NanoScience Technology Center
Advanced Materials Processing and Analysis Center

NSTC/AMPAC
K-12/Undergraduate/RET
2011 Summer Research Showcase

ABSTRACT BROCHURE

August 11, 2011

University of Central Florida

ACKNOWLEDGEMENTS

Organizer.....Prof. Aman Behal (EECS & NSTC)

Posters.....Ernie Gemeinhart (NSTC)

Scheduling.....Usha Lal (NSTC)

Brochures and Certificates.....Ted Molina (NSTC)

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DIFFUSION MG-X (X=AL, ZN, ND, or Y) BINARY SYSTEMS

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ABSTRACT

Magnesium (Mg) alloys are among the lightest weight structural materials available for numerous applications including electronics, defense and transportation. Reliable diffusion data is critical in the design and manufacture of these alloys. In order to obtain this diffusion data solid-to-solid diffusion couples were assembled between pure Mg and pure X (X = Al, Zn, Nd, or Y). These couples were isothermally annealed at various temperatures for different times and quenched to room temperature. The couples were then cross-sectioned and examined using scanning electron microscopy (SEM) equipped with X-ray energy dispersive spectroscopy (XEDS) to determine the intermetallic phases that developed in each couple and to measure the thickness of each phase.

CHARACTERIZATION OF AN ADVANCED NEURONAL MODEL

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ABSTRACT

A linear adaptive sub-threshold model of a motoneuron, with a stochastic firing threshold, that both versatile in its ability to represent a range of experimentally observed neuronal firing patterns as well as computationally efficient for large network simulation, is presented. The parameters that need to be estimated from the model are divided into two sets, the first being assumed to represent sub-threshold dynamics of the system, while the second is associated with the threshold and reset parameters of the neuronal spiking model. The parameter estimation process consists of a dynamic least squares-based update algorithm used to estimate the first set of parameters, while simulated annealing is used to maximize the likelihood of the observed firing pattern in order to estimate the second set of parameters. The presented model and estimation method are implemented in MATLAB and SIMULINK, and validated using synthetic data as well as experimental voltage recordings from *in vitro* embryonic rat motoneurons.

CONJUGATED POLYMER/CNT SUPRAMOLECULAR COMPOSITE AND ITS APPLICATION IN PHOTOVOLTAICS

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ABSTRACT

Conjugated polymer/Carbon Nanotube (CNT) supramolecular composites aimed as active materials in thin film organic solar cells were investigated. CNTs dispersed by P3HT, PQT, PBTTT and PTzQT, respectively, were used to grow conjugated polymer nanowires on CNTs, to form the supramolecular composites. It was found that polymer structure determines interaction between the conjugated polymers and CNTs, subsequently leading to different composite structures. This study can give new insight in the field of material science on polymer interaction with CNTs, and such composites can potentially be utilized to fabricate more efficient organic solar cells.

INTERDIFFUSION INVESTIGATION OF MO AND ZR IN FE AND ITS ALLOYS

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ABSTRACT

Diffusion plays an important role in many materials systems. In nuclear fuels the diffusional interaction between the fuel alloy and the cladding alloy can result in the formation of intermetallic layers with undesired thermal properties. The development of these layers causes swelling of the fuel plates and can potentially lead to fuel plate failure. In order to understand the behavior of these systems a diffusion study was conducted using a series of solid-to-solid diffusion couples between molybdenum/zirconium and iron alloys. The couples were assembled with disks of pure Mo, pure Zr, pure Fe, Fe-15Cr, and Fe-15Cr-15Ni, in wt.%, and were isothermally annealed at various temperatures and times. Following the diffusion anneal, the couples were water quenched to maintain the high temperature microstructure and were cross-sectioned for analysis. Microstructural observations of the interdiffusion zone were made via scanning electron microscopy and intermetallic layer phase constituents have been preliminarily identified using energy dispersive spectroscopy. The development of the intermetallic phases that formed in the binary couples is discussed with regard to the phase diagrams. Also, the effects of the Cr and Ni alloying additions on the diffusion behavior are presented.

MICROSTRUCTURAL UNDERSTANDING OF HIGH-RATE, SEVERE PLASTIC DEFORMATION IN MAGNESIUM ALLOYS

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ABSTRACT

The effects of high-rate severe plastic deformation on the microstructure of a magnesium alloy were examined to better understand how the materials deform under a large magnitude of stress induced with extreme strain rate. Findings are valuable for processing of nanostructured grains and production of impact-resistant materials.

Magnesium is the lightest structural metal that has a great potential for many applications where the strength-to-weight ratio is of critical importance such as biomedical, aerospace, defense and transportation. In many applications, resistance to deformation against high rate impact is of primary concern, and study on high strain rate deformation of magnesium is lacking to date. In this investigation, high strain rate deformation of WE43 magnesium alloy was carried out by high velocity impacts, and the microstructural damage mechanisms were examined. Six samples were subjected to a variety of high velocity impacts that resulted in both partial and full penetration of the alloy. A comprehensive microstructural characterization was performed on samples before and after the deformation. Optical, scanning electron and transmission electron microscopies along with energy-dispersive spectroscopy and electron diffraction analyses were performed in order to identify features relevant to damage mechanisms including grain size, precipitate formation, dislocations, twinning, microcracks, adiabatic shear bands, shear localization, and dynamic recrystallization. These regions of damage are used to map, both quantitatively and qualitatively, the effects of deformation on the microstructural change, and help to provide a better understanding of the rapid accommodation of kinetic energy by the materials. Findings from this study would be utilized to expand the application of WE43 alloys and, in the future, better design magnesium alloys and composites for a variety of applications.

MICROSTRUCTURE OF AL TRIMODAL METAL MATRIX COMPOSITES

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ABSTRACT

Tri-modal metal matrix composites (MMCs), which consist of nano-grained Aluminum, B4C and coarser-grained Aluminum, were characterized to determine the multi-scale microstructural features contributing to the exceptional high strength of Tri-modal Al MMCs. Size and distribution of nano-crystalline Al grains, B4C particles, and coarse-grain Al were quantified. Other features such as dispersoids with and without nitrogen (e.g., Al2O3, Al4C3), dislocation density, crack propagation behavior and interfacial characteristics were also examined with due respect for their contributions to the strength of Tri-modal Al MMCs.

ORGANIC ELECTRONICS DEVICES USING ALIGNED ARRAY CARBON NANOTUBE ELECTRODES

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ABSTRACT

We present fabrication of organic field effect transistors (OFETs) using aligned array carbon nanotube (CNT) electrodes. The high density CNTs were aligned via dielectrophorosis (DEP) from high quality aqueous CNT solution. In order to fabricate the CNT electrodes, aligned CNTs were cut by electron beam lithography (EBL) and precise oxygen plasma etching. To assess the potential of CNT electrodes in the organic devices, we fabricated OFET in a bottom-contact configuration by depositing a thin film of [6, 6]-phenyl-C61-butyric acid methyl ester (PCBM) polymer between the CNT source and drain electrodes. The room temperature electron transport measurement of our device shows better FET characteristics compare to OFET with gold electrodes. Therefore, we can conclude that compared to gold electrodes, CNT electrodes are the better charge injector for OFET devices.

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FABRICATING SUFFICIENT REDUCED GRAPHENE OXIDE DISPERSION FOR ENERGY STORAGE DEVICES

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ABSTRACT

Supercapacitors when compared to conventional capacitors and batteries have higher energy densities and faster power delivery capabilities. This is ideal for wind turbines, automobiles, and other various green energy applications where faster and higher powered energy storage systems are necessary. This project synthesizes a composite of reduced graphene oxide (RGO), the tetrasulfonate salt of copper phthalocyanine (TSCuPc), polypyrrole, and manganese dioxide (MnO_2) for combined use as an electrochemical supercapacitor. In literature a RGO-polyaniline composite is formed and reported to be more efficient than the polyaniline supercapacitor because of less internal resistance. Also studied is the promising ability of MnO_2 to function as a supercapacitor because of its fast charge-discharge process, high theoretical capacitance (1400 F/g), and environmentally friendly nature. From this research it has been determined that when MnO_2 is paired with a conductive polymer, such as polypyrrole, the resulting composite has improved electrochemical properties. TSCuPc is a molecular semiconductor which is able to disperse RGO in aqueous solutions. The RGO-TSCuPc composite forms a viable active material to facilitate and improve the supercapacitor characteristics of polypyrrole-MnO_2. The final composite structure is characterized by transmission electron microscopy (TEM) and atomic force microscopy (AFM) while the electrochemical properties are studied by cyclic voltammetry (CV) and electrochemical impedance spectroscopy (EIS).

DESIGN OF A MOTORIZED RAMP TO ENABLE EASE OF ACCESS FOR DISABLED INDIVIDUALS

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ABSTRACT

This project relates to the design of a motorized ramp in order to assist disabled individuals in climbing in and out of their wheelchair seats. Design criteria for the ramp were compactness, lightness of weight, strength to bear patient weight, and ease of control. In order to meet these criteria, the design uses two small motors, a control board, strong wire/string, a sturdy ramp, a sturdy ramp holster, six wheels, two channels for the wheels, and two spools. Using these materials, the ramp rolls out from underneath the wheelchair seat using gravity, after the user releases it and can, subsequently, be pulled back in using motors, prompted by the user, through the control board. A cardboard and string prototype was built in the lab which helped to find a more intricate design. A virtual model was then made, using Simscape™ simulation software, to improve the basic ramp design. In the future, a working prototype of the design will be made, and attached to a wheelchair for field testing the design.

NANOCERIA SYNTHESIS IN BIOCOMPATIBLE POLYMER SCAFFOLDS

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ABSTRACT

Ceria nanoparticles (nanoceria) have a unique ability to switch oxidation states between III and IV. As a result, nanoceria contains a biological characteristic of radical scavenging and is able to defend against cellular damage in various tissues and organ systems caused by reactive oxygen species (ROS). Despite the capabilities of ceria, this element can be toxic to the human body. A biocompatible and biodegradable matrix is needed in order to prevent direct contact of the nanoceria to human tissues. The objective of the research is to synthesize ceria nanoparticles in into electrospun polyelectrolyte fibers and multilayer films for various applications.

Polyelectrolytes are charged polymers and have excellent biocompatibility to aid in drug delivery and tissue regeneration. Weak polymers, such as poly(acrylic acid) (PAA) and poly(allylamine hydrochloride) (PAH) can be controlled by the pH of the medium. Strong polymers, such as poly(styrene sulfonate) (PSS), are not dependent on the pH. Electrospun polymeric nanofibers have been proven to be useful in the controlled release of various delivery systems (such as protein, drugs, hydrogels, and nanoparticles) as a result of the high surface area to volume ratio and non-toxicity. The layer-by-layer deposition of the multilayer films produce a large, evenly distributed nanoporous coating that does not damage the environment. Polyelectrolytes were used to fabricate electrospun fibers and multilayer films in order to host ceria nanoparticles for biomedical applications. The results concluded that ceria nanoparticles were formed in the fibers and films tested.

NANOPARTICLE-ENABLED DYNAMIC LIGHT SCATTERING ASSAY FOR CANCER BIOMARKER DISCOVERY

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ABSTRACT

Background: Gold nanoparticles (AuNPs) scatter light intensely at or near their surface plasmon wavelength region. Using AuNPs coupled with dynamic light scattering (DLS) detection, we developed a facile nanoparticle immunoassay for serum protein biomarker detection and analysis. A serum sample was first mixed with a citrate-protected AuNP solution. Proteins from the serum were adsorbed to the AuNPs to form a protein corona on the nanoparticle surface. An antibody solution was then added to the assay solution to analyze the target proteins of interest that are present in the protein corona. The protein corona formation and the subsequent binding of antibody to the target proteins in the protein corona were detected by DLS.

Results: Using this simple assay, we discovered multiple molecular aberrations associated with prostate cancer from both mice and human blood serum samples. From the mice serum study, we observed difference in the size of the protein corona and mouse IgG level between different mice groups (i.e., mice with aggressive or less aggressive prostate cancer, and normal healthy controls). Furthermore, it was found from both the mice model and the human serum sample study that the level of vascular endothelial growth factor (VEGF, a protein that is associated with tumor angiogenesis) adsorbed to the AuNPs is decreased in cancer samples compared to non-cancerous or less malignant cancer samples.

Conclusion: The molecular aberrations observed from this study may become new biomarkers for prostate cancer detection. The nanoparticle immunoassay reported here can be used as a convenient and general tool to screen and analyze serum proteins and to discover new biomarkers associated with cancer and other human diseases.

NANOPARTICLE-ENABLED DYNAMIC LIGHT SCATTERING ASSAY FOR CANCER BIOMARKER DISCOVERY

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ABSTRACT

Organic photovoltaics devices (OPVs) have recently become a large topic for studies due to their generally inexpensive manufacturing costs and labor. Difficulties which researchers now are trying to tackle are the overall low efficiencies of these cells which prevent them to be put in to practical use. Our studies focus on the incorporation of low band gap polymers (LBG) which may be introduced to the active layer of the cells and improve their capabilities. We experiment by doping poly-3-hexylthiophene (P3HT) /[6,6]-phenyl C61-butyric acid methyl ester (PCBM) devices at varying concentrations and analyze its effects.

HOW TO INTEGRATE A REAL WORLD DISASTER INTO CURRENT CHEMISTRY CURRICULUM-A 5 WEEK RET PROGRAM

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ABSTRACT

The research experience of teacher at the laboratory in University of Central Florida led to classroom activity which stimulates interest among the students towards science. The teacher was able to create a gas chromic sensor for hydrogen gas using simple chemical synthesis of nanoparticles. The teacher demonstrated the working of the sensor to the student using simple setup. In the classroom activity high school chemistry students (grades 10 through 12) were made aware of a disastrous gas explosion, initiated by an exothermic reaction of water with methyl isocynate that occurred in Bhopal, India in 1984. The activity composed of watching a video, reading a sample article related to the disaster, discussing queries based on observations from the video, integrating the sensor research in the lab with preventive efforts for the disaster, completing questions that are related to concepts taught throughout the year, and a quiz at the end to determine the knowledge gained. The concepts that were integrated into the project from the curriculum included unit conversions, stoichiometric chemical calculations, and polarity, among others.

Acknowledgements: NSF

HYDROTHERMAL SYNTHESIS OF CERIA NANOPARTICLES WITH CONTROLLED MORPHOLOGY FOR ENHANCED CATALYTIC BEHAVIOR TOWARDS CO CONVERSION: A K-12 – UG EXPERIENCE

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ABSTRACT

Nanoceria have been of considerable interest due to their size and shape dependent properties such as oxygen storage capacity, high mechanical strength, oxygen ion conductivity, etc. Hydrothermal synthesis method of nanoceria was used to control the morphology of nanostructures. Cerium hydroxide was prepared using cerium nitrate precursor with sodium hydroxide and placed in autoclave reactor for several hours. The nanoceria samples were characterized by x-ray diffraction, TEM, UV-Vis, DLS. The REU student was involved in redesigning of the reactor and the synthesis of nanoparticles. The catalytic behavior of the synthesized samples was tested by a K-12 student. The K-12 student was also trained (for 4 weeks) on basic characterization technique using AFM, UV-Vis, DLS. The K-12 student tested the doped and undoped nanoceria (prepared by REU) for their catalytic conversion of CO. The results got the K-12 and the REU student motivated for understanding such nanomaterials in greater detail.

Acknowledgement: NSF and Industry Funding

NANO-FUNCTIONALIZED FLY ASH PARTICLES AS OIL ABSORBENTS

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ABSTRACT

Crude oil spill is considered as one of the environmental tragedy in recent days which serves as a threat for ecosystem. It is reasonable to surface modify inexpensive fly ash which is the byproduct of waste material from combustion of coal in power plants. The fly ash particles have been already surface modified and studied for its oil sorption capacity. Our previous findings suggest that the nano-functionalized hydrophobic fly ash particles can be used as an efficient scavenger for oil spills. Our low temperature chemical process functionalizes the surface of raw fly ash powder with Zeolites so that it will rapidly absorb selectively oil from an oil-water mixture on the surface of the particles. To enhance the oil sorption capacity of surface modified fly ash, pore volume has been increased by using templating agents which also assists in preferred growth of the zeolites on the surface of fly ash.

Acknowledgements: NSF RAPID grant and nSolgel/Florida High Tech Corridor

ENHANCED HYDROGEN SENSING PERFORMANCE FROM TIN OXIDE NANOWIRE ARRAYS

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ABSTRACT

The necessity for excellent hydrogen gas sensor goes in parallel with research on hydrogen gas for next generation fuel source. High sensitivity with rapid response and recovery towards hydrogen gas at room temperature is essential for practical applications of such sensors. Here we present synthesis and hydrogen sensing response of nanowire arrays. Tin Oxide (SnO_2) nanowire arrays were prepared on oxidized Si substrates by nanosecond pulse laser irradiation. Atomic Force Microscopy showed the SnO_2 nanowires were of ~20 nm in diameter and tens of microns in length. The SnO_2 nanowire and precursor thin film were tested for sensing hydrogen gas in dynamic testing condition from 6000-300 ppm level. The fabricated SnO_2 nanowire arrays reveal potential for producing devices that have ultra-low detection limit for hydrogen gas with fast response time and quick recovery time for real-life hydrogen sensing applications.

A NOVEL METHOD FOR BIO-CONJUGATION OF CATALYTIC NANOPARTICLES

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ABSTRACT

This project explores the possibility of using biomolecule templating to conjugate and disperse nanoparticles into composite matrices for catalytic purposes. Solid state catalysis is often rate limited by the solid diffusion of catalyst particles to reaction sites, making uniform dispersion of catalysts a desirable trait in solid composite reactions to reduce the overall diffusion distance of the catalyst particles per unit weight. One of the more prevalent methods of nanoparticle conjugation involves DNA based templating, such as Watson-Crick base pairing, a method not suitable for aggressive solvents, or for conjugating a wide variety of particles. Here we explore a novel method for biomolecule based nanoparticle conjugation with application to dispersion of catalytic particles in a solid matrix.

Acknowledgements: NSF