub>/H<sub>2</sub>O Co-electrolysis

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### Abstract

Effective approaches to reduce, manage and even efficiently utilize CO<sub>2</sub> emission are desperately required to mitigate a rapid increasing concentration of effluent greenhouse gas emission. Solid oxide electrolysis cell (SOEC) is expected to be a highly efficient energy storage device, enabling effectively mitigating the increasing CO<sub>2</sub> concentration in the atmosphere, and even directly converting CO<sub>2</sub> into syngas, liquid fuel and hydrocarbon feedstocks through co-electrolysis of CO<sub>2</sub>-H<sub>2</sub>O. For practical application, further improvement of fuel electrode in activity and stability are required to increase electrolysis performance. Recently exsolution of metal nanoparticles from perovskite oxide is considered as a promising method to *in-situ* generate active interfaces for electrochemical reactions during operation, through a phase decomposition process driven by reduction, working temperature, electrical polarization, etc. [1, 2] This provides a new dimension in designing highly efficient electrode for the application of solid oxide fuel cell and electrolyzer devices. More recently we have also reported exsolution phenomenon in another material system, spinel oxide, more specifically in CuFe<sub>2</sub>O<sub>4</sub>, which enables providing promising electrochemical performance and stability in steam and CO<sub>2</sub>/H<sub>2</sub>O co-electrolysis operations. [3, 4]

In this study, an insight in the driving force regarding the evolution of Cu/Fe<sub>3</sub>O<sub>4</sub> composite nanoparticles exsolved from the CuFe<sub>2</sub>O<sub>4</sub> spinel oxide lattices will be investigated as operating in co-electrolysis with various gas compositions of CO<sub>2</sub>/H<sub>2</sub>O. Microstructural observation indicates that interesting 3-D growths of the exsolved composite nanoparticles were dynamically interacted with supplied CO<sub>2</sub>/H<sub>2</sub>O concentration after electrical polarization and thermal annealing processes. The corresponding chemical states and compositions of the CuFe<sub>2</sub>O<sub>4</sub> electrode surface would be also discussed. In addition, a series of control group experiments using CuO, Fe<sub>3</sub>O<sub>4</sub> and Cu-infiltrated Fe<sub>3</sub>O<sub>4</sub> as the fuel electrodes were investigated for comparison. The results confirm that the unique Cu/Fe<sub>3</sub>O<sub>4</sub> composite nanostructure exsolved from the CuFe<sub>2</sub>O<sub>4</sub> spinel matrix plays a crucial role and is catalytically active in the operation. Long-term measurements operated at relatively low and high applied current density (or working voltage, 1.3 - 1.6 V) for 150 h in each operation confirm the excellent electrochemical stability with remarkably steady generation of total CO-H<sub>2</sub> syngas products. Finally, a novel spinel-perovskite composite, designed by mixing this unique CuFe<sub>2</sub>O<sub>4</sub> having active self-exsolved nanostructures with La(Sr)Fe(Mn)O<sub>3</sub> perovskite, enabling a great enhancement in electrolysis current density will also be introduced.


**Keywords:** Exsolution, Spinel, Perovskite, Solid oxide electrolysis cell, Co-electrolysis

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F\_I03

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F\_I03

## Microstructures and Electrical Properties of BaCeZrYYbO<sub>3-δ</sub>/YSZ composites prepared by Solid-State Sintering for Sustainable Energy Application

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### Abstract

High temperature ionic conductors are widely applied to sustainable energy fields, such as solid oxide fuel cell (SOFC) or protonic ceramic fuel cell (PCFC), solid oxide electrolysis cell (SOEC), water-gas shifting reactors, etc. Among kinds of high temperature ionic conductive oxide materials, fluorite-structure oxygen-ion conducting oxides (ex. YSZ) and perovskite-structure proton conducting oxides (ex. BaZrO<sub>3-δ</sub>) are the most popular and widely developed by manufacturers and researchers. In this study, BaCeZrYYbO<sub>3-δ</sub> (BCZYYb)/YSZ composites were developed as a candidate of the electrolyte materials for the sustainable energy application. The composite of BCZYYb/YSZ were fabricated by a die-pressing process after solid-state reaction sintering. The samples were characterized, including the crystal phase of the as-prepared BCZYYb powders and composites by XRD method, the microstructures of composites by SEM, the densities of the composites by Archimedes' method, and the electrical properties by EIS and I-V methods. The results show the compact dual-phasic composites with BCZYYb and YSZ phases can be fabricated after sintered at 1500°C for 24h. The highest density of the composite is up to 99.98%T.D. The result of XRD shows that the composite is still consisted of a dual-phasic structure of BCZYYb and YSZ. The electrical analysis of the composites show an ionic conduction at high temperature. The conductivity of the dual-phase composites at 800°C is approximately  $1.12 \times 10^{-2} \text{ S} \cdot \text{cm}^{-1}$ . The activation energy of conductivity is about 0.633 eV.

**Keywords:** Composite, Microstructure, Electrical conductivity, Protonic ceramic fuel cell, Activation energy

F\_I04

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<b>Experience</b>	<ul style="list-style-type: none"><li>● Associate Professor at the Hong Kong University of Science and Technology (since 2017)</li></ul>
<b>Honors and Awards</b>	<ul style="list-style-type: none"><li>● Fellow of the Royal Society of Chemistry (2020)</li><li>● TIANHE Star Award from the National Supercomputer Center Guangzhou, China (2018)</li><li>● Teaching Excellence Appreciation Award, School of Engineering, HKUST (2014–15)</li></ul>

F\_I04

## High Performance Protonic Ceramic Fuel Cells

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### Abstract

Reversible protonic ceramic cells (RePCCs) are a promising energy storage and conversion device that can accelerate the global transition to renewable energy sources.[1] However, the commercialization of RePCCs is limited by several factors, including high cost, poor stability, and insufficient electrode activity towards fuel oxidization/generation and oxygen reduction/evolution reactions (ORR/OER).[2, 3] Herein, we introduce  $\text{Sr}_{0.9}\text{Ce}_{0.1}\text{Fe}_{0.8}\text{Ni}_{0.2}\text{O}_{3-\delta}$  (SCFN) perovskite-based nanocomposite and Ni-Fe alloy support as RePCCs air and fuel electrode, respectively, to address these issues. First, for air electrode, we rationally design and develop a SCFN nanocomposite, composed of tetragonal and Ruddlesden-Popper perovskite with surface-enriched  $\text{CeO}_2$  and NiO nanoparticles. Experiments and calculations suggest that RP phase promote hydration and proton transfer, while NiO and  $\text{CeO}_2$  nanoparticles facilitate  $\text{O}_2$  surface exchange and  $\text{O}^{2-}$  transfer from surface to major perovskite phases. Hence, SCFN nanocomposite possesses high  $\text{H}^+/\text{O}^{2-}/\text{e}^-$  triple conduction, thereby contributing to good ORR/OER activity.[4] Second, for fuel electrode, we further introduce a Ni-Fe metal-supporter, which possesses good mechanical strength and thermal compatibility with cermet-based electrodes/electrolytes, ensuring a facile cell fabrication and a robust durability. Calculations suggest that the interface of Ni-Fe support/fuel electrode and the diffusion of Fe towards the fuel electrode functional layer provide additional and more active sites for the hydrogen evolution reaction, further promoting  $\text{H}_2$  production. The as-fabricated RePCCs at 700 °C achieved an excellent peak power density of 586  $\text{mW cm}^{-2}$  and an electrolysis current of -428  $\text{mA cm}^{-2}$  (at 1.3 V). Furthermore, the cell was exceptionally stable, as evidenced by 930 h of fuel cell operation with ultra-low degradation ( $\sim 0.78\%$  /kh) and much better than an analogous anode-supported cell ( $\sim 17.78\%$  /kh).[4] In addition, the cell was stable during 50 h of reversible fuel cell/electrolysis cycling further proving the potential of this type of cell. These research works proposes a simple, new, highly active, and durable RePCC, thereby accelerating the commercialization possibilities of this technology.

**Keywords:** Reversible protonic ceramic cells, Nanocomposite, Metal-supporter, Energy storage and conversion

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## H. High performance materials under extreme conditions

H\_I01

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<b>Experience</b>	<ul style="list-style-type: none"> <li>● April, 1998 – February, 2001 Postdoctoral Researcher: Venture Business Laboratory, Nagoya University, Japan</li> <li>● March, 2001 – April, 2005 Assistant Professor: Department of Applied Science for Electronics and Materials, Interdisciplinary Graduate School of Engineering Sciences, Kyushu University, Japan</li> <li>● May, 2006 – March, 2007 Visiting Researcher: Department of Engineering, University of Cambridge, United Kingdom</li> <li>● May, 2005 - present Associate Professor: Department of Advanced Energy Science and Engineering (reorganized from Department of Applied Science for Electronics and Materials), Interdisciplinary Graduate School of Engineering Sciences, Kyushu University, Japan</li> </ul>
<b>Honors and Awards</b>	<ul style="list-style-type: none"> <li>● Guest Editor, IEEE Transactions on Plasma Science, 2013 –2023</li> <li>● The Excellent Paper Presentation Award of Institute of Electrical Engineering of Japan, 1994</li> <li>● The Ishii Academic Encouragement Award, 1998</li> <li>● Research Activities Award of Kyushu University, 2011 –2013</li> </ul>

H\_I01

## Plasma Deposition of High-Quality Cubic Boron Nitride Films for Applications to Ultrahard Coatings and Electronic Devices

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### Abstract

There are a variety of polytypes of boron nitride such as hexagonal, turbostratic, and amorphous in  $sp^2$ -bonded forms and cubic and wurtzite in  $sp^3$ -bonded forms, with similarities to carbon. Cubic boron nitride (c-BN) has a number of highly attractive properties comparable to diamond such as high hardness, large band gap, and high thermal conductivity. Among the potential advantages of c-BN over diamond is that it is chemically inert against ferrous materials and resistant to oxidation even at high temperatures up to  $\sim 1000$  °C, and thus suitable for cutting iron-containing materials and semiconductors for power electronics in high temperature condition.

c-BN can be deposited in form of films from vapor phase by various techniques such as plasma-enhanced chemical vapor deposition (CVD) and sputtering. All these techniques usually require strong ion bombardment with kinetic energies above 50 eV for c-BN formation. The strong ion impact inevitably results in low film quality and poor adhesion to the substrate. Thus, the deposition technique of high-quality c-BN films is highly desired for industrial applications.

In our previous study, high-quality c-BN films were deposited under low-energy ion bombardment (<40 eV) by plasma CVD using the chemistry of fluorine [1]. The mean ion energy for c-BN formation was reduced greatly, then the resulting films consisted of micron-sized grains with crystallographic morphology. In the present talk, firstly, the deposition mechanism of our c-BN films is explained in terms of ion impact and the chemistry of fluorine. Secondly, recent trial results of applications to ultrahard coatings and electronic devices are presented [2-4].

**Keywords:** Plasma CVD, Fluorine, Ion Energy, Semiconductor, Functional Coating

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H\_I02

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	<ul style="list-style-type: none"><li>● 2013 3rd ISHA Lifetime Achievement Award, International Solvothermal and Hydrothermal Association, Austin, Texas, USA</li><li>● 2017 Honorary Fellow, European Ceramic Soc. One of 8 first elected in 2017</li><li>● 2017 Distinguished Life-Member Award, American Ceramic Soc. One of 156 since 1931, 11th in Asia, 10th in Japan</li><li>● 2019 Marquis Who's Who 2019 Award</li></ul>
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H\_I02

## Continuous(Successive) Fabrication of Nano-Structured Ceramic Materials via Soft, Solution Processing without Firing

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### Abstract

Practical devices would be better to be fabricated via continuous and/or successive Processes. Presently, however, they have generally been fabricated artificially and/or industrially by so-called high-technology, where high temperature, high pressure, vacuum, molecule, atom, ion, plasma, etc. using expensive equipments thus they consumed huge amount of resources and energies thus exhausted huge amounts of wastes: materials, heats and entropy. The major reasons might be 1) The reactants should be nano-sized species, 2) high-energy reaction might be required, thus 3) They cost economically and environmentally. To save this tragedy, a) we must consider “Cascade use of Heats”, and b) “Low energy Production of advanced materials via solution-based technologies.” c) Continuous (Successive) Fabrication will be possible in solution process(es). Now, however, 3D-Printing with additive designed Powders have widely been studied, however, they are multistep butch systems with firing(s).


We proposed in 1995 an innovative concept and technology, “Soft Processing” or “Soft, Solution Processing,” which aims low energetic (=environmentally friendly) fabrication of shaped, sized, located, and oriented inorganic materials in/from solutions. When we have activated/stimulated interfacial reactions locally and/or moved the reaction point dynamically, we can get patterned ceramic films directly in solution without any vacuum, firing, masking nor etching. Direct Patterning of CdS, PbS and CaWO<sub>4</sub> on papers by Ink-Jet Reaction method, furthermore, we have succeeded to fabricate BaTiO<sub>3</sub> patterns on Ti by a laser beam scanning and carbon patterns on Si by plasma using a needle electrode scanning directly in solutions. Successes in TiO<sub>2</sub> and CeO<sub>2</sub> patterns by Ink-Jet Deposition, where nano-particles are nucleated and grown successively on the surface of substrate thus become dense even below 300 C could be prepared. Nano-structured films will be also talked<sup>1-3</sup>).

**Keywords:** Continuous, Nano-structured, Cceramics, Solution processing

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L. LED  
L\_I01

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L\_I01

## Nanoporous Silica Materials: A Versatile Supporting Material for the Development of 'Phosphor in Glass

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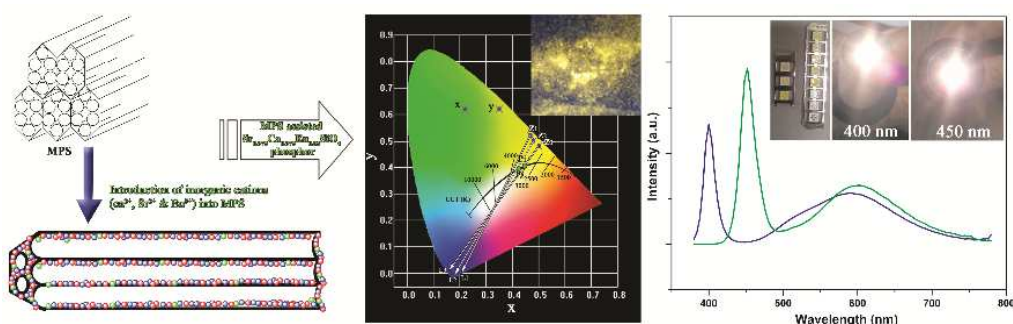
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### Abstract

Phosphor converted warm white LEDs draw a lot of attention due to its notable advantages including power consumption, compactness & environmentally benign nature and thus of more commercial value. The great challenge associated with the improvisation in performance of warm white LEDs can be achieved by protecting the phosphor from thermal and environmental effect. Our work concentrates on this aspect using an efficient nanoporous silica material. The silicate-based phosphor  $M_2SiO_4:Eu^{2+}$  ( $M = Ca/Ba/Sr$ ) is developed by using nanoporous silica materials as silica precursors.


The results confirmed the interesting features such as, good thermal stability of output colour, the shifting of emission wavelengths under the wide range of excitation from violet to deep blue (300 – 450 nm), mechanical stability, and so on. Although, the XRD patterns revealed the similar crystallinity for nanoporous assisted phosphors as well as conventionally developed phosphors, there was a significant difference in the morphology and luminescence behavior. In addition, the CIE color coordinates (on planckian locus), CCT (< 4000 K) & CRI (> 80) obtained for the nanoporous silica assisted  $M_2SiO_4:Eu^{2+}$  confirm that these nanoporous silica material can play a pivotal role in the demerits rectification of the commercial yellow phosphor, YAG:Ce.



**Keywords:** Nanoporous silica, Remote Phosphor, Phosphor in Glass, Solid-State Synthesis

## M. Materials and technologies for a low carbon, sustainable society

M\_I01

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<b>Honors and Awards</b>	



M\_I01

## Ferroelectric and pyroelectric property in antiferroelectric-based composites

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### Abstract


Pyroelectric materials have huge market in daily life applications and high pyroelectric performances near room temperature are highly desired. Here we report the room temperature (RT) ferroelectrics and near RT high pyroelectric performance in antiferroelectric based composite. For  $(1-x)\text{Pb}_{0.99}\text{Nb}_{0.02}[(\text{Zr}_{0.57}\text{Sn}_{0.43})_{0.937}\text{Ti}_{0.063}]_{0.98}\text{O}_3-x\text{ZnO}$  [(1-x)PNZST-xZnO] composite, robust RT ferroelectric and peak pyroelectric coefficient of  $1053.9 \times 10^{-4} \text{ C}\cdot\text{m}^{-2}\cdot\text{K}^{-1}$ , figure of merits of  $F_v = 1249.4 \times 10^{-2} \text{ m}^2\cdot\text{C}^{-1}$ ,  $F_d = 876.3 \times 10^{-5} \text{ Pa}^{-1/2}$ ,  $F_i = 832.7 \times 10^{-10} \text{ m}\cdot\text{V}^{-1}$  around  $39^\circ\text{C}$  was observed in the  $x = 0.1$  composite. The RT ferroelectric state is realized and stabilized due to ZnO-induced internal strain. The thermal-driven ferroelectric to antiferroelectric transition generates high pyroelectric performance. This work may provide some information for designing high performance ferroelectric/pyroelectric materials.

**Keywords:** Antiferroelectric composite, ferroelectric, pyroelectric

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M\_102

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<b>Honors and Awards</b>	<ul style="list-style-type: none"> <li>● Mar. 1997 Encouragement Award, The Surface Finishing Society of Japan</li> <li>● Aug. 1997 Young Researcher Award, International Union on Materials Research Society</li> <li>● Sep. 2000 Best Paper Award and Young Researcher Award, The 8th International Conference on Ferrite</li> <li>● Nov. 2001 Best Presentation Award, The Magnetics Society of Japan</li> <li>● Mar. 2004 Invention Medal, Teshima Memorial Award (Tokyo Tech.)</li> <li>● Apr. 2005 The Commendation for Science and Technology by the MEXT, Research Category</li> <li>● Feb. 2006 Research Award, Materials and Structures Laboratory, Tokyo Tech.</li> </ul>

M\_102

## “Spin-Spray Method” : A Novel Solution Process for Preparing Semiconductor Oxide Films with Low Environmental Load

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### Abstract

In this study, spin-spray method enabled to prepare semiconductor oxide films of ZnO, CuO and C<sub>2</sub>O at the temperature below 100°C through whole processes, and they were applied for the transparent conductive oxide material, humidity- and bending-sensors.

ZnO film with transparency was deposited by the spin-spray method at 90°C. The film resistivity decreased by three orders of magnitude, to  $4.43 \times 10^{-2} \Omega \text{ cm}$ , by Ultraviolet (UV) light irradiation for 60 min. TOF-SIMS depth profile and <sup>1</sup>H solid-state NMR spectroscopy analysis revealed that the as-deposited ZnO film before UV treatment contained a large amount of trapped water, and hydrogen donors including interstitial hydrogen in bond-centered sites ( $H_i$ ), substitutional hydrogen on the oxygen lattice site ( $H_O$ ) and three O–H bonds in a zinc vacancy ( $V_{Zn}-H_3$ ), were generated in the ZnO film after the treatment. UV irradiation of photocatalytic ZnO decomposed the trapped water to form H<sup>+</sup> and OH<sup>-</sup> ions, which associated with the oxygen and zinc vacancies, resulting in the formation of thermodynamically stable hydrogen donors.

CuO nanosheet arrays were fabricated on flexible polyethylene terephthalate (PET) substrates via the spin-spray method. The surface nanostructures adhered strongly to the PET substrate were sufficiently flexible to be used as humidity sensors in a bent state. The CuO nanosheet arrays had excellent humidity-sensing performance as evidenced by the linear resistance behavior with high sensitivity up to 170% as well as short response and recovery times of 2.1 s and 2.8 s, respectively. This humidity sensor based on the nanosheets also exhibited excellent stability and durability against mechanical bending. Their sensitivity and response and recovery times were almost unchanged even after bending-relaxation cycles of 1000 times.


Cu<sub>2</sub>O film was prepared on flexible PET substrate for a bending sensor via the spin spray method. The Cu<sub>2</sub>O bending sensor responded to a wide range of bending with curvatures between 0 and 0.21 mm<sup>-1</sup>. The curve of the resistance variation in the perpendicular bending versus curvature can be divided into two linear parts, which are region I ( $0 < \kappa < 0.05 \text{ mm}^{-1}$ ) and II ( $0.05 < \kappa < 0.2 \text{ mm}^{-1}$ ) with the gauge factor (GF) of 5.88 and 18.2, respectively. The bending sensor responded to very small curvature changes, demonstrating the high-resolution bending performance. Besides, the sensor had fast response time ( $\sim 272 \text{ ms}$ ) between curvatures of 0.153 and 0.156 mm<sup>-1</sup>. All the results demonstrated that the flexible bending sensor based on the Cu<sub>2</sub>O film had a great potential as high-performance wearable electronic devices for health-care monitoring<sup>[2]</sup>.

**Keywords:** Low environmental load, Process temperature below 100°C, Iron oxide films, Zinc oxide films, Copper oxide films

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P. Photovoltaic / Solar power  
P\_I01

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<b>Experience</b>	<ul style="list-style-type: none"> <li>● Dr. Ngoc Duy Pham completed his PhD in Photovoltaics at Queensland University of Technology in Oct. 2019 and worked in the same institute as a Research Associate till Sep. 2020. He joined Macquarie University Sep. 2020 as a postdoctoral research fellow. His research has focused on development of efficient and stable metal halide perovskite-based third-generation photovoltaics. More recently, he has started working with colleagues at Macquarie University to develop highly efficient multijunction solar cells based on metal halide perovskites.</li> </ul>
<b>Honors and Awards</b>	<ul style="list-style-type: none"> <li>● High-degree-research High-achievement Award (Queensland University of Technology)</li> <li>● ACS Applied Energy Materials Best Poster Award (IPS-22)</li> <li>● QUT Postgraduate Research Award (Queensland University of Technology)</li> </ul>

P\_I01

## Novel p-dopant for Spiro-OMeTAD-based Hole-Transporting Materials towards Efficient and Stable Perovskite Solar Cells

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### Abstract


Perovskite solar cell (PSC) is an emerging photovoltaic technology which offers prospects for efficient energy harvesting from sunlight and cost-effective device fabrication.<sup>1</sup> This technology has demonstrated rapid progress in the last ten years reaching a power conversion efficiency of over 25%, on par with silicon cells. Today, most efficient PSCs are made based on Lithium bis(trifluoromethanesulfonyl)imide (Li-TFSI)-doped 2,2',7,7'-Tetrakis[N,N-di(4-methoxyphenyl)amino]-9,9'-spirobifluorene (Spiro-OMeTAD)-based hole-transporting material.<sup>2, 3</sup> However, the rapid aggregation and hydration of Li-TFSI upon moisture exposure has been linked to the instability of PSCs.<sup>4, 5</sup> Here we show that this issue can be tackled by replacing the Li-TFSI with the more hydrophobic alkaline-earth bis(trifluoromethanesulfonyl)imide additives (AEBAs), namely Mg-TFSI<sub>2</sub> and Ca-TFSI<sub>2</sub> owing to the formation of more robust coordination complexes between the TFSI-salts and 4-tert-Butylpyridine. Intriguingly, the presence of AEBAs also improve hole mobilities in Spiro-OMeTAD and energy alignment with adjacent perovskite layer, which ultimately contribute to the favorable carrier extraction at the perovskite/Spiro-OMeTAD interface. Consequently, our PSCs stabilized by the AEBAs yield a champion efficiency of 20.04%, increased from 18.08% for PSCs made with Li-TFSI, while device stability is significantly enhanced.<sup>6, 7</sup>

**Keywords:** Perovskite solar cell, Alkaline-earth bis(trifluoromethanesulfonyl)imide, High-efficiency, Stability.

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P\_I02

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<b>Honors and Awards</b>	<ul style="list-style-type: none"> <li>● Endeavour Postgraduate Scholarship by Australian Government, 2017-20</li> <li>● ISEM, UOW Postgraduate Merit Award, 2019</li> <li>● Pondicherry University Gold Medal for Outstanding Academic Performance, 2013</li> <li>● Indian Institute of Technology Bombay Research Internship Award, 2012-13</li> <li>● South Asia Foundation (SAF) Fellowship, 2011-13</li> </ul>

P\_I02

## Thermoelectric Performance of Nano-engineered Perovskite Oxide Materials: $\text{Sr}_{1-x}\text{La}_x\text{TiO}_3$ and $\text{Ba}_{1-x}\text{La}_x\text{TiO}_3$

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### Abstract

$\text{SrTiO}_3$  and  $\text{BaTiO}_3$  are promising thermoelectric materials specially for high temperature application. Intrinsically, these materials have very low electrical conductivity and high thermal conductivity. The electron doping in the materials was optimized by adding La in different atomic percentage and they were become *n*-type semiconducting material. Nanoscale pores were introduced into the bulk samples for further improvement of thermoelectric performance of  $\text{Sr}_{1-x}\text{La}_x\text{TiO}_3$  and  $\text{Ba}_{1-x}\text{La}_x\text{TiO}_3$ [1]. The powder samples with nanoscale pores were synthesized using the polymeric micelles self-assembly method. The commercially available Pluronic F127 surfactant was used as soft template for nano scale pores formation. Then the powder samples were rapidly solidified using the spark plasma sintering (SPS) technique to prepare bulk samples with nanostructured pores. The sintering conditions such as sintering temperature, pressure, holding time, heating and cooling rate were optimized to fabricate highly dense nano crystalline bulk samples[2].

The X-ray diffraction (XRD) peaks shifting and reduction in lattice parameter confirmed that A site of  $\text{ABO}_3$  crystal system of  $\text{SrTiO}_3$  and  $\text{BaTiO}_3$  were substituted by La atoms. Atomic resolution scanning transmission electron microscopy (STEM) images and energy dispersive X-ray spectrometry (EDS) results also showed that La was doped successfully into the lattice. The electrical conductivity of metal oxide materials was improved due to La doping and their showed *n*-type semiconducting behaviour. The Brunauer–Emmett–Teller (BET) analysis, scanning electron microscopy images and transmission electron microscopy (TEM) images revealed that the samples synthesized using the surfactant F127 have nanostructured pores. There was a large reduction in the lattice thermal conductivity in the F127-treated samples arises primarily from the nanoscale pores distribution which introduces anisotropic phonon scattering within the unique nanoarchitecture[3, 4]. It was also observed that the nanoscale pores in the samples significantly improved the Seebeck coefficient (thermopower). The change in phonon charge-carrier interaction and charge-carrier mobility may be responsible for improvement in the thermopower due to nano pores. Therefore, there was remarkable enhancement in the power factor and the figure of merit (*zT*) of La doped  $\text{SrTiO}_3$  and  $\text{BaTiO}_3$  samples with nanoscale pores.

**Keywords:** Perovskite Oxide, Nanoscale pores, Lattice thermal conductivity, Thermoelectric


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P\_I03

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<b>Experience</b>	<p>After completing my PhD, I undertook research as postdoc fellow in several institutions in Japan, Australia and UK before I joined Queensland University of Technology in 2010 starting as Vice-Chancellor senior research fellow. I was promoted to full professor in 2019 in the same university.</p>
<b>Honors and Awards</b>	<ul style="list-style-type: none"> <li>● Royal Society of Chemistry Highly Cited Author, 2020</li> <li>● Australian Research Council (ARC) College of Expert (2019-2022)</li> <li>● Solar Energy Journal Best Paper Award for 2016'' in the topic of Photovoltaics</li> <li>● Australian Research Council (ARC) Future Fellowship, 2012</li> <li>● Australian Research Council Australian Postdoc Fellow (industry), 2007</li> </ul>

P\_I03

## **Towards Cost-Effective, Stable and Greener Perovskite based Solar Cells and Light Emitting Diode**

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### **Abstract**

The past ten years have witnessed the skyrocketing progress of optoelectrical devices that use metal halides perovskite as key functional materials such as light absorber in solar cells and photoemitter in light emitting diodes (LEDs) etc. Within ten years, the energy conversion efficiency of perovskite solar cells (PSC) have increased from the initial 3.8% to current record efficiency over 25% achieved by solution processing. Meanwhile, perovskite based LEDs also has showed EQE above 23%. These breakthroughs have made perovskite based technologies potentially very competitive in the future market. Nevertheless, currently critical issues such as unsatisfactory stability, toxicity of materials as well as use of precious metal in the state-of-art high efficiency perovskite solar cells (PSCs) are obstacles that need to be overcome urgently in order to make the perovskite based technologies commercially attractive. In my talk, I will present our recent study of using dopants to tune and improve physicochemical properties of perovskite films and hole transport materials to enhance the stability and performance of PSCs. I will also show our strategies to enhance stability of PSCs while reducing material costs by using carbon materials. Finally I will discuss the issue related with using hazardous solvents in perovskite production and the strategy of using green solvent system for synthesis of perovskite films and nanocrystals for applications in solar cells and LEDs.

## Oral Speaker

Paper ID	Corresponding Author	All Authors	Title	Institution	Department
B_001	Debabrata Mohanty	Debabrata Mohanty, Shu-Yu Chen, I-Ming Hung	Effect of different LiTFSI content on Composite Solid Electrolyte with NASICON-type LATP and PVDF-HFP for Solid-State Lithium-ion Batteries	Yuan Ze University	Department of chemical engineering and materials science
B_002	Jeng-Kuei Chang	Rahmandhika Firdausza Hary Hernandha, Purna Chandra Rath, Bharath Umesh, Jagabandhu Patra, Jeng-Kuei Chang	SiOxCarbon Multilayer Coating on Silicon Nanoparticles Synthesized via Supercritical CO <sub>2</sub> Fluid for Li-ion Battery Anodes	National Yang Ming Chiao Tung University	Department of Materials Science and Engineering
B_003	Cheng-Chia Chen	Cheng-Chia Chen, Sutarsis, Jeng-Kuei Chang	Roles of Binders on Self-Discharge for Porous Carbon Supercapacitor Electrodes	Nation Yang Ming Chiao Tung University	Material Science and Engineering
B_004	Alex Chinghuan Lee	Alex Chinghuan Lee, Shih-kang Lin, Jui-po Chen, Kaviarasan Govindarajan	Structure evolution and operando analysis methods of fast-charging lithium titanate materials developed in HiGEM research center	National Cheng Kung University	Hierarchical Green-energy Materials (HiGEM) Research Center
B_005	Tzu Husan Chiang	Yu-Si Chen, Tzu Husan Chiang	Fe-Cu-Schiff base complexes as Electrocatalysts for Zn-Air Batteries	National United University	Materials and Chemical Engineering
B_006	Ngoc Thanh Thuy Tran	Ngoc Thanh Thuy Tran	Insight into the degradation mechanism of the Ni-rich NMC cathode materials	National Cheng Kung University	Hierarchical Green Energy Materials (HiGEM) Research Center
E_001	Hsin-Yi Tiffany Chen	Chih-Heng Lee, Yi-Ting Lu, Chi-Chang Hu, Hsin-Yi Tiffany Chen	A DFT Study of the Effect of Degrees of Inversion on the Electronic Structure of Spinel NiCo <sub>2</sub> O <sub>4</sub>	National Tsing Hua University	Department of Engineering and System Science
E_002	Ying-Hao Chu	Pao-Wen Shao, Heng-Jui Liu, Yuanwei Sun, Mei Wu, Ren-Ci Peng, Meng Wang, Fei Xue, Xiaoxing Cheng, Lei Su, Hsiao-Wen Chen, Meng-Chin Lin, Qian Zhuang, Jiawei Huang, Yachin Ivry,	Flexo-phototronic Effect in Centro-symmetric BiVO <sub>4</sub> Epitaxial Films	National Yang Ming Chiao Tung University	Materials Science and engineering

		Hsiang-Lin Liu, Yu-Jung Lu, Shi Liu, Pu Yu, Long-Qing Chen, Peng Gao, Xiaoqing Pan, Yung-Jung Hsu, Jyh-Ming Wu, Yi-Chun Chen, and Ying-Hao Chu			
E_O03	Feng-Sheng Chao	Feng-Sheng Chao, Chin-Yi Chen	Supercapacitive Properties of Bi-doped ZnCo <sub>2</sub> O <sub>4</sub> Nanostructure Synthesized by In-situ Hydrothermal Method	Feng-Chia university	material science and engineering
E_O04	Deng-Li Ko	Deng-Li Ko, Ying-Hao Chu	High-stability transparent flexible energy storage based on PbZrO <sub>3</sub> / muscovite heterostructure	National Yang Ming Chiao Tung University	Department of Materials Science and Engineering
F_O01	Azam Khan	Azam Khan, Yi-Hung Wang, and I-Ming Hung	Study of BaCO <sub>3</sub> and Samarium-doped Ceria Carbonate Composite Electrolyte for Low-Temperature Solid Oxide Fuel Cells	Yuan Ze University	Department of chemical engineering and materials science
F_O02	Liangdong Fan	Zenghui Wang, Liang Dong Fan	High-performance in-situ Ni nanoparticle exsolved LSTN/LNSDC composites for low-temperature solid oxide fuel cells	Shenzhen University	College of Chemistry and Environmental Engineering
L_O01	Pei-Tzu Cheng	Pei-Tzu Cheng, Chen-Yu Wu, Horng-Yi Chang	Optical Properties of Europium doped Calcium Sulfide Prepared by Carbon	National Taiwan Ocean University	Marine Engineering
L_O02	Henni Setia Ningsih	Henni Setia Ningsih, Huang-Yu Hsuan and Shao-Ju Shih	Synthesis and characterization of Tb-doped Y <sub>4</sub> SiAlO <sub>8</sub> N powder by spray pyrolysis	National Taiwan University of Science and Technology	Department of Materials Science and Engineering
M_O01	Yu-Lin Kuo	Chia-Wei Huang, Yu-Lin Kuo, Henok Atile Kibret, Yao-Hsuan Tseng	Chemical Looping Gasification of Spent Coffee Ground Using Iron ore as Oxygen Carrier	National Taiwan University of Science and Technology	Department of Mechanical Engineering
M_O02	Asit Kumar Panda	Asit Kumar Panda, Ren-Jei Chung	A Non-Enzymatic/Biocompatible Electrochemical Sensor based on N-doped Graphene Quantum Dot-incorporated SnS <sub>2</sub> Nanosheets for In Situ Monitoring of Hydrogen Peroxide in Breast Cancer Cells	National taipei university of technology	department of chemical engineering and biotechnology
M_O03	Lien-Hui Kan	Lien-Hui Kan, Chen-Yu Wu, Horng-Yi Chang	Investigation on Luminescent Layer of Alkaline-earth Aluminates on Aluminum Alloy	National Taiwan Ocean University	Department of Marine Engineering
P_O01	Akira Yamakata	Chia-Yu Chang, Kosaku Kato,	Development of Visible Light Responsive TiO <sub>2</sub>	National Chung Hsing	Materials Science and

		Akira Yamakata, Wenjea J. Tseng	Photoelectrodes by Metal Nanoparticle Loading		University	Engineering
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B. Battery and energy storage  
B\_001

**Effect of different LiTFSI content on Composite Solid Electrolyte with NASICON-type LTP and PVDF–HFP for Solid-State Lithium-ion Batteries\_**

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**Abstract**

The lithium ion batteries are popular energy storage devices due to their high energy density. Traditional organic solvent electrolytes, on the other hand, have significant safety issues, thus developing safer electrolyte materials is a big challenge for lithium ion batteries. Solid electrolytes appear to be a potential replacement for flammable liquid electrolytes in lithium batteries. We developed an ionic conductivity polymer/ceramic hybrid electrolyte membrane. The hybrid electrolyte is made up of PVDF-HFP, which is mechanically stable but soft, LiTFSI which improves lithium ion mobility in the polymer substrate, and LTP, which has excellent ionic conductivity and thermal stability. To establish the optimum composition for electrochemical performance and Li ion mobility, a hybrid electrolyte was produced with varying amounts of LiTFSI. Impedance spectroscopy, linear sweep voltammetry, and charge and structural characterizations were performed on the produced hybrid membranes. The results showed that the percentage of LiTFSI in PVDF-HFP-LiTFSI hybrid electrolytes not exceed 60%. Increasing the lithium salt concentration adds to enhanced lithium ion transfer and ion conductivity, the electrolyte's mechanical strength must still meet membrane formation and protection criteria. such as high ionic conductivity ( $5.43 \times 10^{-5} \text{ S cm}^{-1}$ ), wide electrochemical stability window (3-6 V) and high electrochemical stability. The results show the 60% content of LiTFSI is the best among other which we studied here.

**Keywords:** Solid-state battery; LiTFSI content; PVDF-HFP; Hybrid electrolyte; Lithium ion mobility

B\_002

## SiO<sub>x</sub>/Carbon Multilayer Coating on Silicon Nanoparticles Synthesized via Supercritical CO<sub>2</sub> Fluid for Li-ion Battery Anodes

Rahmandhika Firdauzha Hary Hernandha<sup>1</sup>, Purna Chandra Rath<sup>1</sup>, Bharath Umesh<sup>2</sup>, Jagabandhu Patra<sup>1,3</sup>, Jeng-Kuei Chang<sup>1,2,3,\*</sup>

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### Abstract

Silicon (Si) anode design is essential for development of advanced Li-ion batteries (LIBs) [1]. A systematic study of optimal SiO<sub>x</sub>/carbon multilayer-coating silicon nanoparticles (C/SiO<sub>x</sub>/Si) to resist the large anode volume expansion/compression during charging/discharging and to produce reliable solid electrolyte interphase [2] has been conducted. An easy and eco-friendly technique for coating has been assisted by a supercritical carbon dioxide (SCCO<sub>2</sub>) protocol. It beneficially uses liquid-like SCCO<sub>2</sub> as a primary solvent and is supported by absolute ethanol as a co-solvent [3]. C/SiO<sub>x</sub>/Si samples are produced via SCCO<sub>2</sub> using various kinds of precursor, such as glucose (the sample is named SC-G), sucrose (SC-S), and citric acid (SC-CA). Additionally, glucose is also applied as the precursor for a traditional wet-chemical method, which produces a T-G sample for comparison. The experimental results show that SC-G has a better carbon layer than T-G, SC-S, and SC-CA. The SC-G has a high tap density due to a conformal and homogeneous carbon coating layer. Furthermore, the SC-G electrode exhibits relatively high reversible capacities of >2150 mAh/g at 0.2 A/g and ~920 mAh/g at 5 A/g. It can retain approximately 65 % of the initial capacity after 300 lithiation-delithiation cycles at 1 A/g. The obtained energy density of a SC-G || LiNi<sub>0.8</sub>Co<sub>0.1</sub>Mn<sub>0.1</sub>O<sub>2</sub> full cell (based on the total mass of anode and cathode active materials) is >550 Wh kg<sup>-1</sup>, which indicates the excellence of the proposed anode. This study demonstrates the great potential of the SCCO<sub>2</sub> protocol for C/SiO<sub>x</sub> multilayer coating on Si particles. The synthesis process is easily scaled-up for mass producing ideal Si-based anode materials for LIBs.

**Keywords:** Green process, Secondary battery, Silicon-based anodes, Carbon precursors

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B\_003

## Roles of Binders on Self-Discharge for Porous Carbon Supercapacitor Electrodes

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### Abstract

Supercapacitors are known for their high power density and long cycle life compared to other energy storage systems. However, self-discharge (SD) is a challenging issue for supercapacitors as standby power systems, since the stored energy starts to decay as time goes by. It means that some of the energy is lost before we start using it. The mechanism of supercapacitor SD can be attributed to: (1) charge redistribution and (2) unwanted faradic side reactions. In this work, for the first time, we explore the details of the interplay between various binders and the SD mechanism and how an appropriate selection of binders can suppress SD. Here, we use three commonly used binders: (1) carboxymethyl cellulose/styrene-butadiene rubber (CMC+SBR), (2) poly(vinylidene fluoride), and (3) polytetrafluoroethylene to fabricate activated carbon electrodes. The electrolyte used is 1 M TEABF<sub>4</sub> in PC. The experimental results show an interesting correlation between pore size distribution (caused by different binders), electrode impedance, and SD. The SD mechanism has been depicted using a combination of mathematical fitting and experimental measurements. Among these binders, CMC+SBR can maximize the mesopores/micropores ratio and thus suppress the electrode SD.

**Keywords:** electric double-layer capacitors, activated carbon, organic electrolyte, charge-discharge performance

B\_004

## Structure evolution and *operando* analysis methods of fast-charging lithium titanate materials developed in HiGEM research center

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### Abstract

Fast-charging lithium titanate has received much attentions in applications of energy storage cabinet or electric bus, since this oxide material shows excellent rate performance and cyclability. During electrochemical reaction, lithium titanate proceeds via two phase transition between  $\text{Li}_4\text{Ti}_5\text{O}_{12}$  and  $\text{Li}_7\text{Ti}_5\text{O}_{12}$ . [1] Li-ion insertion/extraction induces a series of structural evolution either in the crystal or at the solid-liquid interface. Lattice site potential analysis is employed using VESTA software to identify site potential of each ion in the unit cell. In the research center, we have developed several *operando* electrochemical testing methods using X-ray diffraction, micro-Raman spectroscopy and attenuated total reflection infrared spectroscopy. The sampling system play an important role in accurate data acquisition. In this presentation will show the structural evolutions, including lattice parameter or Raman-active vibrational modes of crystals and IR-active bonding of electrolyte, in lithium titanate battery system during operating condition. In addition, a preliminary test of gas evolution based on lithium titanate material will present using infrared spectroscopy-Mass spectrometry connecting system as an analyzing platform. The above mentioned experimental information from *operando* electrochemical testing methods would guide the synthesis strategies and develop a robust anode material with high C-rate performance and structural integrity.

**Keywords:** lithium titanate, *operando* electrochemical testing, phase transition

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B\_005

## Fe-Cu-Schiff base complexes as Electrocatalysts for Zn-Air Batteries

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### Abstract

A electrocatalyst with high electrocatalytic activities for oxygen reduction reaction (ORR) are required for high performance of Zn-Air batteries. In this study, Fe-Cu-Schiff base complexes developed using in air cathode of Zn-air batteries. The electrocatalyst activities of Fe-Cu-Schiff base complexes electrocatalyst with Schiff base prepared by different mole ratio of trimesic acid (TA) to triethylenetetramine (TETA) are studied. The ORR activities in 0.1M KOH solution evaluated using cyclic voltammetry (CV), linear scanning voltammetry (LSV), electrical double layer capacitance ( $C_{dl}$ ), rotating disk electrode (RDE).

The results obtained that the bimetallic Schiff base complexes electrocatalyst consist of 1:1 mole ratio of Fe:Cu with 20 mmol TA and 10 mmol TETA exhibited good ORR activity at 0.61V of reduction potential, and durability in alkaline electrolytes.

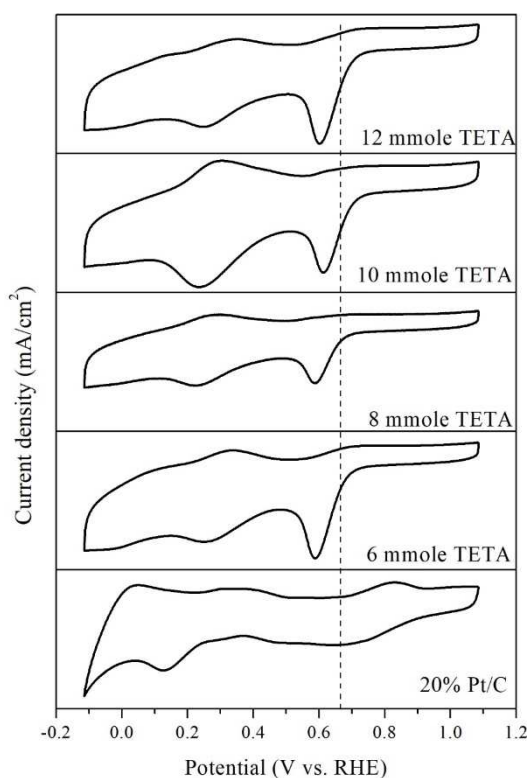


Figure 1. CV curves of various electrocatalysts prepared using 1:1 mole ratio of Fe:Cu with 20 mmol TA and different mole of TETA.

**Keywords:** Electrocatalyst, ORR, Schiff base complex

B\_006

## Insight into the degradation mechanism of the Ni-rich NMC cathode materials

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### Abstract

There have been many efforts to study and produce new materials that would replace the widely used commercial cathode  $\text{LiCoO}_2$ , which has a stable electrochemical performance but on the other hand is neither cost-effective nor environmentally friendly. Recently, Ni-rich  $\text{LiNi}_{1-x-y}\text{Mn}_x\text{Co}_y\text{O}_2$  (NMC) material has been promoted as a likely alternative material due to its higher thermal stability, higher voltage operation, lower cost and enhanced capacity. In this study, the atomistic structures of Ni-rich NMC have been optimized by means of the DFT calculations. Their structure stability and working voltages under different states of charge have been evaluated. Furthermore, the magnetic moments variation, Bader charge analyses and density of states have been taken into account to investigate the mechanism of oxygen evolution during charging. This work is expected to be helpful for experimental researchers to fully comprehend the cause of structure instability and capacity fading in Ni-rich NMC materials, hence, to find out the suitable solutions.

**Keywords:** Battery, DFT calculation, NMC, stability.

## E. Energy efficiency technologies and applications

E\_001

### A DFT Study of the Effect of Degrees of Inversion on the Electronic Structure of Spinel NiCo<sub>2</sub>O<sub>4</sub>

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#### Abstract

NiCo<sub>2</sub>O<sub>4</sub> is widely used in variable application such as supercapacitors, metal-air battery, and water splitting. The presence of Ni<sup>2+</sup>/Ni<sup>3+</sup> and Co<sup>2+</sup>/Co<sup>3+</sup> couples are often reported as the reaction center for various applications.[1,2] In this research, the degree of inversion in NiCo<sub>2</sub>O<sub>4</sub> and its influence on electronic structure of NiCo<sub>2</sub>O<sub>4</sub> are discussed using density functional theory with Hubbard U correction method (DFT+U). The Bader charge, magnetic moment and decomposed density of state have been analyzed on inverse, intermediate and normal spinel structure of NiCo<sub>2</sub>O<sub>4</sub>. The computed result is also shown to be in good agreement with that predicted by the widely used crystal field theory (CFT). Our result found the relationship between degree of inversion and the valence state of NiCo<sub>2</sub>O<sub>4</sub> system, which can be used to predict and design the appropriate electronic properties for various potential application.

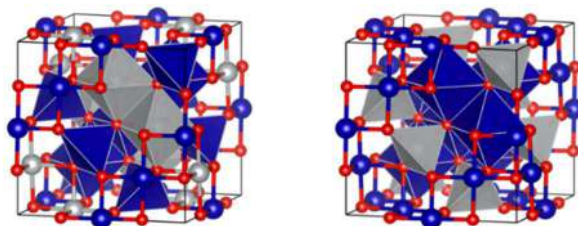


Figure: The conventional inverse NiCo<sub>2</sub>O<sub>4</sub> cell (left) and normal NiCo<sub>2</sub>O<sub>4</sub> cell (right)

**Keywords:** Density Functional Theory, NiCo<sub>2</sub>O<sub>4</sub>, First-principle calculation

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E\_O02

## Flexo-phototronic Effect in Centro-symmetric BiVO<sub>4</sub> Epitaxial Films

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### Abstract

With exciting functionality, topological defects in ferroic system have attracted much attention. Under proper design, the emergence of polar domain walls in non-polar ferroelastics enables flexo-phototronic effect. In this study, we revealed ferroelastic twin texture with localized flexoelectric effect in epitaxial BiVO<sub>4</sub> film by piezoresponse force microscopy. Supported by the strain field analysis, we found the piezoresponse confined at domain wall area is attributed to the flexoelectric effect induced by the presence of ferroelastic twin domains during the paraelastic to ferroelastic phase transition. The mechanism of flexo-phototronic was further supported by dye-degradation and generation of reactive radical experiments. This work not only provides new insights into the introduction of flexo-phototronic effects in non-polar materials, but also sheds light on a new concept to use material inhomogeneity for acquiring multifunctionality.

**Keywords:** Piezo-phototronics, Flexoelectricity, Domain walls, Centro-symmetric BiVO<sub>4</sub>

E\_003

## Supercapacitive Properties of Bi-doped ZnCo<sub>2</sub>O<sub>4</sub> Nanostructure Synthesized by In-situ Hydrothermal Method

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### Abstract

The supercapacitor is an indispensable energy storage device which has recently attracted an extensive research interest from both academic and industrial fields, being considered as important as batteries for future energy storage system applications [1]. Bismuth-doped zinc cobalt oxide (Bi-doped ZnCo<sub>2</sub>O<sub>4</sub>) nanostructures were prepared directly onto a carbon cloth substrate by a one-step in-situ hydrothermal method in this study. The structural properties of the composite nanostructure were characterized by X-ray diffractometry (XRD) and scanning electron microscopy (SEM). The electrochemical properties as well as the long-term cycling stability of the obtained Bi-doped ZnCo<sub>2</sub>O<sub>4</sub> nanostructures were examined by cyclic voltammograms (CV), galvanostatic charge/discharge (GCD) and electrochemical impedance spectroscopy (EIS) as a function of the bismuth doping content.

**Keywords:** supercapacitor, nanostructure, bismuth, zinc cobalt oxide, electrochemical property

### References

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E\_004

## High-stability transparent flexible energy storage based on PbZrO<sub>3</sub>/ muscovite heterostructure

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### Abstract

Antiferroelectric materials for dielectric energy storage with fast charging-discharging rate is an important research direction. In this study, to build a platform for the potential application in flexible transparent devices, a combination of the muscovite substrate and the antiferroelectric PbZrO<sub>3</sub> (PZO) is studied as a model system. The growth of PZO is first optimized on rigid substrates and then transferred to muscovite with the form of epitaxial and polycrystalline films. The energy storage performance with robust electrical and mechanical stability is systematically demonstrated. High energy densities of 46~52 J/cm<sup>3</sup> were obtained; Compared with the epitaxial PZO, the polycrystalline PZO shows an increase of efficiency by 28% and possesses higher heat resistance. Moreover, fabricated on a transparent indium tin oxide electrode, the PZO heterostructure exhibits excellent energy performance and an optical transmittance of up to 70–80%. Through this study, a paradigm for reliable flexible transparent fast charging-discharging energy storage element is developed.

**Keywords:** Flexible, Energy storage, Transparent, PbZrO<sub>3</sub>



F. Fuel Cell  
F\_001

## Study of BaCO<sub>3</sub> and Samarium-doped Ceria Carbonate Composite Electrolyte for Low-Temperature Solid Oxide Fuel Cells

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### Abstract

This article presents the successful testing of 70% w/w samarium-doped ceria mixed with 30% w/w barium carbonate (SDC/BC) electrolyte for use as an improved electrolyte for low-temperature solid oxide fuel cells (LT-SOFCs) [1]. The phase changes, particle size distribution, morphology, electrochemical impedance, conductivity, and maximum power density of the fuel cell based on this SDC/BC composite electrolyte are discussed. The SDC/BC electrolyte is chemically compatible with a Ni-SDC/BC anode. The conductivity of the SDC/BC is 102.7 mS cm<sup>-1</sup> at 600 °C with an activation energy of 36.12 kJ mol<sup>-1</sup>. The maximum power output of the Ni-SDC-BC/SDC-BC/Pt cell is 427 mW cm<sup>-2</sup> at 600 °C, which is attributed to the high electrochemical activity of both the electrolyte and the anode material. These results demonstrate that SDC/BC has potential as a low-temperature electrolyte for LT-SOFC.

**Keyword:** Samarium-doped ceria, Barium carbonate, Mixed-ionic conductor, Electrolyte; Solid oxide fuel cell

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F\_002

## High-performance in-situ Ni nanoparticle exsolved LSTN/LNSDC composites for low-temperature solid oxide fuel cells

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### Abstract

Highly ion-conducting properties in heterostructure composites and semiconductors have drawn significant attention in recent years for developing new electrolytes in low-temperature solid oxide fuel cells (LT-SOFCs). In this study,  $\text{La}_{0.2}\text{Sr}_{0.7}\text{Ti}_{0.9}\text{Ni}_{0.1}\text{O}_{3-\delta}$  (LSTN) material was first prepared by doping Ni in  $\text{La}_{0.3}\text{Sr}_{0.7}\text{TiO}_{3-\delta}$  (LST) material, and r-LSTN with exsolved Ni nanoparticle was obtained from LSTN by treating in 10% hydrogen reduction atmosphere for 10 hour, which is further composited with ionic conductors LNSDC as electrolyte for low temperature SOFCs. To further improve the fuel cell performance, a lithiated metal oxide is used as symmetrical electrode. The cell with NCAL/r-LSTN+LNSDC/NCAL layer structure exhibited a peak power density of  $650 \text{ mW/cm}^2$  along with open circuit voltage of 1.13 V at  $550 \text{ }^\circ\text{C}$ . The experimental results show that the doping and in-situ exsolved of Ni can improve the ionic conductivity of the material, reduce the polarization resistance of the fuel cell. According to the energy band parameters of r-LSTN and LNSDC, a p-n heterojunction effect was proposed to describe the electron blocking and ion promoting processes of r-LSTN-LNSDC electrolyte in fuel cells.

**Keywords:** Solid oxide fuel cell; Ionic- semiconductor composite; In-situ exsolution; Band alignment; Heterojunction.

L. LED

L\_O01

## Optical Properties of Europium doped Calcium Sulfide Prepared by Carbon Sphere Template

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### Abstract

Europium doped calcium sulfide is an important red phosphor for CRI compensation of white light LED [1,2]. Conventional synthesis methods for sulfide phosphors are necessarily high processing temperatures and use a highly toxic sulfur-containing atmosphere ( $\text{CS}_2$ ,  $\text{H}_2\text{S}$  or  $\text{S}_8$ ) to overcome the problem of sulfur deficiency during the synthesis process [3,4]. In this study, the carbon spheres were prepared by hydrothermal method as a template for synthesizing calcium sulfide and  $\text{Eu}^{2+}$  doped precursors. Such carbon spheres were then dispersed in the mixed precursor solution containing calcium acetate,  $\text{Eu}(\text{NO}_3)_3 \cdot 6\text{H}_2\text{O}$  and thiourea  $(\text{NH}_2)_2\text{CS}$  using an ultrasonic vibrator. This ultrasonically mixed solution was poured into a round bottom flask and heated at  $180^\circ\text{C}$  for 9 h by a chemical solution reflux process. The stoichiometric ratio of 1:1 for Ca:S was maintained in the reflux reaction solution. The prepared precursors were collected by centrifugation process and drying, then heat-treated at  $800^\circ\text{C}$  in  $\text{N}_2$  without any excess sulfur atmosphere. The reducing atmosphere generated by the carbon spheres decomposition to obtain the  $\text{CaS}:\text{Eu}^{2+}$  nano-phosphors. XRD patterns proved the CaS phase can be obtained by the stoichiometric precursor without excess sulfur compensation. The highest photoluminescence (PL) intensity of 655 nm excited by 460 nm was found with 0.025 mol% Eu-doping in the range of 0.01~3.0 mol%. The concentration quench of PL occurred at the Eu-doping concentration higher than 0.03 mol%. Temperature dependence of PL measured at  $-196 - 300^\circ\text{C}$  revealed the difference of energy gap change between pure CaS and  $\text{Eu}^{2+}$  doped CaS. Thermal quenching was also found from the synthesized  $\text{CaS}:\text{Eu}^{2+}$  nanophosphors at  $-196^\circ\text{C}$  to  $300^\circ\text{C}$  accompanied emission peak blue shift by 250 nm excitation while measuring temperature rise. Interestingly, the 550 nm PL intensity excited by 380 nm exhibited significant thermal quenching for pure commercial CaS but not obvious for pure CaS synthesized by carbon sphere template.

**Keywords:** calcium sulfide nanophosphor, carbon sphere template, concentration quench, thermal quench

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L\_002

## Synthesis and characterization of Tb-doped $Y_4SiAlO_8N$ powder by spray pyrolysis

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### Abstract

White Light Emitting Diode (W-LED) is a kind of mature technology. The product is widely utilized in home and industrial illumination. Yellow phosphor powder (Ce doped YAG) with blue-chip is the most common product. However, its poor color makes it unsuitable for future use in Ultra High Definition Television (UHDTV), notably in green light. The irregular shape and uniform particle size would eventually produce difficulties like uneven luminous chromaticity and reduce the product's lifespan. Thus, in this study, Tb dopant was proposed to synthesize the green phosphor with a specific shape and particle size. Spray pyrolysis was chosen to produce submicron spheres of phosphor powders with varying calcination temperatures. The phase composition, morphology, and chemical composition of Tb-doped  $Y_4SiAlO_8N$  powders were characterized by X-ray diffraction, scanning electron microscopy, and energy dispersive spectroscopy. In addition, the Optical microscope (OM) was used to observe the particle size distribution of the agglomerated powders. Furthermore, the fluorescence spectrometer (PL) examined the luminescence property to determine the green light emission intensity of different phosphor powders. Finally, the strongest luminous intensity was obtained from the  $Y_{3.92}SiAlO_8N:0.08Tb^{3+}$  phosphors calcined at 1600°C for 1 h in 5%  $H_2$ / 95%  $N_2$  excited by light with a wavelength of 252 nm.

Keywords: Spray pyrolysis, Phosphor, Grain size, Emission intensity

## M. Materials and technologies for a low carbon, sustainable society

M\_O01

**Chemical Looping Gasification of Spent Coffee Ground Using Iron ore as Oxygen Carrier**Chia-Wei Huang<sup>1</sup>, Yu-Lin Kuo<sup>1\*</sup>, Henok Atile Kibret<sup>1</sup>, Yao-Hsuan Tseng<sup>2</sup><sup>1\*</sup> Department of Mechanical Engineering, National Taiwan University of Science and Technology, Taipei, Taiwan<sup>2</sup> Department of Chemical Engineering, National Taiwan University of Science and Technology, Taipei, Taiwan\*Corresponding Author: [ylikuo@mail.ntust.edu.tw](mailto:ylikuo@mail.ntust.edu.tw)**Abstract**

Coffee, the second most bewelcome drink and the second traded item in the world. However, it generates a huge solid waste during the process of coffee beverage preparation, according to the statistics, each kilogram of soluble coffee will produce about 2 kg wet spent coffee grounds (SCG). The high carbon content, high heating value, low ash, and negligible sulfur content, these characteristics make SCG an alternative fuel source through thermochemical conversion. As we know, the low quality and quantity of the syngas is the main limitation of the thermochemical conversion of biomass to energy and fuel. Owing to the advantages of the chemical looping process, it provides a novel way to carry lattice oxygen for biomass gasification and produce higher heating value and lower tar content syngas.

In this study, we used iron ore as oxygen carrier (OC), the effect of OC/B ratio and the synergetic effect of the oxygen carrier and gasification medium (steam and/or CO<sub>2</sub>) on the performance of the process were investigated. The surface morphology and chemical composition of iron ore was carried out via field emission scanning electron microscopy and energy-dispersive x-ray fluorescence. Because of the low density of the SCG suspended above the reactor bed, some char was left mixed with the OC on the bed and the iron ore was not completely reduced after SCG gasification with the existence of OC. Nevertheless, the situation can be improved by adding steam and CO<sub>2</sub> gasification medium, under the conditions of higher CO<sub>2</sub>/B ratio, 1kg/kg OC/B ratio, and 0.27 S/B molar ratio, the carbon conversion became slightly over 100%, and reasonable LHV and cold gas efficiency improvement was fulfilled

**Keywords:** Spent Coffee Grounds (SCG), Chemical looping, Iron ore, Biomass gasification, Waste conversion.

M\_O02

## A Non-Enzymatic, Biocompatible Electrochemical Sensor based on N-doped Graphene Quantum Dot-incorporated SnS<sub>2</sub> Nanosheets for In Situ Monitoring of Hydrogen Peroxide in Breast Cancer Cells

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### Abstract

The current study reports the design and construction of enzyme-free sensors using N-doped graphene quantum dot (N-GQD)-decorated tin sulfide nanosheets (SnS<sub>2</sub>) for sensitive and highly specific in situ monitoring of H<sub>2</sub>O<sub>2</sub> secreted by human breast cancer cells. N-GQDs with nanoparticles having an average size of 2.5 nm were incorporated into SnS<sub>2</sub> nanosheets to form a N-GQDs@SnS<sub>2</sub> nanocomposite using a simple hydrothermal approach. The resulting hybrid material was an excellent electrocatalyst for the reduction of H<sub>2</sub>O<sub>2</sub>, owing to the combined properties of highly conductive N-GQDs and SnS<sub>2</sub> nanosheets. The N-GQDs@SnS<sub>2</sub>-based sensing platform demonstrated substantial sensing ability, with a linear detection range of 0.0125–1128 μM and a limit of detection of 0.009 μM (S/N = 3). The sensing performance of N-GQDs@SnS<sub>2</sub> was highly stable, selective, and reproducible. Practical application of the N-GQDs@SnS<sub>2</sub> sensor was successfully demonstrated by quantifying H<sub>2</sub>O<sub>2</sub> in lens cleaner, human urine, and saliva samples. Finally, the N-GQDs@SnS<sub>2</sub> biocompatible electrode was effectively employed for the real-time quantification of H<sub>2</sub>O<sub>2</sub> released from breast cancer cells and mouse fibroblasts. This study paves a way to designing efficient non-enzymatic electrochemical sensors for various biomolecule detection using a simple method.

**Keywords:** reactive oxygen species, hydrogen peroxide, N-doped graphene quantum dots, live cells, enzyme-free sensor

M\_O03

## Investigation on Luminescent Layer of Alkaline-earth Aluminates on Aluminum Alloy

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### Abstract

Metals are well light reflector and possess shallow skin depth to result in eddy current heating. Hot metallic materials under sun-lighting consume solar energy and induce the thermal effects to decrease the useful applications of metals. The aluminum surface produces thin oxide layer easily under ambient atmosphere to protect the metal from further oxidation. If the alkaline earth species coating on the aluminum alloy surface, it is expected to react into spinel structure. Such a spinel structure doped with rare-earth elements could become luminescent surface layer to promote the energy reuse on the metallic materials. The spinel structures of  $MgAl_2O_4$  and  $SrAl_2O_4$  were investigated to form on A356 aluminum alloy.  $MgAl_2O_4$  can be formed by Al and MgO in air at about 1000 °C [1]. In this study, a substrate of A356 was coated by MgO slurry and co-fired at 1000 °C in an Ar atmosphere. It was found that a  $MgAl_2O_4$  phase formed by XRD analysis. When the  $Eu_2O_3$  slurry was further coated, the  $MgAl_2O_4:Eu^{3+}$  may form to produce luminescent properties. The co-fired  $MgAl_2O_4:Eu^{3+}$  layer was observed a 612 nm peak of photoluminescence emission (PL) under 260 nm excitation. This result is confirmed as a spinel structure of  $MgAl_2O_4:Eu^{3+}$  [2]. The formation of  $MgAl_2O_4$  was proved by EDS that the inter-diffusion of MgO and Al in A356. Similarly, a SrO slurry was further coated on  $MgAl_2O_4$ . The  $(Sr, Mg)Al_2O_4$  structure was detected by XRD pattern. Further luminescent properties and formation mechanism are under investigation. The long afterglow characteristics will be studied by doping multiple rare-earth species.

**Keywords:** spinel structure, photoluminescence, inter-diffusion

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P. Photovoltaic / Solar power

P\_001

## Development of Visible Light Responsive TiO<sub>2</sub> Photoelectrodes by Metal Nanoparticle Loading

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### Abstract

TiO<sub>2</sub> is one of the most used photocatalyst materials because of its nontoxicity and high chemical stability.[1] To use sunlight effectively, visible light for TiO<sub>2</sub> is important since TiO<sub>2</sub> can only absorb UV light. With surface plasmon resonance, electrons could be excited to induce electron transfer from metal particles to TiO<sub>2</sub> under visible light irradiation. In this study, TiO<sub>2</sub> electrodes were first made on FTO glass by spray pyrolysis and atomic layer deposition (ALD). Then, several kinds of metal nanoparticles were loaded on the TiO<sub>2</sub> electrodes by photodeposition method. Three-electrode system was used to measure the photoelectrochemical activity and the electrodes were irradiated by visible light from LED at 0.2 Hz. Water oxidation and reduction take place on metal particles and counter electrode, respectively. A TiO<sub>2</sub> amorphous layer made by the ALD treatment connects TiO<sub>2</sub> particles, thus increases electron-conductivity and the activity accordingly. After annealing, crystallization of TiO<sub>2</sub> amorphous layer increased the mobility of electrons from metal particles to FTO glass, hence, the activity increased. The result of light energy dependence showed shorter wavelength of light gave higher photon energy, hence, electrons were more easily transfer to TiO<sub>2</sub>. The transient absorption spectra showed a broadband absorption appeared in the mid-infrared region and assigned to free electrons excited from metal particles to TiO<sub>2</sub> conduction band. [2] With surface plasmon resonance, ALD treatment and post annealing effect, metal loaded TiO<sub>2</sub> electrodes show photoelectrochemical activity under visible light illumination.

**Keywords:** Titanium oxide, photoelectrochemical, surface plasmon resonance

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## Poster Session

Paper ID	Corresponding Author	All Authors	Title	Institution	Department
A_P01	Hairus Abdullah	Noto Susanto Gultom, Dong-Hau Kuo, Chien-Hui Li, and Hairus Abdullah,	Impressive OER Performance on Micro-Tree-Like Ni <sub>3</sub> S <sub>2</sub> in Alkaline Solution	National Taiwan University of Science and Technology	Department of Materials Science and Engineering
A_P02	Chi-Yuan Lee	Chi-Yuan Lee, Chia-Hung Chen, Shan-Yu Chen, Zhi-Yu Huang	Integration of High Pressure Resistant Flexible 6-in-1 Microsensor and High Pressure Proton Exchange Membrane Water Electrolyzer	Yuan Ze University	Department of Mechanical Engineering
A_P03	Chi-Yuan Lee	Chi-Yuan Lee, Chia-Hung Chen, Guo-Bin Jung, Shih-Hung Chan, Shan-Yu Chen, Jyun-Wei Yu, Bo-Jui Lai	PEMWEs MEA Anode Internal Sensing Technology Development	Yuan Ze University	Department of Mechanical Engineering
A_P04	Jui-Teng Lee	Jui-Teng Lee, Shih-Hsiu Chen, and Chia-Yun Chen	Incorporation of Au@CuSCu <sub>2</sub> S nanoparticles on ZnO nanosheets for efficient photodark responsive degradation of organic pollutants	National Cheng Kung University	Materials Science and Engineering
B_P01	Tai-Feng Hung	Mohamed M. Abdelaal, Tzu-Cheng Hung, Tai-Feng Hung	Polymer-derived Nitrogen-doped Carbon Materials with Hierarchically Porous Architectures toward Capacitive Performances for Lithium-ion Capacitors	Ming Chi University of Technology	Doctoral Degree Program of Energy and Battery Technology
B_P02	Te-Wei Chiu	Dhanapal Vasu, Arjunan Karthi Keyan, Subramanian Sakthinathan, Te-Wei Chiu	Excellent Electrochemical active CuFe <sub>2</sub> O <sub>4</sub> 3D-rGO based Supercapacitor Electrodes with an Ultrahigh Specific Capacitance	National Taipei University of Technology	Materials and Mineral Resources Engineering
B_P03	Arjunan Karthi Keyan	Arjunan Karthi Keyan, Dhanapal Vasu, Subramanian Sakthinathan, Te-Wei Chiu	High energetic supercapacitor electrode of CuCoO <sub>2</sub> P-rGO nanocomposite with ultrahigh specific capacitance	National Taipei University of Technology	Department of materials and mineral resources engineering
B_P04	Zhen Chong	Zhen Chong, Jow-Lay Huang, Chia-Chin Chang, Yu-Min Shen	Performance of Molybdenum-Modified Titanium Oxide as anode for lithium-ion Battery	National Cheng Kung University	Material Science and Engineering

B_P05	Chi-Yuan Lee	Chi-Yuan Lee, Chia-Hung Chen, Chin-Lung Hsieh, Yu-Chun Chen, Siao-Yu Chen	Development of Instant Diagnostic Technology for Hydrogen Vanadium Flow Battery	Yuan Ze University	Department of Mechanical Engineering
B_P06	Jen-Hao Yang	Jen-Hao Yang, Kuan-Zong Fang, and Shu-Yi Tsai	Effect of Synthesis Routes on Nickel rich and Cobalt-free Layered Oxides Cathode for Li Ion Batteries	National Cheng Kung University	Department of Materials Science and Engineering
B_P07	Xiejing Luo	Xiejing Luo, Chaofang Dong, Yarong Xi, Chenhao Ren, Junsheng Wu, Dawei Zhang, Xiongbo Yan, Yajun Xu, Pengfei Liu, Yedong He, Xiaogang Li	Computational simulation and efficient evaluation on corrosion inhibitors for electrochemical etching on aluminum foil	University of Science and Technology Beijing	Institute for Advanced Materials and Technology
B_P08	Jia-Hong Du	Jia-Hong Du, Shu-Yi Tsai, Kuan-Zong Fung	Polarization Reduction of Surface-Modified Garnet Solid Electrolytes for Solid State Li-ion Battery Applications	National Cheng Kung University	Department of Materials Science and Engineering
B_P09	Yu-Hsuan Su	Yu-Hsuan Su, Po-Wei Chi, Tanmoy Paul, Koo-Ting Chan, Hwai-En Lin, Phillip M. Wu, Maw-Kuen Wu	Synthesis and Electrochemical Properties of Single-Crystal $\text{LiNi}_{0.5}\text{Co}_{0.2}\text{Mn}_{0.3}\text{O}_2$ Cathode for Lithium-Ion Batteries	Academia Sinica	Institute of Physics
B_P10	Zih-Heng Hsieh	Zih-Heng Hsieh, Kuan-Zong Fung, and Shu-Yi Tsai	Characterization of spinel cathode material for advanced lithium-ion batteries	National Cheng Kung University	Department of Materials Science and Engineering
B_P11	Yi-Hung Wang	Yi-Hung Wang, Ya-Chen Tsai, Wei-Ning Hsieh, I-Ming Hung, Cheng-You Wu	Effect of concentration on performance of $\text{ZrO}_2$ nanoparticle electrochemical in Vanadium Redox Flow Batteries	Yuan Ze University	Department of chemical engineering and materials science
B_P12	Debabrata Mohanty	Debabrata Mohanty, Jing-Yu Lai, Pao-Wei Ou, I-Ming Hung	Synthesis and Properties of $\text{Li}_2\text{MnO}_3$ - $\text{LiMn}_{1/3}\text{Co}_{1/3}\text{Ni}_{1/3}\text{O}_2$ Cathode Materials for Lithium-Ion Battery	Yuan Ze University	Department of chemical engineering and materials science
B_P13	Jing-Yu Lai	Jing-Yu Lai, Jie-Yu Liao, I-Ming Hung	Synthesis and Material Characteristic of $\text{Li}_{1.3}\text{Al}_{0.3}\text{Ti}_{1.7}(\text{PO}_4)_3$ Solid Electrolytes for Lithium-ion Battery	Yuan Ze University	Department of chemical engineering and materials science
B_P14	Jing-Yu Lai	Jing-Yu Lai, Ming-Yan Chen, I-Ming Hung	Microwave co-precipitation synthesis and electrochemical characterization of $0.4\text{Li}_2\text{MnO}_3$ - $0.6\text{LiMn}_{1/3}\text{Co}_{1/3}\text{Ni}_{1/3}\text{O}_2$ as	Yuan Ze University	Department of chemical engineering and materials

			Cathode Material for lithium-ion battery		science
E_P01	Enzhu Lin	Enzhu Lin, Zihan Kang, Jiang Wu, Rui Huang, Ni Qin, Dinghua Bao	The effects of selectively and randomly deposited Ag nanoparticles on the piezocatalytic activity of BaTiO <sub>3</sub> nanocubes/cuboids	Sun Yat-Sen University	School of Materials Science and Engineering
E_P02	Tung-Wei Chang	Tung-Wei Chang, Ren-Shuo Chang, I-Ming Hung	Development of nano-sized Fe-based powder for Inductance	Yuan Ze University	Department of chemical engineering and materials science
E_P03	Chang-Chun Zheng	Chang-Chun Zheng, Fu-Hsing Lu	Preparation of Nitrogen-doped BaTiO <sub>3</sub> Thin Films on TiNSi by Plasma Electrolytic Oxidation	National Chung Hsing University	Department of Materials Science and Engineering
E_P04	Te-Wei Chiu	Kai-Chun Hsu, Heng-Jyun Lei, Chung-Lun Yu, Te-Wei Chiu	Preparation of CeO <sub>2</sub> -CuCrO <sub>2</sub> composite by electrospinning method	National Taipei University of Technology	Materials and Mineral Resources Engineering
E_P05	Te-Wei Chiu	Bing-Zhen Hsu, Chung-Lun Yu, Te-Wei Chiu, Bing-Sheng Yu	Porous Structure ZnO-ZnFe <sub>2</sub> O <sub>4</sub> Catalyst Applied by Hydrogen from Methanol Steam Reforming	National Taipei University of Technology	Materials and Mineral Resources Engineering
F_P01	Chi-Yuan Lee	Chi-Yuan Lee, Chia-Hung Chen, Yun-Hsiu Chien, Yi-Lun Chien	Flexible Integrated Microsensor for In-situ Monitoring of Proton Battery	Yuan Ze University	Department of Mechanical Engineering
F_P02	Wei-Cheng Chin	Wei-Cheng Chin, Yi-Hsuan Lee	Correlation between NiFe <sub>2</sub> O <sub>4</sub> Cathode Thickness and Hydrogen Production Efficiency for Solid Oxide Electrolyzer Cells	National Taipei University of Technology	Department of Mechanical Engineering
F_P03	Kuan-Lin Chen	Chia-Chieh Shen, Kuan-Lin Chen	Hydrogen Storage Alloy Tanks for Fuel Cell Assisted Bicycles	Yuan Ze university	mechanical engineering
F_P04	Yen-Yu Chen	Wei-I Yen, Hsin-Chieh Hsieh, Ying-Chen Lin, Sih-Yu Chen, Yen-Yu Chen	Preparation of Porous Zirconia by Ceramic Photopolymerization Process	Chinese Culture University	Chemical and Materials Engineering
F_P05	Jhieh-Yu Tang	Jhieh-Yu Tang, Kuan-Zong Fung, Shu-Yi Tsai, Jarosław Milewski, Tomasz Wejrzanowski	Effect of Dual Phases on Ionic Conduction of Consisting of Doped Ceria and Carbonates	National Cheng Kung University	Department of Materials Science and Engineering
F_P06	Yuan-Jie Tsai	Yuan-Jie Tsai, Kuan-Zong Fung, Shu-Yi Tsai	A Modified Solid-State Reaction Method to Synthesize Proton-Conducting BaCe <sub>0.5</sub> Zr <sub>0.3</sub> Y <sub>0.2</sub> O <sub>3-δ</sub> Electrolyte with Improved Sinterability	National Cheng Kung University	Department of Materials Science and Engineering

F_P07	Sheng-Wei Lee	W. Y. Huang, K. R Lee, Jason S. C. Jang, J. C. Lin, I. M. Hung, C. J. Tseng, S. W. Lee	Nd-doped LSCF nano-fibrous cathode for proton-conducting solid oxide fuel cells	National Central University	Institute of Materials Science and Engineering
F_P08	Chia-Chieh Shen	Chia-Chieh Shen, Li Qun Hu, Shen Ta Wei	Small Fuel Cell Powered Vehicle	Yuan Ze University	Department of Mechanical Engineering
F_P09	Liangdong Fan	Shiyi Luo, Liangdong Fan	Intermediate temperature solid oxide fuel cell with nanoscale electrodes fabricated by one-step sintering technology	Shenzhen University	College of Chemistry and Environmental Engineering
F_P10	Liangdong Fan	Yanpu Li, Liangdong Fan	Enhancement of Oxygen Reduction Reaction activity of Cobalt Based Cathode in Solid Oxide Fuel Cell	Shenzhen University	College of Chemistry and Environmental Engineering
F_P11	Azam Khan	Azam Khan, Ko-Yun Chao, Zheng-An Wang, I-Ming Hung	Preparation and Characterization of $Y_xBa_{2-x}Co_2O_{5+\delta}$ Cathode Material for Solid Oxide Fuel Cell	Yuan Ze university	Department of chemical engineering and materials science
F_P12	Ko-Yun Chao	Ko-Yun Chao, Ching-Hsuan Wu, I-Ming Hung	Preparation and Properties of $Y_xSr_{1-x}TiO_{3-\delta}$ anode for Solid Oxide Fuel Cells	Yuan Ze university	Department of chemical engineering and materials science
F_P13	Ko-Yun Chao	Ko-Yun Chao, Kuan-Chi Fu, I-Ming Hung	Preparation and Characterization of High Temperature Mixed Proton-electron Conductors	Yuan Ze university	Department of chemical engineering and materials science
F_P14	Takeshi Kawai	Takeshi Kawai, Takahiko Kawaguchi, Naonori Sakamoto, Hisao Suzuki, Naoki Wakiya	Spontaneous formation of superlattice thin film with perovskite $A^3+B^3+O_3$ structure using dynamic aurora PLD and its effect on physical properties	Shizuoka University	Research Institute of Electronics
F_P15	Haruki Zayasu	Haruki Zayasu, Hiroki Nakane, Takahiko Kawaguchi, Naonori Sakamoto, Hisao Suzuki, Naoki Wakiya	Preparation and characterization of epitaxially grown YSZ thin films on porous silicon substrates for SOFC applications	Shizuoka University	Research Institute of Electronics
F_P16	Kaoru Ogata	Kaoru Ogata, Takahiko Kawaguchi, Naonori Sakamoto, Hisao Suzuki, Naoki Wakiya	Spontaneous formation of superlattice thin films on substrates having heterogenous structure using dynamic aurora PLD	Shizuoka University	Research Institute of Electronics

F_P17	Kazuto Yoshida	Kazuto Yoshida, Hisao Suzuki, Takashi Arai, Takahiko Kawaguchi, Naonori Sakamoto, Naoki Wakiya, Desheng Fu	Low temperature synthesis of PZT thin films with giant piezoelectric displacement on glass substrate by domain engineering from molecular-designed precursors	Shizuoka University	Graduate School of Integrated Science and Technology
F_P18	Ryoya Nishimura	Ryoya Nishimura, Takahiko Kawaguchi, Naonori Sakamoto, Hisao Suzuki, Naoki Wakiya	The effect of starting materials on low-temperature preparation of $\text{Li}_{6.5}\text{La}_3\text{Zr}_{1.5}\text{Ta}_{0.5}\text{O}_{12}$ single crystal using the flux method	Shizuoka University	Graduate School of Integrated Science and Technology
F_P19	Seiji Sogen	Seiji Sogen, Hisao Suzuki, Takashi Arai, Takahiko Kawaguchi, Naonori Sakamoto, Naoki Wakiya, Desheng Fu	Synthesis of PZT thin film with single crystal-like ferroelectricity on SUS substrate	Shizuoka University	Graduate School of Integrated Science and Technology
F_P20	Ayano Iizuka	Ayano Iizuka, Takahiko Kawaguchi, Naonori Sakamoto, Hisao Suzuki, Naoki Wakiya	Computer simulation via phase-field method to consider the effect of magnetic field on the formation process of spontaneous superlattice structure using dynamic auroral PLD	Shizuoka University	Research Institute of Electronics
F_P21	Yi-Chu Han	Yi-Chu Han, Yung-Chin Yang	The study of 8YSZ electrolyte fabrication of the tubular solid oxide fuel cells by the dip-coating method	National Taipei University of Technology	Institute of Materials Science and Engineering
F_P22	Yi-Le Liao	Yi-Le Liao, Sea-Fue Wang	The Research of the Mechanism of in-situ Sintering Solid Oxide Fuel Cell	National Taipei University of Technology	Department of Materials and Mineral Resources Engineering
H_P01	Yi Hsiang Lai	Yi-Hsiang Lai, Yung-Jen Lin	Processing and performance of oxidation-resistant layers on graphite	Tatung University	Department of Materials Engineering
H_P02	Chien-Chih Chiang	Chien-Chih Chiang, Jeou-long Lee, Chang-Chia Chou, Jin-Yih Kao, Ming-Han Tsai, Ya-Chi Wu	Influence of Unipolar Pulsed Two-Stage Rise Voltage on Wear Resistance of Carbon Steel Surface Using MAO method	Lunghwa University of Science and Technology	Department of Chemical and Materials Engineering
H_P03	Kai-Yo Huang	Kai-Yo Huang, Yu-Chuan Wu, Chun Ming	Analysis of the microstructure and dielectric properties on $\text{CaCu}_3\text{Ti}_4\text{O}_{12}$ -based dielectric	National Taipei University of Technology	Materials Science and Engineering

		Huang, Yu Chen Yeh	ceramic materials		
H_P04	Ming-Zhe Lu	Ming-Zhe Lu, Yu-Chuan Wu, Yu-Chen Yeh, Chun-Ming Huang	High temperature stability BaTiO <sub>3</sub> -Bi <sub>0.5</sub> Na <sub>0.5</sub> TiO <sub>3</sub> -based dielectric ceramics of formulation improvement and material properties analysis	National Taipei University of Technology	Department of Materials Science and Engineering
H_P05	Gourav Mundhra	Gourav Mundhra	Use of a composition-graded solid electrolyte for determination of Gibbs energy of formation of lanthanum hafnate A prospective TBC material for turbine applications	National Institute of Technology Durgapur	Department of Metallurgical and Materials Engineering,
H_P06	Tsung-Yang Ho	Tsung-Yang Ho, Shu-Yi Tsai, Kuan-Zong Fung	High Performance Solid State SO <sub>2</sub> sensor using Nano- structured Oxides	National Cheng Kung university	Material science
H_P07	Chien-Chih Chiang	Chien-Chih Chiang, Jeou- long Lee, Ta- Lun Sung, Shin- Cheng Chen, Yuan-Wen Huang, Chi-Yu Hsu, Hsuan- Hsien Chuang	Effects of MAO Coating on the Hardness and Corrosion Resistance of 6032 Aluminium Alloy	Lunghwa University of Science and Technology	Department of Chemical and Materials Engineering
H_P08	Bo-Cheng Lai	S.F. Wang, B.C. Lai, and C.A. Lu	Dielectric properties of CaO- B <sub>2</sub> O <sub>3</sub> -SiO <sub>2</sub> glass-ceramics in the millimeter-wave range of 20-60 GHz frequency	National Taipei University of Technology	Institute of Materials Science and Engineering
L_P01	Mu-Tsun Tsai	Mu-Tsun Tsai, Ya-Chen Lin, Ya- Lun Chug	Luminescence Investigation of Chromium-doped Forsterite Phosphor Thin Films	National Formosa University	Department of Materials Science and Engineering
L_P02	Mu-Tsun Tsai	Mu-Tsun Tsai, Chu-Xian Yao, Yi-Jun Luo	Luminescence Investigation of Blue-emitting Cordierite Phosphor Thin Films	National Formosa University	Department of Materials Science and Engineering
L_P03	Chien-Chih Chiang	Chien-Chih Chiang, Jeou- Long Lee, Ta- Lun Sung, Tzu- Chieh Kao, Chen-Ying Wu, Shin-Tse Chen, Chien-Yu Ku	Structures and Photoluminescence Properties of (Ba/Sr) <sub>1-x</sub> MgAl <sub>10</sub> O <sub>17</sub> Eux <sub>2</sub> / Phosphors	Lunghwa University of Science and Technology	Department of Chemical and Materials Engineering
M_P01	Chung-Lun Yu	Chung-Lun Yu, Subramanian Sakthnathan, Sheng-Yu Chen, Te-Wei Chiu, Yung-Shen Fu, Bing-Sheng Yu	ZnO-ZnCr <sub>2</sub> O <sub>4</sub> Catalyst Fabricated by Glycine Nitrate Process and Used for Hydrogen Generation with the Steam Reforming of Methanol	National Taipei University of Technology	Department of Materials and Mineral Resources Engineering

M_P02	Zhen-Yu Sun	Zhen-Yu Sun, Chung-Lun Yu, Te-Wei Chiu	CuCrO <sub>2</sub> -TiO <sub>2</sub> Nanocomposites Prepared by Glycine Nitrate Process and Photodegradation the Organic Dye with Ultraviolet Light	National Taipei University of Technology	Department of Materials and Mineral Resources Engineering
M_P03	Yung-Fu Wu	Yung-Fu Wu, Yung-Lin Chen, Wei-Teng Wang, Yu-Ya Lin	Nickel Recovery from Spent Plating Solution by Chemical Precipitation	Ming Chi University of Technology	Department of Chemical Engineering
M_P04	Yung-Fu Wu	Yung-Fu Wu, Yung-Lin Chen, Wei-Teng Wang, Yu-Ya Lin	Anticorrosion for 304 Stainless Steel by Using TiO <sub>2</sub> Ag <sub>2</sub> O Protection Layer	Ming Chi University of Technology	Department of Chemical Engineering
M_P05	Chin-Wei Hung	Kai-Chun Hsu, Chin-Wei Hung, Subramanian Sakthinathan, Te-Wei Chiu, Fang-Yu Fan, Yung-Kang Shan	Fabrication of CuYO <sub>2</sub> Nanofibers by Electrospinning	Taipei Medical University	Dental Technology
M_P06	Yu-Feng You	Yu-Feng You, Chung-Lun Yu, Te-Wei Chiu	Preparation of Janus Structure ZnOCuO Composite Oxide Particle	National Taipei University of Technology	Department of Materials and Mineral Resources Engineering
M_P07	Shu-Yi Tsai	Shu-Yi Tsai , Kuan-Zong Fung, Khoiril Metrima Firmansyah	Effect of adding mesoporous silica KIT-6 of V <sub>2</sub> O <sub>5</sub> WO <sub>3</sub> TiO <sub>2</sub> catalyst for selective catalytic reduction	National Cheng Kung University	Hierarchical Green-Energy Materials Research Center
M_P08	Qiaofeng Han	Huiwei Ding, Qiaofeng Han	Synthesis of Bi <sub>4</sub> O <sub>5</sub> I <sub>2</sub> BiOI heterojunction with improved visible-light photocatalytic activity	Nanjing University of Science and Technology	School of Chemistry and Chemical Engineering
M_P09	Min Ao	Min Ao, Hui-min Liu, Chao-fang Dong	The effect of La <sub>2</sub> O <sub>3</sub> addition on intermetallic-free aluminium matrix composites reinforced with TiC and Al <sub>2</sub> O <sub>3</sub> ceramic particles	University of Science and Technology Beijing	Institute for Advanced Materials and Technology
M_P10	Ying-Chieh Lee	Jhen-Hau Jan, Annisa Oktaafianti, Choong Yen Voon , Ying-Chieh Lee	A Study of Low-Temperature Sintering of Al <sub>2</sub> O <sub>3</sub> Ceramics with TiO <sub>2</sub> and Nb <sub>2</sub> O <sub>5</sub> addition	National Pingtung University of Science and Technology	Materials Engineering
M_P11	Li-En Chen	Tzu-Hsuan Tsai , Li-En Chen , Chih-Lung Lin , Teng-Yu Wang	Electrostatic separation for recycling silicon from the crushed photovoltaic modules	National Taipei University of Technology	Institute of Mineral Resources Engineering
M_P12	Zihan Kang	Zihan Kang, Kanghui Ke, Enzhu Lin, Ni Qin, Jiang Wu, Rui Huang and Dinghua Bao	Novel Bi <sub>2</sub> WO <sub>6</sub> /g-C <sub>3</sub> N <sub>4</sub> /ZnO Z-scheme heterojunctions with g-C <sub>3</sub> N <sub>4</sub> interlayer modulated by piezoelectric polarization for efficient piezo-photocatalytic decomposition of harmful	Sun Yat-Sen University	Department of materials science and Engineering



			organic pollutants		
M_P13	Mi Chen	Cheng-Ch Wu, Horng-Show Koo Ming-An Chung and Mi Chen	Characerization of Graphene/CNTs Hybrid Conductive Film by Screen Printing	Minghsin University of Science and Technology, Taiwan	Department of Chemical and Materials Engineering
M_P14	Wan-Chien Wu	Wan-Chien Wu, Yung-Chin Yang	Developments of Calcium Sulfate Coating on $Ti_6Al_4V$ Substrate by Flame Spray	National Taipei University of Technology	Institute of Materials Science and Engineering
M_P15	Ying-Hao Chu	Ti Hsin, Pao-Wen Shao, Ying-Hao Chu	High entropy piezo-catalyst oxide for dye-degradation	National Yang Ming Chiao Tung University	Department of Materials Science and Engineering
P_P01	Chien-Chih Chiang	Chien-Chih Chiang, Jeou-Long Lee, Ta-Lun Sung, Jui-Chang Chen, Chin-Yen Chang, Chih-Chun Kuo	Synthesis and Characteristic of III-VI Metal Chalcogenide semiconductor nanoparticle	Lunghwa University of Science and Technology	Department of Chemical and Materials Engineering , Master.
P_P02	Sea-Fue Wang	Gu-Yan Liao, An-Cheng Aidan Sun, and Sea-Fue Wang	Characteristics of $La^{3+}$ dopants in $CeO_2$ thin films for resistance random access memory application	National Taipei University of Technology	Department of Materials and Mineral Resources Engineering



## A. Alternative energies

A\_P01

### Impressive OER Performance on Micro-Tree-Like Ni<sub>3</sub>S<sub>2</sub> in Alkaline Solution

Noto Susanto Gultom, Dong-Hau Kuo\*, Chien-Hui Li, and Hairus Abdullah\*,

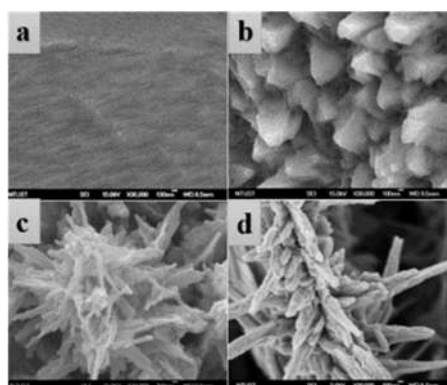
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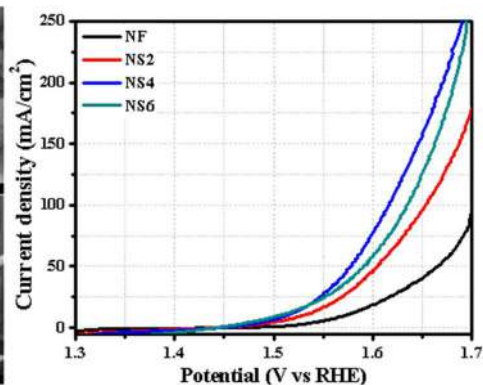
#### Abstract

Water electrolysis is regarded as a green method for producing hydrogen as an energy carrier with great potential. Oxygen evolution reaction (OER) as the half-reaction in water splitting has been the major obstacle for actual application [1]. In this work, we synthesized Ni<sub>3</sub>S<sub>2</sub> directly on nickel foam (NF) which served as the nickel source and the substrate. To optimize the electrocatalytic performance of Ni<sub>3</sub>S<sub>2</sub>, different amounts of thioacetamide (TAA, at 0, 2, 4, 6 mmol) as the sulfur source was added into 50 mL DI water during a hydrothermal process. X-ray diffraction analysis reveals that all samples have Ni<sub>3</sub>S<sub>2</sub> phase with a trigonal crystal structure. As shown in Fig. 1, the scanning electron microscope image exhibits that pure nickel foam has a very smooth surface. After adding a low amount of TAA (2 mmol), the surface becomes much rougher than the NF. The micro-tree-like surface morphology was formed when the amount of additional TAA was more two mmol. Based on X-ray photoelectron spectroscopy analysis, our nickel in NS-4 consists of bimetallic and trimetallic (Ni<sup>2+</sup> and Ni<sup>3+</sup>). Furthermore, the chemical composition of nickel and sulfur was 63.15 % and 36.85 %, respectively. The as-prepared electrocatalyst was then tested for OER in an alkaline environment. The electrocatalytic LSV graph in Fig. 2 shows that OER performances of Ni<sub>3</sub>S<sub>2</sub> are significantly improved after increasing the amounts of TAA. NS-4 with four mmol TAA exhibited the best performance for OER with overpotentials of 0.28 and 0.38 V to reach the current densities of 10 and 100 mA/cm<sup>2</sup>, respectively. The superb performance of NS-4 was contributed by the efficient electron transfer and high surface-active area.

**Keywords:** *Electrocatalyst, Oxygen evolution reaction, Ni<sub>3</sub>S<sub>2</sub>, micro-tree*



**Fig. 1.** Electron microscope of (a) NF, (b) NS-2, (c) NS-4, (d) NS-6



**Fig. 2.** Linear sweep voltammogram (LSV) of Ni<sub>3</sub>S<sub>2</sub> with different amounts of TAA

#### References

[1] Wu, A., et al., *Nano Energy*, 2018. **44**: p. 353-363.

A\_P02

## Integration of High Pressure Resistant Flexible 6-in-1 Microsensor and High Pressure Proton Exchange Membrane Water Electrolyzer

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### Abstract

Atmospheric pressure proton exchange membrane water electrolysis (PEMWE) hydrogen production is an electrochemical reaction, and requires a high operating voltage, which is prone to aging and failure. The uneven distribution of important internal physical quantities of PEMWE operation will affect its performance and life. How to micro-monitor the six important physical quantities of high pressure PEMWE in real time and get the best operating conditions and prevent failure or damage improve performance and safety which is the focus of research and development. The research used micro-electro-mechanical systems (MEMS) to innovatively develop high pressure resistant flexible 6-in-1 (pressure, temperature, humidity, flow, voltage and current) microsensor. The microsensor is embedded in different positions inside in the high pressure PEMWE for real-time microscopic monitoring, and using monitoring data to improve the performance and safety of high-voltage PEMWE.

**Keywords:** High pressure proton exchange membrane water electrolyzer, High pressure resistant flexible 6-in-1 microsensor, Real-time microscopic monitoring

A\_P03

## PEMWE's MEA Anode Internal Sensing Technology Development

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### Abstract

The three important physical parameters inside the membrane electrode assembly (MEA) of proton exchange membrane water electrolyzer (PEMWE). Voltage, current, and temperature are not easy to accurately measure, and these three important physical parameters are related to each other and have a key impact on the performance and local aging of the water electrolyzer. However, the existing measurement methods are difficult to measure the performance changes of the local microscopic dimensions of the water electrolyzer in real time. This also makes the water electrolyzer in the process of repeated operation for a long time, the failure of the water electrolyzer can only be inferred by simulation or extremely high-cost, destructive, and non-immediate analysis and discussion of the causes often result in too macro or narrow-minded. This paper uses MEMS technology to innovate and develop a small size and high sensitivity flexible three-in-one (voltage, current, temperature) microsensor, which can measure and analyze the local performance of the PEMWE's MEA. This flexible three-in-one microsensor has three functions, corrosion resistance, small size, high sensitivity, real-time measurement and can be placed in any position and many other advantages.

**Keywords:** Flexible three-in-one microsensor, proton exchange membrane water electrolyzer, MEMS, MEA

A\_P04

## Incorporation of Au@CuS/Cu<sub>2</sub>S nanoparticles on ZnO nanosheets for efficient photo/dark responsive degradation of organic pollutants

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### Abstract

ZnO has been considered one of the most popular photocatalytic materials because of its nontoxic, intrinsic electronic structure, and remarkable optical property. However, the wide band gap (3.37 eV) and high carrier recombination rate limit its performance of photocatalytic degradation. Therefore, in this study, the novel heterostructures consist of Copper (I) sulfide and Copper (II) sulfide as shells to cover gold nanoparticles as cores that uniformly decorate the ZnO nanosheets for the realization of day-night responsive photocatalysts. Through the band alignment of these heterojunctions, carriers can be separated effectively, but also highly improved the efficiency of photodegradation under light illumination. In a dark environment, the Copper (I) sulfide can catalyze H<sub>2</sub>O<sub>2</sub> and convert H<sub>2</sub>O<sub>2</sub> into hydroxyl radicals. Through this dark-degradation mechanism, hydroxyl radicals can react with organic pollutants even in an environment without light illumination [1]. Moreover, this composite structure can also utilize its adsorption characteristics to make pollutant molecules adsorbed on the photocatalytic surface. From these findings, such Au@CuS/Cu<sub>2</sub>S nanoparticles decorated on ZnO nanosheets can effectively initiate the photocatalytic and dark-catalytic reactions that could be applied for day-night active removal of organic pollutants.

**Keywords:** Photocatalysts, Copper sulfide, ZnO nanosheets, dark degradation

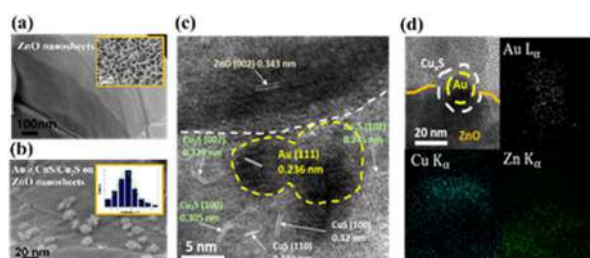


Fig. 1 SEM images of (a) ZnO (b) CuS@Cu<sub>2</sub>S@Au-ZnO nanosheets. (c) HRTEM images of CuS@Cu<sub>2</sub>S@Au-ZnO nanosheets (d) TEM image of CuS@Cu<sub>2</sub>S@Au-ZnO nanosheets and corresponding EDX elemental mapping results.

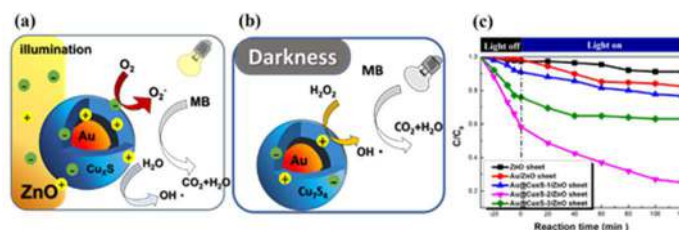


Fig. 2 Schematic presentation of degradation mechanism in the presence of CuS@Cu<sub>2</sub>S@Au-ZnO nanosheets (a) under light illumination and (b) in dark environment. (c) Degradation results of various

ZnO-based photocatalysts.

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## B. Battery and energy storage

B\_P01

### Polymer-derived Nitrogen-doped Carbon Materials with Hierarchically Porous Architectures toward Capacitive Performances for Lithium-ion Capacitors

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#### Abstract

Lithium-ion capacitors (LICs) have gained much attention due to their capability to combine the features of batteries with supercapacitors together. Recently, hierarchical porous activated carbon (HPAC) with high specific surface area (normally more than 1000 m<sup>2</sup>/g) is known for its outstanding energy storage performances as the cathode material for LICs.[1-4] In this study, the activated carbon materials with hierarchically porous architectures and nitrogen doping (N-HPAC) were successfully prepared by the procedures reported previously.[5] The specific surface area of the resulting N-HPAC was as high as 2012 m<sup>2</sup>/g, with a microporous area of 1407 m<sup>2</sup>/g and mesoporous/external area of 605 m<sup>2</sup>/g. Even the mass-loading of a prepared electrode is up to 5.2 mg/cm<sup>2</sup>, it not only revealed a high specific capacity (72 mAh/g at 0.1 A/g) and the excellent rate capability (62 mAh/g at 1 A/g) but also exhibited the Coulombic efficiency larger than 99 %. It could be attributed to their distinctive surface and structural features of the N-HPAC, leading to the remarkable capacitive performances. Consequently, the findings in this study would be beneficial for realizing the practical applicability of the N-HPAC-based electrode in the electrochemical energy-storage applications.

**Keywords:** Lithium-ion capacitors, Hierarchically porous activated carbon, Nitrogen doping, Capacitive performances

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B\_P02

## Excellent Electrochemical active CuFe<sub>2</sub>O<sub>4</sub>/3D-rGO based Supercapacitor Electrodes with an Ultrahigh Specific Capacitance

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### Abstract

The novel and highly enormous multifunctional nanocomposites have attracted more attention because of the materials in energy and wastewater remediation treatment. In addition, growing demands for regenerative energy and electric automotive applications in recent decades. The storage devices in the electrical field such as supercapacitors attractive more applications in consumer alternative electronic products due to their excellent energy density, rapid charge/discharge time, safety, no disposable parts, and long-term operation stability [1]. In this manuscript, CuFe<sub>2</sub>O<sub>4</sub> loaded 3D reduced graphene oxide (3D-rGO) nanocomposites have been prepared by an ultrasonication process. The synthesized nanocomposites were studied by different analytical studies such as X-ray diffraction, Transmission electron microscopy, Scanning electron microscopy, and X-ray photoelectron spectroscopy. As prepared nanocomposites have exhibited an excellent surface area, high energy storage with appreciable durability. In addition, the 3D rGO enhanced conductivity, decrease agglomeration, interfacial charge transportation in the nanocomposites. These properties also playing a major role in nanocomposite's physicochemical properties. A supercapacitor with CuFe<sub>2</sub>O<sub>4</sub> loaded 3D-rGO based electrodes exhibits an excellent specific capacitance of 635.5 Fg<sup>-1</sup> at ambient temperature, and a higher current density of 1 A/g, as well as a higher power density of 809.8 Wkg<sup>-1</sup>. These energy density values are nearby of the commercialized Ni metal hydride capacitor [2]. As a result, intimates that the prepared nanocomposites could be protentional for the storage of energy.

**Keywords:** Nanofiber, Supercapacitors, CuFe<sub>2</sub>O<sub>4</sub>, Specific capacitance.

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B\_P03

## High energetic supercapacitor electrode of CuCoO<sub>2</sub>/P-rGO nanocomposite with ultrahigh specific capacitance

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### Abstract

The three dimensional nanomaterial have received more attention in energy and environment remediation applications [1]. We present the structural and good electronic properties of CuCoO<sub>2</sub>/P-rGO nanocomposite through the hydrothermal method [2]. The phase and surface morphology of CuCoO<sub>2</sub>/P-rGO nanocomposite were confirmed by the various analytical and spectroscopic techniques such as X-ray diffraction, Scanning electron microscope, high resolution transmission electron microscope and X-ray photoelectron spectroscopy. In the field of supercapacitor should be consider as quick charge and discharge time, high energy density and long life cycles. According to the prepared nanocomposite has high specific capacitance of 636.4 Fg<sup>-1</sup> at a current density of 1 Ag<sup>-1</sup> at maintained about 80% retention after 4000 cycles. Herein, addition of P-rGO has improve the surface area and CuCoO<sub>2</sub> catalyst improve the electron conductivity. The CuCoO<sub>2</sub>/P-rGO electrode has excellent electrochemical performance and its suitable for supercapacitor electrodes.

**Keywords:** CuCoO<sub>2</sub>, P-rGO, Hydrothermal method, Supercapacitor.

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B\_P04

## Performance of Molybdenum-Modified Titanium Oxide as anode for lithium-ion Battery

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### Abstract

TiO<sub>2</sub> is one of environmentally friendly anode materials in lithium-ion battery having longer cycle life, better stability without producing dendrite like microstructure. However, the specific capacity (330 mAh·g<sup>-1</sup>) of TiO<sub>2</sub> is significantly low making it undesirable for the high-end applications.[1] Therefore, modification of TiO<sub>2</sub> with molybdenum (Mo) is necessary to boost the capacity and the overall electrochemical properties of anode material. The specific capacity had reached ~1272.6 mAh·g<sup>-1</sup> in the first cycle and the reversible capacitance is 810 mAh·g<sup>-1</sup> at a current rate of 0.1C showing a fading of 36.3%. After 10 cycles, it still maintained a specific capacity of 578.9 mAh·g<sup>-1</sup> having a Coulombic retention efficiency of ~71.5 %. Mo-modified TiO<sub>2</sub> was obtained by reacting (NH<sub>4</sub>)<sub>2</sub>MoO<sub>4</sub> and TiO<sub>2</sub> (rutile phase and anatase phase mixed) followed by annealing at elevated temperature (700°C).[2] The future work would be to do a detail electrochemical analysis (CV, LSV, and EIS test) to determine the Li<sup>+</sup> diffusion rate and electrical conductivity and in-situ XRD to explore the structural behavior of Mo@TiO<sub>2</sub>. The high specific capacity and safety performance of Mo@TiO<sub>2</sub> will widen the possibility of application of TiO<sub>2</sub> in lithium-ion battery.

**Keywords:** Anode material, Lithium-ion Battery, Mo-modified TiO<sub>2</sub>

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B\_P05

## Development of Instant Diagnostic Technology for Hydrogen/vanadium Flow Battery

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### Abstract

The vanadium redox flow battery system is an emerging energy storage technology, it has many advantages in application, such as high efficiency, long life, high power and high safety. The latest document indicates that the hydrogen/vanadium redox flow battery has better energy density and efficiency than vanadium redox flow battery. In addition, the hydrogen concentration, electrical conductivity, voltage, current, temperature, electrolyte flow and flow channel pressure inside the hydrogen/vanadium redox flow battery will affect its performance and life. Therefore, this paper uses micro-electro-mechanical systems (MEMS) to develop a flexible 7-in-1 microsensor and embed it in the hydrogen/vanadium redox flow battery pack for real-time diagnosis, thereby obtaining optimized operating conditions and improving performance and safety.

**Keywords:** Hydrogen/vanadium redox flow battery, Micro-electro-mechanical systems, Flexible 7-in-1 microsensor, Real-time diagnosis

B\_P06

## Effect of Synthesis Routes on Nickel rich and Cobalt-free Layered Oxides Cathode for Li Ion Batteries

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### Abstract

The layered structured cathode material can provide a higher capacity and stable cycle retention, which is a desired property for lithium ion batteries. Among them, NMC composed of Ni, Mn and Co as transition metals is considered a promising positive electrode. However, because Co is slightly toxic and an expensive strategic resource, reducing the Co content and maintaining the capacitance and cycle stability are the objectives of this study.

In this study,  $\text{LiNi}_{0.8}\text{Mn}_{0.1}\text{Co}_{0.1}\text{O}_2$  and  $\text{LiNi}_{0.33}\text{Mn}_{0.33}\text{Fe}_{0.33}\text{O}_2$ , were investigated. The material synthesis adopts the solid-state reaction method, which is divided into one pot method and multi-step method. In  $\text{LiNi}_{0.8}\text{Mn}_{0.1}\text{Co}_{0.1}\text{O}_2$ , the initial discharge capacity of the cathode synthesized by the one pot method in the first attempt was 83.59 mAh/g. After 30 cycles, the remaining capacity is 38.13 mAh/g with 45.62% retention. The initial discharge capacity of the cathode synthesized by the multi-step method is 70.40 mAh/g. After 30 cycles, the remaining capacity is 45.44 mAh/g with 64.55% retention.

For  $\text{LiNi}_{0.33}\text{Mn}_{0.33}\text{Fe}_{0.33}\text{O}_2$ , the sample synthesized by one pot method can clearly see the phase formation of  $\text{Li}_2\text{MO}_3$  (M is a transition metal) in the XRD pattern, while the multi-step method can inhibit the formation of  $\text{Li}_2\text{MO}_3$ . As a result, the first charged capacity is around 140 mAh/g. The difference in capacity will be explained in light of structural and electrical properties.

**Keywords:** Cathode, Lithium ion battery, Nickel rich, Cobalt free

B\_P07

## Computational simulation and efficient evaluation on corrosion inhibitors for electrochemical etching on aluminum foil

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### Abstract

Aluminum foil is the key material for aluminum electrolytic capacitors. To increase the specific surface area and capacitance, the method of electrochemical etching on aluminum foil in solutions with low-concentration corrosion inhibitor has been widely applied [1-3]. In this study, various organic molecules as 8HQ, BTA, MBT, Citric Acid and Oleic Acid were analyzed through DFT calculations and experimental methods. The physicochemical properties of five different organic molecules were analyzed by quantum chemical calculations firstly [4-5]. Furthermore, the hydrated cation models of aluminum ion with various inhibitor molecules have been considered to compare the stability of complex models and their effects on aluminum dissolution behavior [6-8]. Besides, periodic adsorption models were performed to explore the interaction between inhibitor molecules and aluminum surface through dynamic methods [5,8]. Experimentally, the etched tunnels of aluminum foil were tested in various etching solutions and the tunnel densities were integrated respectively [1-3]. Finally, relationship between experimental characterization of etched aluminum foil and physicochemical properties of inhibitor molecules were established. The results indicate that Oleic Acid presents excellent corrosion inhibiting performance on the improvement of tunnel density as  $\rho = 1.5925 \times 10^7 \text{ cm}^{-2}$  and predicted capacitance as  $C = 0.72 \text{ } \mu\text{F cm}^{-2}$  at 520 V.

**Keywords:** DFT calculations, Molecular dynamic, Materials Genome Engineering; Aluminum foil, Electrolytic capacitors

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B\_P08

## Polarization Reduction of Surface-Modified Garnet Solid Electrolytes for Solid State Li-ion Battery Applications

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### Abstract

Since the issues with global warming and climate change received great attention, the demand for renewable energy and energy storage technologies is urgently needed. Among well-known energy storage devices, it is expected that the conventional Li ion batteries using liquid electrolytes will be gradually replaced by the solid-state lithium batteries due to their better safety features. However, challenges with solid state batteries still remain to be overcome. Among several types of inorganic solid electrolyte, Garnet-structured  $\text{Li}_{6.5}\text{La}_3\text{Zr}_{1.5}\text{Ta}_{0.5}\text{O}_{12}$  (LLZTO) is found to be a good candidate with high ionic conductivity ( $10^{-3}$ - $10^{-4}$  S/cm) with adequate stability against pure lithium metal.

However, the high interface polarization and poor wetting ability between solid electrolyte and anode has been a major concern. People have been focusing on the interface engineering and trying to solve the problems with solid-state lithium-ion batteries. Thus, the objectives of this study are using Au as interlayer to obtain better adhesion with electrolyte, suppress the interface polarization between LLZTO and electrodes and verify the effect of interlayer for reduction of interface polarization.

From the results of this study, the interface polarization has reduced to below  $47.71\Omega\text{-cm}^2$  based on EIS measurement from a Li/Au/LLZTO/Au/Li symmetrical cell. In addition, Li stripping/plating tests were also conducted on the same symmetric cell over 200 cycles (200 hours) at  $0.6\text{mA/cm}^2$  current density. Very stable/consistent and minimized voltages were observed indicating a well-functioned interlayer. After 20 cycles of testing at 0.05C, the performance of Li/Au/LLZTO/LCO battery proved the effectiveness of the gold-layer film interface modification for LLZTO electrolyte.

**Keywords:** solid-state lithium-ion battery, LLZTO, interfacial modification

B\_P09

## Synthesis and Electrochemical Properties of Single-Crystal $\text{LiNi}_{0.5}\text{Co}_{0.2}\text{Mn}_{0.3}\text{O}_2$ Cathode for Lithium-Ion Batteries

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### Abstract

It is necessary to develop novel cathode materials with higher energy density, longer cycle life and more reliable safety to meet the market demands for Li-ion batteries [1-5]. In this connection, the capability of layered- $(\text{Li}_{1+x}(\text{Ni}_x\text{Co}_z\text{Mn}_z)_w\text{O}_2)$  NCM can be enhanced by working on high potential ( $> 4.3$  V), but usually it leads to poor cycling performance over numerous charged-discharged cycles. The capacity fading in NCM is caused by increasing interfacial resistance and the formation of insulated phase during the charge/discharge processes. To mitigate the problems, single-crystalline NCM cathodes have attracted attention due to their robust morphological integrity. In this study, single crystalline  $\text{LiNi}_{0.5}\text{Co}_{0.2}\text{Mn}_{0.3}\text{O}_2$  (SC-523) and polycrystalline  $\text{LiNi}_{0.5}\text{Co}_{0.2}\text{Mn}_{0.3}\text{O}_2$  (PC-523) were prepared at lower temperatures via one-step synthesis process. The X-ray diffraction patterns, resemble with  $\alpha$ - $\text{NaFeO}_2$  layer structure (Space Group  $R-3m$ ) for both samples, without exhibiting any impurity phase and shifting in Bragg peak position. The visual comparison of SC-523 and PC-523 is observed by SEM. The morphology of PC-523 sample is consist of micron-sized secondary particles along with agglomerated nano-sized primary particles. In contrast, SC-523 sample consists of larger and single-standing primary particles. The average particle size of SC-523 and PC-523 samples are 4  $\mu\text{m}$  and 12  $\mu\text{m}$ , respectively as confirmed by SEM analysis. The electrochemical behavior of both samples are thoroughly investigated under different high voltages of 4.2 V, 4.4 V, 4.6 V, 4.8 V, and 5 V, respectively. Furthermore, the capacity retention of SC-523 sample after 100 cycles is maintained up to 90%, while for PC-523 sample it is only 70% at 1 C within 3.0-4.6 V (vs.  $\text{Li}/\text{Li}^+$ ) limit. The high capacity retention for SC-523 sample can be attributed due to improved morphological moieties.

**Keywords:** Single crystalline,  $\text{LiNi}_{0.5}\text{Co}_{0.2}\text{Mn}_{0.3}\text{O}_2$ , Cathode, Lithium-ion Battery

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B\_P10

## Characterization of spinel cathode material for advanced lithium-ion batteries

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### Abstract

$\text{LiNi}_{0.5}\text{Mn}_{1.5}\text{O}_4$  is one of the most promising cathode materials for use in either next generation lithium-ion batteries or all solid-state batteries, which provides high working voltage and cyclic stability. Since this material does not contain cobalt, it is environmentally friendly compared to other cathode materials. A two-steps solid-state synthesis method was used for synthesis of single-phase 4.7 V  $\text{LiNi}_{0.5}\text{Mn}_{1.5}\text{O}_4$  (LNMO) spinel. In comparison to one-pot method, two-steps process which was based on formation of single-phase nickel manganese oxide followed by subsequent lithiation. As a result, reflections of  $\text{LiNi}_{0.5}\text{Mn}_{1.5}\text{O}_4$  were observed at temperatures of as low as 400°C. During this lithiation process, migration of transition metal ions (Ni/Mn) from tetrahedral 8a sites (in NMO) toward octahedral 16d site occurred, which can be proved by the emergence of spinel peaks from XRD patterns. The resultant spinel oxide displayed 123.63 mAh/g discharge capacity for the first cycle, a 97% coulombic efficiency and retention of 76% in discharge capacity after 85 cycles at room temperature.

**Keywords:** Cathode, Lithium ion battery, Spinel, Cobalt free material

B\_P11

## Effect of concentration on performance of ZrO<sub>2</sub> nanoparticle electrochemical in Vanadium Redox Flow Batteries

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### Abstract

Zirconium oxide (ZrO<sub>2</sub>) acts as the electrode material for all-vanadium redox flow battery (VRFB). From the result of thermogravimetric analysis, it is found that the content of attached ZrO<sub>2</sub> is about 3.59wt%. Using field emission scanning electron microscope (FE-SEM) and energy dispersive detector (EDS) analysis, it is found that the graphite felt has surface and oxygen particles on the surface. By X-ray diffraction analysis (XRD), the particles contained two-phase ZrO<sub>2</sub>, monoclinic crystal and tetragonal crystal. The specific surface area of the resulting the graphite felt modified by ZrO<sub>2</sub> nanoparticles (ZrO<sub>2</sub>/GF) was as high as 29.34 m<sup>2</sup>/g. The electrochemical characteristics of graphite felt were studied by cyclic voltammetry(CV). The oxidation-reduction potential difference of ZrO<sub>2</sub>/GF was 0.33 V at 10 mVs<sup>-1</sup>, which was lower than that of the unmodified graphite felt electrode ( 0.62 V) and the resistance of charge transfer were decreased from 3.31 Ω to 0.33 Ω. The result shows the ZrO<sub>2</sub> exhibits excellent electrochemical properties than unmodified graphite felt electrode because the ZrO<sub>2</sub> can provide more active site which toward VO<sup>2+</sup>/VO<sub>2</sub><sup>+</sup> redox reaction.

**Keywords:** Vanadium redox flow battery, Graphite felt, Zirconium oxide



B\_P12

## Synthesis and Properties of $\text{Li}_2\text{MnO}_3\text{-LiMn}_{1/3}\text{Co}_{1/3}\text{Ni}_{1/3}\text{O}_2$ Cathode Materials for Lithium-Ion Battery

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### Abstract

In this study, the cathode materials  $\text{LiCoO}_2$ ,  $\text{LiNiO}_2$ ,  $\text{LiMnO}_2$  are used as single-phase layered structure to improve the solid solution  $x\text{LiMnO}_3(1-x)\text{LiMO}_2$  ( $M=\text{Ni, Co, Mn}$ ) composed of two-phase layered structure, allowing for more Li-ions to be deintercalated and improved charge/discharge capacity. The crystallinity becomes more complete with excess lithium concentration more than 7.5wt%, and the  $c/a$  values of the four additives are all greater than 4.9, suggesting that the layered organization structure is good and apparent, as shown by the XRD images. The powders containing 5%, 7.5%, 10% and 12.5% excess lithium had agglomeration, a rough surface, and substantial particle variations, as seen in the SEM image. The cathode material has a specific discharge capacity of  $111.15\text{mAhg}^{-1}$  and a coulombic efficiency of 65 percent when 10wt% extra lithium was added to  $0.5\text{Li}_2\text{MnO}_3\text{-}0.5\text{LiMn}_{1/3}\text{Co}_{1/3}\text{Ni}_{1/3}\text{O}_2$ .

**Keywords:** cathode material, Li-ions, two-phase layered structure

B\_P13

## Synthesis and Material Characteristic of $\text{Li}_{1.3}\text{Al}_{0.3}\text{Ti}_{1.7}(\text{PO}_4)_3$ Solid Electrolytes for Lithium-ion Battery

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### Abstract

During charge and discharge, the lithium ion battery's liquid electrolyte is prone to forming lithium dendrites, resulting in a short circuit. As a result, the pure phase  $\text{Li}_{1.3}\text{Al}_{0.3}\text{Ti}_{1.7}(\text{PO}_4)_3$  (LATP) solid electrolyte material was successfully synthesized using the sol-gel technique in this work, and the influence of various temperatures on its electrochemical performance was observed. Software estimated the LATP lattice constant and  $\text{AlPO}_4$  concentration based on XRD patterns. When sintered at 850°C,  $\text{AlPO}_4$  content was found to be 11.43 %, and when sintered at 900°C, it was found to be 20.43 percent. The SEM image then indicates that when sintered to 850°C, the surface particle structure can still be visible, but when sintered to 900°C, the surface particle structure is molten and compact. The particle size distribution is rather homogeneous, with the primary particle distribution extending from 200 nm to 400 nm, and the peak width of DLS is small. Finally, it can be observed from the EIS findings that when the test temperature rises, the overall impedance lowers, and the ionic conductivity rises.

**Keywords:** solid electrolyte, sol-gel, lithium ion battery

B\_P14

## Microwave co-precipitation synthesis and electrochemical characterization of $0.4\text{Li}_2\text{MnO}_3\text{-}0.6\text{LiMn}_{1/3}\text{Co}_{1/3}\text{Ni}_{1/3}\text{O}_2$ as Cathode Material for lithium-ion battery

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### Abstract

The cathode material of  $x\text{LiMnO}_3(1-x)\text{LiMO}_2$  ( $M=\text{Ni}, \text{Co}, \text{Mn}$ ) with a double-layered structure was synthesized in this study using the microwave co-precipitation technique, resulting in more Li-ions being deintercalated and increased charge/discharge capacity. The lattice volume at 60, 70, 80, 90, and 100°C did not change substantially, and the  $c/a$  value was larger than 4.9, indicating that it had an excellent lamellar structure, according to XRD and software calculations. The disparity between large and small particles decreases as the reaction temperature rises, as can be seen in the SEM image, and the average particle size shows that as the reaction temperature rises, particles tend to get smaller. The battery's discharge capacity at 90°C is  $177.19\text{ mAhg}^{-1}$  at 0.1C rate. The results demonstrate that when the reaction temperature rises, the material's stability rises as well.

**Keywords:** microwave co-precipitation technique, double-layered structure, cathode material

## E. Energy efficiency technologies and applications

E\_P01

**The effects of selectively and randomly deposited Ag nanoparticles on the piezocatalytic activity of BaTiO<sub>3</sub> nanocubes/cuboids**Enzhu Lin<sup>1</sup>, Zihan Kang<sup>1</sup>, Jiang Wu<sup>2</sup>, Rui Huang<sup>3</sup>, Ni Qin<sup>4</sup>, \*, Dinghua Bao<sup>5</sup>, \*<sup>1</sup> PhD student, School of Materials Science and Engineering, Sun Yat-Sen University<sup>2</sup> Post-doctoral, School of Materials Science and Engineering, Sun Yat-Sen University<sup>3</sup> Master student, School of Materials Science and Engineering, Sun Yat-Sen University<sup>4</sup> Associated professor, School of Materials Science and Engineering, Sun Yat-Sen University<sup>5</sup> Professor, School of Materials Science and Engineering, Sun Yat-Sen University

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**Abstract**

The selective deposition of noble metals on catalysts is an attractive modification method for improving catalytic efficiency. However, it is sometimes hard to achieve when facet energies of nanocatalysts show negligible differences. Here, we reported a piezoelectrochemical method which can realize the selective deposition of Ag nanoparticles on the positively polar end of {001}-enclosed BaTiO<sub>3</sub> (BTO) nanocubes/cuboids. Furthermore, BTO nanocubes/cuboids with selectively-deposited Ag nanoparticles show approximately 2 times higher piezocatalytic activity than those with randomly-loaded Ag nanoparticles, and much higher than pure BTO nanocubes/cuboids. The piezocatalytic mechanism revealed that the Ag nanoparticles deposited on positively polar end act as “fast lanes” for electrons to transfer to catalysts/solution interfaces, while those loaded on negatively polar end serve as holes trappers hindering ·OH formation and pollutant degradation. This work confirms an efficient way to improve piezocatalytic performance and provides an insightful discussion of piezocatalytic mechanism.

**Keywords:** BaTiO<sub>3</sub> nanocubes/cuboids; Selective deposition; Piezocatalysis; Steady-state approximation; Kinetics

E\_P02

## Development of nano-sized Fe-based powder for Inductance

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### Abstract

In recent years, passive components have set off an upsurge in the world. Nano-scale metal particles, on the other hand, are not extensively employed in passive components nowadays. In the nanoparticle production process, the liquid phase reduction technique gives the best results. The impact of grain size or the hysteresis curve in varied PVP concentrations is demonstrated in this study. It is shown to be compatible with the Cubic structure of Fe using XRD analysis. It is discovered that there is an impurity phase after adding the iron powder coated with PVP (orthorhombic Fe<sub>3</sub>C). The iron particle size is around 100 nm, and a chain structure can also be detected by SEM, and the iron particle size of PVP (Fe-15PVP) coated with 15 wt% is about 185 nm. The saturation magnetic moment density (Ms) of Fe is 145.8 emu/g, whereas the Ms of Fe-15PVP is 131.6 emu/g, according to SQUID analysis. The reason for this is that Fe<sub>3</sub>C is a non-magnetic substance, which causes the saturation magnetic moment density to drop.

**Keywords:** Passive component, Inductance, PVP, magnetic material

E\_P03

## Preparation of Nitrogen-doped BaTiO<sub>3</sub> Thin Films on TiN/Si by Plasma Electrolytic Oxidation

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### Abstract

Perovskite barium titanate has received extensive attention for its excellent dielectric properties. However, its wide bandgap hinders the application for a promising catalyst. Nitrogen doping has been proved to be an effective approach to decrease the bandgap, which may be applied to visible light catalysts. In this work, an innovative plasma electrolytic oxidation (PEO) method with a DC power source was used to produce the films. A potentiostatic mode at 75 V was applied to the as-deposited TiN films over Si substrates, which acted as working electrodes and a nitrogen doping source, while Pt plates were counter electrodes. The PEO process was conducted at 70 °C in the mixed solutions of 0.5 M Ba (CH<sub>3</sub>COO)<sub>2</sub> and 2 M NaOH. As-deposited Ti films over Si without any nitrogen source was also used as a reference. X-ray diffraction patterns show that obtained oxides with and without nitrogen doping all had cubic BaTiO<sub>3</sub> (BTO) and additional TiO<sub>2</sub> phases. The measured lattice parameter of N-BTO (0.4060±0.0002 nm) was very similar to that of BTO (0.4063±0.0002 nm). Apparently, slight doping could not cause the apparent lattice changes. The presence of TiO<sub>2</sub> phase may be due to the intermediate phase before forming the final product BTO. Field-emission scanning electron microscopy (FE-SEM) revealed that the films were porous layered structures. The average growth rate of N-BTO over TiN/Si was much higher than that of BTO over Ti/Si. Moreover, the XPS spectra show a small amount of nitrogen doping (1.2 at%) for N-BTO. From the UV-visible reflection spectra and the calculated Tauc plot, the bandgap decreased from 2.99 eV for BTO to 2.94 eV for N-BTO. This demonstrates the PEO method with TiN film electrodes is promising to produce nitrogen-doped perovskite barium titanate.

**Keywords:** Plasma electrolytic oxidation, N-doped BaTiO<sub>3</sub>, TiN, films, bandgap

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E\_P04

## Preparation of CeO<sub>2</sub>-CuCrO<sub>2</sub> composite by electrospinning method

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### Abstract

As a result of the energy crisis in recent years, we have been searching for various alternative energy to solve this problem. Although hydrogen is potential energy for the community, hydrogen transportation is a challenge that should be overcome. Therefore, to produce hydrogen nearby the storage equipment could ignore the above problem. Also, the copper-based material is attracting more attention in the industry. In this study, the CeO<sub>2</sub> nanofibers were prepared by the electrospinning method. Due to the adsorption of Cu-Cr-O precursor was difficult initiation on the surface of CeO<sub>2</sub> nanofibers. Tetraethoxysilane (TEOS) was used to coat trace amounts of SiO<sub>2</sub> on the CeO<sub>2</sub> nanofibers' surface to improve the interface between CuCrO<sub>2</sub> and CeO<sub>2</sub>. After the modification, the CeO<sub>2</sub> nanofibers were immersed into Cu-Cr-O precursor and annealing at vacuum to form CuCrO<sub>2</sub> particles on of CeO<sub>2</sub> nanofibers' surface. The microstructure of the CeO<sub>2</sub>-CuCrO<sub>2</sub> catalyst was analyzed through the SEM, TEM, and EDS characterization and confirm the core and particles were CeO<sub>2</sub> and CuCrO<sub>2</sub>. Furthermore, the CeO<sub>2</sub>-CuCrO<sub>2</sub> catalyst exhibited the highest hydrogen production by the methanol steam reforming method, which could reach 1335.16 ml STP min<sup>-1</sup> g-cat<sup>-1</sup> at 500°C. According to the result of the hydrogen production application, the convenience and safety of the process would have a significant industrial and economic impact.

**Keywords:** CeO<sub>2</sub>-CuCrO<sub>2</sub>, Electrospinning, Microstructure, Methanol steam reforming, Hydrogen production.

E\_P05

## Porous Structure ZnO-ZnFe<sub>2</sub>O<sub>4</sub> Catalyst Applied by Hydrogen from Methanol Steam Reforming

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### Abstract

Due to the rapid development of science and technology, energy had gradually been an indispensable place in human life. Because of this, countries consume energy uncontrollably, causing an energy crisis and the emergence of extreme global warming climates. Effective alternative energy became the consensus of everyone, and hydrogen (H<sub>2</sub>) was regarded as potential alternative renewable energy. In this research, ZnFe<sub>2</sub>O<sub>4</sub> and ZnO-ZnFe<sub>2</sub>O<sub>4</sub> catalysts with spinel structure were prepared by the glycine combustion method, which was used for methanol steam reforming (SRM). According to the SEM and TEM, ZnFe<sub>2</sub>O<sub>4</sub> and ZnO-ZnFe<sub>2</sub>O<sub>4</sub> nanopowders catalysts had a porous structure like a coral reef. Besides, the measurement of the BET specific surface area, when the G/N ratio was 1.5, the specific surface area at 5.6680 m<sup>2</sup>/g (ZnFe<sub>2</sub>O<sub>4</sub>) and 8.2073 m<sup>2</sup>/g (ZnO-ZnFe<sub>2</sub>O<sub>4</sub>). When the G/N ratio was 1.7, the specific surface area at 6.0390 m<sup>2</sup>/g (ZnFe<sub>2</sub>O<sub>4</sub>) and 11.6724 m<sup>2</sup>/g (ZnO-ZnFe<sub>2</sub>O<sub>4</sub>). So the Spinel structure was not greatly affected by the G/N ratio. On the other hand, ZnFe<sub>2</sub>O<sub>4</sub> and ZnO-ZnFe<sub>2</sub>O<sub>4</sub> were found to have the best catalytic effect at 450°C and 500°C. In particular, the highest H<sub>2</sub> generation rate of ZnO-ZnFe<sub>2</sub>O<sub>4</sub> at 500°C was 6663.48 (ml STP min<sup>-1</sup> g-cat<sup>-1</sup>). Therefore, we hoped that studying ZnFe<sub>2</sub>O<sub>4</sub> (pure phase spinel) and ZnO-ZnFe<sub>2</sub>O<sub>4</sub> (nano-composite powders) to investigate the high catalytic activity of spinel and good dispersibility of ZnO to improve the specific surface area of the catalyst. The catalyst was going to be applied in methanol steam reforming in the future.

**Keywords:** Glycine Nitrate Process, Spinel structure, ZnO-ZnFe<sub>2</sub>O<sub>4</sub>, Hydrogen production, Steam reforming of Methanol



F. Fuel cells  
F\_P01

## Flexible Integrated Microsensor for *In-situ* Monitoring of Proton Battery

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### Abstract

The proton battery has water electrolysis, proton storage and discharging functions simultaneously, and it can be manufactured without expensive metals. Therefore, this paper uses micro-electro-mechanical systems (MEMS) technology to develop a flexible integrated microsensor, which is embedded in the proton battery to obtain important physical parameters instantly, so that the condition inside the proton battery can be mastered more precisely, so as to prolong the battery life and enhance the proton battery performance.

**Keywords:** Proton battery, MEMS, Flexible integrated microsensor, *In-situ* monitoring

F\_P02

## Correlation between NiFe<sub>2</sub>O<sub>4</sub> Cathode Thickness and Hydrogen Production Efficiency for Solid Oxide Electrolyzer Cells

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### Abstract

In this study, La<sub>0.9</sub>Sr<sub>0.1</sub>Ga<sub>0.8</sub>Mg<sub>0.2</sub>O<sub>3-δ</sub> (LSGM) was applied as the electrolyte. NiFe<sub>2</sub>O<sub>4</sub> and Ni-SDC were applied as the cathode materials for solid oxide electrolyzer cell (SOEC). The different thicknesses of cathode material (NiFe<sub>2</sub>O<sub>4</sub>) was utilized to observed cell performances under 20% H<sub>2</sub>O–80% N<sub>2</sub> atmosphere at 800°C. The correlations between the faradaic efficiency of hydrogen production and cathodic thickness were observed. According to I–V curve results, cell performances could be considered as similar regardless of thickness. In the case of 18 μm-thickness sample, the faradaic efficiency of hydrogen production increased with increasing current density. On the other hand, in the case of 8 μm-thickness sample, the faradaic efficiency of hydrogen production maintained constant after a current density above 100 mA/cm<sup>2</sup>. The results are similar with previous research [1]. Furthermore, comparing with the thinner-thickness sample, the efficiency was significantly high with the 18 μm-thickness sample under high current density condition. It is indicated that insufficient reaction areas induced to lower hydrogen generation efficiency.

**Keywords:** Mechanism of hydrogen production, Solid oxide electrolyzer cell (SOEC), Spinel cathode materials

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F\_P03

## Hydrogen Storage Alloy Tanks for Fuel Cell Assisted Bicycles

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### Abstract

This study is focused on the development of hydrogen storage tank made of 6061-T6 aluminum alloy for fuel cell assisted bicycle application. The hydrogen storage method uses commercial MmNi<sub>5</sub>-based alloys with 900 grams to storage hydrogen gas. The diameter and length of the aluminum alloy tank are 63.4 mm and 240 mm, respectively. The tank was filled with an aluminum honeycomb structure to enhance the internal radial heat transfer of the tank [1]. The ADAM-4000 series acquisition cards were used to acquire the hydrogen charging and discharging behaviors such as temperature, pressure, and hydrogen flow responses. Experimental results showed that the MmNi<sub>5</sub>-based alloys in the tank can absorb 108 liters of hydrogen at room temperature, which is equivalent to a hydrogen content of 0.9 wt% in the MmNi<sub>5</sub>-based alloys. Considering the weights of the tank and honeycomb without the filter, valves, H<sub>2</sub> regulator, the systematic hydrogen content in the tank was 0.6 wt%. To simulate the hydrogen tank employed in the fuel cell, two discharging hydrogen flow rates of 500 ml/min and 1000 ml/min at 50°C were tested, in which the H<sub>2</sub> tank was immersed in a water heating reservoir at 50°C to simulate the operation condition of the fuel cell. During the both discharging rates, discharging hydrogen pressures were higher than 0.1 MPa. Hydrogen discharge rates at 500 ml/min and 1000 ml/min of the hydrogen tank were stable for approximately 170 min. and 85 min., respectively. The hydrogen tank developed this study presents theoretical potentials of electricity outputs of 45 We and 90 We based on the hydrogen energy conversion efficiency of 50% using fuel cells supplied at hydrogen rates of 500 ml/min and 1000 ml/min, respectively.

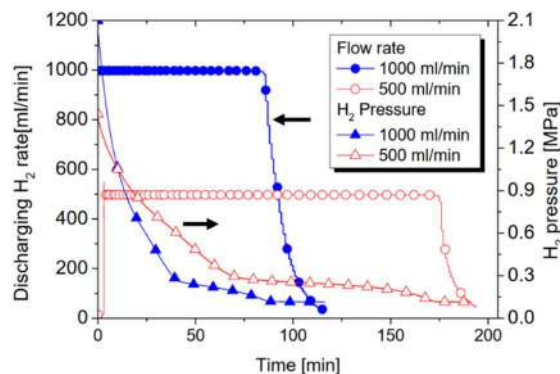


Figure 1. H<sub>2</sub> pressure and flow rate changes during discharging process.

**Keywords:** Metal hydride, Fuel cell, Energy storage, Heat transfer

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F\_P04

## Preparation of Porous Zirconia by Ceramic Photo-polymerization Process

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### Abstract

In this study, porous zirconia were developed by a ceramic photo-polymerization process. The yttria-stabilized zirconia (YSZ) powder was as the starting material, and the photoinitiator-added acrylate monomer as the carrier, after well-dispersed by a ball miller, the precursors were photo-cured by UV light with a wavelength of 405 nm, and the green compacts can be prepared. After thermal pyrolysis and sintering, the porous YSZ samples can be obtained. The as-prepared porous YSZ samples were further analyzed by scanning electron microscope (SEM), X-ray diffraction (XRD), and Archimedes method to understand the microstructures, crystal phases, and calculate the bulk density, as well as porosities. The results show that porous YSZ sample can be prepared after pyrolysis and sintered at 1500°C. Otherwise, the recipes were also employed on a DLP (digital light process) 3D printer to print a basic flow-channel plate of YSZ catalyst carrier in this study. The rheological behaviors of the precursors were also analyzed and compared with that of the commercial DLP resins.

**Keywords:** zirconia, porous materials, photo-polymerization, additive manufacture, DLP

F\_P05

## Effect of Dual Phases on Ionic Conduction of Consisting of Doped Ceria and Carbonates

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### Abstract

Electrolytes based on a dual-phase oxygen ion conductors and carbonates have received great attention for high temperature fuel cell application. For instance, enhanced conduction was observed when the oxygen ion conductor, doped ceria was directly mixed with Li/Na carbonates. It is expected the electrical conduction of composite electrolyte is contributed by the migration of oxygen ions in solid state and carbonate ions in liquid state. It was observed that the dual phase electrolytes exhibit coionic ( $O^{2-}/CO_3^{2-}$ ) conductors during fuel cell operation under the  $H_2$ /air atmosphere. It is expected that highly mobile ions at the interface between doped ceria and carbonates may further contribute to the high conductivity of the composite electrolyte. In other words, the super-ionic phase might exist at the interface between doped ceria and carbonates, where the defect concentrations are high. In this study, the electrical conduction of composite electrolytes with various types of microstructures were evaluated at temperatures ranging from 300 to 700 °C. The composite samples were first prepared by direct mixing of doped ceria and carbonate powders. For 2nd microstructure design, the carbonates were infiltrated into porous ceria substrates at 600 °C. SEM, XRD, and Electrochemical Impedance

Spectroscopy were employed to conduct microstructural, structural and impedance analyses. The electrical conduction behavior of composite electrolytes will be rationalized based on the pore size, pore distribution and interface area.

**Keywords:** Fuel Cell, Composite Electrolyte, Intermediate Temperature Solid Oxide Fuel Cells

F\_P06

## A Modified Solid-State Reaction Method to Synthesize Proton-Conducting $\text{BaCe}_{0.5}\text{Zr}_{0.3}\text{Y}_{0.2}\text{O}_{3-\delta}$ Electrolyte with Improved Sinterability

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### Abstract

In this study,  $\text{BaCe}_{0.5}\text{Zr}_{0.3}\text{Y}_{0.2}\text{O}_{3-\delta}$  electrolyte was studied as a high proton conducting electrolyte for proton-solid oxide electrolyzers (P-SOEC), and a new synthesis method with an improved solid-phase reaction method was proposed.  $\text{BaCe}_{0.5}\text{Zr}_{0.3}\text{Y}_{0.2}\text{O}_{3-\delta}$  powder was synthesized at a temperature as low as 1200°C. The temperature is much lower than the temperature used in the traditional solid-state reaction method (1400°C). Such temperature is also comparable to that used for the sol-gel process. The powder made by this method can obtain the dense ceramics with a relative density of higher than 90% at 1400°C without adding a sintering aid. In addition, adding small amount of sintering aid (ZnO) can obtain a ceramic with relative density more than 97%, which is higher than the reported results of undoped BCZY proton conductor. In addition,  $\text{La}_{1.2}\text{Sr}_{0.8}\text{NiO}_{4-\delta}$  was used as the air electrode. X-ray diffraction (XRD) results show that the perovskite structure BCZY and Ruddlesden-Popper structured LSN coexist. No additional second phase impurity phase was observed.

**Keywords:** Proton conductor,  $\text{BaZr}_{0.5}\text{Ce}_{0.3}\text{Y}_{0.2}\text{O}_{3-\delta}$ , Sintering aid, Calcined temperature, SOEC  $\text{BaCe}_{0.5}\text{Zr}_{0.3}\text{Y}_{0.2}\text{O}_{3-\delta}$

F\_P07

## Nd-doped LSCF nano-fibrous cathode for proton-conducting solid oxide fuel cells

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### Abstract

The electrochemical performances of the solid oxide fuel cells (SOFC) fabricated with Nd-doped LSCF nano-fibrous cathode perovskite cathodes, thin BCZY electrolytes, and BCZY-Ni anodes by tape casting, spin coating, and co-firing are evaluated at 600-800 °C. Material analysis, such as SEM, TEM, and XRD, confirm that no detectable second phase remains in the calcined Nd-doped LSCF nanofibers, indicating that the electrospun nanofibers have good compatibility with the fabrication of anode-supported fuel cells in this study. It can be clearly seen that the Nd-doped LSCF nano-fibrous cathode is highly porous and adhered well to the BCZY electrolyte. Fuel cell testing with the Nd-doped LSCF nano-fibrous cathode exhibits a maximum power density of ~580.0 mW/cm<sup>2</sup> at 800 °C, which is significantly higher than those of cells with a powder-derived LSCF cathode or a LSCF nano-fibrous cathode. The significantly lower polarization resistance elements extracted from electrochemical impedance spectroscopy (EIS) further suggest that the Nd-doped LSCF nano-fibrous cathode has superior catalytic activity for the oxygen reduction reaction and better oxygen ionic transport in the cathode reactions. The performance improvement of Nd-doped LSCF nano-fibrous cathode can be explained in terms of trade-off between electrocatalytic activity, oxygen ionic and electronic conductivity of the Nd-doped LSCF nanofibers. This study shows that Nd-doped LSCF nanofibers would be a promising cathode material for proton-conducting solid oxide fuel cells.

**Keywords:** Nd-doped LSCF, nano-fiber, cathode, oxygen reduction reaction, P-SOFC.

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F\_P08

## Small Fuel Cell Powered Vehicle

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### Abstract

The small self-propelled fuel cell vehicle (FCV) operated by the Arduino program was studied to develop innovative fuel cell teaching aided tools. Based on the experimental results, it can automatically drive along the black ellipse path, indicating that the small vehicle has the ability to smart propel. The fuel cell efficiency is about 21.5%. The vehicle's velocity is 0.7 km/hr. The H<sub>2</sub> used in the small self-propelled FCV can be supplied from the energy storage of power-to-H<sub>2</sub> technology. The clean and smart self-propelled FCV developed here could act as a useful teaching aided tool to educate public and major educational institutions for the development of fuel cell and energy storage technologies.

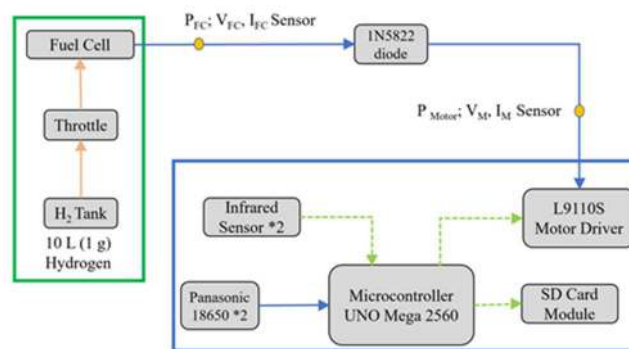


Figure 2. Block diagram of the small self-propelled FCV. Orange arrow as hydrogen flow direction; blue arrow as current flow direction; green dashed arrow as the signal direction.

**Keywords:** Fuel Cell, Energy storage, Self-propelled, Sensor, Arduino.

### References

- [1] J.J. Huang, D.Y. Wang, Development of fuel-cell-powered electric bicycle 2004, *Journal of Power Sources*, 133 (2004) 223-228.



F\_P09

## Intermediate temperature solid oxide fuel cell with nanoscale electrodes fabricated by one-step sintering technology

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### Abstract

Solid oxide fuel cell prepared by one-step technology could significantly reduce the cell fabrication cost and energy consumption. the dedicated low temperature sintering compared with conventional super high temperature ( $\geq 1300$  oC) allows the application of nanoscale electrode with improved electrode activity. In this work, samarium -doped ceria (SDC) with doping of 2-5 mol% of lithium element was synthesized by co-precipitation. the addition of Lithium element served as the sintering aid to dramatically reduce the electrolyte sintering temperature as low as 900 oC based on the XRD and SEM studied. Its ionic conductivity was investigated by the electrochemical impedance spectroscopy (EIS) technique Simultaneously, nanosacle porous ceramic Ni-SDC anode and perovskite oxide cathode were fabricated by the co-precipitation and with a general cotton as templet, and co-assembled to the lithium doped electrolyte in one step sintering process Currently, the electrolyte-supported solid oxide fuel cell gave a peak power density of  $111.8 \text{ mW}\cdot\text{cm}^{-2}$  at  $700 \text{ }^\circ\text{C}$  with the whole cell sintered at  $1000 \text{ oC}$  for 6 hours. The work proposes ia reliable and feasible for fabricate high performance SOFC at the reduced temperatures.

**Keywords:** Solid oxide fuel cell; one step sintering; Porousnanoscale electrode; Sinter addictive

F\_P10

## Enhancement of Oxygen Reduction Reaction Process of Cobalt Based Cathode in Solid Oxide Fuel Cell

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### Abstract

Attracted by the triple (oxygen ion, proton and electron) conductivity and excellent oxygen reduction activity,  $\text{BaCo}_{0.4}\text{Fe}_{0.4}\text{Zr}_{0.1}\text{Y}_{0.1}\text{O}_{3-\delta}$  (BCFZY) is a emergent cathode material in protonic ceramic fuel cells (PCFCs). However, its electrocatalytic activity can be further improved and operational stability under practical fuel cell condition is still bid challenge. In this work, we take BCFZY as cathode and composite with gadolinium-doped ceria (GDC) to improve oxygen reduction reaction performance. By comparison the electrochemical performance of symmetrical and single cell, with different cathodes, we find that the ion transport is the rate determining process on BCFZY cathode, and when GDC was put in, the oxygen diffusion becomes the main process for the oxygen reduction reaction (ORR). And the peak power density of BCFZY based single cell is  $1.02\text{W}/\text{cm}^2$ , which is improved by 20% to  $1.22\text{W}/\text{cm}^2$  with the composed cathode BCFZY+GDC).

**Keywords:** Solid oxide fuel cell;  $\text{BaCo}_{0.4}\text{Fe}_{0.4}\text{Zr}_{0.1}\text{Y}_{0.1}\text{O}_{3-\delta}$ ; Composite electrode; oxygen reduction reaction

F\_P11

## Preparation and Characterization of $Y_xBa_{2-x}Co_2O_{5+\delta}$ Cathode Material for Solid Oxide Fuel Cell

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### Abstract

This experiment used  $Y_{0.9}Ba_{1.1}Co_2O_{5+\delta}$  (YBCO) cathode powder, and the conductivity and oxygen vacancy concentration of this cathode material will be enhanced further by altering the proportion of Yttrium and Barium at the A-site position, through the adjustment of its valence. In two parts, the electrochemical characteristics of this material doping applied to SOFC are examined.

In the XRD analysis graph,  $Y_{0.9}Ba_{1.1}Co_2O_{5+\delta}$  (JCPDs 46-0642) and  $Y_2O_3$  (JCPDs 01-0831) were identified in samples with low  $Y^{3+}$  concentration and samples with high  $Y^{3+}$  content, respectively. In the reactivity test of sintering at 950°C capacitive, the  $Y_{0.98}(CoO_3)$  impurity phase is produced, and the  $Y_{0.9}Ba_{1.1}Co_2O_{5+\delta}-Sm_{0.2}Ce_{0.8}O_{2-\delta}$  composite electrode has a favorable chemical phase. The SEM image shows that  $Y_{0.9}Ba_{1.1}Co_2O_{5+\delta}$  is sintered at a high temperature, resulting in a structure with homogeneous pores. SDC is uniformly distributed throughout the material and adheres well to the dense  $Sm_{0.2}Ce_{0.8}O_{2-\delta}$  electrolyte layer. It has the lowest impedance value of  $0.057\text{ cm}^2$  according to the AC impedance study. The thermal expansion coefficient of the cathode material may be successfully decreased to  $13.7 \times 10^{-6}\text{ K}^{-1}$  by doping SDC in the experiment, which matches the CTE value of the commercial electrolyte SDC, according to the thermal expansion property test.

**Keywords:** YBCO, Composite, Cathode, Solid oxide fuel cell

F\_P12

## Preparation and Properties of $Y_xSr_{1-xy}TiO_{3-\delta}$ anode for Solid Oxide Fuel Cells

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### Abstract

To improve electronic conductivity, catalytic performance, and reduce thermal expansion coefficient, this experiment uses titanium strontate  $SrTiO_3$  electronic ionic-electron conductors (Mixed ionic-electron conductors, MIEC) as the anode material, with doping to replace the A-site and B-site elements. Prepare  $Y_xSr_{1-xy}TiO_{3-\delta}$  (0.06x0.09,  $\gamma=1.5$  YST) powder using the citric acid-EDTA technique, and test its characteristics in a reducing environment.

Sintering the powder in an Ar/4 %  $H_2$  reducing environment reduces the formation of impurity phases, as seen by the XRD pattern. The size of YST rises linearly with temperature, according to the thermomechanical analyser (TMA). Following the calculations, it can be determined that when  $\gamma = 1.5$ , its thermal expansion coefficient is consistent with that of the electrolyte material Yttria-stabilized zirconia (Yttria-stabilized zirconia, YSZ), which has a good match.  $Y_{0.07}Sr_{0.895}TiO_{3-\delta}$  has a high conductivity  $23.48 S cm^{-1}$  after the conductivity measurement result, measured in Ar/4 %  $H_2$  reducing environment, each component is an n-type semiconductor, and the conductivity decreases as the temperature rises. In terms of stability testing, the peak intensity and location of YST after 30 hours in a reducing environment are identical to those before treatment, and no impurity phases are formed. It demonstrates that in a reducing environment, YST has a stable phase structure and might be used as a solid oxide fuel cell anode material.

**Keywords:** Anode, Mixed ionic-electron conductors, Pervoskite

F\_P13

## Preparation and Characterization of High Temperature Mixed Proton-electron Conductors

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### Abstract

The high-temperature hydrogen proton transport membrane (Hydrogen Transport Membrane, HTM) separates and purifies hydrogen to produce high-purity hydrogen, substantially improving SOFC operation efficiency and energy usage.

Sr(Ce<sub>0.6</sub>Zr<sub>0.4</sub>)<sub>0.9</sub>Y<sub>0.1</sub>O<sub>3-</sub> (SCZY) powder is prepared using the citric acid-EDTA technique, while Y<sub>1.0</sub>Ba<sub>1.0</sub>Co<sub>2</sub>O<sub>5+</sub> (YBCO) powder is prepared using the solid-phase reaction method. A 60:40 weight ratio of SCZY/YBCO was used to make a ceramic composite of proton-electron mixed conductor. The effect of sintering temperature and environment on phase analysis, microstructure, and electrical conductivity of ceramic composites was also addressed.

The proportion of impurity phases rises as the sintering temperature increases, and impurity phases such as Ce<sub>0.5</sub>O<sub>3</sub>Y<sub>0.497</sub>O<sub>1.751</sub> and SrCoO<sub>2.29</sub> are produced, as seen in the XRD pattern of the SCZY/YBCO ceramic composite with a weight ratio of 60:40. After sintering at 1250°C, the structure is dense, with a porosity value of around 0.5%, as observed by SEM images and estimated using the Archimedes method. When measured in the air, the electrical conductivity is 13.44 S/cm at 800°C operating temperature. The coefficient of thermal expansion is 17.3 ×10<sup>-6</sup> K<sup>-1</sup>, which is closest to the coefficient of thermal expansion of nickel oxide, which is around 14 ×10<sup>-6</sup> K<sup>-1</sup>. This indicates that this sample might be used for high-temperature hydrogen proton transfer.

**Keywords:** Composite, proton-electron mixed conductor, Hydrogen Transport Membrane

F\_P14

## Spontaneous formation of superlattice thin film with perovskite $A^{3+}B^{3+}O_3$ structure using dynamic aurora PLD and its effect on physical properties

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<sup>5</sup>Professor, Research Institute of Electronics, Shizuoka University

### Abstract

We have reported spontaneous superlattice formation in Sr-excess  $SrTiO_3$  (STO) thin film deposited on STO(001) substrates using dynamic aurora PLD.<sup>[1]</sup> The excess Sr is inserted as Ruddlesden-Popper (RP) type planar fault. Therefore, the spontaneously formed superlattice is composed of two layers having different concentration of RP planar faults. As the condition of spontaneous superlattice formation, we have also found that coherent growth (small lattice mismatch) is essential. Therefore, it was considered that following three conditions are expected to be needed for spontaneous superlattice formation. (1) perovskite type compound having A-site excess composition, (2) small lattice mismatch and (3) deposition under magnetic field. The purpose of this work is to form spontaneous superlattice thin films in  $A^{3+}B^{3+}O_3$  perovskite type compounds where no RP planar faults have been reported. As the candidate of  $A^{3+}B^{3+}O_3$  perovskite type compounds,  $NdFeO_3$  and  $LaCrO_3$  were selected. These two compounds have orthorhombic symmetry in the bulk. However, on the basis of pseudo cubic lattice parameter, very small lattice mismatch is expected. Thin film was deposited on an STO (001) substrate at 800° C in  $1.0 \times 10^{-4}$  Torr  $O_2$  under magnetic field of 2,000 G. We also evaluated the physical properties of the thin films. Specifically, for the  $NdFeO_3$  and  $LaCrO_3$  thin films, gas sensor properties and thermoelectric properties were measured, respectively.

Figure 1 shows XRD patterns of  $NdFeO_3$  thin film with Nd/Fe=1.50 ratio. This figure shows that satellite peaks are observed. This indicates that spontaneous superlattice is formed for Nd-excess  $NdFeO_3$ . The superlattice period for Nd/Fe=1.50 was 26 nm. Figure 2 shows HAADF-STEM image of Nd-excess  $NdFeO_3$  thin film (Nd/Fe=1.50). In this figure, 15-20 nm period is observed which agrees with the superlattice period calculated from XRD pattern. Figure 3 shows XRD patterns of  $LaCrO_3$  thin film with Nd/Fe=1.28 ratio. The superlattice period for La/Cr=1.28 was 18.5 nm.

**Keywords:** Dynamic aurora PLD, Epitaxial, Spontaneous superlattice formation,  $SrTiO_3(001)$  substrate, Superlattice period, Gas sensor properties, Thermoelectric properties

Reference:

[1] N. Wakiya, *et al.*, *NPG Asia Mater.*, **8** (2016) e279.

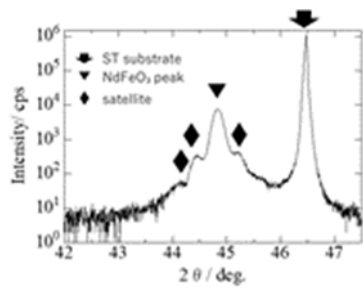


Fig.1 XRD pattern of the Nd<sub>1.50</sub>FeO<sub>3+α</sub> thin film deposited on SrTiO<sub>3</sub>(001) substrate.

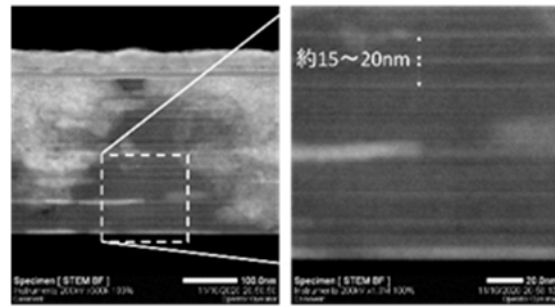


Fig. 2 HAADF-STEM image of Nd<sub>1.50</sub>FeO<sub>3</sub> thin film deposited on the SrTiO<sub>3</sub> (001) substrate.

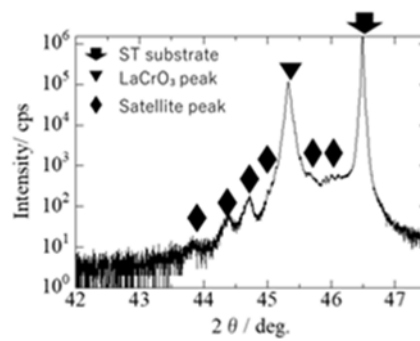


Fig.3 XRD pattern of the La<sub>1.28</sub>CrO<sub>3+α</sub> thin film deposited on SrTiO<sub>3</sub>(001) substrate

F\_P15

## Preparation and characterization of epitaxially grown YSZ thin films on porous silicon substrates for SOFC applications

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### Abstract

Yttria-stabilized zirconia (YSZ) is widely used as an electrolyte for solid oxide fuel cells (SOFCs), but it is required to lower the driving temperature. One method of lowering the drive temperature is to use thin the YSZ layer to reduce the impedance, and the preparation of a YSZ semi-self-supporting thin film on a porous substrate such as a stainless mesh has been studied. We have established the conditions for producing porous Si (PSi) by anodizing a Si substrate, and by peeling off the porous layer to produce a through-type PSi in which vertical pores penetrate from the front surface to the back surface. We think that if the through-type PSi could be used as a substrate and a new thin film SOFC that can be driven at a low temperature could be realized. There are few reports that an oxide thin film having a fluorite structure grows epitaxially on an oxide thin film having a perovskite structure used as an electrode for a thin film SOFC. The purpose of this work is to establish the film formation conditions for epitaxially growing the YSZ thin film on the perovskite structure  $\text{La}_{0.7}\text{Sr}_{0.3}\text{MnO}_3$  (LSMO) thin film and to evaluate the electrical conductivity of the prepared YSZ thin film. The through-type PSi substrate was prepared by anodizing an n-type substrate in a mixed solution of hydrofluoric acid and ethanol (HF solution). After anodizing for a specified time, the current density was rapidly increased to peel off the porous layer. Thin films of YSZ,  $\text{CeO}_2$  as a buffer layer, and LSMO as a bottom electrode were prepared on the Si and through-type PSi using PLD. Platinum top electrodes were vapor-deposited on the prepared thin film sample through a metal mask using a sputtering method, and the electrical conductivity was measured. Figure 1 shows the RHEED images of YSZ,  $\text{CeO}_2$ /YSZ, LSMO/ $\text{CeO}_2$ /YSZ, and YSZ/LSMO/ $\text{CeO}_2$ /YSZ on a silicon substrate. Streak patterns are observed for RHEED images. This means that all layers are epitaxially grown on the each under layers. In addition, when comparing the resurface YSZ thin film and the LSMO streak, the positions of the bright spots are different, and the YSZ streak on the first layer and the resurface surface match, so the YSZ thin film grows epitaxially on the oriented LSMO thin film. Figure 2 shows the change of in-plane electrical conductivity with temperature for an epitaxial YSZ thin film formed on a through-type porous silicon substrate. In this figure, the change of electrical conductivity of a bulk YSZ (averaged values of several reports) were also shown for comparison. This figure suggests that electrical conductivity of epitaxial YSZ thin film is higher than that of bulk YSZ.

**Keywords:** PLD, Porous Si, SOFC, Electrical conductivity



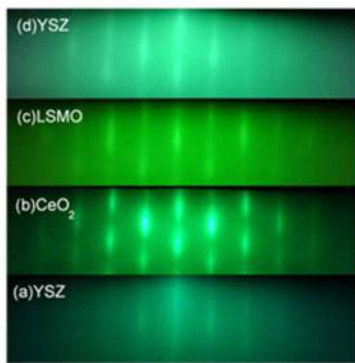


Fig. 1 RHEED pattern of Si[001]  
(a)YSZ/Si , (b)CeO<sub>2</sub>/Si  
(c)LSMO/CeO<sub>2</sub>/Si , (d)YSZ/LSMO/CeO<sub>2</sub>/Si

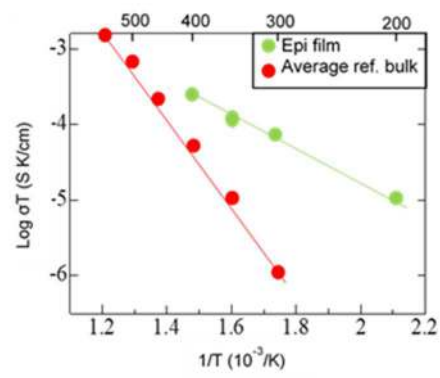


Fig. 2 Arrhenius plot of this YSZ thin film

F\_P16

## Spontaneous formation of superlattice thin films on substrates having heterogenous structure using dynamic aurora PLD

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### Abstract

We have reported spontaneous superlattice formation in epitaxial SrTiO<sub>3</sub> thin films with A-site excess composition (Sr/Ti=1.4) on SrTiO<sub>3</sub>(001) single crystal substrates by PLD under a magnetic field of 2,000 G. As the conditions of spontaneous superlattice formation in Sr-Ti-O system, following 4 conditions are needed. (1) The thin film should have perovskite structure. (2) The perovskite thin film should have A-site excess composition. (3) Coherent growth is needed. (4) Magnetic field application more than 1,000 G is needed during deposition. To satisfy the condition (3), the Sr-Ti-O thin film has been deposited on single crystal substrates having perovskite structure such as SrTiO<sub>3</sub>, LaAlO<sub>3</sub> and (La, Sr)(Al, Ta)O<sub>3</sub>. The purpose of this study is to clarify whether a thin film with a superlattice structure can be spontaneously formed on a non-perovskite MgO substrate if the above conditions (1) to (4) are satisfied. In order to satisfy the condition (3), BaZrO<sub>3</sub> (BZ) was deposited because the mismatch of lattice constant with MgO is as small as -0.46%. BZ thin films were deposited on MgO(001) single crystal substrate in a magnetic field (2000G) during the deposition using dynamic aurora PLD method. The deposition temperature was at 800 °C and the oxygen pressure during the deposition was 1.0×10<sup>-4</sup> Torr. The crystal structure of the thin films was analyzed using precise X-ray diffraction (MRD). The XRD patterns of the BZ thin films are shown in Fig. 1, where the red and blue lines represent the compositions of Ba/Zr=1.35 and 0.99, respectively. From this figure, a satellite peak is observed at the low angle side of the BZ(002) peak at composition 1.35. The reciprocal lattice map around (022) of BZ shown in Fig. 2 reveals the Q<sub>y</sub> value (in-plane reciprocal lattice point) of BZ thin film coincides with that of MgO. This means coherent growth. The data shown in Figs. 1 and 2 mean that spontaneous superlattice formation is observed for BZ thin film deposited on MgO substrate. Since conditions (1), (2) and (4) were satisfied in addition to condition (3), in this work, it was found that the four conditions are applicable to prepare spontaneous superlattice formation of BZ thin film deposited on a non-perovskite MgO substrate.

**Keywords:** Superlattice; PLD; Perovskite; Magnetic field

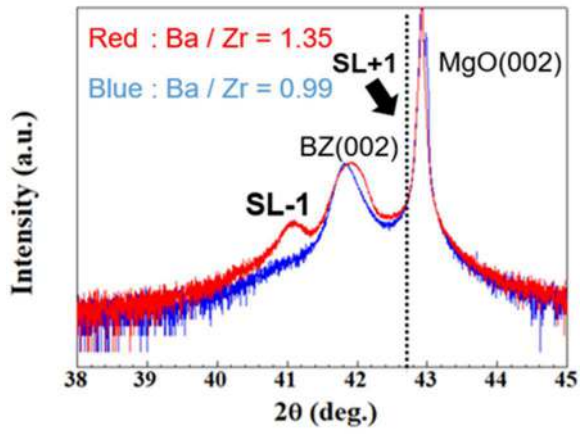


Fig.1 XRD pattern of BaZrO<sub>3</sub> (BZ) thin film

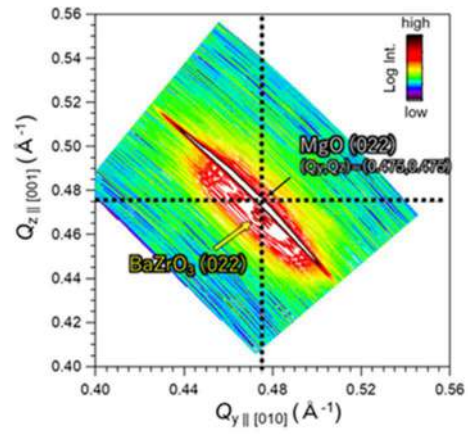


Fig.2 Reciprocal lattice map around BaZrO<sub>3</sub> (022)

F\_P17

## Low temperature Deposition of Transparent PZT Thin Films with Giant Piezoelectricity on Glass Substrate from Molecular-designed Precursors

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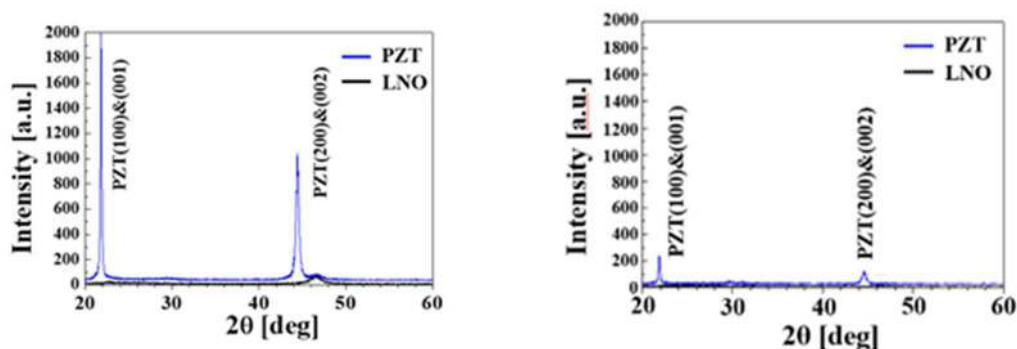
<sup>2</sup> Research Institute of Electronics, Shizuoka University, Hamamatsu, Japan

<sup>3</sup> Department of Chemistry and Biochemistry, Numazu college, National Institute of Technology, Numazu, Japan

### Abstract

In recent years, transparent electronic devices have been attracting much attention in the research field of sensors and actuators. To develop transparent electronic devices, transparent ferroelectric thin films with high ferroelectric and piezoelectric properties are required to reduce the size, and cost. For this purpose, high performance  $\text{Pb}(\text{Ti}, \text{Zr})\text{O}_3$  (PZT) thin films are essential. For example, if a transparent MEMS device is developed by high performance PZT thin films on a glass substrate, a tactile technology of HAPTICS can be introduced to touch panels and so on. To realize such devices, transparent piezoelectric thin films with good piezoelectric properties should be deposited at lower temperatures below 550°. In this study, we successfully deposited transparent PZT thin films with excellent electrical properties on a glass substrate at a low temperature of 500°. For the low temperature deposition, we used the CSD method from molecular-designed precursor solutions consisted of Zr-O-Ti bonds with high polymerization degree to lower the crystallization temperature. We also used the seeding layer of  $\text{LaNiO}_3$  (LNO). As a result, we successfully deposited the transparent high performance PZT thin films on a glass substrate with LNO thin film electrode. As a result of From the XRD patterns shown in Fig.1, the PZT thin film from molecular-designed precursor exhibited preferred orientation in the direction of a- & c-axes even on the glass substrate, and the crystallinity was very high than the films deposited from commercialized precursor. The  $\text{Pb}_{1.20}\text{Zr}_{0.45}\text{Ti}_{0.55}\text{O}_3$  thin film with a tetragonal composition prepared at low temperature of 500°C showed huge piezoelectric response with an average piezoelectric constant,  $d_{33}^*$ , of about 530 pm/V calculated from strain and applied voltage, which is similar to those of PZT ceramics with a MPB composition as shown in Fig.2. This huge response is mainly ascribed to the 90° domain switching. To fabricate PZT thin films with giant piezoelectricity by the domain switching and a good ferroelectricity, domain engineering by the well controlled orientation and residual stress is essential.

**Keywords:** PZT Thin film; Low temperature; MEMS; Glass substrate; Chemical Solution Deposition.



(a) (b)  
Fig.1 XRD patterns for low-temperature annealed PZT thin films with different precursors and compositions on glass substrate. (a)  $\text{Pb}_{1.20}\text{Zr}_{0.53}\text{Ti}_{0.47}\text{O}_3$  film from molecular-designed precursor, and (b)  $\text{Pb}_{1.10}\text{Zr}_{0.53}\text{Ti}_{0.47}\text{O}_3$  film from commercialized precursor

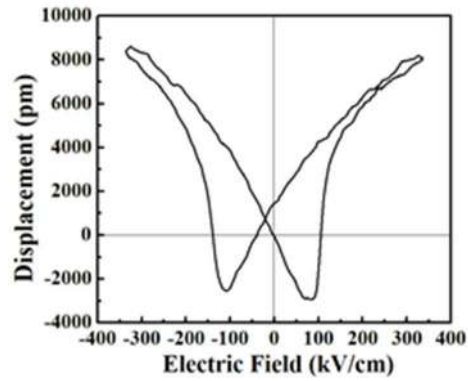


Fig.2 Piezoelectric butterfly curve of  $\text{Pb}_{1.20}\text{Zr}_{0.45}\text{Ti}_{0.55}\text{O}_3$  thin film fabricated at low temperature of  $500^\circ\text{C}$ .

F\_P18

## The effect of starting materials on low-temperature preparation of $\text{Li}_{6.5}\text{La}_3\text{Zr}_{1.5}\text{Ta}_{0.5}\text{O}_{12}$ single crystal using the flux method

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### Abstract

Garnet-type Li-ionic conductor  $\text{Li}_7\text{La}_3\text{Zr}_2\text{O}_{12}$  (LLZO) has attracted much attention as an oxide solid-state electrolyte with high ionic conductivity and wide potential window. Because the ionic conduction is scattered by the dislocations and grain boundaries, LLZO particles with high crystallinity is preferable for higher ionic conductivity. In addition, processing temperature should be lower for saving cost and suppressing lithium evaporation. Recently, single-crystalline LLZO particles using the self-flux growth have been reported [1]. In addition, they also reported that the synthesized temperature can be lowered to 500 °C when pyrochlore phase  $\text{La}_2\text{Zr}_2\text{O}_7$  and LiOH are used as the starting material and flux, respectively. In the report, however, the obtained LLZO single-crystalline powder was not single-phased because of the starting material insufficiently dissolved. In this study, we purposed on the investigation of the effect of starting materials on the low-temperature flux growth and the preparation of single-phased  $\text{Li}_{6.5}\text{La}_3\text{Zr}_{1.5}\text{Ta}_{0.5}\text{O}_{12}$  (LLZTO) single crystals, which has not been prepared by the flux growth.

### Experimental

LLZTO was prepared using the flux method with three kinds of starting materials (SMs)-a, b and c. The SM-a was unreacted raw materials of  $\text{La}_2\text{O}_3$ ,  $\text{ZrO}_2$ , and  $\text{Ta}_2\text{O}_5$  with hand-milling. The SMs-b and c are  $(\text{La}_{0.6}\text{Zr}_{0.3}\text{Ta}_{0.1})\text{O}_{1.75}$  (LaZTO) prepared by the solid-state reaction method after hand-milled and planetary-ball-milled SM-a, respectively. For the flux growth, the powders of  $\text{LiOH}\cdot\text{H}_2\text{O}$  and one of the starting materials were loaded in the alumina crucible with the Li/La ratio of 15.5. The loaded crucible was kept at 500°C for 10 h in the air. In this study, obtained samples after the flux method with SMs-a, b and c are called A, B and C, respectively. The obtained samples were removed from the crucible after natural cooling, and evaluated by X-ray diffraction (XRD) and scanning electron microscopy (SEM).

### Results and Discussion

Fig. 1 shows XRD patterns of the samples obtained from the three kinds of SMs. For the sample A, diffraction peaks of  $\text{La}_2\text{O}_3$  and  $\text{La}(\text{OH})_3$  are observed along with LLZTO peaks. Therefore,  $\text{La}_2\text{O}_3$  is insufficiently dissolved in the LiOH solvent. For the sample B, the main peak of LaZTO around  $2\theta=28^\circ$  is observed, implying that LaZTO still remains in the sample. On the other hand, almost no peak of LaZTO is observed for the sample C. In addition, most of the LLZTO particles in sample C have the diameter of about 5  $\mu\text{m}$  and only {110} faceted plane of rhombic dodecahedron, as shown in Fig. 2. These results indicate that almost single-phased LLZTO single crystals is successfully obtained in the sample C. In contrast, the faceted particle is rarely observed in sample B. The differences observed in XRD and SEM between sample B and C are presumably because of particle size of the starting materials.

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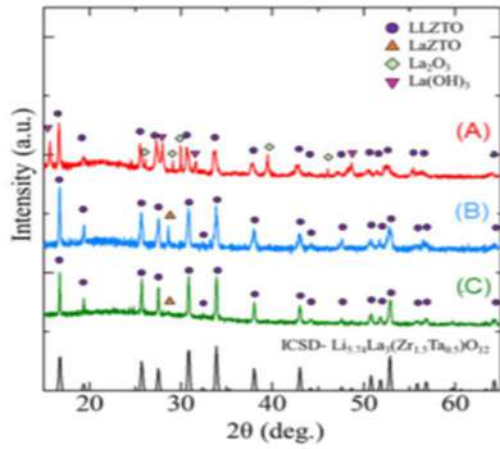


Fig. 1 XRD patterns for the samples A, B and C obtained by the flux method with the starting materials a, b and c, respectively.

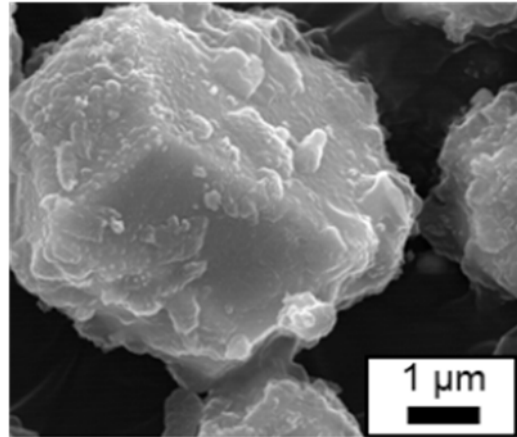


Fig.2 SEM image of the LLZTO single crystalline particle in the sample C.

F\_P19

## Synthesis of PZT thin film with single crystal-like ferroelectricity on SUS substrate

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### Abstract

Pb(Zr,Ti)O<sub>3</sub> (PZT) ceramics and thin films are ferroelectric materials with excellent ferroelectric and piezoelectric properties. Particularly, PZT films have attracted much attention in recent years because of their potential applications in MEMS. Electrical properties of the PZT thin films are greatly affected by many factors and the one of the most important factors are residual stress from substrate. The residual stress caused by the difference in the thermal expansion coefficients between the substrate and the thin film will affect the properties of the thin films. If the thermal expansion coefficient of the substrate is larger than that of the thin film, compressive stress is expected in the thin film, leading to the enhanced ferroelectricity. In this study, we selected SUS430 as a substrate with a large coefficient of thermal expansion to improve the ferroelectricity of the PZT thin films prepared from molecular-designed precursor. Because PZT thin film is easily reacted with the SUS substrate, leading to the decrease of the ferroelectricity. A buffer layer is required to suppress such reaction. In this study, we used two types of buffer layer structure: LaNiO<sub>3</sub> (LNO) and LNO/SiO<sub>2</sub>. LNO buffer layer was prepared by the CSD method from the molecular-designed precursor, and it can be crystallized at a low temperature of 550°C (PZT-1). On the other structure, an additional SiO<sub>2</sub> layer was inserted between LNO and SUS to form the LNO/SiO<sub>2</sub> structure (PZT-2) in which a stable SiO<sub>2</sub> layer was deposited by CSD at 700°C following by the LNO deposition. Fig.1 shows the EDS(energy dispersive spectroscopy) elemental mapping of PZT-1 and PZT-2 films. The results show the diffusion of Cr from the SUS substrate into the PZT in PZT-1 film, while Cr diffusion was suppressed in PZT-2 film, indicating that the insertion of SiO<sub>2</sub> layer was very effective to prevent the diffusion of Cr from the substrate. Fig.2 shows the ferroelectric hysteresis loops for PZT-1 and PZT-2 films. The remanent polarization of PZT-1 and PZT-2 films were very high compared to that of PZT thin film deposited on Si substrate. In addition, the square hysteresis loop for PZT-2 film was very similar to that of single crystal, indicating the high quality of our PZT film.

**Keywords:** CSD(Chemical Solution Deposition); PZT thin films; Electrical properties; Molecular-designed precursor; SUS substrate.



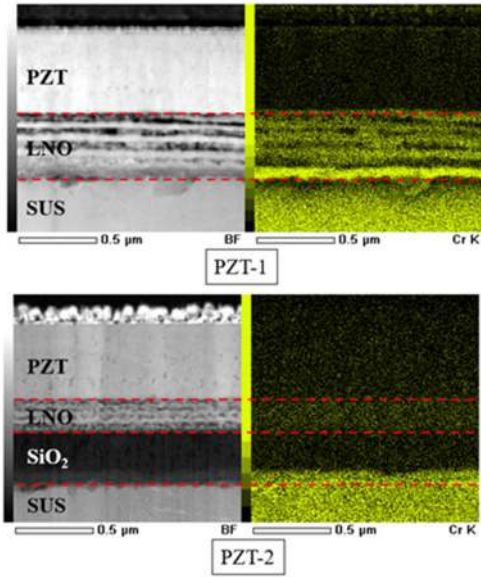


Fig.1 EDS mapping of PZT-1 and PZT2 films.

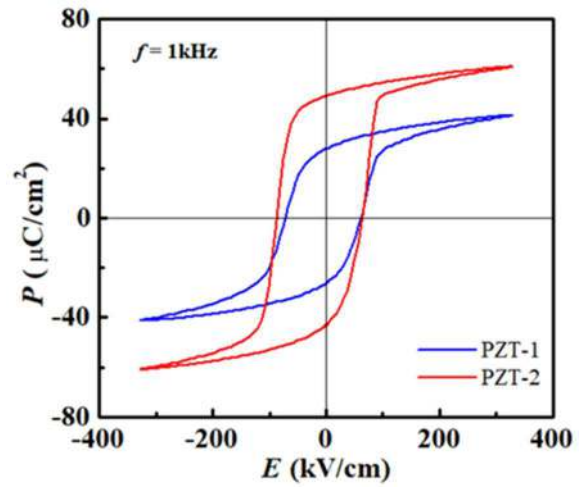


Fig.2 Hysteresis loop of PZT-1 and PZT2 films.

F\_P20

## Computer simulation via phase-field method to consider the effect of magnetic field application on the spontaneous superlattice formation using dynamic auroral PLD

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### Abstract

We have reported spontaneous superlattice formation in epitaxial strontium titanate (SrTiO<sub>3</sub>) thin film deposited on SrTiO<sub>3</sub>(001) having A-site excess composition (Sr/Ti=1.4) by PLD under magnetic field of 2,000 G (dynamic aurora PLD).<sup>[1]</sup> This spontaneous superlattice formation is not observed without applying magnetic field during deposition. The purpose of this work is to reproduce spontaneous superlattice formation in Sr-excess SrTiO<sub>3</sub> thin film using phase-field method without limiting the direction of propagation of the composition wave. For this calculation, the open source-code for AB binary alloy<sup>[2]</sup> was modified. In this simulation, phase separation from uniform solid solution to SrTiO<sub>3</sub> and SrO. To consider the temporal evolution of a composition field, following Cahn-Hilliard diffusion equation was used;

$$\frac{\partial c}{\partial t} = \nabla \cdot \left[ M \nabla \left( \frac{\delta G}{\delta c} \right) \right] \quad (1)$$

( $c$ ,  $G$ ,  $M$  is molar fraction of SrO, total free energy in composition field and mobility, respectively.)

The temporal evolution of a composition is calculated from free energy gradient of the field based on equation (1). In this simulation, chemical free energy and interfacial energy (concentration gradation energy) were considered, and diffusion potential was calculated as the function of position using finite difference computation. In addition, we employed following two additional boundary conditions; (a) excess potential is given at the growing surface of the thin film by the ion impingement (b) the excess energy is lowered exponentially toward the thickness direction. Figure 2 shows the results of simulating the time evolution of the composition under the following conditions: Sr/Ti = 1.4, temperature 700 °C, activation energy of diffusion 1.81 eV, and external magnetic field 2000 G. This result shows that the superlattice structure is formed. This means that the spontaneous formation of the superlattice by spinodal decomposition can be reproduced by computer simulation without limiting the direction of propagation of composition wave.

Figure 2 shows the relationship between amount of increasing potential by colliding cations and superlattice period. This relation agrees well with the experimental results that there is a threshold in the relationship between superlattice period and deposition rate.

**Keywords:** Simulation, Phase-field, Phase separation, Superlattice

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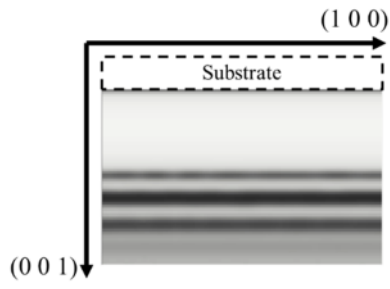


Fig. 1. Result of simulation using phase-field model.

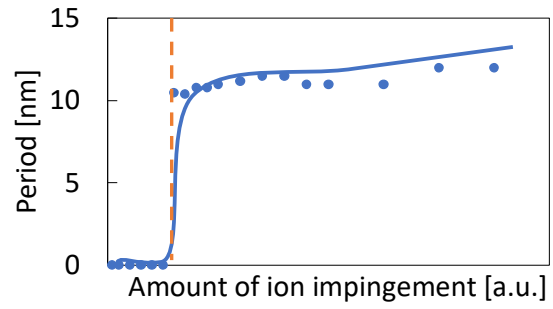


Fig. 2. Relationship between calculated superlattice period and amount of ion impingement.

F\_P21

## The study of 8YSZ electrolyte fabrication of the tubular solid oxide fuel cells by the dip-coating method

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### Abstract

Using the plasma spraying technology to prepare an electrode of tubular SOFC is simple and low-cost process, but use this way to prepare the electrolyte had encounter many question, like not density or lot of porous on the electrolyte. So that prepared the dense electrolyte on plasma sprayed tubular porous anode by the dip-coating method, then prepared porous cathode on the electrolyte by plasma spraying method which is a feasible and commercially competitive with the expected process. This study prepared the 8YSZ electrolyte layer on the porous plasma sprayed anode by the dip-coating method. In the study, using different sintering temperatures and time to improve the density of electrolyte layer, and investigate the anode and electrolyte changes in the microstructure after sintering. By changing humidity in the dipping process can influence the rate of drying the slurry, furthermore the thickness of the electrolyte coating can be improved by increasing the cycle of dipping. According to electrochemical impedance analysis, it can be known that the increase of the sintering temperature can reduce the ohmic resistance of the electrolyte. However, excessive sintering will cause poor adhesion between the anode and the electrolyte, which will cause the electric charge to be difficult to cross and cause the impedance value to be too large. Therefore, 1450 degrees is selected as the best sintering temperature.

**Keywords:** SOFC, Thermal spray

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F\_P22

## The Research of the Mechanism of in-situ Sintering Solid Oxide Fuel Cell

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### Abstract

In this study, three configurations of SOFC cells were prepared by the in-situ sintering method. Both electrodes were Ni-foam coated  $\text{LiNi}_{0.81}\text{Co}_{0.15}\text{Al}_{0.04}\text{O}_2$  (Ni-NCAL) and electrolyte was  $\text{Sm}_{0.2}\text{Ce}_{0.8}\text{O}_{1.9}$  (SDC) in Cell A (Ni-NCAL|SDC|Ni-NCAL). The Ni-Ag electrode was used instead of Ni-NCAL, as cathode in Cell B (Ni-Ag|SDC|Ni-NCAL). For Cell C, the Ni-Ag electrode was used as anode and the Ni-NCAL electrode was used as cathode (Ni-NCAL|SDC|Ni-Ag). The open-current voltages (OCV) of Cell A and cell B were higher than 1.0 V during operating at 550°C. There was no leakage gas and current flow through the electrolyte layer during cell operation. The OCV of Cell C was lower than 0.6 V during operating at 550°C. The power densities of Cell A, Cell B, and Cell C were 535.2, 250.5, and 22.6 mW/cm<sup>2</sup>, respectively. The ohmic impedances of Cell A, Cell B, and Cell C were 0.164, 0.164, and 0.485 Ω-cm<sup>2</sup>, respectively. The polarization impedances of Cell A, Cell B, and Cell C were 0.246, 0.608, and 3.038 Ω-cm<sup>2</sup>, respectively. Absence of the Li element in the Cell C anode caused poor in-situ sintering. The NCAL electrode changed to Ni-Co alloy and LiOH in reducing atmosphere. The LiOH is a well-known CO<sub>2</sub> absorbent that produced Li<sub>2</sub>CO<sub>3</sub> when reacted with CO<sub>2</sub> in the air. The LiOH or Li<sub>2</sub>CO<sub>3</sub> were found in both cathode and anode electrodes via XRD analysis after the cell measurement. The liquid phase of LiOH ( $T_{\text{melting}} = 462^\circ\text{C}$ ) could enhance in-situ sintering, due to the LiOH liquid transport to the electrolyte layer through the capillary phenomenon. It improved the contact of electrode and electrolyte. After the cell measurement, the Li salts were not found in the electrolytes in XRD patterns, due to LiOH or Li<sub>2</sub>CO<sub>3</sub> existed as amorphous phase. The Li<sub>2</sub>CO<sub>3</sub> was identified in the electrolytes by Raman spectra. The Cell C has the lowest intensity of the peak located at 1114 cm<sup>-1</sup>, which corresponds to the Ag vibrational modes of Li<sub>2</sub>CO<sub>3</sub>. The Li salts were transporting from anode electrode to electrolyte was the important factor to improve the performance of SOFC.

**Keywords:** solid oxide fuel cell, in-situ sintering, capillary phenomenon

## H. High performance materials under extreme conditions

H\_P01

### Processing and performance of oxidation-resistant layers on graphite

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#### Abstract

In this study, SiC layers were prepared on graphite surface by silicon vapor infiltration and slurry dipping methods. [1] The phase change, microstructure and oxidation resistance of the reaction layer/coating were investigated. The results showed that using silicon vapor infiltration method, the SiC layer was not observed on the graphite surface after 1500°C/1 h treatment while 1500°C/4 h and 1500°C/9 h treated samples had about 100 μm and 150 μm SiC layer, respectively. The surface roughness of the reaction SiC layer increased with the increase of heating time. In the slurry dipping method, the slurry was prepared with phenolic resin, alcohol, Si powder, and SiC powder. The dip-coated samples were treated in Ar at 1500°C for 2 h. The coating layer was converted into SiC with a thickness of about 150-200 μm. However, there were obvious cracks in the coating layer. In the oxidation resistance test at 1000°C in air, pristine graphite oxidized completely within 2 h. The sample with 150 μm SiC layer, prepared via silicon vapor deposition, retained 17% of graphite after 2 h in the oxidation test. For the slurry dipping sample with comparable thickness of SiC coating, 43% of graphite could survive after 2h in the oxidation test. The discontinuity of the reaction layer/coating exposed inner graphite to the air causing oxidation and loss of graphite.

**Keywords:** Silicon vapor deposition, slurry dipping, graphite, SiC coating

#### References

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H\_P02

## Influence of Unipolar Pulsed Two-Stage Rise Voltage on Wear Resistance of Carbon Steel Surface Using MAO method

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### Abstract

This study aims to use micro-arc oxidation(MAO) technology to prepare micro-arc oxide coatings on low carbon steel (SS400) for increasing its wear resistance[1]. However, as micro-arc oxidation coatings are not easy to be produced on the iron surface, this research attempts to use the aqueous solutions containing aluminum and phosphate salts to be the main electrolytes[2]. The experiment uses a unipolar pulsed two-stage rise power supply at an operating voltage of 425/525V, and the ceramic coatings prepared by micro-arc oxidation can reach a maximum hardness of 1783 Hv in this study (the substrate is 550 Hv), and the MAO coating can reach the highest thickness of 77.81 $\mu$ m in this study; furthermore, MAO coating can obtain the best wear resistance (abrasion loss:.0065g/3000rev.) in this study, which is about 7 times better than the substrate.

**Keywords:** micro-arc oxidation, wear resistance, carbon steel

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H\_P03

## Analysis of the microstructure and dielectric properties on $\text{CaCu}_3\text{Ti}_4\text{O}_{12}$ -based dielectric ceramic materials

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### Abstract

The  $\text{CaCu}_3\text{Ti}_4\text{O}_{12}$  (CCTO) compound had been known since 1967 by Deschanvres et al.[1] CCTO was a ceramic material with a pseudo-perovskite structure which exhibited considerable permittivity ( $10^4 - 10^6$ ) within wide ranges of frequency (1 Hz – 1 MHz) and temperature (100 to 600 K) by Subramanian et al.[2] In this study,  $\text{Ca}_{1-x}\text{Sr}_x\text{Cu}_3\text{Ti}_4\text{O}_{12}$  ( $x = 0.075, 0.1$  and  $0.125$ )(CSCT) ceramic were prepared by conventional solid-state method, and XRD, SEM, EDS and EIS were used to analyze. The XRD results indicated that the dielectric materials were  $\text{CaCu}_3\text{Ti}_4\text{O}_{12}$  cubic phase and no second phase. From SEM analysis, dielectric materials were densification structure. The EDS results indicated that both large and small grains contained Sr signals, indicating that Sr had been successfully doped into the CSCT dielectric material. The EIS results showed that CSCT100 had the largest dielectric constant ( $3.35 \times 10^3$ ), and CSCT75 had the smallest dielectric loss value ( $2.77 \times 10^{-2}$ ) when the frequency was 1 kHz at room temperature.

**Keywords:**  $\text{CaCu}_3\text{Ti}_4\text{O}_{12}$ , Dielectric constant, Dielectric loss, Solid-state reaction

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H\_P04

## High temperature stability BaTiO<sub>3</sub>-Bi<sub>0.5</sub>Na<sub>0.5</sub>TiO<sub>3</sub>-based dielectric ceramics of formulation improvement and material properties analysis

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### Abstract

Nb-doped 0.9BaTiO<sub>3</sub>-0.1Bi<sub>0.5</sub>Na<sub>0.5</sub>TiO<sub>3</sub> ceramic that satisfy the EIA X9R specification were prepared by conventional solid-state method. [1] In this study, 0.9BaTiO<sub>3</sub>-0.1Bi<sub>0.5</sub>Na<sub>0.5</sub>TiO<sub>3</sub> was synthesized by solid-state method, and mixed with specific proportion of Nb<sub>2</sub>O<sub>5</sub>, then transition elements such as Mg or Mn were added to improve its dielectric properties. The phase was identified using X-ray diffraction, it was found that the main phase of the sample was tetragonal BaTiO<sub>3</sub>. After sintering, the sample was polished with sandpaper and thermally etched. Its grain size was observed by scanning electron microscope. In order to determine whether that sintered sample has a core-shell structure, the sintered sample had chemical etching. Its microstructure was observed by scanning electron microscope. The sintered sample was coated by silver glue, and measured the AC impedance from 100 Hz to 1 MHz to understand the frequency dependent of the sample's dielectric constant and dielectric loss at room temperature. Measuring the change of the dielectric properties of the sample at -55°C to 150°C, and use the formula to calculate the dielectric loss and the TCC curve against temperature.

**Keywords:** BaTiO<sub>3</sub>, X8R, TCC

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H\_P05

## Use of a composition-graded solid electrolyte for determination of Gibbs energy of formation of lanthanum hafnate: A prospective TBC material for turbine applications

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### Abstract

Lanthanum hafnate ( $\text{La}_2\text{Hf}_2\text{O}_7$ ) is a potential thermal barrier coating (TBC) material for gas turbines at temperatures above 1473 K. Because of experimental difficulties, Gibbs energy of formation of  $\text{La}_2\text{Hf}_2\text{O}_7$  has not been measured. In this study a novel solid-state electrochemical cell has been designed for measurement of Gibbs energy in the temperature range from 875 to 1275 K. The cell employs a composite solid electrolyte consisting of single crystal  $\text{CaF}_2$  and composition-graded  $(\text{LaF}_3)_y(\text{CaF}_2)_{1-y}$ . The standard Gibbs energy of formation of  $\text{La}_2\text{Hf}_2\text{O}_7$  from component binary oxides,  $\text{La}_2\text{O}_3$  (A-rare earth) + 2  $\text{HfO}_2$  (monoclinic)  $\rightarrow$   $\text{La}_2\text{Hf}_2\text{O}_7$  (pyrochlore), is obtained as  $\Delta G_{(f,ox)}^0 / \text{J mol}^{-1} (\pm 4500) = -111417 - 9.89 (T/\text{K})$ . The result can be used for evaluating compatibility of  $\text{La}_2\text{Hf}_2\text{O}_7$  with bond coat under severe environmental conditions and reactions with entrained calcium-magnesium-alumino-silicates (CMAS).

**Keywords:**  $\text{La}_2\text{Hf}_2\text{O}_7$ , Thermal barrier coatings (TBC), Composition-graded electrolyte, Gibbs energy of formation, Thermodynamic properties.

H\_P06

## High Performance Solid State SO<sub>2</sub> sensor using Nano-structured Oxides

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### Abstract

The emission of SO<sub>2</sub> mainly comes from the burning of fossil fuels such coal and sulfur-containing oil. Thus, the source of SO<sub>2</sub> emission may be contributed from power plants or steel making factories. Exposures to SO<sub>2</sub> can harm the human respiratory system and make breathing difficult. People suffered by asthma are sensitive to these effects of SO<sub>2</sub>. To improve air quality, the concentration of SO<sub>2</sub> is typically limited by national and/or regional standards to reduce emissions of SO<sub>2</sub>. Therefore, the accurate detection of SO<sub>2</sub> is important. Electrochemical solid state sensors are known to provide reliable and stable signals based on the use of solid electrolytes. Oxygen sensors based on oxygen-conducting yttria- stabilized zirconia have shown their wide applications. In this study, a solid state SO<sub>2</sub> sensor are developed using Li-conducting Li<sub>1.3</sub>Al<sub>0.3</sub>Ti<sub>1.7</sub>(PO<sub>4</sub>)<sub>3</sub> (LATP). Li<sub>2</sub>SO<sub>4</sub> is used as electrode. With the application of adequate voltage, Li<sub>2</sub>SO<sub>4</sub> may be formed at the surface exposed to SO<sub>2</sub>-containing atmosphere. Thus, the current measured from the sensors is expected to be proportional to the concentration of SO<sub>2</sub>. The dependence of SO<sub>2</sub> concentration, temperature, and electrode microstructure will be analyzed and discussed.

**Keywords:** LATP, SO<sub>2</sub> sensor, Amperometric sensor,

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H-P07

## Effects of MAO Coating on the Hardness and Corrosion Resistance of 6032 Aluminium Alloy

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### Abstract

This study aims to increase the hardness and corrosion resistance of the surface of commercial pots (6032 aluminum alloy). By use of bipolar pulse power supply for micro-arc oxidation(MAO) surface treatment, the operating parameters include different positive and negative voltages[1-2]. The results of this study show that the coating prepared by micro-arc oxidation with bipolar pulsed power supply, positive and negative voltage (+525V/-50V), has a much higher hardness (836Hv) than that of a commercial aluminum alloy pot(150Hv), and the corrosion resistance (corrosion current density:  $1.46 \times 10^{-7}$  A/cm<sup>2</sup>) of the coating is about 100 times higher than that of the commercial aluminum alloy pot (corrosion current density:  $3.36 \times 10^{-5}$  A/cm<sup>2</sup>).

**Keywords:** micro-arc oxidation, corrosion resistance, aluminum alloy

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H\_P08

## Dielectric properties of CaO–B<sub>2</sub>O<sub>3</sub>–SiO<sub>2</sub> glass-ceramics in the millimeter-wave range of 20–60 GHz frequency

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### Abstract

This work investigates the dielectric and structural properties of the as-quenched melts of three CaO–B<sub>2</sub>O<sub>3</sub>–SiO<sub>2</sub> compositions (denoted CBS-1, CBS-2, and CBS-3), and determined their suitability for millimeter-wave applications. The CBS-1 glass-ceramic exhibited the lowest coefficient of thermal expansion (CTE = 3.2 ppm/°C), the highest breakdown strength of 15.20 kV/mm, lowest dielectric constant ( $\epsilon_r = 4.04$ ) at 60 GHz, and highest dielectric loss ( $\tan\delta = 0.0029$ ) at 60 GHz, which were attributed the presence of quartz (SiO<sub>2</sub>) as the major phase. The CBS-2 and CBS-3 glass-ceramics, possessed a major phase of  $\beta$ -CaSiO<sub>3</sub>, showed relatively high CTEs (6.6 and 5.9 ppm/°C, respectively), relatively high dielectric constants at 60 GHz (6.29 and 7.61, respectively), and relatively low dielectric losses at 60 GHz (0.0020 and 0.0012, respectively). The CBS-1 glass-ceramic exhibited the highest dielectric loss due to the presence of SiO<sub>2</sub> and the lattice scattering induced by the high glassy phase content. The thermal conductivities (K) of the CBS-1, CBS-2, and CBS-3 glass-ceramics were determined to be 2.43, 1.06, and 0.82 W/mK, respectively. Structural analysis showed the absence of nonbridging oxygen by Raman and FTIR spectroscopy. The high CaO content (>40 mol%) of the CBS-2 and CBS-3 glass-ceramics triggered the formation of nonbridging oxygen in the tetrahedral silicate units. The increase in CaO content of the glass-ceramics increased the number of nonbridging oxygen atoms, thereby resulting in the relaxation of the structure. Consequently, the CBS-2 and CBS-3 glass-ceramics exhibited low thermal conductivity. All glass-ceramics presented in this work showed high electrical resistivities of greater than  $5 \times 10^{11} \Omega \text{ cm}$ . The excellent microwave dielectric and thermal properties of the CBS glass-ceramics facilitate for use in millimeter-wave applications.

**Keywords:** millimeter-wave, microwave properties, CaO–B<sub>2</sub>O<sub>3</sub>–SiO<sub>2</sub>

L. LED  
L\_P01

## Luminescence Investigation of Chromium-doped Forsterite Phosphor Thin Films

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### Abstract

Near-infrared (NIR) luminescent materials have recently attracted attention for applications in medical fields, biosensors, luminescent probes, lighting and display devices, and night-vision technologies. In this work, we experimentally investigate the luminescence of Cr-doped forsterite ( $\text{Mg}_2\text{SiO}_4:\text{Cr}$ ) phosphor thin films. The phosphor films were prepared by a sol-gel spin coating process and reported for the first time. The influences of different doping concentrations, film thickness, and heat treatment temperatures on the structure, microstructure and photoluminescence (PL) were examined. The dried films started to produce  $\text{Mg}_2\text{SiO}_4$  crystalline phase after sintering at  $500^\circ\text{C}$ . On heating to  $1300^\circ\text{C}$ , forsterite was the dominant phase with a small trace of enstatite ( $\text{MgSiO}_3$ ). The phosphor thin films demonstrated near infrared (NIR) light emission with a peak at 805 nm under excitation at 532 nm, which corresponds to the  ${}^4\text{T}_{2g} \rightarrow {}^4\text{A}_{2g}$  transition of  $\text{Cr}^{3+}$  centers. The emission intensity of films was dependent upon the dopant concentration and number of coating layer (N). Optimum emission intensity of the films occurred at the coating layer of  $N = 5$  with doping of 2.0 mol% Cr.

**Keywords:** Sol-gel, Cr-doped forsterite, Luminescence, Phosphor film

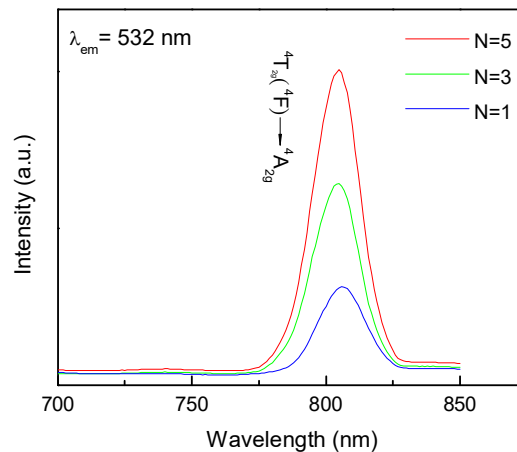


Figure 1. PL spectra of  $\text{Mg}_2\text{SiO}_4:\text{Cr}$  phosphor film with various number of coating layers (N) after sintering at  $1300^\circ\text{C}$ .

### Acknowledgment

This work was supported by the Ministry of Science and Technology, Taiwan, under contract MOST-110-2221-E150-018.

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L\_P02

## Luminescence Investigation of Blue-emitting Cordierite Phosphor Thin Films

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### Abstract

Literature survey shows that cerium-doped cordierite phosphor powders have been prepared by the high temperature solid-state reaction method. In this work, we experimentally investigated the luminescence of Ce-doped cordierite ( $\text{Mg}_2\text{Al}_4\text{Si}_5\text{O}_{18}:\text{Ce}$ ) phosphor thin films. The phosphor films were prepared by a sol-gel spin coating process and reported for the first time. The influences of different doping concentrations, film thickness, and heat treatment temperatures on the structure, microstructure and photoluminescence (PL) were examined. The dried films started to produce  $\mu$ -cordierite crystalline phase after sintering at 900 °C, and pure phase  $\alpha$ - $\text{Mg}_2\text{Al}_4\text{Si}_5\text{O}_{18}$  formed at 1300 °C. PL spectrum of phosphor thin films consisted of an asymmetric broad emission band from 350 to 550 nm with a peak at 426 nm under UV excitation at 243 nm, originating from the  $5d \rightarrow 4f$  transition of  $\text{Ce}^{3+}$  ions. The broad emission band was caused by the splitting of the ground state of 4f level into  $^2F_{5/2}$  and  $^2F_{7/2}$ . The emission intensity of films was dependent upon the dopant concentration and number of coating layer (N).

**Keywords:** Sol-gel, Ce-doped cordierite, Luminescence, Phosphor film

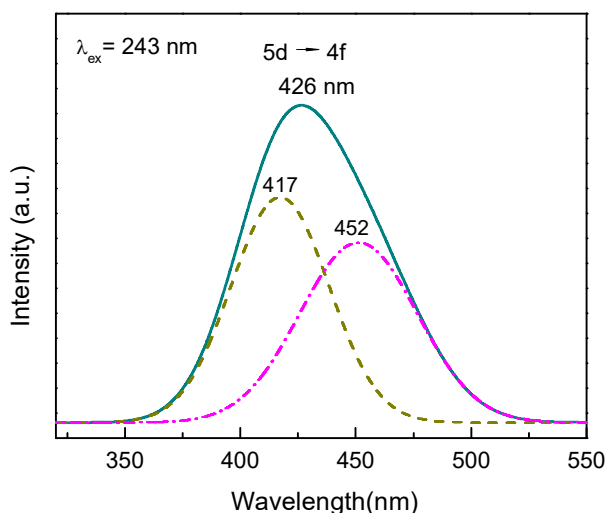


Figure 1. PL spectrum of  $\text{Mg}_2\text{Al}_4\text{Si}_5\text{O}_{18}:\text{Ce}$  phosphor film sintered at 1300°C, showing that the band can be deconvoluted into two Gaussian components with peaks at 417 and 452 nm, which are attributed to the  $5d \rightarrow ^2F_{5/2}$  and  $5d \rightarrow ^2F_{7/2}$  transitions, respectively.

### Acknowledgment

This work was supported by the Ministry of Science and Technology, Taiwan, under contract MOST-110-2221-E150-018.

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L\_P03

## Structures and Photoluminescence Properties of $(\text{Ba,Sr})_{1-x}\text{MgAl}_{10}\text{O}_{17}:\text{Eu}_x^{2+}$ Phosphors

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### Abstract

The UV LED-excited phosphors with multi-function and high efficiency have attracted more and more attention due to the continuous improvement of display technology in recent years. BAM:Eu is a kind of high-efficiency blue phosphor widely used in PDP displays and also have quite good luminous efficiency in VUV application. BAM phosphor are conventionally synthesized by solid state process, but it always required high temperature to improve the phase generate and cation homogeneity. In this paper, a simply, low cost preparation method was being investigated by using chemical precipitation method at room temperature with two kinds of precipitation agent,  $(\text{NH}_4)_2\text{CO}_3$  and  $\text{NH}_4\text{OH}$ . From XRD result, the precursor of using  $\text{NH}_4\text{OH}$  as precipitation agent, named BAM-OH, calcined at 1000-1500 presents some  $\alpha\text{-Al}_2\text{O}_3$  intermedia phase remained in the product. The precursor synthesized by  $\text{NH}_4\text{HCO}_3$ , named BAM-CO, almost convert to pure BAM phase during 1000-1500. From the XRD results, the better precursor formation condition of BAM:Eu was using  $\text{NH}_4\text{HCO}_3$  as precipitation agent, which can obtain good uniformity composition of product. As compared with BAMOH, BAMCO shows better luminescence intensity because of higher crystallinity in each calcined temperature. Using smaller cation,  $\text{Sr}^{2+}$  substitutes for the Ba site not only decreased the C axis of BAM structure and the lattice parameter but also increased the distortion of the lattice. The structural variation of  $\text{Ba}_{0.85-x}\text{Sr}_x\text{MgAl}_{10}\text{O}_{17}:\text{Eu}_{0.15}$  phosphors strongly affects their photoluminescent properties. The distortion induces a higher strain and makes a larger crystal field split. As the concentration of  $\text{Sr}^{2+}$  substituted for  $\text{Ba}^{2+}$  site increase, the maximum excitation and emission band shift to red. The intensity of maximum excitation and emission band decrease by high concentration  $\text{Sr}^{2+}$  and  $\text{Eu}^{2+}$ .

**Keywords:** phosphor, lattice distortion, luminescence property, red shift

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## M Materials and technologies for a low carbon, sustainable society

M\_P01

**ZnO-ZnCr<sub>2</sub>O<sub>4</sub> Catalyst Fabricated by Glycine Nitrate Process and Used for Hydrogen Generation with the Steam Reforming of Methanol**Chung-Lun Yu<sup>1</sup>, Subramanian Sakthinathan<sup>1</sup>, Sheng-Yu Chen<sup>2</sup>, Te-Wei Chiu<sup>1\*</sup>, Yung-Shen Fu<sup>3\*\*</sup>, Bing-Sheng Yu<sup>1</sup><sup>1\*</sup> Department of Materials and Mineral Resources Engineering, National Taipei University of Technology,<sup>2</sup>Institute of Chemistry, Academia Sinica<sup>3\*\*</sup>Key Laboratory for Soft Chemistry and Functional Materials of Ministry of Education, Nanjing University of Science and Technology, (*fuyongsheng@njust.edu.cn*)\*Corresponding Author: *tewei@ntut.edu.tw***Abstract**

The risks caused by the over usage of fossil energy were significant problems in recent years. Various fields spent much concern and funds in addition to develop renewable carriers for decreased environmental effect by existing fossil energy. Among climate change, global warming, and energy crisis, hydrogen (H<sub>2</sub>) can be used as potential energy carrier due to the clean, non-toxic and more efficient, etc. Nowadays, the mainstream for H<sub>2</sub> generation from industrial is steam reforming of methanol (SRM) and usually used the zinc-based commercial catalyst in this process. According to this work, the ZnO-ZnCr<sub>2</sub>O<sub>4</sub> catalyst was successfully prepared by the glycine nitrate process (GNP) and developed for using on H<sub>2</sub> production from SRM. Meanwhile, an increasing specific surface area, porous structure and reaction sites of the zinc-based catalyst could be effectively promoted by the preparation method. As-combusted ZnO-ZnCr<sub>2</sub>O<sub>4</sub> catalyst was immensely porous structure due to the gas released during the GNP reaction process. Moreover, according to ZnO distribution and different G/N ratios, the specific surface area (*S<sub>BET</sub>*) of as-combusted ZnO-ZnCr<sub>2</sub>O<sub>4</sub> catalyst revealed varied from 29.65 m<sup>2</sup>/g to 46.27 m<sup>2</sup>/g. The ZnO-ZnCr<sub>2</sub>O<sub>4</sub> catalyst (G/N 1.7) exhibited its highest hydrogen production at reaction temperature of 450°C that could reach 4814.25 ml STP min<sup>-1</sup> g-cat<sup>-1</sup> without activation treatment. However, after activating the ZnO-ZnCr<sub>2</sub>O<sub>4</sub> catalyst hydrogen production performance reached 6299.28 ml STP min<sup>-1</sup> g-cat<sup>-1</sup> at reaction temperature of 500°C. The hydrogen production performance of ZnO-ZnCr<sub>2</sub>O<sub>4</sub> catalyst improved by the uniformly addition of ZnO dispersibility with the ZnCr<sub>2</sub>O<sub>4</sub>. Based on the performance, ZnO-ZnCr<sub>2</sub>O<sub>4</sub> catalyst was great potential for industrial and economic impact due to its high efficiency of hydrogen production.

**Keywords:** Hydrogen production, ZnO-ZnCr<sub>2</sub>O<sub>4</sub>, glycine nitrate process, steam reforming, methanol.**References**

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M-P02

## **CuCrO<sub>2</sub>-TiO<sub>2</sub> Nanocomposites Prepared by Glycine Nitrate Process and Photodegradation the Rhodamine B Organic Dye with Ultraviolet Light**

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### **Abstract**

In recent years, organic dyes used in several fields of applications such as leather, textile, paper, and cosmetics, etc. Meanwhile, Rhodamine B was used as printing dyes of the industry which was usually added to the product. Therefore, the harmful potential factors belong to Rhodamine B which influenced for the environment and living things, especially human. Moreover, to human cancer could be caused by the Rhodamine B organic dyes. To solve the environmental pollutions caused by organic dyes, degradation of organic dye is the potential application in recent years which used the Cu-based material as the degradation catalyst. In this work, CuCrO<sub>2</sub>-TiO<sub>2</sub> composite prepared by glycine nitrate process and applied to the degradation of Rhodamine B under UV light condition. The as-prepared composite powder was investigated by XRD and SEM to confirm the morphology and crystal structure of the catalyst. Through Rhodamine B photodegradation, the degrading efficiency by CuCrO<sub>2</sub>-TiO<sub>2</sub> composite could reach 90.78% and the constant reaction rate was estimated at about  $3.77 \times 10^{-3} \text{ min}^{-1}$ . According to the RhB degradation studies, CuCrO<sub>2</sub>-TiO<sub>2</sub> composite exhibited high catalytic activity and could apply to degrade and remove the dye industry pollution for environmental purification.

**Keywords:** Photodegradation, CuCrO<sub>2</sub>-TiO<sub>2</sub>, glycine nitrate process, Rhodamine B, ultraviolet light.

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M-P03

## Nickel Recovery from Spent Plating Solution by Chemical Precipitation

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### Abstract

Nickel plating is widely used in an electronic manufacturing. An adequate renewal of plating baths can retain the yield of plating processes. However, changing the bath in a short period generates a large amount of spent solution, causing an impact on our environment. Therefore, this study investigated the removal of nickel from the spent solution through a simple chemical precipitation. In addition, the complexing agent and reducing agent in the plating bath are also unfriendly to our environment, so this study adopted the chemical precipitation to remove them through the reaction between these agents and nickel ions. When the pH of the spent solution increased by adding NaOH, nickel hydroxide was generated. The experimental results show that the complexing agent in the solution could reduce the precipitate size to a level of several micrometers, even though the precipitation rate decreased by the complexing agent. If the pH, temperature, and agitation speed were adjusted, the results revealed that the precipitation rate can be effectively controlled. The particles with a size of average 5.31  $\mu\text{m}$  could be obtained from the reaction at pH 12 and 50°C for 60 min under stirring at 600 rpm. XRD and FTIR analyses verified that the precipitate is made of amorphous  $\text{Ni}(\text{OH})_2$  and  $\alpha$ -phase  $\text{Ni}(\text{OH})_2$ . This type of micro-sized particles can be applied to fabrication of the energy-storage materials, such as the electrode of nickel-based secondary batteries. Furthermore, the proposed precipitation provided a Ni removal efficiency of more than 98%. Therefore, this study can be used to sustain a circular economy by turning Ni waste to energy-storage materials.

**Keywords:** Nickel, Plating waste solution, Chemical precipitation, Micro sized particles

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M-P04

## Anticorrosion for 304 Stainless Steel by Using TiO<sub>2</sub>/Ag<sub>2</sub>O Protection Layer

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### Abstract

In order to prevent the metal corrosion, the cathodic protection method is widely used through a sacrificial anode or an applied electrical current. However, applying electrical current or using sacrificial anode increase the usage of fossil fuel, and even cause the pollution of soil and underwater. In this study, an anticorrosion method combining the electrical current and non-sacrificial anode was therefore proposed. Our method is performed by coating the TiO<sub>2</sub> layer including Ag<sub>2</sub>O, which can absorb solar energy to protect 304 stainless steel (304SS). The TiO<sub>2</sub>/Ag<sub>2</sub>O anticorrosive layer was fabricated using a blade. The resulted protection characteristics could be shown through the induced photocurrent of the TiO<sub>2</sub>/Ag<sub>2</sub>O layer and open circuit potential (OCP) of stainless steel. The specimen of stainless steel was immersed in a 3.5 wt.% NaCl solution for simulating the condition of metal in seawater. Under illumination of white light, negative changes in the OCP of 304SS by more than 600 mV from its initial value could be found. The negative shifts attribute to the transfer of photoelectrons from TiO<sub>2</sub>/Ag<sub>2</sub>O layer to 304SS. However, a pair of photoinduced electron and hole were generated, indicating that these photoelectrons may recombine with photo-induced holes easily. The photocurrent analysis show that adding citric acid as a hole scavenger can decrease the possibility of recombination and enhance the protection efficiency. Furthermore, the OCP shift for the TiO<sub>2</sub>/Ag<sub>2</sub>O layer also indicates the effect of the cathodic protection. An antibacterial experiment was conducted to test the feasibility of protection layer containing Ag from biological corrosion. The experimental results verified that the growth of Escherichia coli can be thoroughly inhibited by the TiO<sub>2</sub>/Ag<sub>2</sub>O layer. Consequently, the proposed layer hardly dissolves during the cathodic protection process, and meanwhile the proposed method can utilize solar energy, conforming to the goal of green process.

**Keywords:** Anticorrosion, Antibacterial, Photoelectrochemical cathodic protection, Solar energy

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M\_P05

## Fabrication of CuYO<sub>2</sub> Nanofibers by Electrospinning

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### Abstract

In this work, CuYO<sub>2</sub> nanofibers were successfully prepared by the electrospinning method with post annealing process. First, the metal nitrate precursor is used to produce as-spun fiber via the electrospinning method, and annealed in air atmosphere to remove Polyvinylpyrrolidone, which was contained in Cu<sub>2</sub>Y<sub>2</sub>O<sub>5</sub> nanofibers. After that, Cu<sub>2</sub>Y<sub>2</sub>O<sub>5</sub> nanofibers were annealed in a nitrogen atmosphere to form CuYO<sub>2</sub> nanofibers. XRD and TEM SAED analysis confirmed that the product revealed various crystal phase of CuYO<sub>2</sub>, R $\bar{3}$ m space group and P6<sub>3</sub>/mmc space group. Furthermore, SEM and TEM studies were used to observe the morphology and structure of CuYO<sub>2</sub> nanofibers, then apply to the methanol steam reforming produce for hydrogen production. The CuYO<sub>2</sub> nanofibers to confirm its catalytic ability and analyze the difference after catalysis.

**Keywords:** Delafossite, CuYO<sub>2</sub> nanofibers, methanol steam reforming, Electrospinning, hydrogen production

M\_P06

## Preparation of Janus Structure ZnO/CuO Composite Oxide Particle

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### Abstract

The chemical solution was used to prepare copper oxide microspheres, which were then RF sputtered with zinc oxide nano-seed coating. Then, using the water bath process, zinc oxide nanowires were grown on the surface of copper oxide microspheres. The micron ZnO/CuO composite was successfully prepared. As copper nitrate and ammonium nitrate were used as copper oxide precursors, and then poloxamer (Pluronic P123) was added, the spherical micelles formed when put in a deionized water. The precursor of as-prepared zinc oxide was used zinc acetate and hexamethylenetetramine were dissolved in a deionized water until uniformly mixed. Finally, the ZnO/CuO micron composite material was prepared by radio frequency sputtering and water bath method. According to the suitable characterization analysis, the STEM images and TEM-EDS of ZnO/CuO micron composite revealed janus structure. The zinc oxide nano-pillars were grown on the copper oxide micron spheres. The XRD result ZnO/CuO micron composite of exhibited the phases of zinc oxide copper oxide in diffraction pattern, respectively.

**Keywords:** ZnO/CuO composite materials, CuO microspheres, ZnO nanorods, Hydrothermal, Sputter

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M\_P07

## Effect of adding mesoporous silica KIT-6 of V<sub>2</sub>O<sub>5</sub>/WO<sub>3</sub>/TiO<sub>2</sub> catalyst for selective catalytic reduction

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### Abstract

Nitrogen oxides (NO<sub>x</sub>) has been a major pollutant for air pollution, which bring about photochemical smog, acid rain, ozone depletion and atmospheric deposition. Selective catalytic reduction (SCR) of NO<sub>x</sub> with NH<sub>3</sub> is given more attention by researcher due to SCR is the most efficient and widest commercialized technologies for removal NO<sub>x</sub> emissions in exhaust gas from diesel engines. The key factors to improve the NO<sub>x</sub> conversion efficiency for these catalysts are the surface area and the active site. In this study, the V<sub>2</sub>O<sub>5</sub>-WO<sub>3</sub>/TiO<sub>2</sub> catalysts containing different loadings of mesoporous silica KIT-6 were synthesized and characterized by X-ray diffraction, nitrogen adsorption, FTIR and NH<sub>3</sub> temperature programmed desorption. The catalyst with a KIT-6 loading of 6 wt% is very active in the SCR of NO with NH<sub>3</sub> at 300 °C, leading to an NO conversion of close to 90%.

**Keywords:** mesoporous silica, selective catalytic reduction, NO conversion

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M\_P08

## Synthesis of $\text{Bi}_4\text{O}_5\text{I}_2/\text{BiOI}$ heterojunction with improved visible-light photocatalytic activity

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### Abstract

Photocatalysis has been deemed to be the green technology for pollutant degradation in water or air using solar energy. Constructing high-efficiency heterojunction has been considered as a promising method to enhance visible-light photocatalytic activity of single component. Pristine BiOI has a unique layered structure and a wide adsorption range, which endows it with excellent photocatalytic activity [1]. However, its narrow band gap results in the rapid recombination of photogenerated carriers. By forming a heterojunction with other materials, the separation efficiency of hole-electron pairs can be improved [2,3]. In this work, a series of photocatalysts have been fabricated by adjusting pH in the presence of urea. Among those,  $\text{Bi}_4\text{O}_5\text{I}_2/\text{BiOI}$  heterojunction obtained at pH = 5.30 exhibits the highest photocatalytic performance toward degradation of tetracycline (TC) under visible light irradiation. In addition, if using pure water as solvent, the photocatalytic activity is greatly reduced, which is because urea solution can facilitate the uniform dispersion of  $\text{Bi}^{3+}$  and induce homogeneous nucleation of nanoparticles. This work provides an rational route for design and fabrication of  $\text{Bi}_4\text{O}_5\text{I}_2/\text{BiOI}$  heterojunction photocatalyst at room temperature for environmental remediation.

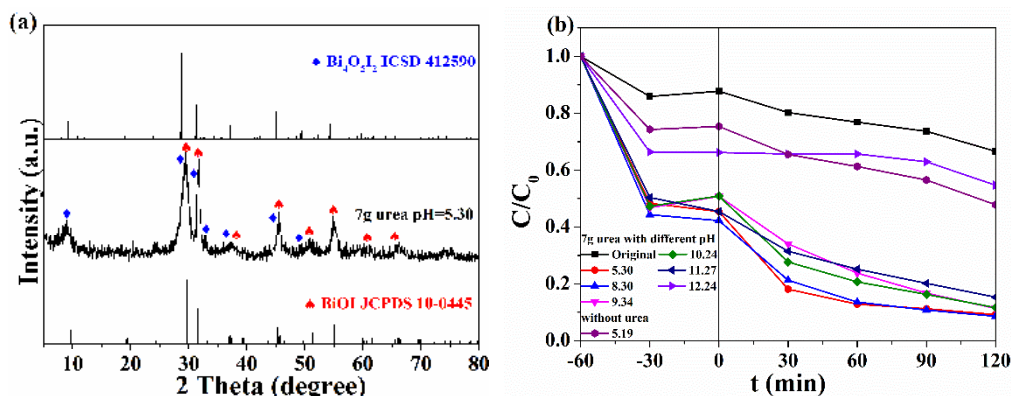


Figure 1. (a) XRD pattern of  $\text{Bi}_4\text{O}_5\text{I}_2/\text{BiOI}$ ; (b) Photocatalytic activity of the photocatalysts prepared at different pH values for the degradation of TC ( $30 \text{ mg L}^{-1}$ ) under visible light irradiation.

**Keywords:**  $\text{Bi}_4\text{O}_5\text{I}_2/\text{BiOI}$ ; Heterojunction; Urea solution; Photocatalyst.

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M\_P09

## The effect of La<sub>2</sub>O<sub>3</sub> addition on intermetallic-free aluminium matrix composites reinforced with TiC and Al<sub>2</sub>O<sub>3</sub> ceramic particles

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### Abstract

Aluminum matrix composites reinforced by *in situ* particles exhibit high specific strength and stiffness, excellent wear resistance and thermal stability as well as attractive mechanical properties [1,2]. These outstanding properties are attributed to the reinforced phase and its *in situ* nucleation, growth, thermodynamic stability and contaminant-free enhanced surface, which are beneficial to the matrix. Many methods are used to fabricate aluminum matrix composites with *in situ* reinforced particles. Among them, self-propagating high-temperature synthesis, which has the advantage of simplicity and lower cost, has attracted much attention [3-5]. At present, a variety of reaction systems are used to prepare *in situ* particles with different shapes and sizes, such as the Al-Ti-C reaction system and the Al-Ti-B reaction system [6,7]. However, the large intermediate phase size and poor solubility of C in Al melt are problems in those reaction systems [8,9]. In this work, intermetallic-free aluminium matrix composites reinforced with TiC and Al<sub>2</sub>O<sub>3</sub> ceramic particles were successfully prepared via an *in situ* reaction of Al-Ti-C-CuO-La<sub>2</sub>O<sub>3</sub> during self-propagating high-temperature synthesis. The effect of adding the rare earth metal oxide La<sub>2</sub>O<sub>3</sub> was studied by using differential scanning calorimetry, X-ray diffraction, scanning electron microscopy, optical microscopy and Brinell hardness tests. The results showed that La<sub>2</sub>O<sub>3</sub> could promote the wettability of the C and Al melt in the Al-Ti-C-CuO system. The final products of the *in situ* reaction for the 2.5Al-1Ti-1.2C-0.5CuO-0.005La<sub>2</sub>O<sub>3</sub> system were TiC particles and Al<sub>2</sub>O<sub>3</sub> particles, and the system was free of intermetallic compounds. The prepared aluminium matrix composites were greatly refined with an average grain size of 20.6 μm. The intermetallic-free aluminium matrix composites reinforced with TiC and Al<sub>2</sub>O<sub>3</sub> particles showed up to two times higher Brinell hardness value than the matrix 6063 aluminium alloy.

**Keywords:** Aluminium matrix composites, La<sub>2</sub>O<sub>3</sub>, TiC, Al<sub>2</sub>O<sub>3</sub>

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M\_P10

## A Study of Low-Temperature Sintering of Al<sub>2</sub>O<sub>3</sub> Ceramics with TiO<sub>2</sub> and Nb<sub>2</sub>O<sub>5</sub> addition

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### Abstract

The effects of TiO<sub>2</sub> and Nb<sub>2</sub>O<sub>5</sub> dopant on the physical, mechanical, and dielectric properties of Al<sub>2</sub>O<sub>3</sub> ceramics at sintering temperatures 1250~1500 °C were investigated. The results showed that TiO<sub>2</sub> doped into Al<sub>2</sub>O<sub>3</sub> ceramics has a significant influence on microstructure and mechanical property at lower sintering temperatures ( $\leq 1500$  °C). Besides, add an appropriate amount of Nb<sub>2</sub>O<sub>5</sub> (>1.5 wt%) can further reduce the sintering temperature of TiO<sub>2</sub> doped-Al<sub>2</sub>O<sub>3</sub> ceramics and keep good mechanical properties. When the sintering temperature decreased to 1350 °C, Al<sub>2</sub>O<sub>3</sub>-0.5%TiO<sub>2</sub> ceramics added with 1.5% Nb<sub>2</sub>O<sub>5</sub> has higher relative density. However, the Nb<sub>2</sub>O<sub>5</sub> addition will induce internal point-defects in the Al<sub>2</sub>O<sub>3</sub> ceramics which causes the deterioration of mechanical properties. Al<sub>2</sub>O<sub>3</sub>-0.75% TiO<sub>2</sub> ceramics added 1.5% Nb<sub>2</sub>O<sub>5</sub> at a sintering temperature of 1350 °C exhibited higher relative density 94%, compressive strength 1372 MPa, the abrasion rate  $1.36 \times 10^{-4}$  mm<sup>3</sup>/N•m.

M\_P11

## Electrostatic separation for recycling silicon from the crushed photovoltaic modules

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### Abstract

The waste of PV modules increases substantially with approaching their end-of-life and becomes a serious problem. It is very important to develop a recycling method for solar cell modules. For recycling the waste of PV modules, the aluminum frame and junction box are disassembled from the module first, followed by separating glass, EVA and solar cells. In order to recover complete silicon cells and glass, the plastic encapsulation (such as EVA) is usually removed by chemical dissolution, thermal decomposition, or melting with heated blade etc. For just downcycling, mechanical crushing is also considered because this method with relatively low-energy consumption and low-carbon emission is eco-friendly and avoids most masses to be landfilled. This study chose the mixture particles from the crushed silicon photovoltaic modules as samples. The mixture contained glass, silicon and aluminum mainly, and the screened size was about 0.8~1 mm. Due to the difference of resistivity between glass, silicon and aluminum, they might be separated by electrostatic action. In order to make the particles of insulator (glass), semiconductor (Si) and conductor (Al) have different trajectories during electrostatic separation, and recover silicon from the mixture, many parameters need to be adjusted. We used computer-aided engineering to simulate the potential line and the electric field strength of the electrostatic separation system. The operating parameters included geometry, size, relative position and voltage etc. The simulation results show that under the same roller radius, the corona electrode is closer to the roller or the applied voltage is greater, resulting in a higher strength of electric field. When the operation is limited to a low voltage, the distance between the corona electrode and the roller can be reduced to obtain the similar strength of electric field. Under an appropriated distribution and strength of electric field, the insulator could attach on the roller, the conductor bounced off, and the silicon particles moved between them.

### Keywords:

Photovoltaic module, Electrostatic separation, Corona electrode, Silicon, Glass

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M\_P12

## **Novel Bi<sub>2</sub>WO<sub>6</sub>/g-C<sub>3</sub>N<sub>4</sub>/ZnO Z-scheme heterojunctions with g-C<sub>3</sub>N<sub>4</sub> interlayer modulated by piezoelectric polarization for efficient piezo-photocatalytic decomposition of harmful organic pollutants**

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### **Abstract**

It is of great significance to understand the role of carrier in piezocatalysis of composites by studying the separation mode of carriers under dynamic polarization field. Herein, the separation and migration pathways of carriers under piezoelectric field are investigated by synthesizing heterojunctions with Bi<sub>2</sub>WO<sub>6</sub> (BWO) nanosheets grown vertically on g-C<sub>3</sub>N<sub>4</sub> (CN) coated ZnO nanorods and directly on ZnO. Compared with the photocatalysis, the piezocatalytic efficiency of Rhodamine B by BWO/ZnO is significantly increased to 0.121 min<sup>-1</sup>, which indicated the polarization field promotes band tilt and Z-scheme formation. After introducing the CN interlayer, the piezocatalytic efficiency of BWO/CN/ZnO is further improved (0.217 min<sup>-1</sup>), which can be attributed to the unique core-shell structure with Z-scheme heterojunctions. This unique structure provides more active sites and excited carrier concentration, the intermediate layer CN also reduces the direct contact and recombination of electrons and holes controlled by polarization potential at the interface between BWO and ZnO. This work deeply analyzes the influence of carrier concentration, separation efficiency and transport process on piezocatalysis, which provides a reference for the design of efficient catalyst.

**Keywords:** Bi<sub>2</sub>WO<sub>6</sub>/g-C<sub>3</sub>N<sub>4</sub>/ZnO heterojunctions, Z-scheme structure, piezocatalysis, dye decomposition.

M\_P13

## Characerization of Graphene/CNTs Hybrid Conductive Film by Screen Printing

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### Abstract

In recent years, conductive paste have been widely used in the printed electronics industry, such as electronic circuit boards, 5G antennas, solar cells, flexible displays, and radio-frequency identification. Graphene and carbon nanotubes(CNTs) have excellent properties. In this study, Graphene and CNTs were added into surfactant and dissolved by solvent to prepare conductive paste. The dispersion of carbon materials and viscosity of conductive paste is the key technology for preparing conductive paste. In this study, various amount graphene were added into poly-vinyl-pyrrolidone(PVP) to prepare graphene conductive paste. Changing the CNTs amount doped into the optimal graphene addition parameter and prepared graphene/CNTs conductive paste. The conductive paste was printed on substrate by the screen printing method and then annealed to prepare a conductive film. Characterization were determined by Scanning Electron Microscope, Raman spectroscopy, Hall Effect measurement system, Thermo-gravimetric Analysis to obtain the optimal parameters of preparing high quality and electrical properties conductive paste. The results show that the printed conductive film could not completely cover the substrate, making the graphene sheets discontinuous of conductive film at low graphene addition amount. The lowest sheet resistance is  $23.54 \Omega/\square$  of printed conductive film with 4 wt% graphene conductive. The printed conductive film of 0.5wt% CNTs and 4 wt% graphene hybrid conductive paste has the best electrical properties. The best sheet resistance of hybrid film is  $15.87 \Omega/\square$ . So, this study can successful prepare high stability and conductivity graphene/CNTs hybrid paste for applications and fabrication low cost of electrical devices.

**Keywords:** Graphene, CNTs, Conductive paste, Screen printing, Conductive film

M\_P14

## Developments of Calcium Sulfate Coating on Ti6Al4V Substrate by Flame Spray

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### Abstract

Due to the aging of global population, the demand of artificial joints is gradually rising. And in dental and orthopedic prosthesis, the outcome of the procedure depends greatly on the fixation of the implant. Covering the artificial joints with proper bio-ceramic can help the bone tissue grow into the porous structure. Thus, the purpose of this study is to create a ceramic-metal composites to accelerate the recovery after implanting. Calcium sulfate is a degradable bio-ceramics used widely as bone filler in current. It has good biocompatibility, no toxicity, osteoconductivity and abundant as well. In this study, calcium sulfate coating was successfully prepared on the Ti-6Al-4V substrate by flame spraying technique, and each property of the coating was analyzed. The experiment results showed that the bonding strength between substrate and calcium sulfate coating prepared by flame spraying could reach 37.02 MPa. The average porosity of the coating was 18.9% and the porous structure led the coating to rapid degradation and collapse. In the degradation test, the accumulated weight loss of the coating soaked in Hank's solution reached 100% on the fifth day. Besides, the high temperature of flame spray caused the calcium sulfate to decompose into calcium oxide and led the pH value of the SBF (simulated body fluid) to rise to 12 after 1 day of immersion. The power of flame spray was then lower to avoid the calcium oxide to appear. The pH value of the SBF after 1 day of immersion dropped to 11.3.

**Keywords:** Thermal spray, Ca<sub>2</sub>SO<sub>4</sub>, bio degradable coating

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M\_P15

## High entropy piezo-catalyst oxide for dye-degradation

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### Abstract

As the contamination in soil, water and air keeps increasing, the remediation of the environmental contamination has become an important issue. However, the mainstream solution for water pollution decomposition, which is a photocatalyst, is limited by the absorption efficiency and the intermittency of visible light. Hence, this research intends to use the piezoelectric effect to fabricate a composite high-entropy piezoelectric catalyst, so that the organic pollutants in the water can be effectively decomposed by vibrational stimuli in a non-illuminated environment. With pulsed laser ablation in liquid (PLAL) and pulsed laser deposition (PLD) technique, Pb(Mg, Nb, Ti, Hf, Zr)O<sub>3</sub> nanoparticles and thin films that possess piezoelectric, ferroelectric, and high-entropy lattice distortion effects can be successfully produced. Through the central asymmetric structure, the internal electric field is modulated by vibrational stimuli, thus an additional radical is produced to achieve charge neutrality at boundary condition i.e. surface, and due to high specific surface area, the dye degradation efficiency could therefore be enhanced. The piezoelectric catalyst of this research induces multiple cations which can increase the activity of the catalyst, and the stability of redox reactions would not be affected by environmental factors such as intensity of illumination. It maintains high efficiency in dye degradation and provides a more effective method for dealing with industrial wastewater.

**Keywords:** contamination remediation, piezoelectric catalyst, high entropy oxides, PLAL, PLD



P. Photovoltaic/Solar power  
P\_P01

## Synthesis and Characteristic of III-VI Metal Chalcogenide semiconductor nanoparticle

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### Abstract

Metal chalcogenide semiconductor nanostructures show novel electronic, physical, optical, and magnetic properties that are controllable by their composition and stoichiometry. III-VI metal chalcogenide,  $\text{In}_2\text{Se}_3$  and  $\text{Ga}_2\text{Se}_3$  have been studied as important materials to CIGS solar cells, water splitting, and optical applications. However, despite all of these attractive properties, but the material is not ready for mass production yet. Many different methods have been employed to prepare  $\text{In}_2\text{Se}_3$  films, including co-evaporation from elemental sources, sputtering, or annealing of metal and Se multilayers. In this paper, a simply, low cost preparation method was being investigated by using chemical precipitation method and annealing in Se vapor environment at difference temperature to synthesis  $\text{In}_2\text{Se}_3$  and  $\text{Ga}_2\text{Se}_3$  nanoparticle. In, Ga metal or  $\text{In}_2\text{O}_3$ ,  $\text{Ga}_2\text{O}_3$  are dissolved in nitric acid and the resulting solution with the total concentration of the cation of 0.04 M. A precipitation process, with 0.2 M ammonium hydrogen carbonate (AHC) as the precipitation agent. After precipitation process, the carbonate precipitate then was calcined with Se powder and calcined at 500 °C 30min under a  $\text{H}_2$  atmosphere.

From SEM result, the precursor,  $\text{In}(\text{OH})_3$  synthesized by  $\text{NH}_4\text{HCO}_3$ , present nanoscale morphology. It provides high surface area to react Se vapor and transfer to  $\text{In}_x\text{Se}_y$ . XRD and SEM show the pure phase  $\text{In}_2\text{Se}_3$  and present uniform morphology after repeat 4 times selenization process. Nano-ink preparation and thin film formation by non-vacuum printing process will be also discussed in this study.

**Keywords:** metal chalcogenides,  $\text{In}_2\text{Se}_3$ , selenization process

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P-P02

## Characteristics of La<sup>3+</sup> dopants in CeO<sub>2</sub> thin films for resistance random access memory application

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### Abstract

In this study, a 60 nm-thick CeO<sub>2</sub> film was prepared by RF magnetron sputtering as an insulating layer for Resistive random access memory (RRAM) device application. The upper and lower electrodes in the device are pure Pt thin film with a thickness of 120 nm. Unipolar measurements were performed to understand the nature of the device's resistance transition condition. Results showed that around 12.9 V was the forming voltage of the conduction path and is unstable during the resistance conversion process and cannot be maintained well during 10<sup>4</sup> sec retention tests. Doping La into the CeO<sub>2</sub> thin film led to the improvement of the configuration conversion stability. Additionally, the doping also resulted to the forming voltage reduction which can be attributed to the increased amount of oxygen vacancy. The XPS analysis showed that for CeO<sub>2</sub> films, Ce exists in both trivalent and tetravalent energy states combined with oxygen. The resistance switching mechanism of CeO<sub>2</sub> film is based from the conducting filament (CF) theory which is explained by the formation and rupture of the CF wherein the device is switched between low resistance state (LRS) and high resistance state (HRS). This work highlights the potential use of CeO<sub>2</sub> films for RRAM application.

**Keywords:** Resistive random access memory (RRAM), Conductive filament, doping

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