

Proceedings of the 2nd NanoWorld Conference in Boston (NWC-2017). Part IV: Emerging Researchers Forum

The conference also included this special session for young scientists which provided a platform to present their cutting edge research in Nanotechnology. Around 25 young scientists have participated in this session

Using a Sub-nanopore to Discriminate Residue Substitutions in a Single Protein Molecule

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Abstract

It is now possible to routinely create, in a thin inorganic membrane, a single, sub-nanometer-diameter pore, i.e. a subnanopore, about the size of an amino acid residue. To explore the prospects for sequencing protein with it, measurements of the force and current were performed as two denatured histones, differing by four amino acid residue substitutions, were impelled one-at-a-time, systematically through the sub-nanopore using an atomic force microscope. The force measurements revealed that once the denatured protein, stabilized by sodium dodecyl sulfate (SDS), translocated through the sub-nanopore, a disproportionately large force was required to pull it back. This was interpreted to mean that the SDS was cleaved from the protein during the translocation. The force measurements also exposed a dichotomy in the translocation kinetics: either the molecule slid nearly frictionlessly through the pore or it slipped-and-stuck. When it slid frictionlessly, regular patterns were observed intermittently in the force and blockade current fluctuations that corresponded to the distance between stretched residues. Furthermore, the amplitude of the fluctuations in the current blockade were correlated with the occluded volume associated with the amino acids in the pore. Finally, a comparison of the patterns in the current fluctuations associated with the two practically identical histones supported the conclusion that a sub-nanopore was sensitive enough to discriminate amino acid substitutions in the sequence of a *single protein molecule* by measuring volumes $> 0.1 \text{ nm}^3$ per read—no other technology for sequencing protein shows such extraordinary sensitivity.

Detection and Imaging of Quorum Sensing in *Pseudomonas aeruginosa* Biofilm Communities by Surface Enhanced Resonance Raman Spectroscopy

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Abstract

Most bacteria in nature exist as biofilms, which support intercellular signaling processes such as quorum sensing (QS), a cell-to-cell communication mechanism that allows bacteria to monitor and respond to cell density and changes in the environment. Because QS and biofilms are involved in the ability of bacteria to cause disease, there is a need for the development of methods for the non-invasive analysis of QS in natural bacterial populations. Here, by using surface enhanced resonance Raman scattering spectroscopy, we report rationally designed nanostructured plasmonic substrates for the *in-situ*, label-free detection of a QS signaling metabolite in growing *Pseudomonas aeruginosa* biofilms and microcolonies. The *in situ*, non-invasive plasmonic imaging of QS in biofilms provides a powerful analytical approach for studying intercellular communication on the

basis of secreted molecules as signals.

Biomedical Applications of Superparamagnetic Iron Oxide Nanoparticles

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Abstract

Superparamagnetic iron oxide nanoparticles (SPIONs) are widely investigated due to their multiple potential applications in biomedicine such as drug delivery, hyperthermia, MRI contrasting or cell separation [1]. 15 nm SPIONs were synthesized by thermal decomposition of iron (III) acetylacetonate. Subsequently, nanoparticles were functionalized (with various ligands) to obtain water solubility and required properties. Nanoparticles were characterized by Transmission Electron Microscopy (TEM), Dynamic Light Scattering (DLS), Zeta Potential and Fourier Transformed Infrared Spectroscopy (FTIR).

In the first approach the assembly of virus-like particles (VLPs) was performed with two distinct viral proteins, plant origin Brome Mosaic Virus (BMV) capsid protein and human Hepatitis B Virus core antigen (HBcAg). Successful creation of core-shell VLPs containing SPIONs (functionalized with HOOC-PEG-PL and dihexadecyl phosphate (DHP)) was confirmed by TEM microscopy. Hydrodynamic size and monodispersity were established by DLS. Spectroscopic characterization of VLPs was performed with FTIR. Also cytotoxicity tests of constructs were performed [2, 3].

In the second study we tested the ability of SPIONs for direct cell labeling. They are tested *in vitro* for their cytotoxicity, influence on differentiation potential and cell retention. Human myoblasts and human mesenchymal stem cells (hMSCs) were used for tests and were treated with various concentrations of DMSA-coated nanoparticles. Our results show that nanoparticles render no significant toxicity in MTS tests. Cells retain their potential for differentiation as they form multinuclear myocytes. We observed that nanoparticles stay in cells for up to two weeks. Next steps in our research will be tests *in vivo* in mice [4, 5].

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References

1. Wu W, Wu Z, Yu T, Jiang C, Kim W-S. 2015. Recent progress on magnetic iron oxide nanoparticles: synthesis, surface functional strategies and biomedical applications. *Sci Technol Adv Mater* 16(2): 023501. <https://doi.org/10.1088/1468-6996/16/2/023501>
2. Huang X, Bronstein LM, Retrum J, Dufort C, Tsvetkova I, et al. 2007. Self-assembled virus-like particles with magnetic cores. *Nano Lett* 7(8): 2407-2416. <https://doi.org/10.1021/nl071083l>
3. Shen L, Zhou J, Wang Y, Kang N, Ke X, et al. 2014. Efficient encapsulation of Fe₃O₄ nanoparticles into genetically engineered Hepatitis B core virus-like particles through a specific interaction for potential bioapplications. *Small* 11(9-10):1190-1196. <https://doi.org/10.1002/smll.201401952>
4. Azene N. 2014. Tracking of stem cells *in vivo* for cardiovascular application. *J Cardiovasc Magn Reson* 16(1): 7. <https://doi.org/10.1186/1532-429X-16-7>
5. Kolanowski TJ, Rozwadowska N, Malcher A, Szymczyk E, Kasprzak JD, et al. 2014. *In vitro* and *in vivo* characteristics of connexin 43-modified human skeletal myoblasts as candidates for prospective stem cell therapy for the failing heart. *Int J Cardiol Apr* 173(1): 55-64. <https://doi.org/10.1016/j.ijcard.2014.02.009>

Selective Formation of Aluminium/Copper Nanocomposite Particles from Acid Mine Drainage using Nanoscale Zerovalent Iron Particles

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Abstract

Here nanoscale zerovalent iron particles (nZVI) has been investigated for the removal of aqueous metals and metalloids from acid mine drainage (AMD) taken from Parys Mountain, Wales, UK. Batch sorption isotherms experiments were conducted using nZVI at 0.1, 0.2, 0.5, 1.0 and 2.0 g/L concentrations. Results demonstrate nZVI as able to selectively remove near-total concentrations of aqueous Cu and Al, but only when using concentrations > 0.5 g/L, despite appreciable concentrations of numerous other metal and metalloids present (namely: Na, Ca, Mg, K, Mn, As and Zn). TEM-EDX analysis of extracted

nanoparticulate solids from the batch systems confirmed the formation of discrete spherical nanoparticles comprised of Fe, O, Cu and Al, with a relatively narrow size distribution (typically 20-100 nm diameter). Overall these results demonstrate that nZVI can not only be utilized for the remediation of AMD, but can also be used to simultaneously generate useful nanoparticulate products which can be used for a wide range of applications including catalysis, optics, electronics and antifungal/antibacterial applications. Future work will investigate the use of nZVI physicochemical modifications and/ or complimentary reagents in order to further enhance the selectivity of nZVI for certain metals present in AMD. This will enable the rapid and highly selective valorisation of pollutant metals present in acid waste streams (such as AMD) into high value functionalised nanomaterials.

The Influence of KIT-6 Pore Size of 3D-MnO₂ for Ethanol Catalytic Oxidation

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Abstract

Formaldehyde (HCHO) is a carcinogenic and teratogenic substance, and has strong photochemical activity. It is emitted during the production of textiles, agrochemicals, sheet materials, and fine chemicals, from motor vehicle exhausts, and from various indoor decorating materials. HCHO removal is necessary to protect human health and the atmospheric environment. The removal of HCHO through catalytic oxidation is a more promising technique than adsorption methods. The key to this technique is the development of suitable catalysts. Catalytic materials for HCHO oxidation can be divided into noble-metal and transition-metal oxide systems. Noble-metal catalysts are generally prepared by loading noble metals (Pt, Pd, Au, and Ag) on various supports. Supports can be classified as common supports, traditional metal oxide supports, and metal oxide support with special morphologies. Noble-metal catalysts have excellent catalytic activities because of the addition of noble metal. Transition-metal oxide catalysts have cheap and plentiful sources, and have been widely studied. Single transition-metal oxide catalysts such as MnO₂ nanorods, cryptomelane nanospheres, and mesoporous MnO₂, Co₃O₄, and Cr₂O₃ have excellent catalytic activities in HCHO oxidation, and their T₅₀ and T₁₀₀ HCHO conversions are less than or equal to 110 and 140 °C, respectively. Some metal elements (such as Ce, Sn, Cu, and Zr) can be doped into MnO_x and Co₃O₄ to prepare composite metal oxides when a single metal oxide does not give a good catalytic performance. At present, the development of effective and low-cost catalysts for HCHO oxidation at low temperatures, even room temperature, is still an important challenge.

Fabrication of Novel FeOOH/Cu₂O Nanostructures for Enhanced Solar Hydrogen Application

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Abstract

Solar-driven water splitting with photoelectrochemical (PEC) reaction is a clean and sustainable approach for hydrogen (H₂) production. Recently, enormous effort has been substantial research are being performed to improve the conversion efficiency. We present an active photocathode for solar H₂ production, consisting a stable P-type cuprous oxide (Cu₂O) photoelectrode has been fabricated by direct galvanostatic electrodeposition of the Cu foil substrate, followed by treatment to introduce a protective nanolayers of Iron oxide-hydroxide(FeOOH) penetrating the surface of the Cu₂O layer. The novel FeOOH/Cu₂O nanostructures were well-characterized by XRD, UV-VIS, SEM, XPS, and synchrotron analyses. Results showed that the FeOOH/Cu₂O were dominated by Cu₂O phase after sintering at 500 °C. XPS finding confirmed XRD results that the copper element in FeOOH/Cu₂O was Cu (I) instead of Cu (II). SEM images illustrated the diameter and the length of supported FeOOH/Cu₂O nanowires was approximately 200 nm and 10-20 μm, respectively. After FeOOH introducing, the Cu₂O nanowires structure kept its integrity with no significant morphological change, which was beneficial for PEC performance applications. Results in the best performance case electrodes showed photocurrents of CuFe₇ (-1.8 mA/cm²), under -0.2 V bias potential, was about 5 times higher than that of pure Cu₂O (-0.4 mA/cm²). The improvement in PEC efficiency by introducing the FeOOH material can be regarded as a suitable hetero partner, it provides useful insights into the development of a Cu₂O photoelectrode, as its stability remained as the main challenge.

Facile Preparation of Metal Layers on Photo-curable Polymers for 3D Printing Materials

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Abstract

Metallization on 3D printed polymer objects have attracted great attention because of their adaptability to various applications such as electronic device and optical device. However, experiments to fabricate metallic layers on photocurable polymers for 3D printing have not yet been clearly demonstrated. Here, we present a novel photo-curable polymer containing metal anchoring group and demonstrate the fabrication of uniform metal layers on 3D printed polymer substrates. Metal anchoring groups effectively tuned the interfacial interaction between photo-curable polymer substrates and metal precursors. In order to improve the adhesion and uniformity of the metal layers, the density and type of metal anchoring groups of photo-curable polymers were precisely and systematically controlled. Then, contact angle measurement, fourier transform infrared spectroscopy (FTIR) and nuclear magnetic resonance (NMR) were used to verify the presence of metal anchoring group on the 3D printed polymer substrates. In stark contrast to pristine photo-cured polymer substrates, uniform metal layers were successfully fabricated on the photo-cured polymer substrates containing metal anchoring groups. Our approach paves a new method for the fabrication of metal layers on photo-curable polymer substrates which offers great potential for various 3D printing-related applications, including wearable devices and flexible electronics.

Bioinspired - Soft(Small) Robots

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Abstract

During their movement, soft animals can deform their bodies to large extent in order to adapt to the environment. This mechanism has inspired scientists to seek novel strategies for bio-inspired soft machines. One of the long-standing challenges is to develop remotely powered and controlled systems that could mimic biological locomotion in miniaturized devices. However, currently available materials and fabrication techniques prevent miniaturization. Liquid-crystal elastomers (LCEs) are smart materials that can exhibit large shape changes under external stimuli such as light irradiation. Over the past few years, we have developed sub-micron-resolution laser writing lithographic techniques as well as molecular alignment engineering methods, that allow us to pattern these materials into three-dimensional light-actuated forms, for applications in micro-robotics.

I will introduce the fabrication process of the LCE actuators, from microscopic manipulation of LC molecular orientation to diverse light-induced shape-changes in macroscopic actuators. Several bioinspired micro-robots are also demonstrated, such as millimeter-scale crawling caterpillar, micrometer-sized walker and light-driven micro gripper.

Transparent Conductive Graphene-coated Textile Fibres as a Platform for Wearable Electronics

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Abstract

The concept of smart-textiles is witnessing a rapid development with recent advances in nanotechnology and materials engineering. Bearing in mind that the concept of textiles is much wider than clothes and garments, the potential is immense. While most current commercial applications rely on conventional hardware simply mounted onto fibres or fabrics, a new approach to e-textiles consisting in using functionalised textiles for several technological applications has the potential to change the paradigm of wearable electronics completely.

Conducting fibres are an important component of any e-textile, not only because they can be used as wiring for simple textile-based electronic component, but also because they can be used to build electronic devices directly on textile fibres. We have reported a new method to coat insulating textile fibres with monolayer graphene to make them conductive while preserving their appearance [Sci. Rep. 2015, 5, 09866]. There are a number of factors that can greatly influence the sheet resistance achieved

by graphene-coated textile fibres. In order to understand the influence of the topography of the fibres on the effectiveness of the graphene coating, an extensive study encompassing microscopy techniques like Atomic Force Microscopy and Scanning Thermal Microscopy, as well as Raman spectroscopy was performed.

This method has proven to be a versatile tool to achieve flexible, transparent and conducting fibres of different materials, sizes and shapes. The first applications of electronic devices built on such fibres are demonstrated, opening up the way for the realization of wearable devices on textiles.

How Do You Control the Morphology of Carbon Fibers?

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Abstract

The process of producing carbon nanofibers (CNF) over metal catalysts has been the subject of study for several decades, with particular interest been paid towards their synthesis and application. However, control over the size and shape of these materials still remains a challenge. It has been noted that catalyst morphology and the carbon source plays an important role in controlling CNF growth and morphology, as such, one of the challenges is to produce catalyst particles that would yield the desired CNF morphology. In using trichloroethylene (TCE), acetylene and their mixtures (C₂H₂/TCE) as a carbon source to make carbon materials over Ni nanoparticle catalysts in a chemical vapor deposition (CVD) process [1], we have observed that the Ni particle size and shape impacts dramatically on the carbon structure formed. The synthesis of the Ni catalyst was achieved by reduction of Ni(acetate)₂ with hydrazine (35%). Ex-situ TEM analysis of the reduced NiO particles revealed that the Ni particles underwent a morphological change in the presence of TCE (and H₂) with change in (i) temperature and (ii) H₂ flow rate, and that this affected the shape of the carbon material that formed. The TEM data also reveal that the fragmentation and sintering of the Ni to give differently sized Ni particles, especially as it is affected by H₂, determines the morphology of the carbon materials grown from the Ni. This study reveals that careful control of Ni catalyst shape and size leads to control of the carbon structures produced.

Reference

1. Shaikjee A, Coville NJ. 2012. Catalyst restructuring studies: the facile synthesis of tripod-like carbon fibers by the decomposition of Trichloroethylene. *Mater Lett* 68: 273-276. <https://doi.org/10.1016/j.matlet.2011.10.083>

Novel Catalyzation Technique for Improving the Hydrogenation/Dehydrogenation Behavior of Nanocrystalline MgH₂ Powders

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Abstract

Mg and Mg-based materials have opened promising concept for storing hydrogen in a solid-state matter. The natural abundance, cheap price, operational cost effectiveness, light weight, and high hydrogen storage capacity (7.60 wt.%, 0.11 kg H₂L⁻¹) are some advantages of Mg making it desirable storage materials for potential applications. Unfortunately, MgH₂ shows a high thermal stability making the hydrogen releasing at moderate temperatures (below 300 °C) very difficult. In addition, MgH₂ exhibits very slow kinetics of hydrogenation/dehydrogenation at temperatures less than 350 °C. Amongst the several methods used for enhancing the kinetics behaviors of MgH₂ powders, mechanically milling the powders with one or more catalyst species has shown obvious advantages.

Here we are proposing a new approach for gradual doping of MgH₂ powders with Ni particles upon ball milling the powders with Ni-balls milling media. This proposed *in-situ* method showed mutually beneficial for overcoming the agglomeration of catalysts and the formation of undesired Mg₂NiH₄ phase. The decomposition temperature and the corresponding activation energy showed low values of 218 °C and 75 kJ/mol, respectively. Moreover, the hydrogenation / dehydrogenation kinetics examined at 275 °C of the powders milled for 25 h took place within 2.5 min and 8 min, respectively. These powders containing 5.5 wt.% Ni performed 100-continuous cycle-life time of hydrogen charging/ discharging at 275 °C within 56 h without failure or degradation.

Development of High-performance Stainless Steel Nanocomposites by Additive Manufacturing

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Abstract

Additive manufacturing (or 3D printing) belongs to a class of advanced technologies, which can directly use three-dimensional computer aided design data to automatically fabricate multifunctional parts in a layer-by-layer manner. Metal matrix nanocomposites (MMCs) possess excellent mechanical and thermal properties and thus possibly have a great potential for widespread use in the automotive and aerospace industries. The research objective is to develop a high performance stainless steel matrix reinforced with TiC or TiB₂ nanoparticles. The changes in the densification degree, phases, microstructure, and mechanical properties of components produced using different processing conditions were studied. The nanoparticles were homogeneously dispersed and they formed nanoscale ring-like structures along the grain boundaries. In contrast to the SLM-processed unreinforced stainless steel part, the nanocomposites exhibited higher hardness and yield strength while showing low coefficients of friction and wear rates; this was owing to the combined effects of grain refinement and grain-boundary strengthening. We believe that MMCs fabricated by the alternative route of additive manufacturing is a promising method to produce cheaper components that fulfill the increasing demand for high performance with their superior properties.

Porous Silicon Waveguides – A Sensor Platform

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Abstract

Standard micro-electronic fabrication techniques employed in the complimentary-metal-oxide-semiconductor (CMOS) industry are combined with electrochemical etching of silicon wafers to make porous silicon waveguide optical sensors. The readily reproducible electrochemical process of etching porous silicon allows one to tune the pore size and hence tune the refractive index of the porous silicon layer. By etching multilayers of porous silicon with different refractive indices and patterning the multilayers, it is possible to fabricate optical waveguides. Due to the porous nature of these waveguides, the specific surface area of the waveguide increases by several orders of magnitude.

The surface chemistry of silicon readily allows for functionalized surfaces to change how hydrophobic the surface is and to create waveguides that bind specific target molecules. The presence of any chemicals or bio molecules in the pores will change the refractive index of the porous layer which in turn can change the optical signal through the waveguide. By taking advantage of the high specific surface area, it is possible to push down the limit of detection of chemicals.

The research project undertaken aims to demonstrate the fabrication of waveguides using standard CMOS methods and of changing the surface chemistries to show that porous silicon waveguides are an ideal sensor platform which would allow for better commercialization of this technology.

Multifunctional Nitride Nanocomposites through Chemistry of Preceramic Polymers

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Abstract

Nano-structuring allows nanomaterials to be designed with enhanced properties or even new functionalities that do not exist in conventional materials. The preparation of nitride based nanocomposites is a challenging task using conventional processes as they unavoidably lead to size and structural inhomogeneity of the different phases and presence of impurities which affect the properties.

Hence we use a Polymer derived Ceramics (PDC) route to design these nitride based nanocomposite. We specifically focus on synthesis of titanium nitride/silicon nitride nanocomposite system. Using inorganic (preceramic) polymers as ceramic precursors we are able to tune the ceramic compositions and micro-/nanostructures of ceramics and are able to process materials at low processing temperatures in particular shapes and morphologies (dense or porous) that are difficult, or even impossible to obtain by conventional routes. We discuss the effect of varying the nanophase content in the preceramic polymer on the final ceramic and the high temperature behavior of this system. Also we discuss the effect of changing the nature of matrix forming

polymer on the ceramic.

Further on we demonstrate the synthesis of this nitride nanocomposite system as 3D mesoporous support for low content (< 1 wt.%) noble metal catalyst in hydrolysis of sodium borohydride to generate hydrogen.

Enhanced Solar Water Splitting on Ag Modified Titanium Oxynitride Nanotube Arrays

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Abstract

We report, for the first time, the synthesis of high order titanium oxynitride nanotube arrays sensitized with Ag nanoparticles (Ag/TiON) as an active material for visible-light-driven water splitting. The TiO₂, TiON and Ag/TiON nanostructures topology was investigated using FESEM and TEM. The energy dispersive X-ray spectroscopy (EDX) and the X-ray photoelectron spectroscopy (XPS) analyses confirm the formation of the oxynitride structure. These materials were used under photoelectrochemical conditions to split water (under AM 1.5 G illumination 100 mW cm⁻² in 0.1 M KOH). The TiON nanotube array films showed significant increase in the photocurrent compared to the TiO₂ nanotubes counterpart. Moreover, modifying the TiON nanotubes with Ag nanoparticles (13 ± 2 nm in size) lead to significant high photocurrent reaching 14 mA cm⁻² at 1.0 VSCE, see Figure 1. Such high activity in the photocurrent is attributed to the synergetic effect of Ag nanoparticles, N doped, and unique properties of the as prepared nanotube arrays.

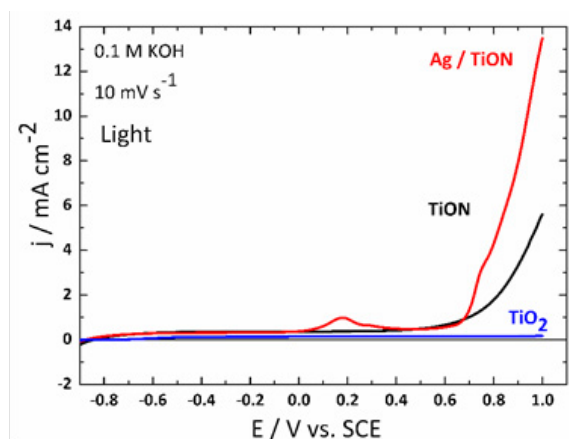


Figure 1: linear sweep voltammetry under illumination for air-annealed, ammonia-annealed, and Ag modified ammonia-annealed titanium nanotube arrays.

Sandwich Structure as Photocathode for Solar Hydrogen Application

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Abstract

Sunlight is a clean, renewable and abundant energy source on the earth. Photoelectrochemical (PEC) water splitting is a promising route for synthesizing hydrogen using solar energy. The materials should have high efficiency, high stability, and low cost. Cuprous oxide (Cu₂O) has the potential to be a powerful material used to produce hydrogen via solar water splitting due to its abundance and ideal band gap for solar energy harvesting. However, Cu₂O has poor photostability, charge carrier density and mobility. Plasmon decay generates hot electrons which can be transferred to a surface molecule for direct reduction or injected into an adjacent wide band gap catalyst, effectively limiting carrier recombination through charge separation and expanding the usable portion of the solar spectrum. To take advantage of plasmonic catalysis, Au-Ag alloy with strong plasmonic behavior have been synthesized in this work. For the configuration of the photoelectrodes, the sandwich structure consisting of p-n junction

and plasmonic nanoparticles can achieve high performance at a relatively low applied bias. Their surface chemistry, structural, optical, electrical, interfacial electronic structure along with their efficiency have been thoroughly investigated at synchrotron radiation facilities.

Theoretical and DFT Analysis of the CO Adsorption Mechanism Late Transition Metal Surfaces

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Abstract

The efficiency of CO₂ reduction into hydrocarbons is far too low for commercial applications. This is due to the large limiting potential (U_L) required for the protonation of CO*, which is considered the rate limiting step (RLS) that occurs after the formation of CO on the electrode surface. Statistical analysis of CO adsorption on different adsorption sites, surfaces, and monolayer (ML) coverages for FCC transition metals (Cu, Ni, Pd, and Pt) displays a fundamental variation in the surface properties of different metal-CO complexes and within different adsorption sites for the same metal surface. DFT computations were utilized to predict surface properties and to visualize charge transfer between the CO molecule and the surface atoms. Investigations of the adsorption mechanisms of CO, from molecular orbital principles, can help in revealing the reasons behind the different properties exhibited upon adsorption and thus a design principle for an optimized electro-catalytic surface can be established to reach higher efficiencies and a better product selectivity.

Electrodeposition of Highly Luminescent Tb Incorporated Si Nanowires from Room Temperature Ionic Liquids

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Abstract

Tb³⁺ doped Si/SiO₂ nanostructures have gained much attention due to their applications in silicon based opto-electronic devices. A number of techniques have been developed such as ion implantation, magnetron co-sputtering, PECVD etc. to incorporate the rare earth ions into the silicon matrix. However most of these techniques include constraining deposition conditions such as high vacuum, high temperature and needs the use of complex instruments.

In the present study, electrodeposition from ionic liquid is proposed as a simple and low cost alternative for the single step fabrication of Tb incorporated Si nanowires. Nanoporous polycarbonate membranes were used as the template for the deposition. The co-deposition of Tb with Si was carried out from an electrolytic solution containing precursors of both (SiCl₄ and TbCl₃) in 1-butyl-1-methylpyrrolidinium bis(trifluoromethylsulfonyl) imide ionic liquid.

In order to achieve the electrochemical doping, the amount of Tb incorporated in the Si matrix has to be controlled. We show here that the content of Tb in the Nanowires can be tuned by adjusting a simple electrochemical parameter, i.e. applied potential. Depending on the deposition conditions, Si nanowires with Tb content ranging from 3 to 20 at. % has been obtained. The nanowires deposited were 1-2 μm long with uniform size and shape. Photo and cathodoluminescence measurements were done on the wires, which gave intense green luminescence resulting from the transition between intra 4f energy levels of the Tb³⁺ ions. A comparison of the PL spectra of Si:Tb nanowires with different Tb content will be discussed.

Electrochromic/Supercapacitive Dual Functional Fibers

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Abstract

Wearable electronics have opened up a new chapter in our lifestyle. Most existing wearable electronics are based on either yarns or fabrics, which have poor wear comfort and durability. Single fibers integrated with electronic functions show advantages over their yarn- or fabric-based electronics. They avoid the vulnerability to physical deformation caused by twisting or wrapping of two electrodes in yarns. The single fiber electronic devices can be woven into clothes. In this study, we have prepared a novel fiber electronic device which has electrochromism and supercapacitor functions. It differs to the previous fiber devices in that the two metal electrodes are formed on a fiber substrate in the form of a parallel coil pattern, and the active substance, poly(3,4-ethylenedioxythiophene), is applied on both electrode surfaces. The device showed a reversible electrochromic effect with fast response time (< 5 s). It had a specific capacitance of 20.3 F/g. The two functions happened simultaneously without interference

with each other. In addition, a finite element method was used to analyze the electric potential distribution on the fiber devices. Such an electronic fiber may find applications in wearable displays, personal power supplies and protective garments.

Synthesis and Highly Effective Purification of Silver Nanowires to Enhance the Transmittance at Low Sheet Resistance with Simple Polyol and Scalable Selective Precipitation Method

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Abstract

Networks of metal NWs have the highest performance of any solution-coatable to replace expensive indium tin oxide (ITO) as the transparent conducting electrode material in next generation devices. However, there is as yet no published process for producing NW films with an optoelectronic performance that exceeds that of ITO. Here, we examine a process for the synthesis and purification of uniform AgNWs that, when coated with a spin coating to create a transparent conducting film (TCF), show properties exceed that of ITO. The morphology AgNWs can be controlled by adjusting the concentration of silver nitrate (AgNO_3) and [PVP] to $[\text{AgNO}_3]$ molar ratio. AgNWs with average diameters of 20 nm and aspect ratios > 1000 were obtained by added 30.5 mM of AgNO_3 and 6:1 molar ratio of [PVP] to $[\text{AgNO}_3]$ to a silver nanowire synthesis, but these NW were contaminated by some Ag nanoparticles. Selective precipitation was used to purify the NWs from nanoparticles, resulting in a transmittance improvement as large as 2%. The transmittance of the purified AgNW film was 97.5% at a sheet resistance of below $70 \Omega \text{ sq}^{-1}$. The synthesized and purified AgNWs were analyzed by field-emission scanning electron microscopy (FE-SEM), atomic force microscopy (AFM), transmission electron microscopy (TEM), Energy Dispersive Spectrometer (EDS), Energy Dispersive X-ray spectroscopy (EDX), X-ray diffraction (XRD), X-ray photoelectron spectroscopy (XPS), Ultraviolet-visible-near-infrared (UV-Vis-NIR) and four-point-probe technique.

Fabrication of Copper Pattern on Flexible Substrate by Solvent-free Dry Deposition Method

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Abstract

The coating of an electrically conductive and mechanically stable metallization pattern on flexible substrate is a main issue for the application of flexible electronic devices. While the metallization pattern can be fabricated by lithography related with metal thin film deposition, lithography is highly expensive and needs a number of deposition steps as well as etching to make patterns. The increasing need for simple and low-cost fabrication on flexible substrate searched replacement to the conventional lithographic process. Inkjet printing is considered to be a promising alternative to lithography-based approaches. However, inkjet printing equipment is expensive, and it takes long processing time due to drying solvents.

In this study, a nanoparticle deposition system (NPDS) was used to deposit Copper patterns onto flexible substrate at room temperature. It is one of dry deposition techniques in which compressed air and super or subsonic nozzle were used to obtain high kinetic energy of nano-powder. The air compressor provides the high-pressure airflow that carries particles from the powder feeder to the nozzle. The powder is ejected through the nozzle at room temperature with low vacuum conditions and strikes on the substrate. Here, Copper powder was deposited onto flexible substrates, such as Polyimide (PI) and Polyethylene Naphthalate (PEN). Finally, the deposited patterns were sintered at low temperature through flash light sintering.

The microstructure of the copper patterns was examined using field emission scanning electron microscopy. The change in electrical Resistivity of the fabricated copper patterns was studied through varying substrates, bending of substrates and its sintering conditions.

Risk-Based and Prevention-Based Methods for Nanomaterial Governance

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Abstract

As the use of manufactured nanomaterials continues to grow internationally, policymakers and key stakeholders in industry are increasingly tasked with the need to foster governance for such materials and their resulting products in the near future. Such governance has traditionally utilized a certain type of tools that utilize available quantitative data for exercises as with

dose-response or environmental fate assessment. This exercise has been referred to in literature as risk based governance, where quantitative data is used to derive safe exposure limits and best practices for materials. However, where manufactured nanomaterials largely do not have robust sources of quantitative data to populate such tools and models, a different set of tools may be needed to facilitate risk and policy decisions for such nanomaterial governance moving forward. One option here includes prevention-based governance, which seeks to avoid or minimize hazard, effects, and exposure by mandating, directly incentivizing, or encouraging the adoption of inherently safer alternative technologies. However, such governance requires flexible and adaptive risk assessment tools to drive decision making – particularly those that operate despite limited quantitative guidance for material properties. This talk discusses the underlying requirements of risk- and prevention-based governance as they apply to the risk management of manufactured nanomaterials, and offers suggestions with respect to how prevention-based governance may spur a more adaptive and anticipatory framework for nanomaterial governance moving forward.

Nonlinear Optical Properties and Photoacoustic Studies of Copper Oxide Nanoparticles

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Abstract

Copper chalcogenide nanomaterials such as copper sulphide, copper oxide, copper selenide and copper telluride have been investigated for their use in molecular imaging and medical therapy. Especially, copper oxide (Cu₂O) nanoparticles possess variety chemophysical properties and are being widely studied for potential applications as solar cells, sensors, magnetic storage media, field emission devices etc. In the present work, Cu₂O nanoparticles are prepared by chemical precipitation method, an efficient synthesis process which yields high quality and advanced materials properties. The band gap of nanoparticles was calculated as 2.32 eV and grain size was found to be 21 nm. The nonlinear optical and photoacoustic properties were studied using PAZ-scan technique at 532 nm with a frequency doubled Nd:YAG laser as the source of light. For these studies, aqueous suspensions of nanoparticles were prepared in double distilled water with optical density of 0.7 at 532 nm. The real and imaginary components of the third order optical nonlinearity are obtained using well known optical z-scan technique. Through PAZ-scan experiment, we also recorded the scattered signal amplitude of the laser light at 450, and generated photoacoustic signal using a 10 MHz focused ultrasonic transducer and obtained the value of high order nonlinear absorption coefficient. The variation of nonlinear absorption coefficient with intensity suggests a reverse saturable based nonlinear absorption. These studies shows that Cu₂O nanoparticles are suitable for photonic applications and its photoacoustic response can be further exploited as contrast agents in photoacoustic imaging.

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