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Poster Presentations

New Features for Nanosensors Backed by the Uncertainty Principle

Igor Filikhin^{*}, A. Karoui and B. Vlahovic

North Carolina Central University, USA

Abstract

A novel type of detection of dwarf substances (nanosized or smaller) through their effects on electron tunneling in a double nanoscale semiconductor heterostructure is reported. The energy spectra of double quantum wells, double quantum dots (QDs), or quantum rings heterostructures is formed of a set of quasi-doublets. In such systems, the electron wave function could be localized in one of the QDs or delocalized over the whole system. When these quantum systems are weakly coupled, the transition localized-delocalized states induced by tunneling in the quasi-doublets becomes possible. Single electron spectra of such systems in relation to the electron tunneling and localization were reported in our prior work (e.g., *Quantum Matter* 3, 549 (2014)).

Electron energy uncertainty is limited by energy differences in the spectra of separated quantum objects. We establish, here, a direct relationship between the uncertainty of electron localization and the energy uncertainty. The spectral distributions of localized/delocalized states in symmetrical double quantum systems strongly differ from those in asymmetrical systems. We have shown in various instances that a small violation of symmetry drastically affects the electron localization and the energy spectrum. These phenomena can be used to devise new sensing function. In such device, the charge transport is highly sensitive to minuscule symmetry violation caused by the detected substance, and the electron localization constitutes the sensor signal. The symmetry violation can be also induced by electric or magnetic fields. Hence, one can apply such fields to control the asymmetry effects.

Effect of Ionic Liquid on Electrical Conductivity of PEDOT: PSS Composite Nanofibers

Tae Hwan Oh^{*}, Sung Won Park, Gyu Sik Kim and Yeu Jin Kim

Department of Nano, Medical and Polymeric Materials, Yeungnam University, South Korea

Abstract

In this work, ionic liquid (IL) was added to investigate its effect on electrical conductivity of poly(3,4-ethylenedioxythiophene) polystyrene sulfonate (PEDOT:PSS)/polymer composite nanofibers. Poly(vinyl alcohol) (PVA) and poly(ethylene oxide) (PEO) were blended to enhance the spinnability of PEDOT:PSS. Electrical sheet resistivity and current to voltage response were measured with different IL contents. Morphological change was also investigated by using scanning electron microscopy (SEM) and optimum content of IL was suggested.

The Use of Sunlight to Remove Carbon Dioxide from the Atmosphere: Efficient STEP Solar Electrolysis of CO₂ to a High Yield Carbon Nanofiber Product

Stuart Licht^{*}, Jiawen Ren, Fang-Fang Li and Jason Lau

George Washington University, USA

Abstract

Displaying superior strength, conductivity, flexibility and durability, carbon nanofiber (CNF) applications had been limited due to the cost intensive complexities of their synthesis. We present an inexpensive, high-yield and scale-able synthesis of CNFs. We show that common metals act as CNF nucleation sites in molten media to efficiently drive the unexpected, high yield electrolytic conversion of CO₂ dissolved in molten carbonates to CNFs, and that CNT yield and conformation is controlled by oxide concentration and current density. We accomplish this by electrochemically reducing CO₂ on steel electrodes in a lithium carbonate electrolyte. The structure is tuned by controlling the electrolysis conditions, such as the addition of trace common metals to act as CNF nucleation sites, the concentration of added oxide, the addition of initiators and the control of current density. The process can be driven by efficient solar, as well as conventional, energy in a STEP, solar thermal electrochemical process. Scalability of the process is demonstrated from 1 A to 100 A. An inexpensive source of CNFs made from carbon dioxide will facilitate the rate of its adoption as an important societal resource for the building, aerospace, transportation, renewable energy, sporting and consumer electronics industries, while concurrently consuming carbon dioxide.

Dye Sensitized Solar Cell Based on Carbonate Doped-TiO₂ Microspheres

Saleh A. Ahmed^{1,4}, Zaki S. Seddigi², Samim Sardar³ and Samir Kumar Pal³

¹Chemistry Department, Faculty of Applied Sciences, Umm Al-Qura University, Saudi Arabia

²Department of Environmental Health, Faculty of Public Health and Health informatics, Umm Al-Qura University, Saudi Arabia

³Department of Chemical, Biological and Macromolecular Sciences, S. N. Bose National Centre for Basic Sciences, India

Abstract

In the present study, we have considered the parameters in the context of a model Dye Sensitized Solar Cell (DSSC), where the density of light harvesting centre is directly dictated by the concentration of the sensitizing dye (here N719) and indirectly porosity of host oxide layer (TiO₂ in the present case). Our experimental studies reveal that carbonate doping of TiO₂ mesoporous microspheres (doped MS) makes positive influence to all the above mentioned key parameters responsible for the enhanced solar cell efficiency. A simple two step method has been employed to synthesize the doped MS for the photoanode of a N719 (ruthenium dye)-based DSSC. A detail electron microscopy (FEG-SEM and HRTEM) has been used to characterize the change in morphology of the MS upon doping. The optical absorption spectrum of the doped MS reveals significant shift of TiO₂ (compared to that of the MS without doping) towards maximum solar radiance (~500 nm) and the excellent scattering in the entire absorption band of the sensitizing dye (N719). The ability of direct light harvesting (without dye) and the efficient photoelectron injection from a covalently attached model dye (coumarin 343) at the surface of doped MS are also investigated using picosecond resolved fluorescence spectroscopy (Figure 1). Finally, and most importantly, for the first time we have demonstrated that the solar cells with doped MS offers better efficiency (7.6%) in light harvesting compared to MS without doping (5.2%) and also reveal minimum self-recombination of photoelectrons in the redox chain.

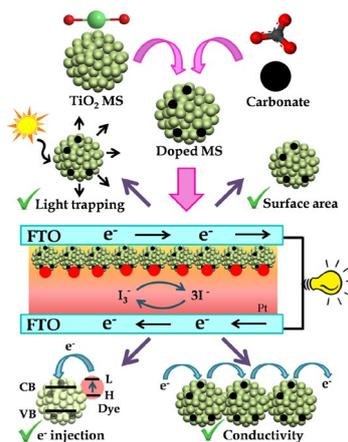


Figure 1: Synthesis of doped TiO₂ MS and their advantages in the dye-sensitized solar cells.

Nanosized Graphene Crystallite Induced Strong Photoelectric Behavior in Pure Carbon Film on p-Silicon Substrate

Gaijuan Hu, Xi Zhang and Dongfeng Diao*

Institute of Nanosurface Science and Engineering, Shenzhen University, China

Abstract

As a 2D material, graphene was considered as a promising material for ultrafast electro-photo sensor by virtue of its massless Dirac Fermions, though the responsivity was limited to tens of mA/W due to the fast recombination of photo-created carriers. External atomic-scale modulations can tune the Fermi-energy and change the conductive behavior of graphene, leading to a high responsivity, though the response time was as slow as millisecond. There lacks a way to manipulate Fermi-level and to enhance both responsivity and response speed through tuning quantum states in graphene itself.

Here, we proposed a method of self-raised Fermi-level and self-reduced recombination rate by introducing electron-trapping quantum wells of graphene nanocrystallite structured carbon film, which deposited on p-silicon substrate by low energy electron irradiation in electron cyclotron resonance plasma. The dependence of the photoelectric behavior on amorphous, nanocrystallite and graphite-like structures were investigated. The results show that: (1) The amorphous/p-Si photodiodes showed poor photoelectric properties, nanocrystallite/p-Si photodiodes exhibited strong photoelectric properties, and graphite-like/p-Si photodiodes corresponded with a lower photoelectricity; (2) When the size of the graphene nanocrystallite was 1.34 nm, the n-nanocrystallite/p-Si junction had the best photoelectric performance with photoresponsivity of 218 mA·W⁻¹, rise and fall time of 2.6 and 2.4 μs for 850 nm light; (3) The origin of strong photoelectricity in nanocrystallite/p-Si was ascribed to the edge-quantum well effect at the graphene nanocrystallite edges. These findings indicate that the graphene nanocrystallite structured carbon films have the great potential for developing novel photo-electric devices.

Magnetic Nanoparticles for Gas Detecting Applications

D. Matatagui*, O. V. Kolokoltsev, N. Qureshi, E. V. Mejía-Uriarte and J. M. Saniger

Centro de Ciencias Aplicadas y Desarrollo Tecnológico, Universidad Nacional Autónoma de México, Mexico

Abstract

In this work, we present an innovative, simple and inexpensive gas sensors based on the variation in the magnetic properties of nanoparticles due to their interaction with gases, on which very little progress has been reported. To measure the nanoparticle response a magnetostatic spin wave (MSW) tunable oscillator has been developed using an yttrium iron garnet (YIG) epitaxial thin film as a delay line (DL). In order to obtain a high response to toxic gases, three sensors have been prepared by coating a uniform layer of CuFe₂O₄, MnFe₂O₄ and ZnFe₂O₄ nanoparticles on the YIG film. The unperturbed frequency of the oscillator is determined by a bias magnetic field, which is applied parallel to the YIG film and perpendicularly to the wave propagation direction. In this device, the total bias magnetic field is the superposition of the field of a permanent magnet and the field associated with the layer of magnetic nanoparticles. The perturbation produced in the magnetic properties of the nanoparticle layers due to its interaction with gases induces frequency shift in the oscillator, allowing the detection of low concentrations of gases. In order to demonstrate the ability of the sensors to detect gases, they have been tested with organic volatile compounds (VOCs) which have harmful effects on human health, such as dimethylformamide, isopropanol or the aromatic hydrocarbons like, toluene and xylene. All of these were detected with high sensitivity, short response time, and good reproducibility.

Elastic Properties of ITO Nanoparticles Layer to Detect Gases

D. Matatagui^{1,*}, M.J. Fernandez², J. Fontecha², J.P. Santos², M.C. Horrillo², I. Sayago² and I. Gràcia³

¹CCADET, Universidad Nacional Autónoma de México, Mexico

²GRIDSEN, Instituto de Seguridad de la Información, CSIC, Spain

³Instituto de Microelectrónica de Barcelona, CSIC, Spain

Abstract

The efficiency of the devices based on surface acoustic waves (SAW) as gravimetric sensors for gases has been proved in the last decades. In literature, many reports proposed the use of polymers as sensitive layers. However, recent reports showed that the oxide thin films used as sensitive layers of SAW devices have advantages such as their long-term reliability and stability. In this work, novelty sensor based on the elastic properties of Indium Tin Oxide (ITO) nanoparticles layer is presented as a high sensitivity sensor. SAW were generated in quartz piezoelectric substrate and a double guiding layer (SiO₂ - ITO nanoparticles) was studied to maximize the sensitivity, confining the energy of the waves in nanoparticles layer.

The ITO nanoparticles layer had two advantages: firstly, in gas detecting process, the area of reaction with the gaseous environment was two or three orders of magnitude greater than in a continuous layer; secondly, in mechanical process, the wave was propagated as in a continuous layer without scattering due to the wavelength (28 μm) being much higher than the diameter of the nanoparticles (average size about 50 nm). The sensor was characterised in different toxic environments: toluene and NO_2 , and concentrations as low as 1 ppm and 0.1 ppm respectively were detected. Therefore, according to theory, velocity of the wave was highly affected by elastic properties of nanoparticles layer that was very sensitive to the gas interaction. The results showed that sensor was highly effective in detecting gases with high sensitivity, and reproducibility.

Improved SERS-based Nano-immunoassay for Detection of Cancer Biomarkers

Alexey Krasnoslobodtsev^{1,2,4}, M.P. Torres³, S. Kaur³, M. Jain³, S.K. Batra³ and Y.L. Lyubchenko²

¹Department of Physics, University of Nebraska at Omaha, USA

²Department of Pharmaceutical Sciences, University of Nebraska Medical Center, USA

³Department of Biochemistry and Molecular Biology, University of Nebraska Medical Center, USA

Abstract

The ability to detect specific cancer biomarkers in human serum provides an effective test for early diagnosis, predicting relapse, prognosis, and assessing response to therapy. It has been indicated that the expression of mucins, high molecular weight and heavily glycosylated proteins, is one of the most prominent characteristics in many types of cancer. Conventional platforms routinely used in clinical settings such as enzyme linked immunosorbent assay (ELISA) and radioimmunoassay (RIA) are not capable of detecting mucin based biomarkers in serum at low levels suitable for early cancer detection. On the other hand, nano-immunoassay utilizing the effect of the surface-enhanced Raman scattering (SERS) is a promising analytical technique that surpasses capabilities of conventional methods. We have used Raman signal enhanced on Au nanoparticles as the readout strategy for the immuno-assay which allowed us to discriminate samples of healthy individuals from samples of pancreatic cancer patients. We have also introduced several strategies designed to improve performance of the SERS-based detection system. We demonstrate that reproducibility of the platform is enhanced by using atomically smooth mica surface as a template for preparation of capture surface in SERS sandwich immunoassay. Furthermore, assay's stability and sensitivity can be improved by using a thin protective layer (either polymer or graphene mono-layer) applied on top of the assay addresses or polymer brushes surrounding nanoparticles.

Hijacking Natural Nanovesicles for Targeted Drug Delivery in Breast Cancer Treatment

Laroche Fabrice Jean-Francois^{1,4}, Wong Joyce² and Feng Hui¹

¹Department of Pharmacology and Experimental Therapeutics, Cancer Research Center, Section of Hematology and Medical Oncology, Boston University School of Medicine, USA

²Department of Biomedical Engineering & Materials Science, Boston University, USA

Abstract

Breast cancer is a major health problem. Triple negative breast cancer is a subtype of the disease with a poor prognosis due to the lack of specific therapy. There is a clear need to develop new strategies to specifically seek and eradicate breast cancer cells, the metastasized ones in particular. My research evaluates the homing properties of extracellular natural nanovesicles (ENV) toward triple negative breast cancer (TNBC) cells and their ability to deliver therapeutic agents to kill tumor cells, without affecting healthy tissues. We are using the zebrafish as an optically transparent vertebrate animal for this research. Candidate ENV can be repurposed using different Poly-Ethylene-Imine (PEI) and various therapeutic agents for breast cancer cells. A panel of TNBC cell lines will be used to determine the efficiency and safety of the candidate hybrid ENV/PEI/cargo *in vitro* and in zebrafish. We have purified ENV that target TNBC cells and are in the process of determining the most suitable PEI and anti-cancer agents that can be used in the hybrid-ENV system. Preliminary data will be presented in a poster at the Nanoworld conference.

Novel Ultrabright NIR Fluorescent Mesoporous Silica Nanoparticles for *in vivo* Applications

Saqib Ahmed M. A. Peerzade^{1,4}, Shajesh Palantavida¹, Rui Tang², Gail P. Sudlow², Samuel Achilefu² and Igor Sokolov¹

¹Tufts University, USA

²Washington University, USA

Abstract

In recent years, NIR fluorescence imaging has gained prominence as an emerging modality in cancer diagnosis. Here we present a novel nanoparticle fluorescent contrast agent which is bright and can avoid fast *in vivo* clearance for NIR bio-imaging. An approach of physically encapsulating NIR fluorescent dye in mesoporous channels of surfactant templated silica nanoparticles was followed to prepare the particles. Methylene blue NIR fluorescent dye, FDA approved for internal use was utilized in this study. In order to impart *in vivo* stealth properties to the particles, a PEG modified ormosil precursor was co-condensed with silica precursor during the synthesis of the particles. Dynamic light scattering measurements showed that PEGylation resulted in particles with an increased particle size, 78 nm, compared to unmodified particles 61 nm, indicating the successful PEGylation. Effective brightness relative to a dye molecule for a Non-PEGylated and PEGylated particle were 457 ± 8 and 247 ± 43 , respectively. These numbers are at par with the ultrabright NIR particles reported recently. *In vivo* imaging studies in a 4T1 xenograft tumor mice model was used to confirm the longer circulation time of PEGylated particles. The PEGylated particles showed improved circulation time for hepatobiliary clearance until 24 h after intravenous injection, whereas the non-PEGylated particles were mostly cleared. The high brightness, biocompatibility of the dye and silica make these particles promising candidate for *in vivo* imaging applications.

Melt-extracted Soft Ferromagnetic Microwires for Advanced Sensing Technology

O. Thiabgoh[✉], T. Eggers, A. Galati, H. Srikanth and M. H. Phan

Materials Institute and Department of Physics, University of South Florida, USA

Abstract

The discovery of the giant magneto-impedance (GMI) effect in soft ferromagnetic materials has made them ideal for a wide range of technological applications, including biomagnetic field detection. While the GMI effects have been reported in the various forms of microwire, ribbon and thin film, current research is focused on tailoring the GMI response of Co-rich soft ferromagnetic microwires. In this study, we demonstrate multistep Joule annealing as an effective method for improving the high frequency low-field GMI response of Co-rich microwires fabricated by melt-extraction technique. We show that the presence of a small volume fraction of nanocrystals embedded in an amorphous matrix due to annealing can facilitate the magnetic domain structure of the microwire and hence improve its GMI response. Our study paves the way for developing novel materials for advanced sensor technology.

Nanoporous Metal Doped Silica Aerogel Synthesis and Characterization

Burcu Karakuzu[✉], Sevil Yücel, Tülay Merve Temel, Ecem Tiryaki and Deniz Ismık

Faculty of Chemical and Metallurgical Engineering, Department of Bioengineering, Davutpasa Campus, Yildiz Technical University, Turkey

Abstract

Silica aerogels have extraordinary features such as high surface area, nano-sized porous, high porosity and very low density. Because of these properties of aerogel has several usage areas such as adsorption studies, immobilization of biomolecules, chromatographic separation techniques.

Various adsorbent has been studied especially in oil industry such as silicate adsorbents (Ca silicate, Mg silicate, pure silicate), bentonite (Ca-bentonite, Al-bentonite, K-bentonite etc.) and they are used for bleaching step. Nanopore size, high surface area and high porosity are very important features for achievement of adsorbent. Pore size and surface area can change with the addition of metal ions into silica. In this frame, this study aimed that improve a metal doped nanoporous silica as a new adsorbent for oil industry having superior adsorption properties. In this study, water glass was used as silica source ($\text{Na}_2\text{O} \cdot 3.2\text{SiO}_2$). Sodium silicate solution and metal salts were mixed in different molar ratios and a slurry mixture was obtained. After washing of slurry with distilled water, solvent exchange procedure was applied using ethanol and n-heptane. The mixture was dried in an oven to obtain metal doped nanoporous silica aerogels. FTIR, BET and SEM analysis and density measurements were used for characterization. It was observed that surface area, pore size and density of aerogels were affected significantly by changing of ratio of silica and metal ions.

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Multifunctional Nanoprobes for Detection and Targeting of Biological Species

Shiyao Shan[✉], Jing Li, Fangfang Chang, Shan Yan, Zakiya Skeete and Chuan-Jian Zhong

SUNY Binghamton, USA

Abstract

While significant advances have been made using nanomaterials for enabling nanoscale manipulation and imaging of biological species, a key challenge is the lack of multiplex detection and targeting of biological species through magnetic, optical, or electrical pathways to enable high sensitivity, high selectivity, and biocompatibility at the molecular level. This presentation will discuss recent findings of our investigations of novel nanomaterials such as core-shell magnetic nanoparticles and nanowires for the creation of the multifunctional nanoprobe, focusing on sensitive detection of cancer biomarkers and controlled delivery of biomolecularly-active species. One example involves the synthesis of core-shell types of nanoparticles or nanowires consisting of magnetically-active alloy core and optically-functional gold shell for surface-enhanced Raman scattering detection of cancer biomarkers on a microfluidic platform with magnetic focusing for signal amplification. Implications of our findings for a wide range of theranostic applications will also be discussed.

2D Misfit Layer Structure of Heavily Boron-Doped Diamond

Sergey Zolyudev[‡], Sergey Polyakov, Victor Denisov, Victor Aksenkov, Stepan Martyushov, Sergey Terentiev and Vladimir Blank

Technological Institute for Superhard and Novel Carbon Materials, Russia

Abstract

We have recently demonstrated that a heavily boron-doped diamond (BDD) can be categorized as a material with two-dimensional (2D) misfit layer structure. Boron atoms, incorporated in a diamond unit cell in definite positions, form nanosheets at boron concentration $> 4 \times 10^{18} \text{ cm}^{-3}$ and bilayers when concentration of boron atoms is $\sim 2 \times 10^{20} \text{ cm}^{-3}$ along which there is a metallic conductivity.

These data require a new insight on the semiconducting properties of boron-doped diamond. The emergence of a new shallow acceptor level, associated with the formation of 2D layers opens the way of the creation of new high-speed electronic devices. Metallic conductivity of the layers in the near future can solve the problem of contacts in the construction of power electronic devices. BDD periodic structure with alternating layers behaves similarly to the multilayer mirror and X-ray interferometer that paving the way to design the new X-ray optics. Designing of these devices requires more detailed studies of BDD structure.

This work presents the results of BDD crystal structure investigations in a wide range of boron content by high resolution X-ray diffraction, X-ray topography and Raman spectroscopy.

Facile Synthesis of Core/Shell-like NiCo₂O₄-Decorated MWCNTs and its Electro-catalyst and Supercapacitor Applications

Tae Hoon Ko^{1,‡}, Jiyoung Park¹, Danyun Lei², Hak-Yong Kim^{1,2} and Byoung-Suhk Kim^{1,2}

¹Department of Organic Materials & Fiber Engineering, Chonbuk National University, Republic of Korea

²Department of BIN Convergence Technology, Chonbuk National University, Republic of Korea

Abstract

The design and development of an economic and highly active non-precious electrocatalyst for methanol electrooxidation and energy storage applications are challenging due to expensiveness of the precursors as well as processes and non-ecofriendliness. In this study, a facile preparation of core/shell-like NiCo₂O₄ decorated MWCNTs based on a dry synthesis technique was proposed. The synthesized NiCo₂O₄/MWCNTs were characterized by infrared spectroscopy, scanning electron microscopy, transmission electron microscopy, X-ray diffraction, and selected area energy dispersive spectrum. The bimetal oxide nanoparticles with an average size of $6 \pm 2 \text{ nm}$ were homogeneously distributed onto the surface of the MWCNTs to form a core/shell-like nanostructure. The NiCo₂O₄/MWCNTs exhibited excellent electrocatalytic activity for the oxidation of methanol in an alkaline solution. The NiCo₂O₄/MWCNTs exhibited remarkably higher current density of 327 mA/cm^2 and a lower onset potential of 0.128 V in 1.0 M KOH with methanol concentration as high as 5.0 M . Further, as prepared NiCo₂O₄/MWCNTs has been successfully applied for supercapacitor applications. It showed a maximum specific capacitance of 822 F/g at 5.0 mV/s scan rate. The remarkable electrochemical properties of the NiCo₂O₄/MWCNTs are promising for development of direct methanol fuel cell based on non-Pt catalysts as well as supercapacitor applications.

Targeted and Accumulated Au/Ag Hollow Nanoshells on Lung Cancer Cell Membranes for Effective Near-IR Induced Drug Release and Photothermal Therapeutic Strategy

Mi Suk Noh^{1,✉} and Myung-haing Cho²

¹Medical Supplies Evaluation Center, Korea Testing Certification, South Korea

²Laboratory of Toxicology, College of Veterinary Medicine, Seoul National University, South Korea

Abstract

Multifunctional therapeutic agents using Au/Ag hollow nanoshells (AuHNSs) were developed for effective, targeted, photothermally induced drug delivery under near-infrared (NIR) light. AuHNSs were synthesized from AgNSs by galvanic replacement reactions. The precursors of AuHNSs, AgNSs were prepared by seedless, one-step synthetic route. To improve lung cancer treatment, we further conjugated antibodies to the PEGylated AuHNSs against the epidermal growth factor receptor (EGFR) and loaded antitumor drug, doxorubicin (AuHNS-EGFR-DOX). AuHNSs and gold nanorods showed similar photothermal efficiency under optimized NIR laser power. AuHNS-EGFR-DOX demonstrated the specific targeting ability on the cell membrane by light scattering images of A549 cells and doxorubicin release from the AuHNSs under low pH and NIR-irradiated conditions. Diverse functions of AuHNS-EGFR-DOX induced photothermal ablation to the targeted A549 cells and rapid doxorubicin release by irradiation with NIR laser. Furthermore, we compared the effectiveness of AuHNS-EGFR-DOX drug delivery between receptor-mediated endocytosis and cell-surface targeting. AuHNS-EGFR-DOX accumulation on cell surfaces by EGFR targeting was more effective for lung cancer therapy than uptake of AuHNS-EGFR-DOX. Taken together, NIR-controlled and targeted drug-delivery techniques were suggested an optimal method via the accumulation of targeted AuHNS-EGFR-DOX on cancer cell membranes and showed the possibility of the high and selective performance with a new anticancer drug-delivery method in coming clinical approaches and technical applications.

Effect of Nanoporous Silica Aerogel Structure for Vitamin C Release

Ecem Tiryaki[✉], Alexandra Cernencu, Yeliz Elalmis, Burcu Karakuzu and Sevil Yücel

Faculty of Chemistry and Metallurgy, Department of Bioengineering, Yıldız Technical University, Turkey

Abstract

Aerogels have gained increasing attention in the biomedical field as a potential tool for targeted drug delivery system based on its properties. The high surface area and the porous structure, as well as their non-toxicity and biocompatibility, are the key properties of silica aerogels that insure them as suitable drug delivery systems.

The density and hydrophobicity of aerogels have a strong influence on both the adsorption and release profile of drugs. Aerogels were synthesized by sol-gel process using Tetraethylorthosilicate (TEOS) and sodium silicate as silica sources for hydrophilic aerogels. Furthermore, a commercial hydrophobic aerogel was used for comparison. The specific surface area, pore size distribution and pore volumes were determined by N₂ adsorption. Vitamin C was used as model drug and drug loaded silica aerogels were characterized by Fourier transform infrared spectroscopy (FT-IR) analysis. The drug release profile was determined in simulated body fluid (pH: 7.4), simulated gastric fluid (pH: 1.2) and simulated intestinal fluid (pH: 6.8).

Experimental results showed that the synthesized aerogels exhibit good load/release properties and the hydrophobicity of the surface is a strong influencing factor. Hydrophobic aerogels have shown a higher adsorption capacity of water-soluble drug and a slower release, while within hydrophilic aerogels, TEOS based-aerogel has the lowest adsorption capacity. Effect of pH on the drug release rate was studied at physiological temperature. According to our results, silica aerogels are promising pH-responsive systems for drug delivery.

Evaluation of Nanoporous Silica Aerogel for Dye Industry

Deniz Ismik^{1,✉}, Burcu Karakuzu¹, Tülay Merve Temel¹, Sevil Yücel¹ and Pınar Terzioğlu²

¹Faculty of Chemical and Metallurgical Engineering, Department of Bioengineering, Davutpasa Campus, Yıldız Technical University, Turkey

²Department of Chemistry, Faculty of Science, Muğla Sıtkı Kocman University, Turkey

Abstract

Silica has extensive usage areas including paint and coating industry. Utilization of silica in polymeric films improves the mechanical strength of polymeric films, this property increases abrasion and scratch resistance of paint and coatings. Also, the usage of silica which produced in various properties improves isolation and thermal resistance and the resistance to UV light of paint and coatings. Paints and coatings with desired characteristics and different requirements can be produced with cheap and suitable silica sources. Silica can be used directly in polymer latex or water-based paints and coatings, also silanized silica can be

used in solvent-based paints and coatings.

In paint and coating industry, generally, precipitated silica, fumed silica and colloidal silica are used. In this study, nanoporous silica aerogels used in matte polyurethane (PU) wood varnish and effects on paint and coating properties such as flammability, thermal conductivity, roughness, brightness and mechanical strength were examined. Standard matte PU wood varnish used as a con with the sample which contains nanoporous silica aerogel instead of commercial silica in standard matte PU wood varnish formulation.

The prepared varnish was applied to a glass surface and the required tests were performed. As a result of dye tests, the sample which contains nanoporous silica aerogel have similar brightness and mechanical strength properties with standard matte polyurethane wood varnish mixture. Therewithal, fire retardant and thermal conductivity properties of the sample which contains nanoporous silica aerogel are better than standard matte PU wood varnish mixture.

Effect of Production Parameters on Nanopore Biogenic Silica Aerogel

Tülay Merve Temel^{1, *}, Sevil Yücel¹, Burcu Karakuzu¹, Yeliz Elalmış¹ and Pınar Terzioğlu²

¹Faculty of Chemical and Metallurgical Engineering, Department of Bioengineering, Davutpasa Campus, Yildiz Technical University, Turkey

²Department of Chemistry, Faculty of Science, Mugla Sıtkı Kocman University, Turkey

Abstract

Silica aerogel is a nanostructured material with high specific surface area, high porosity, low density, low dielectric constant and excellent heat insulation properties silica aerogels have attracted increasingly due to their extraordinary properties and their existing and potential applications in wide variety technological areas such as chemistry, energy, electronics etc. Silica aerogels are synthesized by sol-gel method using sodium silicate solution produced with high energy consumption and high cost silicate precursors (TEOS, TMOS). Synthesis of silica aerogels from silica containing waste materials easily found in nature can make its industrial production more economic and thus can find wide application areas. Therefore, rice hull ash was preferred as the silica source in this study. In industrial applications, aerogels are usually dried in supercritical conditions which is a quite expensive method. Proceeding on drying at atmospheric pressure and inexpensive methods is aimed to reduce the production costs of aerogels.

In this study, Sodium silicate solution was obtained by rice hull ash, synthesis of silica aerogel was completed by sol-gel method. Silica aerogels were produced at pH 7 and using different acid (nitric and citric acid). Aerogels with nitric acid were obtained with TEOS and without TEOS during aging stage of production. The gels produced after aging period were dried in cost-effective ambient pressure drying. Chemical and surface properties aerogels were determined by SEM-EDX, FTIR and BET analysis. Aerogel densities were found between as 0.13-0.46 g/ml and aerogel surface area as 202-340 m²/g. Although TEOS addition affected surface area negatively, density affected positively.

Significant Enhancement on Power Conversion Efficiency of Perovskite Solar Cells Based on Hydrothermally-Grown ZnO Nanowires

Shiu-Ting Yang^{*,} Yu-Ren Li, Yi-Hsiang Chao and Huang-Chung Cheng

Department of Electronics Engineering and Institute of Electronics, National Chiao Tung University, Taiwan

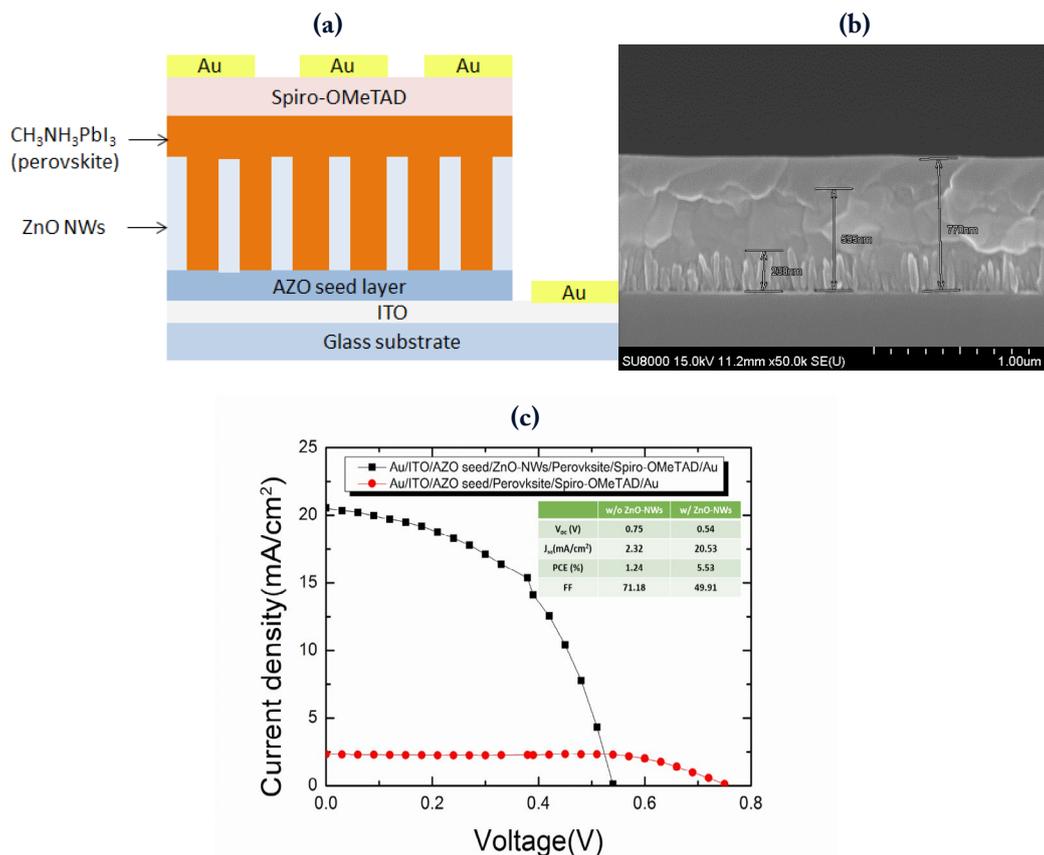
Abstract

A significant improvement of 3.46% on the power conversion efficiency (PCE) of the perovskite solar cells has been achieved by inserting vertically-aligned ZnO nanowires (NWs) between the cathode and the active layer. Compared with the devices without ZnO-NWs, the great enhancement on PCE was mainly attributed to the increased surface area of the 3D nanostructures and the excellent electron transport property of the ZnO-NWs.

The experiment detail was described as below. First, a thin AZO layer was sputtered on ITO coated glass substrate as the seed layer and the ZnO NWs as the electron transport layer were grown on the AZO seed layer through the hydrothermal method. After that, the active layer (CH₃NH₃PbI₃) was spin coated by the two-step method. Sequentially, the hole transporting layer (Spiro-OMeTAD) was deposited on the perovskite film by spin-coating. Finally, an 80 nm-thick gold (Au) was deposited as the anode through thermal evaporation.

The SEM images showed that the as-grown ZnO-NWs with the length of 238 nm were vertically-aligned to the substrate. Besides, it was obvious that the perovskite layer with thickness of 357 nm was uniformly coated on the ZnO-NWs and the thickness of the Spiro-OMeTAD on the top of the perovskite film was about 175 nm.

Under AM1.5G illumination, the PCE were 1.24% and 5.53% for the devices without and with ZnO-NWs, respectively. The increased PCE were due to the enhanced surface area and excellent electron transport property of the high-quality ZnO-NWs.



Figures: (a) The device structure of perovskite solar cell with ZnO-NWs. (b) The cross-sectional SEM image of perovskite solar cell with ZnO-NWs. (c) Photovoltaic performances of perovskite solar cell w/ and w/o ZnO-NWs.

Uniform ZnO Nanowire Arrays: Hydrothermal Synthesis, Formation Mechanism and Field Emission Performance

Zhiyong Zhang, Yaunyan Lv, Junfeng Yan, Dandan Hui, Jiangni Yun, Chunxue Zhai and Wu Zhao

School of Information Science and Technology, Northwest University, China

Abstract

Uniform ZnO nanowire arrays were perpendicularly grown on the Zn substrate deposited with the ZnO seed layers by a low-temperature hydrothermal method for the field emission applications. The results indicate that uniform nanowires with the length of about 9 μm and diameter of about 70 nm are single crystalline with hexagonal wurtzite structure growth along the c-axis and it enables ZnO nanowires to be a flexible bundling structure. A possible growth mechanism of the ZnO nanowire arrays has been proposed. Raman scattering spectra and photoluminescence spectra confirm that Al-ZnO nanowire arrays have higher structure quality than undoped ZnO nanowire arrays. In addition, the turn-on field and field emission factor were found to be approximately 1.60 V/μm and 10835 for the 0.66% Al-ZnO nanowire arrays and it can considerably enhance the field emission performances of the sample after the Al doping, which indicates that Al-doped ZnO nanowire arrays are promising candidate for field emission application.

Self-powered Flexible Electronics Based on Self-poled “Ferroelectric” Nanogenerator

Sujoy Kumar Ghosh^{1, *}, Tridib Kumar Sinha² and Dipankar Mandal¹

¹Department of Physics, Jadavpur University, India

²Materials Science centre, Indian Institute of Technology, India

Abstract

Energy harvesting from small ambient vibrations is a new pathway for production of green and renewable energy. Piezoelectric

nanogenerator (PNG) is an energy harvesting device that converts ubiquitous vibrations into a form of electrical signal based on the energy conversion by nano-structured piezoelectric materials. Harvesting energy from our surroundings is a good choice to meet the energy needs without causing unexpected environmental issues. Among various energy sources, mechanical energy is universally available, environmental friendly and reliable energy sources in our daily life, which is accompanying us regardless of the weather or temperature conditions as for solar and thermoelectric energy. Meanwhile, the choice of material is another critical issue to meet the criteria of environmental viability. Piezoelectric polymer, poly(vinylidene fluoride) [PVDF, (CH₂-CF₂)_n] and its co-polymers are classified as good ferroelectric bio-polymer materials and exhibits electroactive response, including piezo, pyro- and ferro-electric effects. In this work, a self-poled piezoelectretic nanogenerator (PNG) based on novel hybrid ferroelectretic polymer nanocomposite film composed of β -crystalline phase and porous structure is demonstrated. This film possesses large piezoelectric strength with square shaped hysteresis loop. The PNG delivers sufficient amount of power that easily drives several consumer electronics such as, more than 50 LEDs, digital wrist watch, calculator etc. without any subsidiary batteries rather under gentle touch of human finger. This self-powered system is highly applicable as a strain sensor that can be used in wireless transport monitoring system where the input of the traffic can be sensed and electrical signal is being generated

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