



20th International Conference on

Advanced Energy Materials and Research

August 13-14, 2018 | Dublin, Ireland

Posters

Advanced Energy Materials 2018

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TEM studies of epitaxial oxide films for advanced all solid Li-ion batteries

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Besides being of technological interest, thin films of different battery components, especially active cathode materials, can be utilized for fundamental studies of the processes that govern the battery's properties. Cathodes utilized in commercial lithium batteries are complex systems consisting of a polycrystalline active material in the form of a powder mixed with conductive carbon and a binding material. A simple system with no additives is desirable for use in the investigation of interfacial reactions, especially for local microstructural studies by transmission electron microscopy (TEM). Such systems, when synthesized in the form of a thin film, especially as a single (or pseudo-single) crystal epitaxial film, can provide powerful insight into the processes occurring on a well-described two-dimensional interface, as well as the film interior. In our recent works we successfully utilized LiCoO₂ epitaxial films to study details of structural changes during electrochemical cycling. In the work presented here the similar approach was extended to other important cathode systems, as well as for studying some solid electrolytes.

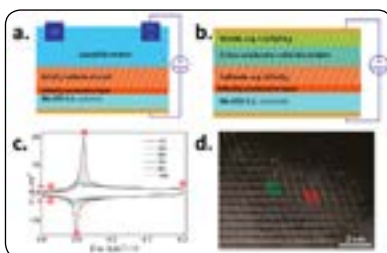


Figure 1: (a, b) Schematic drawings of studied thin-film configurations; (c) Cyclic voltammograms of LiCoO₂/SRO/STO configuration and; (d) Structural changes in the LiCoO₂ film seen by HAADF-STEM.

Recent Publications:

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2. Johnston Peck A C, Takeuchi S, Bharathi K K, Herzing A A and Bendersky L A (2018) Local degradation pathways in lithium-rich manganese-nickel-cobalt-oxide epitaxial thin films. *Journal of Materials Science* 53(2):1365-1379.
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4. Young K H, Ng K and Bendersky L A (2016) A technical report of the robust affordable next generation energy storage system-basf program. *Batteries* 2(1):2.
5. Tan H, Takeuchi S, Bharathi K K, Takeuchi I and Bendersky L A (2016) Microscopy study of structural evolution in epitaxial LiCoO₂ cathode films during electrochemical cycling. *ACS Applied Materials & Interfaces* 8(10):6727-6735.

Biography

Leonid A Bendersky is a Research Scientist at Materials Science and Engineering Laboratory of National Institute of Standards and Technology (NIST). He received his PhD degree in Materials Science from the Technion, Israel in 1982. From 1983 he has been with NIST working on a variety of advanced materials and technologies including rapid solidification, quasicrystals, structural intermetallics, functional oxides, hydrogen storage and Li-ion batteries. His research is focused on applying advanced transmission electron microscopy and crystallography to understand structural phase transitions and relation between properties and structures. He is the author of over 200 publications.

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Asymmetric rolling of polycrystalline metals: Modification of microstructure and mechanical propertiesA. Uniwersał¹, S. Wroński¹, K. Wierzbowski¹, M. Wróbel¹, M. Wroński¹ and B. Bacroix²¹AGH University of Science and Technology, Poland²LSPM-CNRS, Université Paris 13, France

Asymmetric rolling process is a subject of many research works in the last years. In this kind of rolling some technological parameters can be modified, like: normal force and torque, sample shape (by bending) and power requirements. The material properties are also noticeably modified. An important shear deformation, characteristic for this process, leads to texture rotation, microstructure refinement and increase of material strength. Asymmetric rolling can be realized by a modification of existing rolling mills, therefore its industrial application is possible at a relatively low cost. The aim of the present study was to characterize this process and resulting material modifications of face centered cubic (fcc) and hexagonal close packed (hcp) metals: aluminum, copper and titanium. The cases of low and high deformations were examined. The electron backscatter diffraction (EBSD), X-ray diffraction (XRD), calorimetry and microhardness measurements were performed. Texture and mechanical characteristics were studied using a crystal deformation model and finite element method (FEM). The following material and process modifications were found as a result of asymmetric rolling: sample bending, which can be partly controlled; decrease of mill load and an increase of the average rolling torque; increase of microhardness mechanical strength; increase of energy released during recrystallization; texture rotation around transverse direction; decrease of the average grains size (persisting in some extent also after recrystallization) and formation of more fragmented grains and; modification of lattice misorientation distributions.

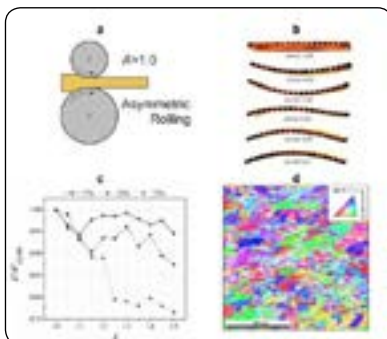


Fig.1. a) geometry of asymmetric rolling, b) shape of asymmetrically rolled sheets vs. asymmetry ratio **A**, c) reduction of normal rolling force vs. **A**, d) microstructure of asymmetrically rolled copper sample.

Recent Publications:

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3. S. Wronski, B. Ghilianu, T. Chauveau, B. Bacroix (2011), Analysis of textures heterogeneity in cold and warm asymmetrically rolled aluminium, *Mater. Charact.*, 62:22-34
4. A. Uniwersał, M. Wróbel, K. Wierzbowski, S. Wroński, M. Wroński, I. Kalembe-Rec, T. Sak, B. Bacroix (2016) Microstructure, texture and mechanical characteristics of asymmetrically rolled polycrystalline copper, *Mater. Charact.* 118:575–583
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Biography

K Wierzbowski has his expertise in the field of mechanical properties of metals, residual stresses and crystallographic textures. He developed crystalline models for elastoplastic deformation and for recrystallization of metallic materials. He performed also analysis and interpretations of experimental results in the domain of X-ray diffraction, electron backscattering diffraction (EBSD) and mechanical testing. He gives academic lectures in the field of General Physics and Material Science. He is author of 180 publications and of numerous presentations in conferences dedicated to material science.

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Water contained ionic liquid medium for V(III)(acac)₃ reduction: A paired electrolysis and application studies

Il Shik Moon and G Muthuraman

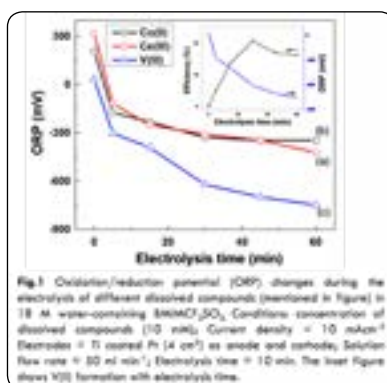
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Statement of the Problem: The green solvent nature of the ionic liquids have potential application in many fields especially battery, sensor, electro-organic synthesis due to non-volatile and having wide electrochemical potential window. However, the generation of an electro-active species by paired-electrolysis is a difficult task. In order to harvest the high value of the ionic liquid, herein, water content effect was investigated to reduce the V(III)(acetylacetonate)₃ and its application as reductant. Initial water content analysis with a 1-butyl-3 methyl imidazolium trifluoromethane sulfonate [BMIM CF₃SO₃] ionic liquid revealed a minimum cell potential of 6 V at 18 M water.

Methodology: A Nafion 324 membrane divided plate and frame electrolytic cell was adopted for the paired electrolysis experiments and the results obtained by a constant applied current method.

Findings: Along with V(III)(acetylacetonate)₃, other two compounds Ce(III)(SO₄)₂ and [Co(II)(CN)₅]³⁻, were tested in the water contained ionic liquid medium. The potentiometric titration with H₂O₂ enabled reuse of the spent ionic liquid after mediator quantification. The electrolytic reduction of V(III)(acetylacetonate) metal complex in 18 M water-containing BMIM CF₃SO₃ under optimized conditions revealed 65% of V(II)(acetylacetonate) formation. The applicability was checked by using an organic compound dichloromethane, where found a well-defined change in the concentration of V(III)(acetylacetonate) from 18% to 6% upon the addition of 20 mM dichloromethane demonstrated that dichloromethane reduction follows the mediated electrochemical reaction (MER).

Conclusions & Signifigans: The developed system allows the use of galvanostatic mode to generate an electron active species in an ionic liquid medium.



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Biography

I S Moon is working as full Professor at Suncheon National University, Suncheon, South Korea. He has over 18 years of experience on the electrochemically assisted removal of liquid and air pollutants at electro-scrubbing process and its design development sector. His credentials include a Master of Engineering (ME) in Chemical Engineering, and Bachelor of Engineering (BEng) in Chemical Engineering. His expertise includes desalination using DCMD (direct contact membrane desalination) with modelling. Currently, he has collaborate work at Cranfield University, UK, for CO₂ removal by electro-scrubbing process.

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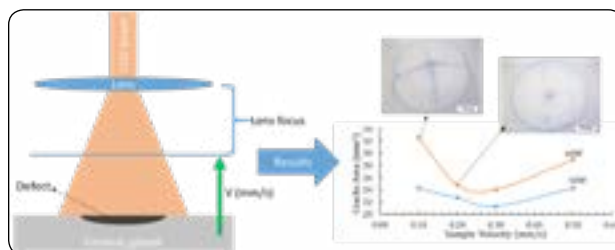
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New approach for local treatment of defects on glazed ceramics by CO₂ laser

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The evolution on ceramic industry is constant and significant improvements in automation and process efficiency are necessary. The treatment of small defects usually involves a new firing to repair small defects with only a few mm², representing a significant increase in costs productions. One option is the use of laser technology to in situ repair defects of the ceramic pieces, preventing all the extra costs associated with a re-firing. Several authors indicating that CO₂ laser is strongly absorbed by the ceramic material, allowing the repairs in a rapid and highly localized manner. This study present a new approach of using a CO₂ laser to repair small defects on the surface of ceramics glazed. The application of laser technology to the traditional repairing material proved problematic since it was detected the formation of microcracks ascribed to thermal stresses generated by the high temperature gradients. To overcome this, alternative approaches through changing the interaction area of the laser beam on the piece to repair, in order to reduce the thermal stresses due to the heat by laser beam. Repaired defects were evaluated based on the velocity of the piece motion to laser focus, power of the laser, presence of cracks on the surface and the size of microscopic cracks. The incident laser power, duration of laser heating/cooling and velocity of approach were analysed. After laser treatment the restored surfaces and cross sections were analysed by μ -Raman spectroscopy, 3D optical profilometry and optical microscopy together with optical and chemical/mechanical characterization. The results show the effect of velocity and power laser of the spread of cracks and microcracks on the surface of material irradiated. Nevertheless, this new approaches show good results to implement laser technology in the repair of ceramic industry.



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6. N. Basile, M. Gonon, F. Petit, and F. Cambier, "Processing of a glass ceramic surface by selective focused beam laser treatment," *Ceram. Int.*, 2016.
7. D. Triantafyllidis, L. Li, and F. H. Stott, "Crack-free densification of ceramics by laser surface treatment," *Surf. Coatings Technol.*, 2006.

Biography

Nuno Ferreira, is a PhD in Physics Engineering (2014), currently is a post-doc researcher at i3N, Physics Department and CICECO, Department of Materials and Ceramic Engineering at University of Aveiro, Portugal. He participated as a collaborator and research fellow in several R&D projects on material science. He is an experienced researcher in study and development of ceramics-based materials, prepared through conventional methods (melting, solid stated), with particular focus on laser processing (crystal growth – LFZ and surface sintering). Present sample characterization skills include various techniques such as, electrical conductivity and magnetic properties of various oxide materials. Current focus materials: thermoelectrics, ferroelectrics and glass matrices doped with transition metals and rare earth for energy storage and conversion applications. Main expertise is related to structural, magnetic and electrical properties of materials prepared by laser processing.

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Notes:

Support less Ag-Rh bimetallic nanostructures as efficient cathodic electro catalyst for di oxygen reduction in alkaline fuel cellsIl Shik Moon¹, B Narayanamoorthy² and S Balaji^{1,2}¹Sunchon National University, South Korea²Sri Chandrasekharendra Saraswathi Viswa Mahavidyalaya, India

The non-platinum d-block elements can be employed as ORR electrocatalysts due to their catalytic activity which help us to reduce or replace the usage of expensive precious metal catalysts in alkaline fuel cells. A number of cathode electrocatalysts are available such as non-platinum metals (Ag, Au, Pd, etc.) and the non-noble metals (Fe, Co, Ni, Cu, etc.) but they either suffer from low activity or poor stability. Among the noble metal electrocatalysts, Ag is relatively inexpensive (ca. 1% the price of Pt), abundant and reasonably active catalyst with moderate stability and therefore, Ag is an attractive choice for enhancing the kinetics of oxygen reduction in alkaline medium. The redox potential of Rh³⁺ to Rh is 0.76 V whereas the redox potential of Ag⁺ to Ag is 0.8 V. The electrochemical activity of pure Rh is very poor but it could provide the additional stability when mixed with other catalyst materials. Hence, formation of Ag-Rh nanostructures may provide to be useful approach for improving the stability in a cost effective way. Silver-rhodium (Ag-Rh) nanostructured electro catalysts were synthesized by one step chemical reduction method and used to catalyze the oxygen reduction reaction (ORR) in an alkaline medium. The crystalline nature was ascertained by x-ray diffraction (XRD), elemental composition was estimated by energy dispersive spectroscopy and morphology was confirmed high resolution transmission electron microscope. The electrochemical properties were studied by cyclic and linear scan voltammetry techniques under hydrodynamic conditions. The supportless Ag-Rh catalyst exhibited a good catalytic activity for ORR and the quantified values in terms of higher mass and intrinsic activities were determined to be 951.7 mA/mg and 1.45 mA/cm² respectively. Accelerated durability test revealed that the catalyst could withstand nearly 7000 potential cycles with 5% increment in limited current density while retaining nearly 70% of its initial electrochemically active surface area. This study indicates the superior activity and stability of Ag-Rh (compared to Ag-Rh/VC) undoubtedly places it as one among the promising electrocatalysts for ORR in alkaline medium.

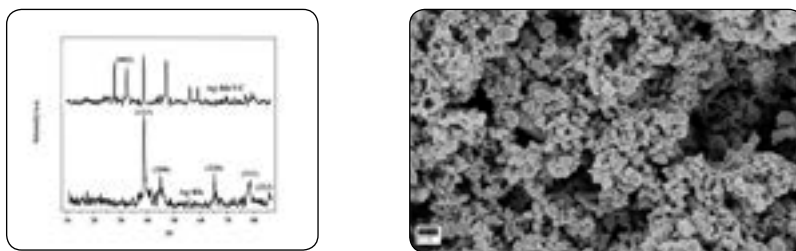


Fig. 1 XRD patterns of supportless and VC supported Ag-Rh catalyst & SEM image of Ag-Rh catalyst.

Recent Publications:

1. Slanac D A, Hardin W G, Johnston K P, Stevenson K J (2012) Atomic ensemble and electronic effects in Ag-rich Ag-Pd nanoalloy catalysts for oxygen reduction in alkaline media, *Journal of American Chemical Society* 134:9812-9819.
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3. Nguyen S T, Law H M, Nguyen H T, Kristian N, Wang S, Chan S H, Wang X (2009) Enhancement effect of Ag for Pd/C towards the ethanol electro-oxidation in alkaline media, *Applied Catalysis B*, 91:507-515.
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5. Yasmin S, Ahmed M S, Jeon S (2016) A noble silver nanoflower on nitrogen doped carbon nanotube for enhanced oxygen reduction reaction, International Journal of Hydrogen Energy, 42:1075-1084.

Biography

Il Shik Moon is working as full Professor at Suncheon National University, Suncheon, South Korea. He has over 18 years of experience on the electrochemically assisted removal of liquid and air pollutants at electro-scrubbing process and its design development sector. His credentials include a Master of Engineering (ME) in Chemical Engineering, and Bachelor of Engineering (BEng) in Chemical Engineering. His expertise includes desalination using DCMD (direct contact membrane desalination) with modelling. Currently, he has collaborate work at Cranfield University, UK, for CO₂ removal by electro-scrubbing process.

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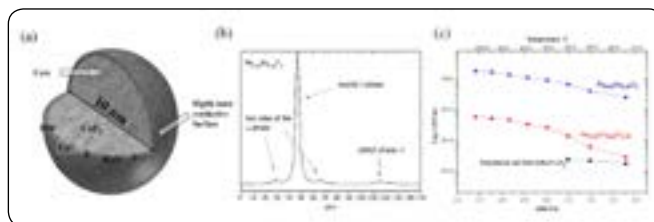
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Advances in room temperature fluoride-ion batteries

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All-solid-state secondary batteries employing solid electrolytes are potentially more stable and safer than conventional batteries. At present, investigations and improvements of the ionic conductivities of solid electrolytes are attracting great attention. Here, we discuss the creation of defects (vacancy or point defects) in $\text{Pb}_{x-1}\text{Sn}_x\text{F}_2$, $\text{Ba}_{x-1}\text{Sn}_x\text{F}_2$, CaF_2 and (interstitial defect) $\text{Sm}_{1-x}\text{Ca}_x\text{F}_{3-x}$ systems. Also, we discuss the introduction of additional surface defects to enhance conductivities at grain boundaries and nano-particle surfaces. Our samples were prepared by high-energy planetary ball-milling. Structural, morphology and conductive properties of the synthesized electrolytes were examined. Crystal structure, crystal/particle sizes and local molecular environment were examined with X-ray diffraction (XRD), high-resolution field emission scanning electron microscope (FESEM) and nuclear magnetic resonance (NMR) studies. At room temperature, the ionic conductivities of the systems were obtained to be between 10^{-3} to 10^{-5} S/cm. Finally, based on these solid-state electrolytes, different fluoride ion batteries (FIB) at room temperature performance (RT-FIB) were prepared and electrochemical cycling behavior studies carried out.



Recent Publications:

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3. Mohammad, I., et al., Synthesis of Fast Fluoride-Ion-Conductive Fluorite-Type $\text{Ba}_{1-x}\text{Sb}_x\text{F}_{2+x}$ ($0.1 \leq x \leq 0.4$): A Potential Solid Electrolyte for Fluoride-Ion Batteries. *ACS Applied Materials & Interfaces*, 2018.

Biography

Palanivel Molaiyan obtained his Master's in Materials Science (2010) at PSG College of Technology, India. During a three years period in the industrial sector he worked as a Technician and Application Scientist at Hind High Vacuum Co. Pvt. Ltd., Bangalore, India. Currently, he is pursuing his PhD in Science (2014-2018) from Tallinn University of Technology, Tallinn, Estonia. His research topic is on fluoride-ion based batteries using solid-state electrolytes under the supervision of Prof. (Associate) Dr. Raiker Witter, TUT, Estonia and KIT, Germany. His research expertise is in materials science and electrochemistry, especially working on new solid-state electrolytes based on rare earth and alkali fluoride materials for the development of room temperature fluoride-ion based batteries.

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Experimental analysis of the behavior of OM37 phase change material during discharge stage

Arvind Kumar and Vikram Soni

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Solidification of phase change materials (PCMs) in thermal energy storage (TES) systems, in general, constitute a challenging research area due to numerous intricacies involved in the process. In PCM based TES systems, the stability of these materials during the discharging stage is one of the main concerns. One of the major contributors to this key problem is the existence of undercooling (also referred to as subcooling or supercooling of the liquid) during the energy discharging stage (solidification of the PCM). It not only degrades the thermal performance of the TES system but also causes the system prone to failure due to repetitive thermal shocks. To capture the effect of undercooling on the system performance, an experimental investigation of discharging stage in a PCM based TES system is performed. The transient real-time temperature distribution within the cavity is measured by making the cavity instrumented with thermocouples. In addition, various solidification characteristics visualization and measurement in real-time (for example, solidification interface, mushy zone, etc.) are captured using High-Speed imaging. An interesting phenomenon of the formation of dendritic flakes and their detachment from the developing mushy zone is observed. The detached dendritic particles provide many nucleation sites for the initiation of the solidification in the domain. The insights from the current study of solidification process of OM37 PCM during the energy discharge stage delineated really important insights to avoid failure of TES systems.

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Thermal and economic evaluation of a new thermal insulation materials based on textile waste for building envelope

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Sustainability in buildings are currently evaluated not only based upon thermal insulation thickness and heating demand, but also according to primary energy demand, CO₂ reductions, and ecological properties of the building materials. Ecological insulation materials have been available on the market for a long time; however, conventional materials are still predominantly used. In this work, the potential applicability of a recycled textile materials, based on acrylic and wool waste is investigated. The thermal insulation materials are fabricated by needle punching technique which is based on mechanic consolidation. The developed insulations are thermo-physically characterized in term of density, air permeability and thermal conductivity. Their properties are inserted into a numerical model, which simulates an external wall exposed to the real climatic conditions of Casablanca, Morocco, in order to study their thermal performance. Finally, an economic model based on life cycle cost analysis (LCC) is adopted to investigate the competitiveness of the developed insulation based on their cost. An interesting result is obtained in terms of thermal performance and cost and will be presented in the conference.

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Extremely foldable and highly transparent nanofiber-based electrodes for liquid crystal smart devices

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In recent years, flexible transparent electrodes have attracted great attention in many wearable optoelectronic devices, such as touch screens, organic light-emitting diodes (OLEDs), solar cells, electronic skins, etc. The basic requirements for foldable transparent electrodes are optical transparency, low electrical resistance, and high level of extreme bending toughness without significant decrease in the electrical performance. Generally, resistivity and optical transmittance follow opposite trends. It is therefore important to achieve the optimized balance between the electrical resistivity and optical transmittance in order to get a highly conductive transparent electrode. Traditionally, commercial indium-tin oxide (ITO) electrodes have been widely used in transparent conducting optoelectronic devices. However, there are still some disadvantages of ITO electrodes in flexible electronic applications, such as the scarcity of indium, the high cost of manufacturing processing, and their mechanical brittleness, which prompt the research for the alternative materials to replace the ITO electrodes for next generation optoelectronic flexible devices. In this work, the nylon 6 nanofiber-reinforced cellulose acetate (NF-r-CA) film as a fiber-based transparent substrate was used to develop the highly transparent electrodes with excellent durable and extremely foldable properties. The NF45-r-CA electrodes prepared using AgNWs concentration of 0.025 wt% and electrospinning time of 45 min were highly transparent (~ 90%), mechanically robust (59.6 MPa) and lower sheet resistance (20~30 Ω sq⁻¹) even under extreme bending radius of 1 mm for 10,000 cycles. In addition, the NF-r-CA based PDLC (Polymer Dispersed Liquid Crystal) film could retain the working stability even after bending test of 500 cycles at an extreme bending radius of 1.5 mm, whereas ITO PDLC film was stopped working after bending test of merely 50 cycles. This result demonstrates the excellent foldable stability of NF-r-CA PDLC films at an extreme bending radius of 1.5 mm.

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Insights into the dynamic interplay between mobile ions and photovoltaic performance of organometal halide perovskites

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A mong various photovoltaic energy conversion systems, organometal halide perovskite (OHP) has gathered much attention over the past few years, as the OHP-based solar cells have demonstrated high power conversion efficiency (> 22%) and long-term stability. However, the mixed ionic/electronic conducting nature of OHPs allows the migration of mobile ionic species (vacancy and/or interstitial defects) during solar cell operation, which is pinpointed as the major cause of anomalous current-voltage (J-V) hysteresis. The timescales of ion diffusion span the range between sub-second to more than a minute, and are highly dependent on the types of ions and OHPs' nanostructures. Such ion diffusion, in combination with electron-hole recombination, results in the complex time-dependent temporal evolution of photovoltage and photocurrent, emphasizing the importance of frequency- and time- dependent responses of solar cells to enable high photovoltaic performance. Herein, the photovoltaic performance of solar cells based on $(\text{FAPbI}_3)_{0.83}(\text{MAPbBr}_3)_{0.17}$ and Cs-doped one (FA stands for $(\text{NH}_2)_2\text{CH}^+$, and MA for CH_3NH_3^+) was addressed utilizing various analysis methods such as impedance spectroscopy, transient voltage and current measurements coupled with light/bias control (e.g., photovoltage rise, open-circuit voltage decay, photocurrent profile, etc.) to reveal the influence of mobile ions on the photovoltaic performance. The variations of OHPs' properties in microscopic scale were rationally minimized (such as grain size, crystallographic orientation, crystallinity, etc.) by minimally changing the processing parameter (e.g., annealing time) to reduce their influences on the photovoltaic performance, thereby distinguishing the role of nanoscale defects. Nanoscopic analyses utilizing noise spectroscopy were conducted to comprehend the effects of mobile ions on the electronic traps and thereby the photocurrent behaviors. These analyses strongly suggest that the time-dependent photocurrent and/or photovoltage behavior are strongly correlated to the nanoscale ionic defects and their migrations, providing deeper understanding of the operation of OHP-based solar cells.

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An energy-efficient single-pane “green window” via the photothermal effect of chlorophyll thin film coatings

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To prevent heat loss through windows in cold climates, the conventional methods mainly rely on low-e coatings and thermal insulating materials on double-pane windows. In this study, naturally occurring chlorophyll is utilized as a thin film coating on glass (also known as “Green Window” for its natural and green appearance) and demonstrates applicability to significantly reduce thermal loss, thus improving energy savings. Chlorophyll exhibits a unique optical characteristic with strong absorptions in the blue-violet and NIR regions while remaining highly transmissive in much of the visible region. This unique property allows, on one hand, simulated solar energy, in the non-visible region, to be converted to heat by chlorophyll through the so-called photothermal effect. Only slight heating due to the photothermal effect on the window surface is required to significantly reduce the U-factor (related to thermal loss). On the other hand, the chlorophyll coating density required to generate this temperature rise by thin film deposition on glass retains high light transmittance attributable to minimum absorption in the visible range. This concept lifts the dependence on insulating materials making single-pane windows highly possible. Chlorophyll synthesis, thin film deposition, optical characterization, photothermal effect, and energy performance quantification are carried out in this study with engineering considerations in window designs.

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20th International Conference on

Advanced Energy Materials and Research

August 13-14, 2018 | Dublin, Ireland

Combinedoxidation of methane to synthesis gas

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Biogas is a promising source of hydrocarbons capable of providing the current and future needs of mankind for energy and hydrocarbon feedstocks [1]. The main components of biogas obtained in anaerobic bioreactors are methane and carbon dioxide, as impurities can contain carbon monoxide and oxygen [2]. Biogas obtained in this way can be converted to synthesis gas by dry ($\text{CH}_4 + \text{CO}_2$) or steam reforming ($\text{CH}_4 + \text{H}_2\text{O}$) using appropriate catalysts [3-5]. In the present work, a modified nickel catalyst supported on alumina was used as catalysts for the combined oxidation of methane. Experiments on testing the efficiency of catalysts were carried out on an automated flow catalytic unit (PKU-1). The reaction products were identified chromatographically on a device of "CHROMOS GC-1000". The figure shows the results of the effect of promoting additions of lanthanum (La_2O_3), molybdenum (MoO_3) and cerium (CeO_2) oxides on the catalytic activity of the nickel catalyst in the combined methane oxidation reaction involving oxygen, carbon dioxide and water vapor, under process conditions: $\text{CH}_4 : \text{CO}_2 : \text{O}_2 : \text{H}_2\text{O} = 2 : 2 : 1 : 0.5$, $T_r = 850^\circ \text{C}$ and $W = 1000 \text{ h}^{-1}$. As can be seen from the figure, the promotion of nickel catalyst with cerium, lanthanum or molybdenum oxides results in an increase in the activity and selectivity of nickel catalyst. The highest activity and selectivity of the nickel catalyst is observed when oxides of cerium and molybdenum are promoted. On the promoted 3% NiO-1% $\text{MoO}_3 / \text{Al}_2\text{O}_3$ catalyst, the selectivity for hydrogen was 66%, for carbon monoxide 47%. At the same time, the concentration of H_2 reaches 52 vol. %, CO up to 33.9 vol. % and methane conversion 95%. For a catalyst of 3% NiO-1% $\text{CeO}_2 / \text{Al}_2\text{O}_3$, the selectivity for hydrogen is 50% and for carbon monoxide 60%. In this case, the concentration of H_2 obtained reaches 41 vol.%, CO up to 42.8 vol.% and methane conversion 98%. Thus, the activity and selectivity of oxide-supported nickel-containing catalysts promoted by MoO_3 , CeO_2 and La_2O_3 oxides during methane reforming into synthesis gas was tested. It is determined that the promotion of nickel catalyst with cerium or molybdenum oxides leads to an increase in the selectivity and activity of the catalysts for the desired products.

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20th International Conference on

Advanced Energy Materials and Research

August 13-14, 2018 | Dublin, Ireland

Numerical studies on the movement and structural stability of IPMC system operating in the ocean environment

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It is a well-known fact that the ocean's waves contain an infinite potential energy source which has resulted in the development of a wide variety of offshore projects all over the world. In this research, we applied ionic polymer metal composites (IPMCs) to absorb the kinetic energy of the ocean waves to generate electricity. Experimental results showed that the IPMC materials application has many advantages since they are soft and durable; as a result, they may faster respond to every wave's parameters such as frequency, amplitude, wavelength, etc. This paper shows a simulation model of the energy harvesting system based on IPMC assembled in the ocean by using AQWA software within ANSYS Workbench. The simulation results focused on the movement and the structural stability of the system design in the ocean wave environment to bring out the movement and deformation of IPMC which affect directly to the power performance output. The experimental test under real sea condition was also performed to analyse the electrical performance harvesting from IPMC system.

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20th International Conference on

Advanced Energy Materials and Research

August 13-14, 2018 | Dublin, Ireland

Fast optical response time and high contrast ratio after dispersion of fluorescent dye into the nematic liquid crystal

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Fluorescent dye Benzo 2,1,3 thiadiazole has been dispersed into the pure nematic liquid crystal (NLC) 1550C which is consisted of 4'-(trans,trans-4-alkylbicyclohexyl)carbonates and 4'-(4-(trans,trans-4-alkyl)-4-cyanobicyclohexane, with in three different concentration in the present investigation. Electro-optical and dielectric parameters have been investigated here. In this work response time has been measured by Optical Switching Method and found to be decreased after the dispersion of fluorescent dye into the pure NLC 1550C. This fast optical response time measurement is the main finding of the present investigation. Rotational viscosity has also been calculated here and found to be decreased for dispersed system as compare to pure NLC. Polarizing Optical Microscope (POM) images have also been taken in the current study which shows that alignment as well as contrast has been improved after the dispersion of fluorescent dye. Contrast Ratio (CR) has also been measured here by applying a square wave and found to be increased for the dispersed system. This is also a promising result of this investigation. The outcome of present investigation may be very useful in the liquid crystal displays (LCDs) and other devices which requires fast response time.

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20th International Conference on

Advanced Energy Materials and Research

August 13-14, 2018 | Dublin, Ireland

Surface modification of cotton using slaughterhouse wastes

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Cotton dyeing using reactive dyes is one of the major water polluter; this is due to large amount of dye and salt remaining in effluent. Recent adverse climate change and its associated effect to human life have lead to search for more sustainable industrial production. Cationization of cotton to improve its affinity for reactive dye has been earmarked as a major solution for dyeing of cotton with no or less salt. Synthetic cationizing agents of ammonium salt have already been commercialized. However, in nature there are proteinous products which are rich in amino and ammonium salts which can be carefully harnessed to be used as cationizing agent for cotton. The hoofs and horns have successfully been used to cationize cotton so as to improve cotton affinity to the dye. The cationization action of the hoof and horn extract on cotton was confirmed by dyeing the pretreated fabric without salt and comparing it with conventionally dyed and untreated salt free dyed fabric. UVVIS absorption results showed better dye absorption (62.5% and 50% dye bath exhaustion percentage for cationized and untreated respectively) while K/S values of treated samples were similar to conventional sample.

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20th International Conference on

Advanced Energy Materials and Research

August 13-14, 2018 | Dublin, Ireland

Material innovation in solar selective absorber coatings

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Statement of the Problem: Spectrally selective coatings are common in low and medium temperature solar applications ranging from water solar heating collectors to parabolic trough absorber tubes. They are also essential elements for achieving high efficiency in higher temperature applications such as Concentrating Solar Power (CSP) systems. The mid-temperature coatings are used for solar water and industrial heating applications, while the high temperature absorber coatings are used for thermal power plants. The commercialisation of solar selective absorbers necessitates that the expensive oxide coatings are to be replaced by cheaper efficient materials, where the most feasible and practical deposition methods may be used. The material requirements will vary for low and high temperature applications.

Methodology & Theoretical Orientation: In this work, different solar selective absorber coatings are prepared by different methods and their optical absorbance is compared and assessed for solar selective absorbance applications. The materials assessed include natural materials, PVD deposited layers on metal substrates and nanoreinforced polymeric based composite material coatings. The characterisation methods included Spectrophotometry and Fourier transform spectroscopy (FTIR).

Findings: For low temperature applications, it was shown that adding 1.5 and 2.5% nano-graphite particles to a commercial polymer based black coating causes an increase in the optical absorbance to values above 0.96 and a decrease in emittance to values below 0.35, where the highest absorbance and lowest emittance were obtained for 2.5% addition. CuO shows the highest absorbance amongst other natural materials, due to its amorphous structure and its black colour. For high temperature applications, AlN was found to have higher absorbance at longer wavelength, whereas TiN has higher absorbance at short wavelength. A new material is proposed for high temperature applications.

Conclusion & Significance: It has been shown that nano-reinforced polymers are good candidates for low temperature selective solar absorbers, while TiN and AlN are good candidates for high temperature applications.

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20th International Conference on

Advanced Energy Materials and Research

August 13-14, 2018 | Dublin, Ireland

Cyclic oligosaccharide modification of lanthanide-doped upconversion nanoparticles: as novel nanostructural drug carriers via host-guest interactions

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Statement of the Problem: Carbohydrates are biological macromolecules involved in life activities, not only providing energy and intracellular tissue support, but also mediating the occurrence of inflammatory reactions, affecting cell growth, division, differentiation, and transduction of intercellular cell signaling. However, low targeted delivery and lack of fluorescent labeling are two major problems with natural polysaccharide (GA) drugs. The purpose of this study is to describe the experience of designing a unique pH-sensitive drug carrier based on host-guest interaction between rhodamine and β -cyclodextrin. This strategy can be extended to other pH-sensitive drug delivery system.

Methodology & Theoretical Orientation: UCNPs were synthesized following Chemical protocol. Rhodamine was conjugated with *Ganoderma applanatum* polysaccharide (GAP) through reductive amination reaction to form rhodamine polysaccharide complex (R-GAP). The cytotoxicity of CD-UCNPs and R-GAP-CD UCNPs was examined using a methyl thiazolyl diphenyl tetrazolium (MTT) assay.

Findings: The UCNPs were synthesized using a typical solvothermal method and UCNPs were modified with β -CD to form a water-solubility nanocarrier. Rhodamine was conjugated with GAP through reductive amination reaction to form R-GAP so that it makes the GAP fluorescently trackable. R-GAP was loaded on CD-UCNPs and estimated the drug loading and releasing behaviors. The results revealed that it was a good pH-sensitive drug carrier and the maximum release amounts of R-GAP reach up to 67.2% after incubated in PBS for 36 h at pH 5.5.

Conclusion & Significance: The strategy described in this work is simple and effective to fluorescently mark the GAP and can enhance the targeting delivery. This article give an evidence to improve natural polysaccharide antitumor drug efficiency by a proper modifications.

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20th International Conference on

Advanced Energy Materials and Research

August 13-14, 2018 | Dublin, Ireland

Ordered liquid crystal hierarchical superstructures enabled by photoalignment

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Mesoscopic hierarchical superstructures bridge the micro worlds, and provide insights for the development of new functional materials. Much effort has been devoted to mimic the hierarchical organization observed in nature, however, the precise realization and rational control of ideal large-area hierarchical superstructures remains challenging. Liquid crystals (LCs) are excellent building blocks due to their extra field controllable self-assembly behavior and resultant physical property. Among them, cholesteric liquid crystal and smectic liquid crystal which are featured by periodic helices and ordered lamellar structures have drawn intensive attention. Here, a LC photopatterning technique [1,2] which enables the accurate, arbitrary and reconfigurable azimuthal angle control of LCs is introduced to manipulate the LC hierarchical superstructures. By this means, the in-plane helical axes of cholesteric liquid crystals [3] and the spatial smectic layer curvature of SmA phase [4] are rationally designed and arbitrarily controlled over centimeter scales. The growth of unique fingerprint textures including spiral and wave-like continuous gratings are demonstrated. And freely tailoring of the geometry and clustering characteristics of focal conic domains has been realized. This study broadens the fundamental understanding of self-assembled soft materials and enhances the construction of desired hierarchical superstructures. It will bring new opportunities to the design of novel advanced photonic devices.

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20th International Conference on

Advanced Energy Materials and Research

August 13-14, 2018 | Dublin, Ireland

Photoferroic (ZnSnO₃) for photovoltaic applications

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In the recent decades, the field of renewable clean energy i.e., solar energy has emerged as an alternative to the traditional power sources. Solar energy is one of the most important resources which have been harvested through Photovoltaic (PV) effect. Photovoltaic effect typically involves two basic processes: generation of electron-hole pairs as and separation of electrons and holes. In semiconductor based solar cell, the generation and separation of electrons and holes usually takes place at a material interface and the maximum open-circuit voltage is equal to the semiconductor band gap. Since there is observation of bulk photovoltaic effect in the ferroelectric materials, the open-circuit voltages exceeds the band gap due to the separation of electron-hole pairs by the built-in potential induced by intrinsic polarization. The bulk photovoltaic effect has been reported in several ferroelectric perovskite oxides, such as Pb(Zr,Ti)O₃, BaTiO₃ and LiNbO₃ family. These oxides have relatively large internal electric fields that could be exploited in photovoltaic applications. Hence, harvesting solar energy from ferroelectrics is still a new field of research and which grew considerable attention in the recent years. Therefore, the LiNbO₃ type ZnSnO₃ is prepared by hydrothermal method. The prepared ZnSnO₃ is explored as photoanode in the solar device and the device performance is tested using I-V characteristics. The photo-physical properties are analyzed and explained using appropriate mechanisms. X-ray diffraction confirms the R3C symmetry of polar ZnSnO₃ phase. Scanning electron micrograph shows an agglomeration of square shaped particles. Ferroelectric behaviour is confirmed by P-E loop tracer. Double semicircle, one in the low frequency and other in the relatively high frequency explains the charge transport characteristics between the interfaces of the fabricated device. An open circuit voltage of 0.64 V, a short circuit current density of 1.39 mA/cm² and a conversion efficiency of 0.5% are obtained for the constructed device. These results show the potential value of ferroelectric ZnSnO₃ for use in solar cells, although the efficiency cannot yet compete with semiconductor materials. An effort is hence put forth for the deep understanding on photovoltaic mechanisms in ferroelectric materials.

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20th International Conference on

Advanced Energy Materials and Research

August 13-14, 2018 | Dublin, Ireland

Synthesis and Mechanical Behavior of (Al/SiC) Functionally Graded Material Using Powder Metallurgy Technique

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This paper focuses on the Synthesis and mechanical behavior of functionally graded material using powder metallurgy technique. Owing to its low density and high strength to weight ratio, pure aluminum is chosen as matrix. Silicon carbide is selected as reinforcement in view of its hardness. Functionally graded materials (FGM) with 4 layers containing increasing volume fraction of SiC (0%,3%,7%,10%) were sintered at 5800C in inert atmosphere. The microstructure analysis revealed homogeneous mixtures and crack free layers and the mechanical properties hardness and toughness of the FGM attained better results than pure aluminum.

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20th International Conference on

Advanced Energy Materials and Research

August 13-14, 2018 | Dublin, Ireland

Effect of universal trimming on electrical characteristics of polymer thick film resistors

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Statement of the Problem: The purpose of this paper is to study high-voltage interactions in polymer thick-film resistors, namely, polyvinyl chloride (PVC)-Graphite thick-film resistors, and their applications in universal trimming of these resistors.

Methodology & Theoretical Orientation: The authors applied high voltages in the form of pulses and impulses of various pulse durations and with different amplitudes to polymer thick-film resistors and observed the variation of resistance of these resistors with high voltages.

Findings: The paper finds that high voltages can be used for trimming of polymer thick-film resistors in both directions, i.e. upwards and downwards. The practical implications of this paper is that one can trim the polymer thick-film resistors, namely, PVC-graphite thick-film resistors, in both directions, i.e. upwards and downwards, by using this method.

Originality/value: The value of the paper is in showing that high voltages can be used to trim downwards and also upwards in the case of polymer thick film resistors. This type of trimming is called universal trimming, developed first time for polymer thick-film resistors.

Findings: When high voltage pulses are applied to a polymer thick film resistor with a particular resistivity either it is higher or lower one, it leads to increase in resistivity with shorter pulse duration of high voltage pulses and decreases in resistivity with longer pulse duration of the applied high voltage pulses. This clearly shows that there is a phenomenon similar to local heating which arises due to high voltage and leads to micro-welding between the particles and breaking of the conducting paths. Therefore, the authors looked for a mechanism with local heating which can lead to decrease or increase in resistance with the application of a voltage.

Conclusion & Significance: This paper describes some investigations carried out on the universal trimming method of polymer thick film resistors using high voltages. It is reported that there is a reduction or increment in the resistance with the application of high voltage beyond a certain (threshold) value which depends up on the value of the voltage and the effective duration for which it is applied. By using this process, the polymer thick film resistor can be trimmed both upwards and downwards which leads to universal trimming of these resistors, just by changing the effective duration of the applied high voltage pulses.

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20th International Conference on

Advanced Energy Materials and Research

August 13-14, 2018 | Dublin, Ireland

Biocide encapsulated zeolite-epoxy nano hybrid coatings

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The present study aims on the fabrication of diglycidyl ethers of bisphenol-A (DGEBA) based epoxy coating containing low cost as well as less toxic antifoulants viz., benzoic acid (BA) and sodium benzoate (SB). These two antifoulants were introduced into epoxy resin through nano-zeolite containers separately in the amount of (1, 3, 5, 7 and 10 wt. %) to investigate their corrosion resistant behaviour and antifouling capabilities. Corrosion rate of 3 wt. % SB incorporated epoxy AF coating was determined to be much lower than that of 3 wt. % BA incorporated epoxy AF coating. A direct relationship between the corrosion rate, antifouling nature, antibacterial behaviour and toxicity was observed by electrochemical impedance spectroscopy, salt spray test, static immersion study, antibacterial test and acute toxicity tests. The SB encapsulated coating with 3 wt. % loading exhibits enhanced antifouling and corrosion resistance performance, while for AF coatings containing 5 wt. % loading of BA showed a marked reduction in fouling attachment than other coating compositions.

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20th International Conference on

Advanced Energy Materials and Research

August 13-14, 2018 | Dublin, Ireland

Elucidating the role of Sn-substitution and Pb-Vc in regulating stability and carrier concentration in $\text{CH}_3\text{NH}_3\text{Pb}_{1-x}\text{Sn}_x\text{V}_c\text{I}_3$

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Inorganic-organic perovskites, $\text{CH}_3\text{NH}_3\text{PbI}_3$ in particular, have recently drawn significant attention in improving solar cell's performance due to their long diffusion length, high carrier mobility, suitable optical band gaps, and strong absorption of light. However, the presence of Pb has rendered its usage in developing non-toxic lead-free devices. Therefore, reducing the extent of Pb by substituting a suitable alternative metal (e.g. Sn, Ge, Sr, etc.) in the perovskite has become extremely important. Moreover, inclusion of Sn in the perovskite network (i.e. $\text{CH}_3\text{NH}_3\text{Pb}_{1-x}\text{Sn}_x\text{I}_3$) can reduce the optical band gap. This enables the perovskite to absorb all visible lights of the solar spectrum along with some ultraviolet to near-infrared photons (up to 1.1 eV). Therefore, digging deep into the atomistic insights and electronic structure of Sn based perovskites has become profoundly important for designing efficient energy harvesting materials. In this talk, I shall address the role of Sn-substitution and Pb-vacancy (Vc) in regulating stability and carrier concentration of $\text{CH}_3\text{NH}_3\text{Pb}_{1-x}\text{Sn}_x\text{V}_c\text{I}_3$ using state-of-the-art density functional theory (DFT). The finite temperature effect is duly included in our theoretical calculations involving lattice thermal vibration at a given temperature. We find that at low temperature the system prefers Pb-Vc and the most stable configuration does not prefer any Pb at 50% Sn concentration. However, the Pb-Vcs become unfavourable above 250K due to the reduced linearity of I-Sn-I bonds. For n-type host the Sn substitution is more preferable than Pb-Vc formation, while for p-type host the trend is exactly opposite. The charge states of both substituted Sn and Pb-Vc are found to be dependent on the Sn concentration, which in turn alters the perovskite's property from n-type to p-type beyond 50% Sn substitution. All our theoretical explanations, that were hitherto unknown, are perfectly in agreement with previously available experimental-observations.

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20th International Conference on

Advanced Energy Materials and Research

August 13-14, 2018 | Dublin, Ireland

Influence of Electrodeposited Polypyrrole Layer on the Capacitive Performance of Hybrid NiCo₂O₄/Carbon Fiber Paper Composites

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Recently, electrochemical capacitors have been carried out with emphasis on the development of hybrid electroactive electrode materials, based on metal oxide, carbon materials and conducting polymers. The hybrid NiCo₂O₄ modified carbon fiber paper (NiCo₂O₄/CFP) composites with different electrodeposited times of polypyrrole (PPy) layers were prepared by two-step process. At first, NiCo₂O₄ was prepared by low temperature hydrothermal method. Secondly, PPy layer were coated onto the NiCo₂O₄/CFP composites by using electrochemical deposition method. The potential sweeping between -0.2 to 1.0 V at a scan rate of 50 mV/s was performed for various potential sweeping cycles (0, 5, 10, 15 and 20) in 0.5 M KCl solution in the presence of pyrrole monomer. SEM images clearly indicated that the NiCo₂O₄ nanoneedles were uniformly grown over the CFP. Further, PPy layer was uniformly deposited over the NiCo₂O₄/CFP composites. In the present work, we have fabricated various hybrid NiCo₂O₄/CFP composite electrodes with different electrodeposited PPy layers, and the effects of electrodeposited PPy layer were investigated. The as-prepared NiCo₂O₄/CFP composite electrodes with PPy layer electrodeposited for 15 cycles (NiCo₂O₄-PPy15/CFP) showed good electrochemical performance. Further, NiCo₂O₄-PPy/CFP composite electrode was successfully utilized for solid-state high performance supercapacitor applications. It showed high capacitance value with high energy and power density as well as high rate capability, which were evaluated from galvanostatic charge-discharge and electrochemical impedance spectroscopy.

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20th International Conference on

Advanced Energy Materials and Research

August 13-14, 2018 | Dublin, Ireland

Online structural health monitoring of composites using screen printed nano-composite sensors

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This research aims to develop CNPs based piezoresistive sensor through screen printing and correlate the strain rate to predict the failure response of glass fibre composites. This involves homogenous dispersal of carbon nano-particles (CNPs) in polystyrene (PS) resin through sonication. The smart sensing layer is deposited on glass fibre reinforced composite structures for sensing. The concentration of CNPs was maintained at the percolation threshold of 35% by weight which ensured higher sensitivities and damage detection capability. The composite notched specimens were tested in tension according to ASTM standard to validate the sensing characteristics of the smart layer. It was found that the screen printed smart sensing layers were capable of monitoring strains like traditional strain gauges but with higher gauge factors of 20. The screen printing techniques, due to its low cost and easy implementation, is recommended as a reliable method of sensor integration on various types of substrates including plastics & composites.

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20th International Conference on

Advanced Energy Materials and Research

August 13-14, 2018 | Dublin, Ireland

Research and development results on advanced materials for light water reactors and future works

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In the nuclear power industrial field, all materials for nuclear power plants must be materials that have sufficient experience in other industrial fields, or those that have been sufficient comprehensive test data accumulated. Author has been studying on the many kinds of advanced materials for many components of the light water reactors, during more than 47 years. For example, Thermally Treated Alloy 690 which is applying to steam generator tubes, control rod drive mechanism tubes, etc., for pressurized water reactors (PWRs) in a world, irradiation assisted stress corrosion cracking (IASCC) resistant modified 316 stainless steel which is applying to baffle former bolts and barrel bolts of core internals for Japanese PWRs, Iron base wear resistant alloy which is applying to valve sheets for Japanese PWRs, etc. And also, author has developed on new conceptual stress corrosion cracking (SCC) resistant austenitic stainless steel. The SCCs were detected in non-sensitized but heavily cold worked austenitic stainless steels for some components of boiling water reactors (BWRs). So, author idealized that the SCC should be caused by low stacking fault energy of that stainless steel, and developed the highly SCC resistant austenitic stainless steel which has high stacking fault energy, based upon the comprehensive basic study, as shown in Figure 1. Author has studied on the comprehensive long-term corrosion tests and SCC tests, mechanical tests, weldability tests, inspectability tests, etc., for these advanced materials, to apply to the components of commercial PWRs or BWRs. Even after these advanced materials have been applied practically, author has been continuing the studies on the long-term corrosion, SCC test, etc., as pro-active research up to the end of plant life for light water reactors. That is a feature of the field of nuclear industry, and the material used for nuclear power plants must never be disposable on the spot.

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