NanoFlorida 2013

Abstract book

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ORALS

POSTERS

O1A - NANOSCALE PHENOMENON

O1A-2

Electron Transport Properties of Reduced Graphene Oxide Sheets

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The easy processibility of reduced graphene oxide (RGO) sheet and its composites offer interesting electronic, chemical and mechanical properties that are currently being explored for advanced electronics and energy based materials. However, a clear understanding of electron transport properties of RGO sheet is lacking which is of great significance for determining its potential applications. In this talk, we will present fabrication of high-yield solution based graphene field effects transistor (FET) using AC dielectrophoresis (DEP) and investigate the detailed electronic transport properties of the fabricated devices. The majority of the devices show ambipolar FET properties at room temperature. However, the mobility values are found to be lower than pristine graphene due to a large amount of residual defects in RGO sheets. We calculated the density of these defects by analyzing the low temperature (300 to 77K) charge transport data using space charge limited conduction (SCLC) with exponential trap distribution. At very low temperature (down to 4.2 K), we observe Coulomb blockade (CB) and Efros-Shklovskii variable range hopping (ES-VRH) conduction in RGO implying that RGO can be considered as a graphene quantum dots array (GQD), where graphene domains act like QDs while oxidized domains behave like tunnel barriers between QDs. This was further confirmed by studying RGO sheets of varying carbon sp^2 fraction from 55-80% and found that both the localization length and CB can be tuned. From the localization length and using confinement effect, we estimate tunable band gap of RGO sheets with varying carbon sp^2 fraction.

O1A-3

Omniphobic Surfaces via Repulsive van der Waals Systems

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Quantum levitation through specific combinations of materials resulting in repulsive van der Waals forces has gained an increasing amount of attention in recent years. It promises to reduce friction between surfaces and reduce or completely avoid the sticking/wetting of liquids or solid particles on solid surfaces. These relatively unique material combinations are predicted using simplified Lifshitz theory to identify when the Hamaker constant describing an interaction becomes negative, i.e. shows van der Waals repulsion instead of the attraction normally seen. Until now, reported combinations have been limited to interactions between a base surface and contacting particle or atmosphere through a liquid film.

Our research focuses on overcoming this fluid film dependence by incorporating an ultra-thin solid film to act as the intervening medium instead. By using Lifshitz theory to quantitatively predict Hamaker constants for many different interactions we find that certain combinations of ceramic films may result in quantum levitation for many common solvents. Additionally, when using ceramic combinations possessing large dielectric constants, the number of materials, including many solid particles as well, for which this quantum levitation is predicted, is maximized, resulting in an omniphobic surface. Additionally, because such a system would not require any topographic modification to repel contacting fluid droplets, it would be much more robust than previously described super-hydrophobic surfaces relying on hairs, micro-hoodoo, etc. This lack of topography would also mean that there would be no “Cassie-Baxter” to “Wenzel” wetting state transition over time, resulting in a truly omniphobic surface, rather than omni-resistant.

O1A-4

Influence of *In Vivo* Agglomeration Behavior on the Oral Bioavailability and Tissue Retention of Gold Nanoparticles

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Particle size is thought to be a critical factor affecting the oral bioavailability of nanoparticles (NPs). Nearly all studies of NP bioavailability focus on the characterization of primary particle size of the material as dosed, not the effective particle size observed within the gastrointestinal tract (GIT). In the study reported here, transmission electron microscopy (TEM) was used to investigate agglomeration behavior of gold nanospheres throughout the gastrointestinal tract (GIT) of mice. *In vivo* agglomeration state was then correlated with bioavailability as indicated by tissue levels of gold detected using inductively coupled plasma mass spectrometry (ICP-MS). Mice were dosed (10mg/kg) with either 20nm PEG-coated or uncoated AuNPs. TEM images from within the GIT have shown that PEG-coated AuNPs can be observed as primary, non-agglomerated NPs in all tissues of the GIT; while uncoated AuNPs form agglomerates of several hundred nanometers in the stomach and remain agglomerated throughout the GIT. At 24 hours post-gavage there was significantly more gold detected in the spleen, kidney, heart, lung and brain ($p < 0.01$) of animals dosed with PEG-coated vs. uncoated gold particles (figure 1A). However, at 30 days post-gavage there was significant excretion of gold from these tissues in mice treated with PEG-coated AuNPs (figure 1B), compared to no change in Au tissue levels of mice treated with uncoated particles (data not shown). The characterization of these particles *in vivo* demonstrates that agglomeration behavior is important in determining both oral bioavailability and tissue retention of gold nanoparticles.

Figure 1. Oral Bioavailability and Elimination of PEG-coated and Uncoated 20nm Gold Spheres

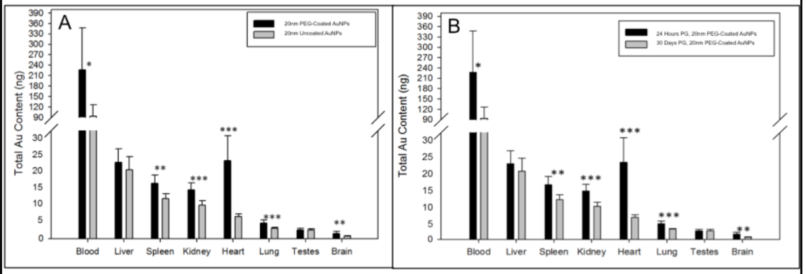

Figure 1A: Differential oral bioavailability of 20nm PEG-coated vs. uncoated AuNPs twenty-four hours following oral gavage. Figure 1B: Demonstrates excretion of gold from tissues between 24 hours and 30 days following oral gavage of 20nm PEG-coated AuNPs. Total gold content in tissues was measured using ICP-MS. Data are presented as the average ± SD, n=5. Statistical significance: * indicates a p-value ≤ 0.05, ** indicates a p-value ≤ 0.01 and *** indicates a p-value ≤ 0.005. PG= post-gavage.

O1A-5

Nanoparticle-protein studies to probe electrostatic interactions and changes in rotational diffusivity at high protein concentrations

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A technique to study nanoparticle-protein interactions *in situ* is proposed and consists of measuring the rotational diffusivity of magnetic nanoparticles in protein solutions. To illustrate the technique we studied the effect of nanoparticle zeta potential of various degrees of carboxylic acid substitution in carboxymethyl dextran (CMDx) coated magnetic nanoparticles and their interaction with proteins, such as albumin (BSA), lysozyme (LYZ), immonuglobulin G (IgG), fibrinogen (FIBR), apo-transferrin (TRANS), and histone (HIS). Experiments indicated that interactions between negatively-charged nanoparticles and negatively-charged proteins BSA, IgG, FIBR, and TRANS were negligible. On the other hand, positively-charged proteins LYZ and HIS seemed to readily absorb on the nanoparticle surfaces, as evidence by an increase in size and eventual aggregation of the particles. Onset of this effect seemed to happen at lower concentration of HIS, compared to LYZ. The technique can be applied to the other particle surface coatings and to particles in complex protein mixtures, allowing systematic *in situ* studies of nanoparticle-protein interactions. In addition, suspensions with high BSA concentration were tested using negatively-charged and neutral charge nanoparticles. The concentration dependence of the rotational diffusivity, and therefore of the hydrodynamic drag and solution viscosity, was studied in the range of 0-200 mg/mL protein. When parameterized as a viscosity these results indicated that the viscosity of the protein solution increased in comparison with other studies. Rotational diffusivity sensed through the different charged nanoparticles showed only similar tendency, which leads to study the role of particle surface coating in rotational diffusivity at high concentrate protein systems.

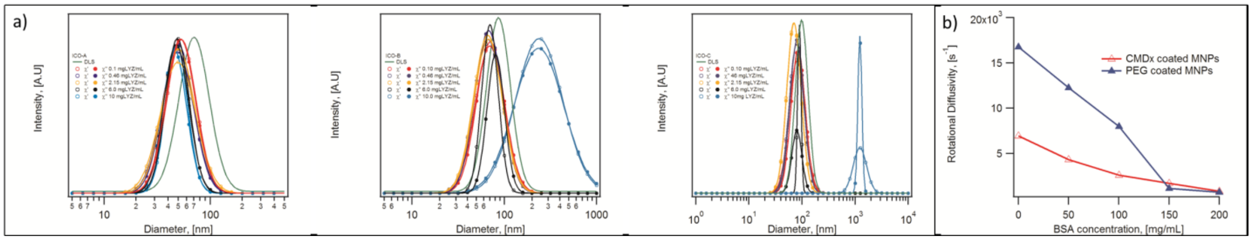

Figure 1: Nanoparticle-protein studies to probe electrostatic interactions with lysozyme protein and changes in rotational diffusivity at high BSA concentrations.

O1B- BIO-TECHNOLOGY 1

O1B-2

Multivalent DNA Nanospheres for Enhanced Capture of Cancer Cells in Microfluidic Devices

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Abstract: Isolation of Circulating tumor cells (CTCs) from peripheral blood or cancer cells from bone marrow has significant applications in cancer diagnosis, therapy monitoring and drug development. CTCs are cancer cells shed from primary tumors; they circulate in the bloodstream, leading to metastasis. The extraordinary rarity of CTCs in the bloodstream makes their isolation a significant technological challenge. Herein, we report the development of a platform combining multivalent DNA aptamer nanospheres with microfluidic devices for efficient isolation of cancer cells from blood. Gold nanoparticles (AuNPs) were used as an efficient multivalent platform for assembling a number of aptamers for high-efficiency cell capture. Up to 95 aptamers were attached onto each AuNP, resulting in enhanced molecular recognition capability. An increase of 39-fold in binding affinity was confirmed by flow cytometry for AuNP-aptamer conjugates (AuNP-aptamer) when compared with aptamer alone. With a laminar flow flat channel microfluidic device, the capture efficiency of human acute leukemia cells from a cell mixture in buffer increased from 49% using aptamer alone to 92% using AuNP-aptamer. We also employed AuNP-aptamer in a microfluidic device with herringbone mixing microstructures for isolation of leukemia cells in whole blood. The cell capture efficiency was also significantly increased with the AuNP-aptamer over aptamer alone, especially at high flow rates. Our results show that the platform combining DNA nanostructures with microfluidics has a great potential for sensitive isolation of CTCs, and is promising for cancer diagnosis and prognosis.

O1B-3

Extended Multiple Drug Delivery with Vitamin E Modified Silicone-hydrogel Contact Lenses for Glaucoma Therapy

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Glaucoma affects about 60.5 million people worldwide and cannot be cured but it can be managed by medications that reduce the intraocular pressure (IOP). Glaucoma drugs are exclusively delivered through eye drops which have a low patient compliance, low bioavailability and potential for side effects. To overcome all the limitations of eye drops we propose to use extended wear contact lenses for glaucoma therapy. However, commercial contact lenses cannot provide extended delivery of drugs. To extend the release duration we loaded the lenses with nano-sized vitamin E diffusion barriers, which increases the release time due to the increase in path length of the drug molecules.

Two glaucoma drugs, timolol and dorzolamide, were loaded into one single lens and the simultaneously *in vitro* releasing profiles were measured. The release duration of the two drugs from lenses without modification is less than 3hr. With diffusion barriers, the release duration increases to about 72 hr.

The therapeutic effect and safety of the lenses were also evaluated in beagle dogs. *In vivo* studies showed that lenses without vitamin E could be replaced daily to maintain constant IOP reduction. For the vitamin

E loaded lens experiment, each lens was worn for 48hr and replaced with a fresh one for another 48hr. After 96hr, all lenses were removed from the eyes but the IOP reduction effect sustained for another 7-8 days (Figure 1).

To our knowledge, this is the first study on extended delivery of multiple ophthalmic drugs from the same delivery device. This talk will also give explanation to the extended IOP reduction phenomenon after lenses removal from dogs' eyes.

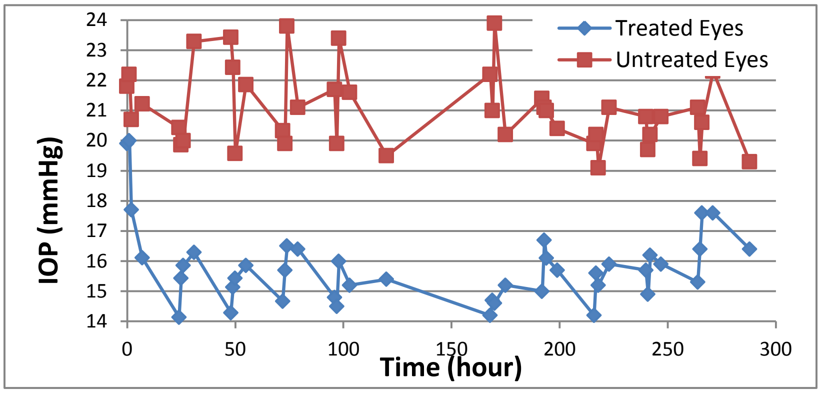

Figure 1: Measurement of IOP changes with time. Each point represents the average value collected from 10 dogs.

O1B-4

Conical Nanopore: A platform for Sensing Protein-Protein Molecular Interaction

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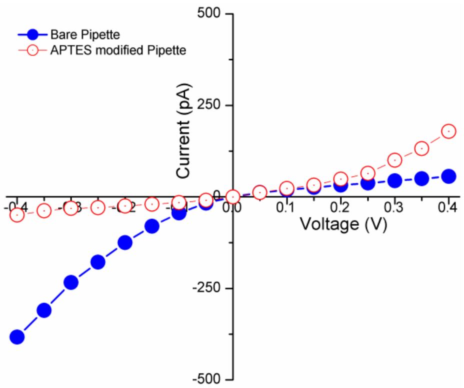
The conical nanopipettes have been exciting platform for the study of single molecule translocation and protein-metal ion interaction due to the low-cost and simplicity of fabrication. Here we present the capability of nanopipettes as a sensor to detect protein-protein interaction. The conical shaped geometry of the nanopipette has interesting feature of rectifying ion current which is very sensitive to surface charge near the opening of the pipette. The binding of charged molecules on the pipette wall near the pore often induces obvious change in the ionic current. The nanopipettes have been fabricated using laser based pipette puller and the pore of nanopipette has been modified with protein at the aim of demonstrating the ability of the nanopipettes as a sensor for the detection of protein-protein binding. The well-studied protein pair, neuroglobin-cytochrome c, has been used as a model system to probe their interaction via the measurement of equilibrium dissociation constant (K_d). The K_d value determined for the neuroglobin-cytochrome c binding using nanopipette sensor is in the line with K_d value as determined by surface plasmon resonance technique suggesting that the nanopipettes could be used as a biosensor for the study of protein-protein molecular interaction.



O1B-5

Cell-chip for real time evaluation of nanotoxicity on a single cell

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Traditional methods of analyzing cells are based on the averaging of results studied from multiple cells in an assay. The results are correlated and assumed to be equally contributed to by all cells of the population under study. However, recent advancements in single cell studies have shown that individual cells behave differently from the population even under the same environmental conditions. Therefore, to study the true functionality of a single cell, it is really important to study a single cell independently without interference from neighboring cells. Studying multiple cells in a single assay might obscure some important information that can only be understood by a single cell study. We used lithography techniques to fabricate a lab on chip device to study cells that were captured using a high throughput single cell capturing technique. The chip includes microwells on top of active sensing electrodes. These electrodes can be independently selected to capture a single cell in a single desired microwell. Positive-dielectrophoresis (pDEP) was employed to achieve quick and efficient single cell capturing in individual wells. We examined changes in impedance properties of the electrode to verify cell capturing in microwells. Electrochemical characterization of the chip showed reliable behavior.

O1C - NANOMATERIALS 1

O1C-2

Flexible, large-area nanostructured electrodes for high performance supercapacitor

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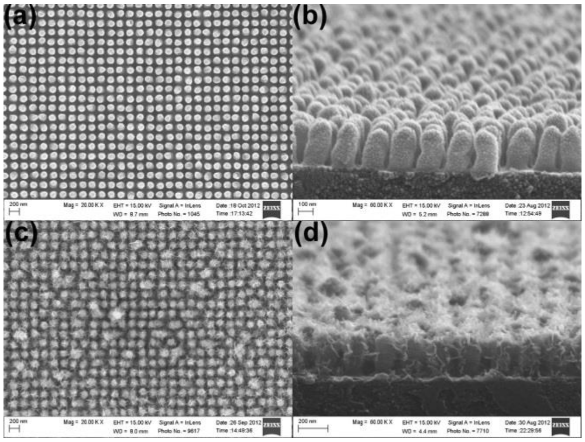
Fabrication of highly ordered nanostructures over a large and flexible substrate area has attracted considerable attentions in recent years due to its increasing applicability in potential markets such as energy storage devices, smart paper, displays, etc. Thermal nanoimprint lithography (T-NIL) has become a promising candidate for preparing nanoscale structures since it can print nanostructure in a very short time. However, only thermoplastic materials without a cross-linking reaction during heating process can be printed through T-NIL. Moreover, it is challenging to print a large nanostructured area using T-NIL since it requires a heating and cooling treatment each time a structure needs to be printed. Here, we present a facile method called spin-on nanoprinting (SNAP) to print large area well-ordered nanostructures. We have successfully printed a 1 cm × 1cm footprint with nanostructures within 3 minutes without using any expensive equipment. Moreover, a large nanostructured area can be easily printed by stitching one film next to another. In addition, it is possible to print these structures on a flexible substrate. We have successfully fabricated nanostructured electrode for supercapacitors using SNAP. Our nanostructured electrodes show remarkable charge/discharge ability, high power and energy densities, and good cycle stability. The simplicity of the nanoarchitectured electrodes and their phenomenal performances has shown promising features for future energy storage systems.



O1C-3

Self-Assembled Broadband Antireflection Coatings

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Antireflection coatings (ARCs) are widely used in photovoltaic and many other optoelectronic applications. A large variety of techniques currently exist in fabricating ARCs but unfortunately many of them suffer from being very expensive and involving complex steps. Here a novel method of fabricating ARCs is demonstrated on both glass and crystalline silicon substrates. Both sides of the substrates were easily coated with a closely packed monolayer of silica nanoparticles using a modified Langmuir-Blodgett method. The coatings produced were extremely uniform and had a minimum reflection of 1% for a broad range of visible and near-infrared wavebands. The coated monolayer of silica nanoparticles was then used as a mask in a reactive ion etching process to fabricate broadband moth-eye ARCs. These subwavelength-structured moth-eye ARCs comprise of periodic arrays of nanopillars that result in superior broadband antireflection and self-cleaning properties compared to traditional ARC technologies. The method of templating the moth-eye ARCs is a simple and scalable technology that lowers reflection to about 0.1% which is highly promising for applications ranging from highly efficient solar cells and photodetectors to flat panel displays.

O1C-4

Synthesis of High Aspect-Ratio ZnO Nanowires by Hydrothermal and CVD Methods

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Dye-sensitized solar cells (DSSCs) have been extensively studied for the past few years for their low-cost and high-efficiency. The surface area of the photoanode, which determines the amount of photons absorbed, is one of the most critical factors to improve the efficiency of DSSCs. Although conventional TiO_2 nanoparticle-based DSSCs have shown promising results, their performance has been limited to ~11% because of diffusion and back reaction problems. Due to its excellent band gap (3.37eV) and high exciton binding energy (60 meV) properties, one-dimensional (1D) ZnO nanowires are capable of overcoming the limitation of nanoparticle-based DSSCs by improving electron injection and axial electron diffusion. Based on models proposed by our group, the efficiency of DSSCs based on TiO_2 core-shell ZnO nanowires can surpass current efficiencies if the photoactive surface area is significantly improved. To reach our objective, we focused on using two-step anodized aluminum oxide (AAO) as a template to control the dimension of nanowires. The synthesis of ZnO nanowires was carried out by both hydrothermal method and catalyst-free CVD method of thermal decomposition zinc acetate dihydrate in the AAO pores. After transferring embedded ZnO nanowires to a PDMS substrate, AAO was etched and an electrostatic repulsion technique was applied to provide vertically-aligned ZnO nanowires. After that, SEM and XRD were applied to characterize these nanowires. This technique provides a new approach to obtain vertically-aligned ZnO nanowires with both high density and aspect-ratio through a large-scale process.

O1C-5

Magnetic nanocomposites formed by electro-infiltration

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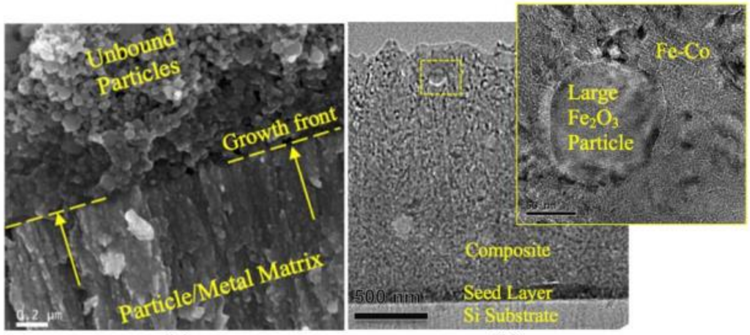
We report the development of a wafer-level fabrication method for forming nanocomposite magnetic materials, such as high-frequency soft magnetic cores or high-energy-density permanent magnets. The basic concept is to direct the assembly of magnetic nanomaterials into structurally defined molds, forming porous microstructures, and then to electroplate a magnetic metal up from the substrate to fill in the void spaces. The result is a fully-dense, two-phase nanocomposite, where the nanoparticles area inclusion phase embedded in the electroplated metal matrix phase. Traditional thin-film deposition methods are challenged to yield sufficiently thick magnetic layers[1], whereas particle/polymer composite materials suffer from low magnetic moment due to low volumetric particle fractions [2]. The novel electro-infiltration process overcomes these limitations and offers enormous flexibility for nano-engineering the material properties by tailoring the sizing and ordering of the nanoscale inclusions.

We demonstrate this process using ~30-nm-diameter maghemite (γ-Fe2O3) nanoparticles electro-infiltrated by an iron cobalt alloy (Fe-Co), and characterize the material structure and magnetic properties. Fig. 1 shows an SEM image of a cleaved sampled cross-section illustrating the progression of the electroplating growth front moving up through the nanoparticles and a TEM image for displaying details of both phases. Such nanocomposite structure could be envisioned to enable high saturation, low-loss magnetic materials at high-frequencies, wherein the non-conductive iron oxide particles inhibit the formation of eddy currents as compared to a uniform Fe-Co alloy. Magnetic characterization shows that the Fe2O3/Fe-Co composite retains a low coercivity similar to the Fe-Co film alone, which illustrates exchange coupling between the phases.

[1]D. P. Arnold and N. Wang, “Permanent magnets for MEMS,” J. Microelectromech. Syst., vol. 18, no. 6, pp. 1255 -1266, Dec. 2009.

[2]I. Kowase, T. Sato, K. Yamasawa, and Y. Miura, “A Planar Inductor Using Mn-Zn Ferrite/Polyimide Composite Thick Film for Low-Voltage and Large-Current DC-DC Converter,” IEEE Trans. Magnetics, 41(10), 3991-3993, Oct. 2005.



(a) (b)

Figure 1: SEM image (a) and TEM image (b) of sample cross-section

O2A - OPTICAL & ELECTROCHEMICAL DEVICES

O2A-2

Air-Stable Infrared Through Visible Photodetectors From All Solution-Processed Inorganic Semiconductors With Low Noise and High Detectivity

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Infrared (IR) and visible light detection systems are widely used in optical communications, security, ranging, and household electronics. Due to the proliferation of these systems in modern society, high quality photodetectors made from inexpensive and high throughput manufacturing techniques are in high demand. Currently, the most popular photodetectors in use are grown by epitaxial deposition techniques, which are costly and only allow for small area device fabrication. To circumvent the drawbacks of current manufacturing technology, we demonstrate a novel infrared photodetector with tunable absorption spectra by employing all solution-processed inorganic materials. Specifically, colloidal quantum dots (QDs) made from lead sulfide are used as the IR-visible absorbing layer, while wide bandgap solution-processed metal oxides are used as the p-type and n-type charge blocking layers in a P-I-N configuration. The absorption spectrum of these QDs can be tuned throughout a wide swath of the NIR and visible spectra. Devices have an attractive peak responsivity of greater than 0.2 A/W and external quantum efficiency (EQE) of 25% at -1V. The photodetectors have a 3 dB bandwidth of greater than 20 kHz and extremely low noise equivalent power, leading to high specific detectivity on the order of 10^{12} cm $Hz^{1/2}$/W, the same as many commercially available photodetectors fabricated from expensive, low throughput epitaxial growth techniques. The oxide charge blocking layers and PbS QDs make these devices stable in air without any encapsulation for several months.

O2A-3

Material Characterization and Fracture Mechanics of Laser Machined Sapphire for High Temperature Pressure Sensors

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UF, FSU, FAMU-FSU College of Engineering

Commercial pressure sensors typically use silicon on insulator (SOI) technology which often requires active cooling for high temperature applications greater than 600°C.In order to overcome the temperature limitations of existing pressure sensors, we are developing optical based pressure sensors that use sapphire. Sapphire is known to have a significantly high melting temperature; however, this comes with a trade-off in the manufacturing process. Due to chemically inert properties, sapphire must be laser machined. This process can influence the fracture toughness. We show that laser machining increases toughness through the creation of dislocations underneath the laser machined surface. We quantify this behavior using indentations of pristine and laser machined specimens which illustrate no crack formation in laser machined specimens. We further quantify the formation of dislocations using transmission electron microscopy (TEM).To further understand how the formation of dislocations influences fracture

toughness, we developed a model to simulate the formation of slip (indirectly via dislocations) in a material and see how the evolution of these systems influences the fracture toughness.

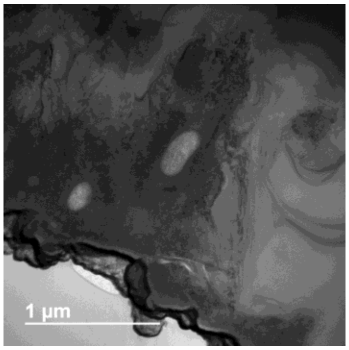

Figure - Laser induced dislocations in single crystal sapphire.
Darker regions are dislocations and lighter regions are pristine.

O2A-4

Proton selective ionic graphene based laminate for high concentration direct methanol fuel cell

Abhilash Paneri[1], Yunseon Heo[2], Gregory Ehlert[1], Anton Cottrill[3], Henry Sodano[1,2], Peter Pintauro[3],Saeed Moghaddam[1]

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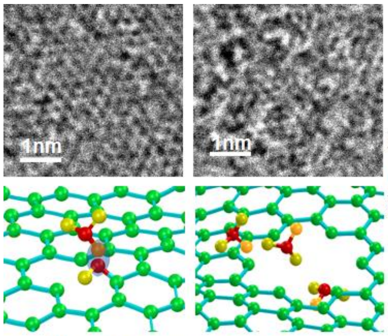
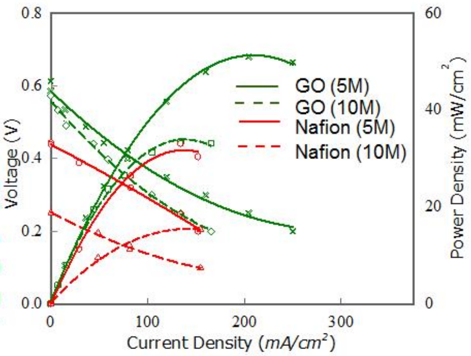
[3]*Department of Chemical and Biomolecular Engineering, Vanderbilt University, Nashville, TN-37235*

Development of a proton exchange membrane (PEM) with insignificant methanol permeability at highly concentrated methanol supply is considered a major advancement in the direct methanol fuel cell (DMFC) technology. Here, we discuss development of a graphene-based PEM with three orders of magnitude lower methanol diffusion coefficient and two orders of magnitude higher proton selectivity compared to Nafion. Direct methanol fuel cell measurements of the membrane at high fuel concentrations showed almost no drop in open circuit potential (OCP); with a 120% increase in power density at 10 M methanol compared to that of Nafion. The membrane was prepared through lamination of graphene-oxide (GO) nanoplatelets. Parametric studies suggested that the membrane methanol permeation rate declines linearly as the nanoplatelets size is increased, while proton conductivity changes rather insignificantly. The observed transport characteristics are attributed to different conduction pathways adopted by protons and methanol molecules. The finding implies that the GO nanoplatelets contain atomic formations that are more selective to protons than methanol molecules, compared to a typical ion channel in polymer electrolyte membranes.



H⁺ and H_3O^+ transport through GO



O2A-5

Fabricating Si Nanowires for Li-ion Batteries

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Li-ion batteries find wide applications from portable electronics to electric vehicles owing to their high power density and energy density, light weight, and minimum memory effect. Currently, graphite stands as the state-of-the-art material for the anode in commercial Li-ion batteries and it has a theoretical capacity of 370 mAh/g. Si is a promising material to substitute for graphite since it has a theoretical capacity more than 10 times (4200 mAh/g) that of graphite. However, during battery cycling, Si experiences up to 400% volume change, which causes pulverization of the anode and subsequent performance degradation. Si nanowire-based anodes are an effective way to circumvent this problem since nanowires offer good strain relaxation. Other benefits of using Si nanowires include efficient 1D electron transport along the nanowire axis and shorter diffusion length for Li^+. In this work, Si nanowires are fabricated by an electroless Ag-assisted chemical etching technique. Ag nanoparticles are deposited on Si wafers, which are subsequently etched in an aqueous solution containing HF and H_2O_2. Figure 1 shows an SEM image of Si nanowires typically fabricated with a diameter of ~200nm and length ~10 µm. The impact of different etching parameters on the formation of Si NWs will be discussed, including the sizes of Ag particles, etching time, and concentrations of HF and H_2O_2. Coin-cell Li-ion batteries based on these Si nanowires are assembled and initial testing results will be presented.

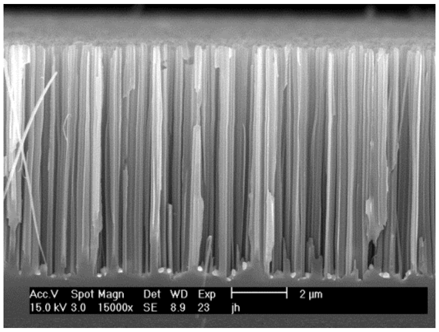

Figure 1. SEM image of Si nanowires fabricated by an electroless Ag-assisted chemical etching technique.

O2B - BIO-TECHNOLOGY 2

O2B-2

Underlying mechanisms of antimicrobial activity of the alternative antimicrobial agent, chitosan nanoparticles, and potential use to intervene in pelvic inflammatory diseases in cows

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The rise of antimicrobial resistant microorganisms (ARMs) is a tremendous concern for animal and human health. Despite its negative and growing impact on food animal production and public health, there are few effective strategies for reducing the prevalence of ARMs in farm animals. Recently, we developed chitosan nanoparticles (CN) as an alternative antimicrobial agent for reducing pathogens in cattle. The purpose of this study was to understand the underlying mechanisms of the antimicrobial activity of CN. In addition, CN activity was evaluated against intrauterine pathogenic *Escherichia coli* (IUPEC) in cows with uterine disease. We identified a specific CN binding protein in pathogenic *E. coli* by the gene deletion method. Deletion of the outer membrane protein OmpA significantly reduced binding activity to CN and antimicrobial susceptibility in *E. coli* O157:H7. CN bound to the OmpA protein to disrupt bacterial membrane permeability resulting in bacterial cell death. The antimicrobial activity of CN was profound and rapid, preventing bacteriophage induction and Shiga-toxin production. Furthermore, CN activity was evaluated in cows with uterine disease. A total of 8 cows with metritis were treated with CN and it was compared to Ceftiofur, a commonly used antibiotic to treat uterine disease in cows. The antimicrobial activity of CN was greater than that of Ceftiofur. CN eliminated IUPEC within 6 days of treatment while Ceftiofur eliminated the pathogen in only 50% of IUPEC positive cows. Taken together, CN can be an alternative antimicrobial agent for treatment of diseases caused by pathogenic *E. coli*.

O2B-3

DNA-Directed Silver Nanoparticles on Graphene Oxide: An Antimicrobial Wrap around a Model Plant Pathogenic Bacteria

Ismail Ocsoy, Mathews L. Paret, Muserref Arslan Ocsoy and Weihong Tan

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[&]*Plant Pathology Lab, North Florida Research and Education Center, University of Florida, Quincy 32351*

The *Xanthomonas perfornas* (*X. perfornas*) causes serious disease on tomato plants. This bacterial lesions turning out considerable reduction on tomato production have been commonly seen in the equatorial regions of the world (tropical and sub-tropical regions). The climate conditions play a major deterministic role for disease occurrence and transfer and for yield of tomato production. To manage disease, copper (Cu) based materials as pesticide has been extensively used in past decades. However, currently in Florida, most of the isolated *X. perfornas* strains from tomato are highly resistant towards Cu based bactericide. In this report, for the first time, we developed and used DNA directed growth silver nanoparticles (Ag NPs) to effectively inactivate X. *perforans* cell both in culture and on tomato leaves. The Weight percentage of Ag NPs in Ag@dsDNA@GO composite is around 27%, then even at very low concentration of metallic Ag NPs such as 16 ppm, Ag@dsDNA@GO composites consisting of ~4.3 ppm and 100 ppm Ag@dsDNA@GO composites consisting of ~27 ppm Ag show excellent antibacterial effect in culture and greenhouse experiment respectively.

O2B-4

Real-time Characterization of Mechanical Properties of cell membrane in presence of nanoparticles

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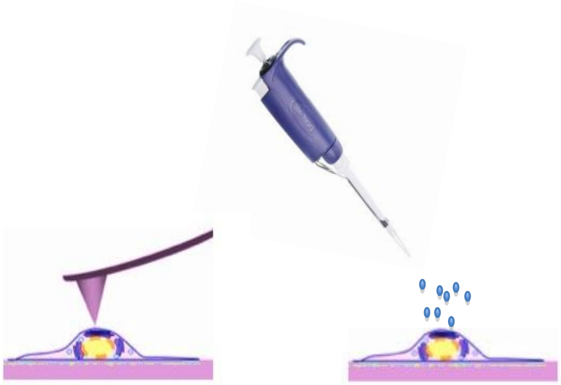
University of Central Florida, Orlando, FL-32816

Recent years, several research groups are looking into nanoparticles (NPs) as an efficient drug delivery system for better delivery and minimum side effects. However, to develop better drug delivery tool, it is important to understand the interaction between NPs and cell membrane. Interaction of NPs and cell membrane is still not fully understood. In this study we have analyzed mechanical property of cells' membranes using Atomic Force Microscopy (AFM) with and without nanoparticles. In particular, Force-Distance spectroscopy mode was used to estimate elasticity of cells membrane. Cerium oxide nanoparticles (CNPs also known as nanoceria) have been recently reported to have therapeutic potential, specifically abnormalities associated with oxidative stress. Therefore, CNPs (size 3-5nm) were selected as a model nanoparticle. Different concentrations (0.1, 50, 125, and 250μM) of CNP were added to the cells and incubated for different time period (0, 15, 30 and 60 minutes). Cell membrane elasticity/Young's modulus was calculated using Hertz model. Changes in cell elasticity were observed in high concentration of CNPs over 1hr of time. At 250μM concentration of CNPs there were a significant changes in cell elasticity observed at 1hr of nanoparticles incubation with cells. However, no significant change in cell elasticity was observed over 1hr time period for 0.1μM of CNPs. This result indicates that nanoparticles interaction/internalization to cell can change the cell membrane elasticity.



AFM in measuring the Young modulus of cell in their medium environment

Cell with nanomaterial added (for 30 mins and then clean)

O2B-5

Sex Specific Nanomaterial Protein Coronas Following Exposure Fish Plasma

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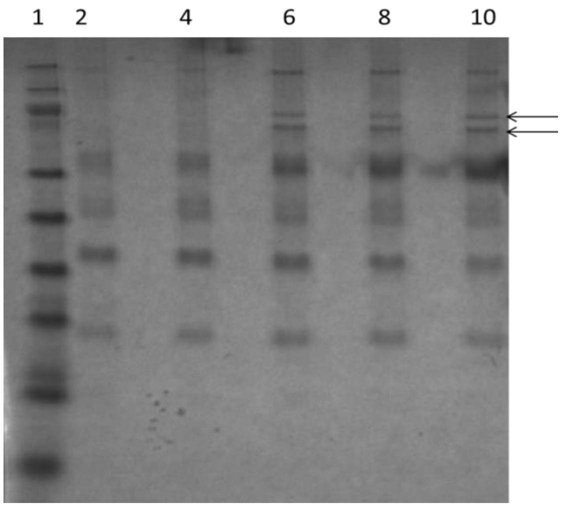
Toxicity screening of namomaterials (NMs) relies on the ability to link high-throughput assessments with whole organism level effects. Interactions of NMs with the proteins in biological environments, including culture media and plasma, allows for the formation of a protein corona that contains proteins with different affinities. It has been shown that the identity of proteins in the corona surrounding the NMs surface can direct bio-distribution *in vivo.* The protein composition of fish plasma is sexually distinct, with the plasma of reproductively mature female fish containing high levels (10-20 mg/mL) of the egg yolk pre-cursor protein, vitellogenin (VTG). VTG serves an important function as a carrier of essential minerals to developing oocytes and may facilitate NM uptake into developing oocytes as well. *In vivo* studies found that quantum dot (QD; or constituent) uptake into ovaries to be significant and dependent on surface functionalization following multiple oral doses. Therefore, it is likely that the NM specific uptake could be mediated by the protein composition of the corona. The specificity of protein adsorption to different NMs can be visualized in the gel below, as the plasma proteins associated with carbon nanotubes differs from those associated with QDs. We have begun to analyze the samples using isobaric tagging for relative and absolute quantification (iTRAQ) and mass spectrometry. This analysis will elucidate sex specific protein corona differences of differentially surface modified NMs. Quantitative proteomics enables a better understanding of the protein corona of NMs and how these proteins may influence their effects *in vivo*.



SDS-PAGE of the proteins adsorbed to two different nanomaterials. Lane (1) SeeBlue 2 Plus protein ladder, (2) single wall carbon nanotubes coated with gumarabic, (4)single wall carbon nanotubes coated with pluronic, (6-10) Qdot 705 surface functionalized with carboxyl groups. Of note is the consistency in the bands seen with the three replicates of the QDs. Additionally, there are prominent bands observed in the QD samples that are not observed in the nanotube samples (arrows), demonstrating that the composition of the protein corona will be specific to individual nanomaterials.

O2C - NANOMATERIALS 2

O2C-2

Mixed Valence Copper (Cu)/ Silica Nanocomposite: Synthesis, Characterization and Systematic Antimicrobial Studies

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Copper (Cu) compounds are widely used as effective agricultural fungicides/bactericides. The United States Environmental Protection Agency (US EPA) is concerned about Cu leaching from soil and potential Cu contamination in the environment. Improving biocidal efficacy of Cu is an attractive alternative, allowing reduction of Cu amount per application. In this research, we focused on making water-soluble mixed-valence Copper/Silica composite nanogel (CuSiNG) material. The objective is to improve the efficacy of Cu by manipulating Cu valence states. It is hypothesized that mixed valence Cu will exhibit improved efficacy over Cu (II). To test this hypothesis, water-soluble mixed valence Cu/silica nanogel (MV-CuSiNG) composite has been synthesized and characterized. Structure, morphology, crystallinity and composition of the MV-CuSiNG material was characterized using High-Resolution Transmission Electron Microscopy (HRTEM), HRTEM Selected Area Electron Diffraction (SAED) and - X-ray Photoelectron Spectroscopy (XPS). To confirm presence of Cu (I) in the MV-CuSiNG material, Neocuproine (Nc, a Cu (I) specific chelator) assay was used. Antimicrobial efficacy of MV-CuSiNG and CuSiNG was evaluated against *X.alfalfae, B.subtilis* and *E.coli* using Kocide® 3000 ("Insoluble Cu (II)" compound), Copper sulfate ("Soluble Cu (II)" compound) and Cuprous chloride (Copper (I) compound) as positive controls and silica "seed" particles (without Cu loading) as negative control. Antimicrobial studies included observing bacterial growth inhibition and determining the Minimum Inhibitory Concentration (MIC). Improved antimicrobial efficacy was observed in MV-CuSiNG when compared to CuSiNG and other controls. For the assessment of plant safety of MV-CuSiNG and CuSiNG materials, phytotoxicity studies were conducted using *Vinca sp* and *Hamlin orange* under environmental conditions.

O2C-3

A Facile Synthesis of Octahedral Iron Oxide Nanoparticles

Frances Ooi[†], Joseph S. DuChene[†], Jingjing Qiu[†], Jeremy O. Graham[†], Mark H. Engelhard[ǂ], Guixin Cao[ǁ], Zheng Gai[ǁ], and W. David Wei*[†]

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A facile, hydrothermal method for synthesizing ferrimagnetic, octahedral magnetite (Fe_3O_4) nanoparticles is reported. The crystal structure, chemical composition, and particle morphology were characterized using X-ray diffraction (XRD), X-ray photoelectron spectroscopy (XPS), and scanning electron microscopy (SEM), respectively. To elucidate the growth mechanism, a time-dependent study on the formation of the octahedral iron oxide nanoparticles was conducted. These investigations suggest that the evolution of the iron oxide nanoparticles is governed by a kinetically controlled dissolution and recrystallization growth mechanism. Interestingly, these studies revealed a synergistic interaction between the surfactants 1,3-diaminopropane and oleylamine of the reagents oleylamine and DP were investigated and found to work synergistically to direct the growth of octahedral iron oxide nanoparticles.

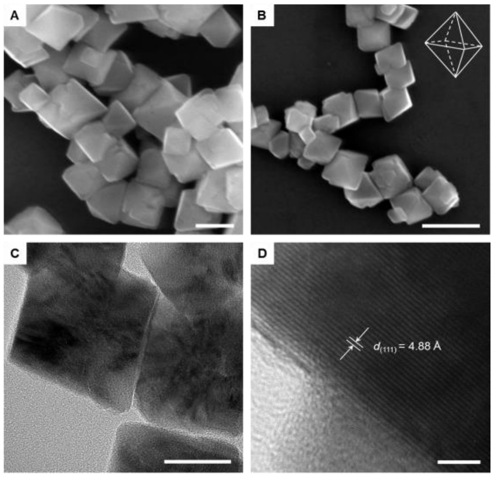

Figure 1: (A) SEM image of iron oxide octahedral nanoparticles – scale bar: 50 nm; (B) SEM image of iron oxide octahedral nanoparticles – scale bar: 100 nm; (B, inset) Diagram of octahedral geometry; (C) TEM image of a single iron oxide octahedral nanoparticle – scale bar: 50 nm; (D) HRTEM image of iron oxide octahedral nanoparticle – scale bar: 5 nm

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O2C-4

Preparation of Fe_3O_4/Ag Magnetic Nanostructures for Surface Enhanced Raman Spectroscopy

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Melatonin plays an important role in Alzheimer's disease as an antioxidant and as a neuroprotector. This study developed a novel substrate, Fe_3O_4/Ag magnetic nanostructures, which would be employed for melatonin detection by Surface Enhanced Raman Spectroscopy (SERS).Fe_3O_4/Ag nanostructures were synthesized, and their surface morphology and structure were characterized by using TEM, SEM and EDS.Fe_3O_4 nanoparticles with size of 10 nm were coated with silver as shell, and the shell thickness of nanostructures became tunable through the adjustment of the ratio between Fe_3O_4 and silver precursor salts. The SERS sensitivity and reproducibility of these nanostructures were tested by using Rhodamine 6G and 4-aminothiophenol as target molecules.Fe_3O_4@Ag magnetic nanostructures offer advantages of both extraction and detection of melatonin and other biomolecules.

O2C-5

Gold Nanoparticles on Oxide-coated Metal Substrates as a Stable Controlled Plasmonic Sensing Platform

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Localized Surface Plasmon Resonances of gold nanoparticles have been studied and proposed to serve in wide range of applications. One of the most active areas is plasmonic sensing. In this work, we present a study of gold nanoparticle resonances on Al_2O_3-coated gold films. This chemically and thermally stable structure could lead to a robust molecular plasmonic sensing platform. Gold nanoparticles with a 60 nm diameter are deposited on Al_2O_3-coated gold films with different Al_2O_3 thicknesses. Spectral images of nanoparticles recorded using a hyperspectral camera shows multi-colored scattering spots corresponding to distinct plasmon resonance polarization directions. Single particle scattering spectra of the gold nanoparticles on each substrate reveal that the vertically polarized (long wavelength) resonances of gold nanoparticles reproducibly undergo a blueshift from 690 nm to 610 nm as the Al_2O_3 thickness increases from 0 nm to 3.4 nm. The results are compared with numerical simulations. Finally, the gold nanoparticle resonances on Al_2O_3-coated gold film are proven to persist upon high-power irradiation at the plasmon resonance frequency (100 W/mm^2). The demonstrated structure could lead to a prototype of a highly controllable, wide wavelength tuning range, and stable sensing platform.

O3A - SENSORS AND ELECTRONIC DEVICES

O3A-2

High Performance Semiconducting Enriched Carbon Nanotube Thin Film Transistors using Metallic Carbon Nanotube Electrode

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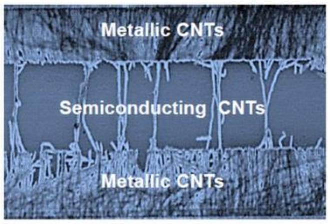
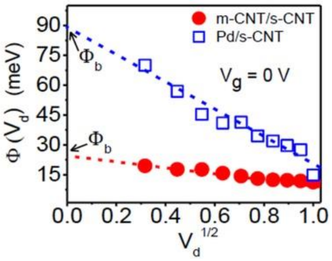
Carbon nanotubes (CNTs) have attracted a significant attention in recent years due to their exceptional electronics, optical and mechanical properties. In particular, CNT thin film transistors (TFTs) are considered as promising active components in the next-generation flexible, transparent, and invisible electronics. Due to lack of transparency and flexibility, metal electrodes are not suitable for CNT TFTs in their transparent and flexible electronic applications. In this talk, we will discuss the high-performance CNT TFTs where densely aligned array of metallic single walled carbon nanotubes (m-CNTs) were used as source and drain electrodes while semiconducting enriched aligned SWNTs (s-CNT) were used as a channel material. The both m-CNTs in the electrodes and s-CNTs in the channel are aligned via dielectrophoresis using a high quality surfactant-free solution. We show that the performance of the s-CNT devices with m-CNT electrodes is significantly improved than that of the devices with Pd electrodes. In order to find the information about injection barrier between s-CNT and m-CNT interface, we carry out low temperature electron transport measurement of our devices. We will discuss the detailed analysis of the low temperature data.





O3A-3

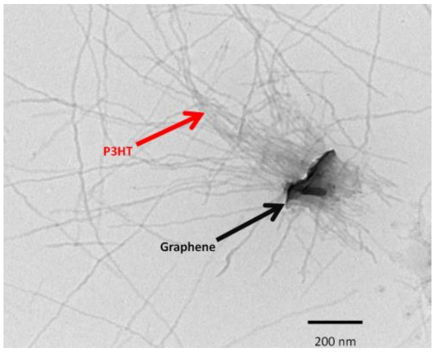
Bottom-up Assembly of Poly(3-hexylthiophene) Nanowires from Graphitic Surfaces for Organic Electronic Devices

Matthew McInnis*, Dr. Lei Zhai*

**University of Central Florida Nanoscience and Technology Center, 12424 Research Parkway, STE 400, Orlando, FL 32826*

Using organic polymers to produce electronic devices such as field-effect transistors (FETs) and organic photovoltaic (OPV) cells could be a viable replacement for traditional silicon-based technologies owing to the ease in their processing, low cost and tunable properties. Necessary hurdles to overcome for this technology include the reproducible incorporation of highly crystalline semi-conducting polymers into strict device geometries and poor metal-organic electronic interface. Conductive polymers, due to their conjugated backbone, have been shown to exhibit one-dimensional fibril growth due to the relatively

strong Van der Waals force of pi-pi intermolecular interaction. Graphite is assembled from many two dimensional, atomically thin sheets of conjugated carbon-carbon bonds adhered through similar pi-pi interaction. Because of the similar surface chemistry, conjugated polymers adsorb to the surface of graphene, creating a nucleation site for further crystallization. Poly(3-hexylthiophene) (P3HT) is a well-studied, conductive polymer that can be crystallized from hot marginal solvent to form nanowires wires that are ~10 nm in width, and microns in length in the pi-pi stacking direction. Through a facile, bottom-up and readily scalable approach, we have shown ordered crystallization of P3HT, nucleated from the graphene surface from solution. This process allows for the self-assembly of conducting and semi-conducting materials into hierarchical structures. Direct growth of P3HT provides an excellent electronic contact with graphene, and the induced ordering during crystallization is enough to permit placement and directionality of P3HT in devices. This should produce FETs with reduced short channel effect and OPV cells with nearly optimal morphologies.



O3A-4

Platinum-black decorated graphene for amperometric sensors

D.C. Vanegas, S.L. Burrs, M. Taguchi, P. Chaturvedi, E.S. McLamore

Carbon and metal nanomaterials exhibit unique properties that are advantageous for electrochemical biosensing such as vast surface area per mass unit, enhanced electrocatalysis, and biocompatibility. Codeposition of nanomaterials together with biorecognition molecules (e.g., proteins) improves the sensitivity, operating range, and response time of amperometric biosensors. This study compares the electrochemical behavior and surface characteristics of four metal-carbon nanomaterial platforms based on platinum-black (nPt) and reduced graphene oxide (GO). The behavior of nPt-graphene composites with different concentrations of GO (1, 2 and 3 mg/ml) was tested for four nanomaterial configurations: electrode/GO, electrode/GO/nPt, electrode/nPt/GO, and electrode/nPt/GO/nPt. The different nanomaterial platform designs were assembled onto Pt/Ir working electrodes and tested against Ag/AgCl reference electrodes. Electrochemical performance was assessed using cyclic voltammetry in potassium ferrocyanide ($K_3Fe(CN)_6$) and DC-potential amperometry in phosphate buffer solution (PBS). Surface characteristics were evaluated through electron dispersive X-ray spectroscopy (EDS) scanning white light interferometry (SWLI) and scanning electron microscopy (SEM). Comparative results on electroactive surface area and sensitivity of the nanomaterial mediated electrodes show a significant improvement in electrochemical activity for the nPt/GO/nPt functionalized electrode relative to the other nanomaterial platforms. Significant differences in surface topography of the different nanomaterial platforms were observed in SEM micrographs and optical profiles. The resulting nanomaterial mediated electrodes will be useful for further development of amperometric biosensors.

O3A-5

Paper-based Electrochemical Immunosensor for DNA Oxidative Damage Biomarker Detection

Xuena Zhu, Chenzhong Li*

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Oxidative stress is an abnormal oxidant system which can be caused by many toxicants exposure. In the presence of oxidative stress, reactive oxygen species generated in vivo can directly cause oxidative damage to lipids, proteins and DNA. In DNA, 8-hydroxy-2’-deoxyguanosine (8-OHdG) is one of the predominant forms of free radical-induced oxidative lesions, and therefore has been widely used as a biomarker for oxidative stress and carcinogenesis. Studies showed that urinary 8-OHdG is a good biomarker for risk assessment of various cancers and degenerative diseases. Urinary 8-OHdG has been measured by many methods, but most of them are usually time-consuming, require specialized lab based equipment, dedicated sample preparation process and professional operators. There is great need for a portable sensing system capable of rapid 8-OHdG measurement in readily available biosamples. Here we develop a carbon nanotube electrode integrated immunochromatographic paper strip capable of quantitative analysis of 8-OHdG in samples. The sensing device combined competitive gold nanoparticle based immunoassay of lateral-flow format with flexible carbon nanotube electrodes for both optical and electrochemical detection. The test strip will provide a point of care testing method for quantitative assessment of DNA oxidative stress with high sensitivity, specificity, speed of performance and the advantages of simplicity.

O3B - BIO-MAGNETICS

O3B-2

Magnetic Microdiscs for Biomedical Applications

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Micron-sized spin vortex discs are of significant interest for various biomedical applications, due to their near-zero remanence but significantly larger mass/volume compared to nanometer-sized superparamagnetic nanoparticles. Their larger magnetic moment (up to 10,000x) enables much larger forces to be applied to target structures, such as cells. Another advantage of these discs in bio-applications is their anisotropy, enabling the generation of a magnetic torque via application of an AC external magnetic field [1,2].

Magnetic discs are fabricated in large arrays on a 200-nm thick sacrificial layer made of PMMA, and then released in a solvent. First, a mask is obtained by exposing a bi-layer of a positive photoresist and a lift-off resist by UV direct laser lithography. Then, a 50-nm thick supermalloy ($Ni_{80}Fe_{15}Mo_5$) layer is sputtered and lifted-off to obtain 1 µm magnetic discs (Figure 1-a). This process produces 28 million magnetic discs/cm^2, which are then magnetically characterized. Here, measurements of hysteresis loops are made on disc arrays for different angles with the external field. These measurements will enable the evaluation of the 3D tensor of the apparent susceptibility, needed in further work on computational simulations of rotational Brownian dynamic in colloidal suspension.

For biomedical applications, the magnetic discs can be released from the substrate in acetone (Figure 1-b). These micro-structures, after surface chemistry functionalization, will be investigated in biological environments (Figure 1-c) to facilitate targeted drug delivery and/or actuation of cell membranes when applying an AC external magnetic field.

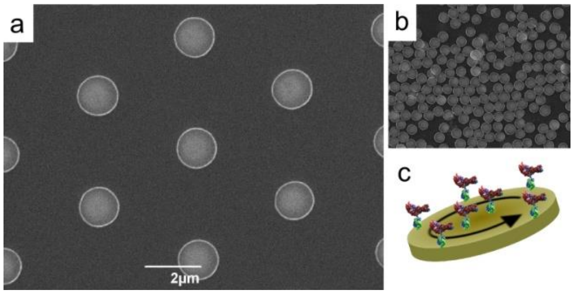

Figure 1: a) Magnetic discs fabricated on a sacrificial layer, b) released discs, and c) schematic of functionalized spin vortex disc

[1] D.-H. Kim, E.A. Rozhkova, I.V. Ulasov, S.D. Bader, T. Rajh, M.S. Lesniak and V. Novosad, "Biofunctionalized magnetic-vortex microdiscs for targeted cancer-cell destruction", Nature materials, Vol. 9 (2010)

[2] E.A. Rozhkova, V. Novosad, D.-H. Kim, J. Pearson, R. Divan, T. Rajh, and S. D. Bader, "Ferromagnetic microdisks as carriers for biomedical applications", Journal of Applied Physics, Vol. 105, 07B306 (2009)

O3B-3

Soft ferromagnetic amorphous microwires as promising magnetic biomarkers in biosensing applications

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Magnetic nanoparticles are being used as magnetic biomarkers in biomolecular detection [1]. In this case, they are required to have high magnetic moment and negligible coercivity and can be easily functionalized with a biopolymer. However, the magnetic properties of nanoparticles after functionalization are reduced significantly, making them impractical for such applications. Recent research has thus been focused on exploring magnetic nanowires and magnetic carbon nanotubes as promisingly alternative magnetic biomarkers [2].

Here, we propose an approach to using soft ferromagnetic glass-coated amorphous microwires as an alternative to magnetic nanoparticles for biomolecular detection. These microwires exhibit very high magnetization and nearly vanishing coercivity and have been extensively explored for making sensitive magnetic sensors based on the giant magneto-impedance effect [3]. $Co_{68}B_{15}Si_{10}Mn_7$ microwires fabricated by the Taylor-modified technique have been functionalized with an elastin-like biopolymer. A new type of sensor that utilizes change in the inductance of a non-magnetic coil with magnetic field has been developed to detect the magnetic signal of these functionalized microwires. We find that the presence of even a single microwire results in a large change in the inductance of the coil ($\Delta X/X = 120\%$ at 0.5 MHz) and increases significantly with increasing the number of microwires. This shows the sensor's high capacity of detecting microwire-based biomarkers at various concentrations. As compared to Fe_3O_4 nanoparticles and magnetic carbon nanotubes, the functionalized microwires yield much higher detection sensitivity (~35 times). These results indicate that soft ferromagnetic glass-coated amorphous microwires have potential to replace magnetic nanoparticles as magnetic biomarkers in biosensing systems.

[1] J.B. Haun et al., Wires Nanomed. Nanobi. 2 (2010) 291-304.
[2] I. Monch et al., J. Magn. Mgn. Mater.290–291 (2005) 276–278.
[3] M. H. Phan and H. X. Peng, Prog. Mater Sci. 53 (2008) 323–420.

Acknowledgements:

This work was supported by was supported by the Florida Cluster for Advanced Smart Sensor Technologies (FCASST) and USAMRMC through grant number W81XWH-07-1-0708.

O3B-4

Optimization of GMI effect and field sensitivity of soft ferromagnetic amorphous ribbons for sensitive detection of weak fields arising in biomarkers

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Giant magnetoimpedance (GMI) effect of soft ferromagnetic materials is a promising candidate for the development of a new class of highly sensitive, portable, and low cost magnetic biosensors [1].GMI is a large change in the ac impedance of a magnetic conductor under the presence of an external dc magnetic field. Research has shown that it is highly sensitive to detect low concentration of magnetic nanoparticles [2].In order to realize its full potential and apply to detect very small concentrations of magnetic biomarker in biological fluids, however, the detection sensitivity of the sensor has to be optimized.

In this study, we present the optimization of GMI ratio and field sensitivity of a soft ferromagnetic amorphous ribbon by controlling the anisotropy effect and edge geometry. The anisotropy effect was studied by comparing the GMI profiles of two identical samples with transversely and longitudinally aligned magnetic moments. We find that the GMI ratio and field sensitivity of the sample with transverse anisotropy is much higher than that with longitudinal anisotropy. The effects of trapezoidal, rectangular, half hexagonal, and triangular geometries on GMI were also studied on both samples. The observed results reveal that the GMI effect and field sensitivity of a soft ferromagnetic amorphous ribbon could be improved by optimizing the transverse anisotropy and edge geometry. This study is of high importance in developing a highly sensitive magnetic biosensor to detect very weak fields arising in biomolecules.

1. M.H. Phan and H.X. Peng, Prog. Mater. Sci. **53**, 323 (2008)
2. J. Devkota et al., J. Appl. Phys. **113**, 104701 (2013)

Acknowledgments:

This work was supported by was supported by the Florida Cluster for Advanced Smart Sensor Technologies (FCASST), USAMRMC through grant numbers W81XWH-07-1-0708 and W81XWH1020101/3349, and the research experience for undergraduates program at University of South Florida.

O3B-5

Near Infrared Fluorescent and Magnetic Silica Nanoparticles for Bio-imaging

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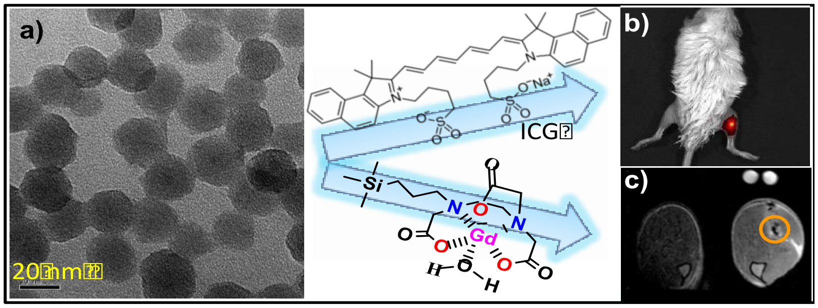
[1]Materials Science and Engineering & Particle Engineering Research Center, [2]Physiology and Functional Genomics, [3]Advanced Magnetic Resonance Imaging and Spectroscopy Facility, Mcknight Brain Institute, National High Magnetic Field Laboratory, [4]Molecular Genetics and Microbiology, [5]Department of Surgery, University of Florida

Indocyanine Green (ICG) dye is the only Near Infra red (NIR) imaging dye approved by Food and Drug Administration (FDA) for clinical applications. Its applications are however limited due to rapid binding to albumin leading to fast *in vivo* clearance. ICG encapsulation in silica nanoparticles has remained challenging due to its amphiphilic nature and chemical instability in physiologically relevant conditions. We have recently reported a reverse microemulsion based approach to synthesize ~25 nm ICG doped silica nanoparticles. The encapsulation of ICG was achieved by manipulating coulombic forces using a combination of bivalent ions and aminated silanes. Dye degradation during synthesis was prevented by carrying out the silica synthesis in mildly basic pH conditions in AOT/heptane/water microemulsion system. The encapsulation of ICG in silica enhanced its photostability and minimized photobleaching as compared to dye alone. In addition paramagnetic properties were added to the nanoparticles by chelating Gadolinium, which allows the particle to act as MR contrast agents. The MR and optical imaging capabilities of these multimodal nanoparticles have been demonstrated through *in vitro* and *in vivo* experiments. The applications of NIR imaging in Duchenne muscular dystrophy will be illustrated.



Figure(a) Shows representative TEM of multimodal nanoparticles; (b) Optical image showing nanoparticles labeled macrophages in mouse thigh muscle; (c) T2 weighted image showing contrast generated from nanoparticles in mouse calf muscle.

[1] Sharma, P., *et al*., Small, **8(18)**, 2856-68 (2012).

O3C - GRAPHENE & CARBON NANO-TUBES

O3C-2

Resistive-elastic behavior of the carbon nanotube/graphene hybrid foams

Francois Wolmarans, Hai H. Van, Shengjuan Li, Alice Daramola, Mei Zhang

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Carbon nanotube (CNT) foam and aerogels hold promise in the area of strain sensors because of their resistive-elastic behavior under compressive strain. To date one of the largest impediments in the area of CNT foam and aerogels has been the lack of control over the porosity and microstructure. Here we show that using thermoplastics to create pores in our CNT foam, we can control the size and shape of the pores, and therefore the porosity of our foam. By using polyacrylonitrile (PAN) as precursor, we made CNT/graphene hybrid foam (Fig. 1a). Carbonization of the PAN precursor creates graphene features in CNT foam, which dramatically improve the robustness of the foam. By varying the ratio of thermoplastic, as well as PAN, to CNT, we successfully controlled the porosity, density, and the resistivity of the foam.

We then investigated the resistivity response of the hybrid foams to elastic deformation. When constant voltage was applied over cycles of compression and release, the foam exhibited cyclical resistive behavior in response to the cycling force. In compressive strain testing, samples subjected up to 60% strain kept their original shape and elasticity (Fig. 1b).Most importantly, the sample exhibited equal and corresponding resistive behavior during the release portion of cycling, thereby exhibiting reliability as a strain sensor. In a world where information systems are becoming more and more dynamic, our CNT foam holds promise as a lower cost alternative to the status quo of CNT foams for dynamic sensing purposes.

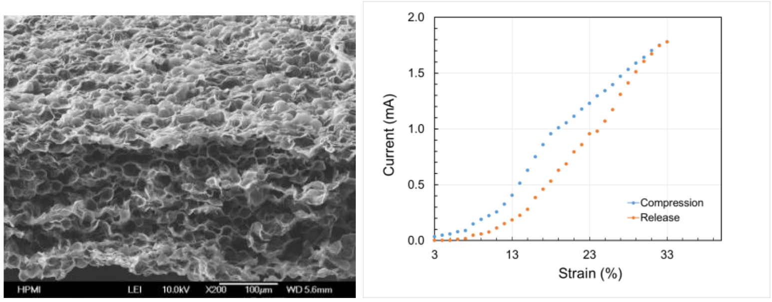

Figure 1. (a) The scanning electon microscope (SEM) image of the CNT/graphene hybrid foam and (b) Current response to compressive strain cycling.

O3C-3

Performance Enhancement of Phase Change Memory by Carbon Nanotube Contacts: a 3D Simulation

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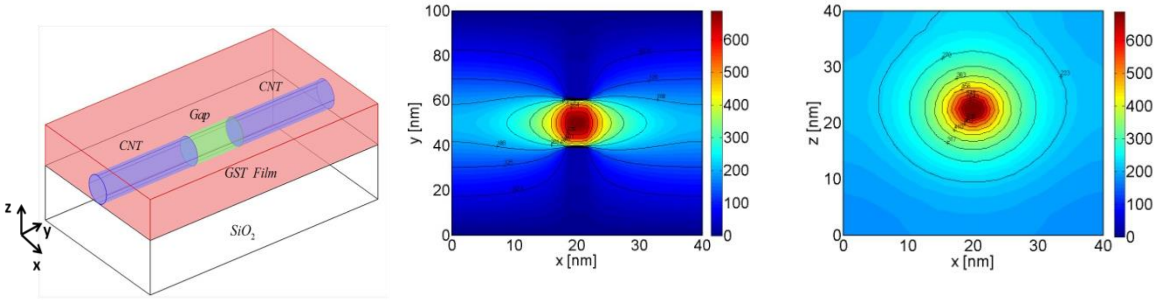
Carbon nanotube enabled phase change memory (CNTPCM) has been experimentally investigated and demonstrates two orders of magnitude less current/power consumption compared to state of the art PCM technology [1], providing a promising alternative for next generation data storage devices. A three-dimensional finite element simulator is developed to provide a rigorous physical description of thermal conduction behavior of CNTPCM for device performance optimization purpose. Thermal boundary resistance (TBR) which plays a critical role in heat confinement is treated carefully by introducing an interface region with a certain thermal conductivity corresponding to the value of thermal boundary resistance. Engineering of TBR is helpful to improve PCM performance. Transient analysis is also performed and concludes that CNTPCM has much quicker response time to programming current pulse showing potential for lower programming time and hence low energy consumption. Scaling analysis of gap size shows there is an optimum gap size between carbon nanotube contacts, however the relatively small gap may have not enough resistance for differentiating its amorphous state from crystalline state and thus affect bit detection. Simulations shows carbon nanotube diameter scaling plays the most important role on improving device performance, and the set/reset power can be reduced to 1 µW/1.5 µW with a 1nm diameter carbon nanotube.

[1] F. Xiong , et al., Science 332, 568, 2011.



(a) (b) (c)

Fig. 1 (a) Simulated device structure. Here, the GST film is treated as electrical insulator because current mainly flows through nanotube due to its large electrical conductivity. (b) Temperature change profile in x-y plane cutting in the middle of nanotube. (c) Temperature change profile in x-z plane cutting at the middle of the gap region.

O3C-4

Selective Graphene Synthesis by Pulsed Laser Annealing Ion Implanted SiC substrates

Kara Berke[2], Xiaotie Wang[3], Dinesh K. Venkatachalam[4], Maxime G. Lemaitre[1], Sefaattin Tongay[2], Joel Fridmann[5,6],Brent P. Gila[1,6], Robert G. Elliman[4], Fan Ren[1,3], Arthur F. Hebard [2] and Bill R. Appleton[1,6]

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We investigate a method for site-selective graphene growth on SiC substrates as a means of accomplishing direct nano-scale patterning of graphene, eliminating the need for conventional lithographic techniques. Through ion implantation, crystalline SiC substrates are amorphized then subjected to pulsed laser annealing; graphene growth occurs only where ions have been implanted. This process can be implemented in a variety of environments (air, Ar, N_2, vacuum, etc.) while the bulk of the substrate remains close to room temperature. Our previous work in this area involving Au, Cu, and Ge implants suggests that both the implanted species and the surface damage during ion implantation are factors in the selective synthesis of graphene. In this work we investigate to what extent each of these factors contributes to the growth process. Sic samples were prepared under a variety of ion implantation conditions and annealed using a 25ns pulsed ArF laser. Rutherford Backscattering (RBS) measurements were used to determine the depth profiles of implanted species and the corresponding thickness of the amorphized surface layers prior to annealing. Raman spectra, scanning electron microscopy (SEM) and cross sectional transmission electron microscopy (TEM) images were taken to confirm the presence of graphene after annealing and identify structural changes in the substrate.

O3C-5

Interface and Performance Improvement of CNT Buckypaper Composite Actuators

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CNT buckypaper composite actuators (BCAs) have displayed great potential as artificial muscles due to their lightweight, large deformation, ease of fabrication and potential for mass production. The muscles that birds utilize during flight have provided an adequate model and information for the design of artificial muscles using lightweight and flexible actuator materials. Their muscles expend minimal energy to produce large displacement and blocking force at various frequencies for a long period of time. The BCA is a bimorph structure comprised of a soft Nafion ionomer membrane sandwiched between two sheets of high conductive buckypaper. Nafion's ion diffusion capability is crucial for the BCA actuation performance, while the BPs function as electrical contacts. The key performance mechanism lies within the interface between the electrode and Nafion electrolyte, as ions migrate through the interface into the BP's network inducing BCA deformation. During actuation, the interface weakens due to lack of stability, and the actuator's performance diminishes significantly. The interface is created by casting a thin Nafion film onto the BP before fabrication. The film is casted from a purchased Nafion solution diluted by alcohol and water; this solution produces an easily dissolvable and brittle film. In this research, a mixture of dimethylformamide (DMF) and tetrachloroethylene (TCE) has proven to be a much better bi-solvent for creating a strong film with good ion transport properties. The proposed approach is able to create a stronger interface that facilitates the ion diffusion. This paper will introduce the approach and evaluate the performance against current approaches.

PA - NANOMATERIALS

PA-01

Band Offsets in nm-Scale Dielectric/$InGaZnO_4$ Heterojunctions

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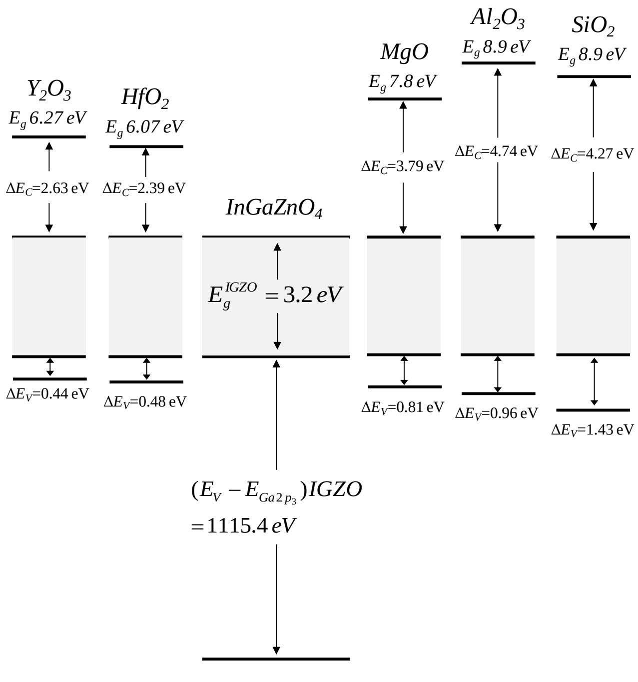
$InGaZnO_4$ (IGZO) is attracting much attention for flat panel displays and flexible thin film transistors (TFTs) because it is optically transparent in the visible range, can be deposited at room temperature and exhibits superior electrical characteristics (10-50 $cm^2 \cdot V^{-1} \cdot s^{-1}$ even in the amorphous state). This raises the possibility of making low-cost electronics on a very wide range of arbitrary substrates. A major remaining issue with IGZO is a better understanding of the appropriate choice of compatible gate dielectrics for TFTs fabricated using IGZO channels. We have determined the energy discontinuity in the valence band (ΔE_V) and conduction band (ΔE_C) of various dielectric/IGZO heterostructures determined from X-ray photoelectron spectroscopy (XPS). Dielectrics included nm layers of SiO_2, Al_2O_3, HfO_2, MgO, and Y_2O_3. Values of ΔE_V and ΔE_C for each of these dielectric/IGZO heterostructure systems were obtained by using the Ga 2p3/2, Zn 2p3/2 and In 3d5/2 energy levels as references. The measured energy discontinuity in ΔE_V and ΔE_C of various dielectric/IGZO heterostructures is shown below. These results are important for designing structures with good carrier confinement in transparent IGZO TFTs.



PA-02

A New Platform for Multiferroic Materials: Multilayer Magnetoelectric Nanofibers Synthesized via Electrospinning

Justin D. Starr and Jennifer S. Andrew

University of Florida, Department of Materials Science and Engineering Gainesville, FL 32611

Nanofibers are excellent candidates for magnetoelectric multiferroic composites that rely on strain-induced coupling. Well-designed structures can create a large contact area between phases while retaining access to each of the constituents. In this research, we describe a new platform for multiferroic materials: layered, Janus-type nanofibers. These fibers are synthesized by electrospinning ferroelectric ($BaTiO_3$) and ferromagnetic ($CoFe_2O_4$) phases such that they are aligned along the length of a nanofiber. While this platform was initially created for bilayer structures, we have demonstrated that it can be easily extended to trilayer, and multilayer designs. Further, we show that the degree of magnetoelectric coupling is closely tied to nanomorphology, and by changing the arrangement of layers and interfacial contact area, we are able to tune the overall multiferroic behavior of these composites. Magnetization as a function of time data and its first-derivative, collected using a vibrating sample magnetometer (VSM), reveals a marked change in the magnetization behavior of the composites near the ferroelectric Curie temperature of barium titanate. The magnitude of this change varies based on the number and arrangement of the ferroelectric and ferromagnetic layers, showing a direct link between processing, structure, and properties of these composite materials.

PA-03

Polymer Nanocomposites for Early Diagnosis of Lung Cancer

Stefan J. Kelly, Emilie Secret, Kelsey E. Crannell, & Jennifer S. Andrew

Lung cancer is the most frequent cancer worldwide for men, and second only to breast cancer for women. However, lung cancer is the leading cause of cancer death worldwide. Yet, if cancer is detected at its earliest stages it is a treatable, if not curable disease. In this study enzymatically degradable hydrogels loaded with Si quantum dots will be utilized for lung cancer detection. An enzymatically cleavable peptide linker will be incorporated into the polymer backbone and will break down in the presence of matrix metalloproteinase-9 (MMP-9) enzymes, which are overexpressed in lung cancer. The release of Si quantum dots from the gel will indicate a positive diagnosis. Shallow degradation profiles of the polymer-peptide hydrogels in the presence of a PBS solution indicate a slow breakdown of the hydrogels in the body with the absence of the MMP-9 enzyme, which will prevent the release of quantum dots in the case of a negative diagnosis. Current research shows the peptide has been fully incorporated into the hydrogel, confirmed by FTIR. Hydrogel swelling experiments reveal that crosslink density, mesh size and swelling ratios can be tuned by varying the concentration of peptide linkers in the hydrogel matrix. Degradation profiles of the hydrogel nanocomposite in a MMP-9 concentrated solution will be presented. Cell toxicity data will also be reported.

PA-04

Removal of Silver form Aqueous Solution by Multi-Functional Nanocomposites Prepared from Biochar, Chitosan, and Nanoscale Zero Valent Iron

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In this work, synthesis, characterization, and environmental applications of carbon based nanocomposites made from nanoscale zero valent iron, chitosan, and bamboo biochars (BBCF) were investigated. We found the BBCF could quickly and efficiently remove Ag(I) ions from aqueous solutions. The zero valent iron on the nanocomposites surfaces reduced the Ag(I) ions to nanosized Ag^0 particles, and the removal kinetics could be well described by the pseudo-second order kinetics model. The removal mechanism was determined by comparing the characterization data of the pre- and post-sorption BBCF. In addition, growth inhibition experiments were conducted and showed that the post-adsorbed BBCF can inhibit the growth of E. coli. Thus, the spent adsorbent can be used as a sterilizer.

PA-05

Scalable fabrication of monolayer colloidal crystals and plasmonic nanostructures

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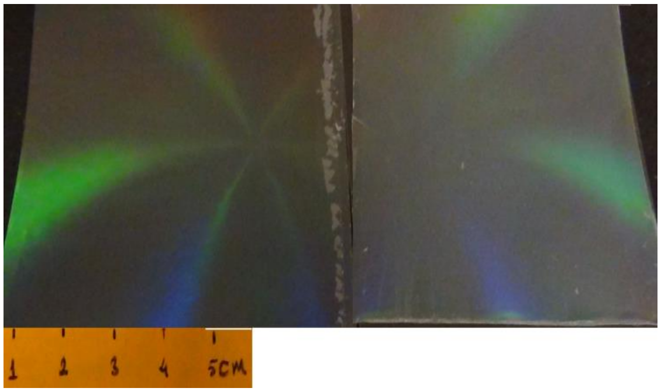
Self-assembled two-dimensional (2-D) colloidal crystals have been extensively utilized in the so-called colloidal lithography (or nanosphere lithography) for fabricating a wide spectrum of functional periodic nanostructures for important technological applications ranging from sensitive plasmonic biosensors to high-density magnetic recording media. Here we report a simple and scalable colloidal transferring technique for fabricating highly ordered 2-D colloidal monolayers with unusual non-close-packed structures on a large variety of substrates (e.g., plastics and glass). A copolymer consisting of 1:1 ratio of ethoxylated trimethylolpropane triacrylate (ETPTA) and polyurethane is used as the particle transferring agent to transfer colloidal monolayers from a self-assembled 3-D colloidal crystals in a layer-by-layer manner. The optical transparency, flexibility, and durability of the copolymer enable wafer-scale transfer of colloidal monolayers onto both flat and curved surfaces, which are not easily available by current top-down and bottom-up approaches. We also demonstrate the templating fabrication of periodic arrays of plasmonic nanostructures, such as gold nanodots and nanoholes, by using a transferred monolayer non-close-packed colloidal crystal as structural template. The resultant plasmonic arrays exhibit high surface plasmon resonance (SPR) sensitivity and surface-enhanced Raman scattering enhancement factor.



PA-06

Size and Phase Selective Synthesis of TiO2 Nanoparticles and their Catalytic Activity

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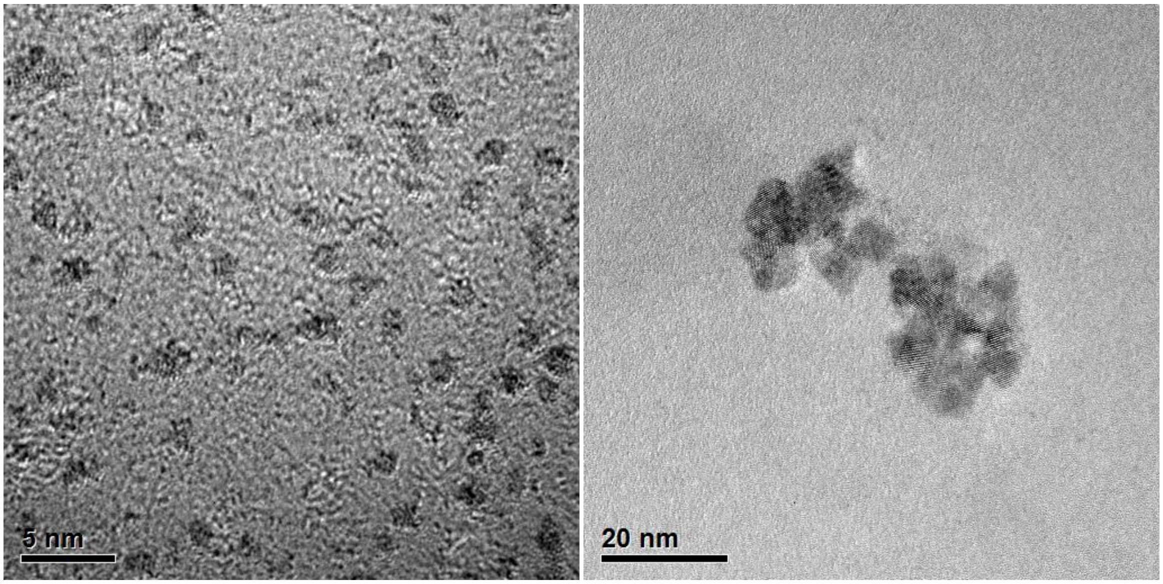
Advanced Materials Processing and Analysis Center, University of Central Florida, Orlando, FL-32816

Nanotechnology is emerging as a promising field to deal with the long lasting environmental and energy challenge. Redox active nanoparticles are the key solve these problems and TiO2 is one of them. TiO2nanoparticles are well known for its catalytic activity in water splitting, gas conversion, solar cell etc. Catalytic activity of TiO2 highly depends on phase and size of the nanoparticles. Present work focus on the size and shape selectivity of the synthesis route for rutile, anatase and amorphous TiO2 nanoparticle. Titanium isopropoxide was used as precursor. Hydrolysis of titanium isopropoxide was carried out at different temperature to obtain crystalline and amorphous structure. Temperature variation during the synthesis also leads to polymorph anatase and rutile. Nanoparticles were characterized using Fourier transform infrared (FR-IR) spectroscopy, x-ray diffraction (XRD), high resolution transmission electron microscopy (HRTEM), visible and ultra violet (UV-Vis) spectroscopy, and photo luminance (PL). Catalytic activity of the TiO2 nanoparticles is evaluated.



PA-07

Large Area Deposition of Nanofibers using Multiple Tube Nozzle Electrospinning and Spatial Thickness Variation Analysis

Sheng-Po Fang, Pit Fee Jao, and Yong-Kyu Yoon

Electrical and Computer Engineering, University of Florida

High throughput, large area nanofiber deposition could be realized using multiple tube nozzle electrospinning (TNE). Since a discrete number of tubes and nozzles are used in multiple TNE and the pitch between tubes and nozzles are nontrivial, the thickness of the deposited nanofiber stacks on a large substrate shows spatial variation. In this work, large area deposition of nanofibers using electrospinning with 2 tubes with 2, 4, and 8 nozzles is investigated and the spatial thickness variation on a substrate with a 3” span is analyzed. Two low density polyethylene tubes with 2, 4, and 8 nozzles are implemented to increase a nanofiber deposition rate. The polymer solution consisting of 60.85 wt% of SU8 2025 (Microchem, Inc.) and Cyclopentanone is used. The diameter of the electrospun SU8 nanofibers is in the range of 287 nm to 566 nm. Nanofiber stacks with a porosity of 29.1% and an average pore size of 0.31 μm^2 are obtained. An SU8 nanofiber stack with a maximum thickness of 81.84 μm is obtained in 480 seconds as shown in Fig. 1. Variation of porosity and pore size as a function of the nozzle number and the nozzle diameter are studied and summarized in Table 1. The average thickness of the outer portion from each tube is 1.73 times thicker than the center portion between two tubes. This is speculated that the micro jets from each tube have the same electrical polarity and therefore experience repulsion force, resulting in being pushed away from the center line.

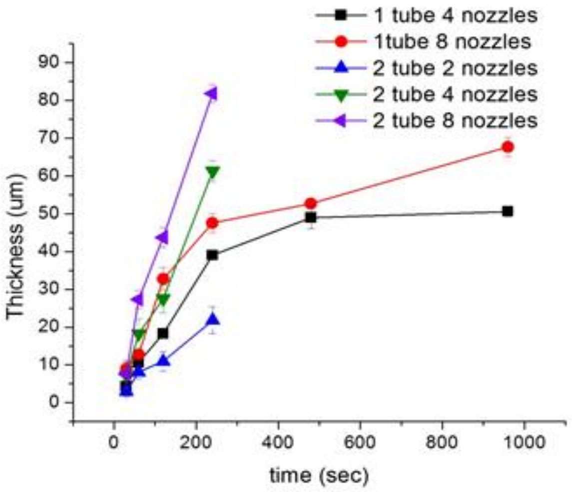


Figure1. Deposition rate of multiple TNE compared with single TNE

Table 1. Porosity and average pore size with different nozzle size and tip-to-collector distance at a constant voltage of 12.5 kV

Tip-to-collector distance [cm]	7.5	10	12.5
Nozzle diameter = 0.2mm			
Porosity [%]	29.1	31.0	35.3
Pore area [μm^2]	0.31	0.52	0.57
Nozzle diameter = 0.5mm			
Porosity [%]	56.9	59.0	-
Pore area [μm^2]	0.28	2.46	-

PA-08

Optimization of atomically smooth and metallic surface of $SrTiO_3$

In Hae Kwak, Sima Saedi Varnoosfaderan, Arthur Hebard, Amlan Biswas

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Atomically smooth, TiO_2 terminated $SrTiO_3$ substrates can be prepared using a combination of chemical and thermal annealing treatments. Such substrates have been widely used to grow sharp oxide interfaces between $SrTiO_3$ and materials such as $LaAlO_3$. Insulating $SrTiO_3$ can also be made metallic by inducing oxygen vacancies or by doping with metals such as niobium. However, such treatments usually generate a rough surface. Thus, further growth of epitaxial thin films or study of the surface itself has been limited despite the potential applications of metallic $SrTiO_3$. Here, we report the optimal conditions to fabricate atomically smooth and metallic $SrTiO_3$ surfaces. We have combined previous methods of obtaining atomically flat $SrTiO_3$ with an additional vacuum annealing. Compared to the long annealing times and high annealing temperatures used previously, this method yields atomically smooth surfaces with roughness less than one unit cell height. We directly confirmed the metallic characteristic of $SrTiO_3$ using sheet resistance vs. temperature ($R(T)$) measurements (Fig. 1). Atomic force microscope images show the unit cell steps on the surface of this metallic $SrTiO_3$ (Fig.1, inset). The $R(T)$ graph provides information on the physical origin of metallic behavior in $SrTiO_3$, which might also contribute to the current research interest in 2DEG $SrTiO_3$ and oxide interfaces.

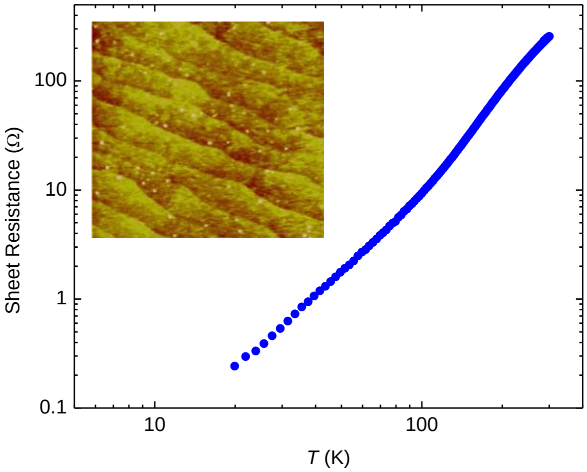

Fig. 1.Sheet resistance vs. temperature curve of vacuum annealed $SrTiO_3$. The inset shows a $3 \times 3\ \mu m^2$ atomic force microscope image of the metallic $SrTiO_3$.

PA-09

Growth and Transfer of High-Aspect Nanowires onto Flexible Substrates

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Nanowire-based devices have gained tremendous interest because of their potential in fabricating devices with ultra-high energy conversion and storage, such as photovoltaics, thermoelectrics, capacitors, batteries, spintronics, and piezoelectrics. Since the device performance is often directly proportional to the active surface area, fabricating vertically aligned nanowire arrays with high density and aspect ratio is important to maximize their efficiencies beyond the current limit. More importantly, many of these devices require substrates with specific properties of flexibility, transparency, and light weight. Thus, the key challenge lying ahead is not only to improve methods to maximize surface area of nanowires but also fabricate them onto a desired substrate. Currently, researchers have not been able to produce nanowire devices with maximum density. Many methods struggle with difficulties in obtaining catalytic seeds with small diameter and maintaining nanowires with small diameter during growth due to the high surface energy associated with substrates. While templated approaches provide an excellent way of demonstrating nanowire density control, it is difficult to form and remove the back electrode and integrate these nanowires into useful devices. In this study, we focused on using the anodized alumina oxide (AAO) as a template for nanowire deposition and then transferring the vertically aligned nanostructure onto a transparent flexible substrate. AAO provides maximum density with its closely-packed hexagonal pore arrangement and, by carefully tuning the experimental conditions, the pore diameter and interpore distance can be precisely controlled. To demonstrate the transfer process, nanowires with various dimensions and materials, including Au, Ag, Cu, Pt, and ZnO, were fabricated using electrodeposition or chemical vapor deposition (CVD). These embedded nanowires were then lifted off and transferred onto a polydimethylsiloxane (PDMS) or ITO substrate. During the AAO etching and drying process, an electrostatic repulsion (ESR) technique was applied to prevent aggregation and keep the nanowires vertically aligned. The current-voltage (IV) response before and after nanowire transfer were measured and compared to demonstrate the efficiency of the transfer process. As a result, nanowires were fabricated and transferred on a flexible substrate with densities and aspect-ratios of 10^{11}/cm^3 and 1000:1 respectively while keeping the vertically aligned architecture. This technique provides a new route of fabricating large-scale, cost-effective flexible optoelectronic devices.

PA-10

New Carbazole-based Host Materials for Highly Efficient, Low Roll-off Phosphorescent Blue Emitting OLEDs

Chaoyu Xiang[1], Rui Liu[1], Wei Wei[2], Pengjie Shi[2], Yong Zhang[2], Viktor Balema[2], Bryce Nelson[2] and Franky So[1]

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Three novel carbazole-based host materials, 9'-ethyl-9,3':6'9"-(9CI)-Ter-9H-carbazole (ETC), 3,3",6,6"-tetrakis(1,1-dimethylethyl)-9'-(ethyl)-(9CI)-9,3':6'9"-Ter-9H-carbazole (BETC) and 9'-phenyl-9,3':6'9"-(9CI)-Ter-9H-carbazole (PTC), are designed and synthesized. These hosts exhibit high triplet energy levels (2.90–3.02 eV) and high glass transition temperatures (> 147℃), which promises high efficiency and improved thermal stability comparing with commonly used carbazole-based host material, 1,3-Bis(*N*-carbazolyl)benzene (mCP).Blue emitting phosphorescent organic lighting-emitting diodes (OLEDs) were fabricated with such host materials doped with the iridium(III) bis (4,6-difluorophenylpyridinato)-picolinate (FIrpic). The optimized device with ETC host showed a turn-on voltage of 2.9 V and a maximum efficiency of 48.4 cd/A at 260 cd/m^2 with a small reduction to 44.5 cd/A at 2600 cd/m^2. The PTC device showed a turn-on voltage of 3.1 V and a maximum efficiency of 35.4 cd/A at 200 cd/m^2, which only reduced to 33.9 cd/A at 2000 cd/m^2. Even though the turn-on voltage of BETC device was up to 5.1 V, the maximum efficiency reached 30.6 cd/A at 124 cd/m^2 with a reduction to 27.8 1240 cd/m^2. Device physics study indicated that not only the mobility of BETC is nearly 2 order magnitudes lower than that of ETC, but also the BETC device was carrier injecting limited.

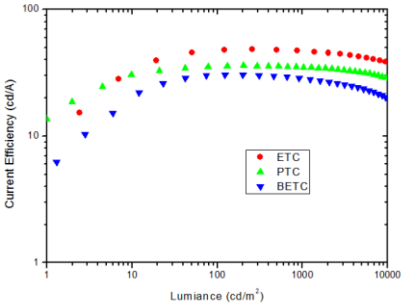

Figure: Efficiency of Blue emitting phosphorescent OLEDs with different host materials

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PA-11

Electrochemical performance enhancement on electrospun TiO_2 nanofibers via calcination atmosphere modification

Rui Qing[1], Wolfgang Sigmund[1]

Department of Materials Science and Engineering, University of Florida

Lithium ion batteries had drawn significant attention for the past decades as the principle energy storage units in portable electronics. However, they barely met the requirements for recent developments in hybrid electric vehicles. The structure stability and rapid solid electrolyte interface (SEI) layer formation in graphite limited expanding applications of LIB. In this presentation, anatase TiO_2 based anode materials with high structure stability for safe applications were studied. TiO_2 nanofibers were prepared using electrospinning. Interwoven morphology of fibers built a hollow framework through which the ternary interface of anode, electronic conductor and electrolyte were increased. Excellent capacity as high as 250 mAh/g and good cycling performance were confirmed for as synthesized fiber in coin cell setup. Direct calcination in argon and post heat-treatment in hydrogen both benefited electronic conductivity and lithium diffusivity in anatase TiO_2 which lead to an improved high rate performance.

PA-12

Electrospinning and Characterizing Polypeptide-based Fibers for a Potential Biomaterial

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Materials made of synthetic organic polymers are ubiquitous. The field of advanced functional biomaterials constitutes a relatively new discipline that blends traditional materials research with the unique properties inherent to biological macromolecules. Genetically engineered, biologically inspired elastin-based materials are such biomaterials of increasing interest for biomedical applications. Our research seeks to exploit the results of genome sequencing for innovative materials design. We investigated the feasibility of utilizing bacteria to synthesize the polymers called elastin like polypeptides (ELPs) needed to manufacture the next generation of materials. The research also has direct relevance to the global competition for energy resources and the need for alternative materials. The goal was achieved by innovatively combining principles and practices drawn from bioinformatics, biotechnology, and materials science and engineering. In the present study a fusion protein strategy was utilized for three crucial purposes: to prepare polymers, to achieve unprecedented material properties and to test fundamental aspects of polymer interaction.

We design novel ELP fusion peptides, joining a spinnable ELP to key sequence motifs from proteins or amino acid compositions based on proteins and thus creating novel bio-inspired peptides. The fusion peptides for electrospinning were selected for water solubility – a pioneering effect of the laboratory. We utilized electrospinning as an inexpensive, scalable, reliable, established and low-risk means of producing fibrous materials. A novel and environmentally benign bio-inspired approach to electrospun fiber crosslinking was investigated. Specific properties of the resulting fibers were determined by physical, chemical and biological methods. The results of this work are relevant to applications of electrospun materials in medicine and biotechnology, for example, tissue engineering scaffolds and wound healing biomaterials. Our work also seeks to develop materials that are innovative and widely useful, display novel material properties and have a minimal environmental footprint.

PB - GRAPHENE

PB-01

One-step Facile Preparation of Graphene Quantum Dots for Ovarian Cancer Detection

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Ovarian cancer is one of the most common cancers among women worldwide. Most ovarian cancer patients are diagnosed at advanced stages and do not live longer than two or three years. Current detection methods have various limitations, including insensitivity, inaccuracy (false positive cases), high costs, and even harmful side-effects. Therefore, early detection of ovarian cancer is highly demanding. In this study, we used graphene quantum dots (GQDs), a type of nanocrystal, as a novel and promising alternative probe for ovarian cancer detection. Due to their unique optical properties, such as strong fluorescent signals and high resistance to photobleaching and chemical degradation, GQDs exhibit excellent potential to be used as a cancer detection probe. Since 90% of ovarian cancer overexpress folate acid receptor, we hypothesize that when conjugated with folic acid (FA) as a specific tumor target ligand, GQDs could be a specific, biocompatible, and affordable probe to detect ovarian cancer at early stages. Highly fluorescent GQDs had been synthesized by a one-step hydrothermal method at our laboratory with an average size of 3.0 nm and height of 1.6 nm. Transmission electron microscopy (TEM), Fourier transform infrared spectroscopy (FTIR), and Raman Spectroscopy were used to characterize the synthesized GQDs. Two ovarian cancer cell lines, SKOV3 cells (FA receptor positive) and OVCAR-3 cells (FA receptor negative), were applied to characterize the detection effects. In conclusion, a facile method has been used to synthesis the GQDs and developed a GQD-based ovarian cancer detection probe by conjugating the GQDs with folic acid. This nano probe will not only help detect early ovarian cancer, but may also be widely used to detect other diseases with specific targets.

PB-02

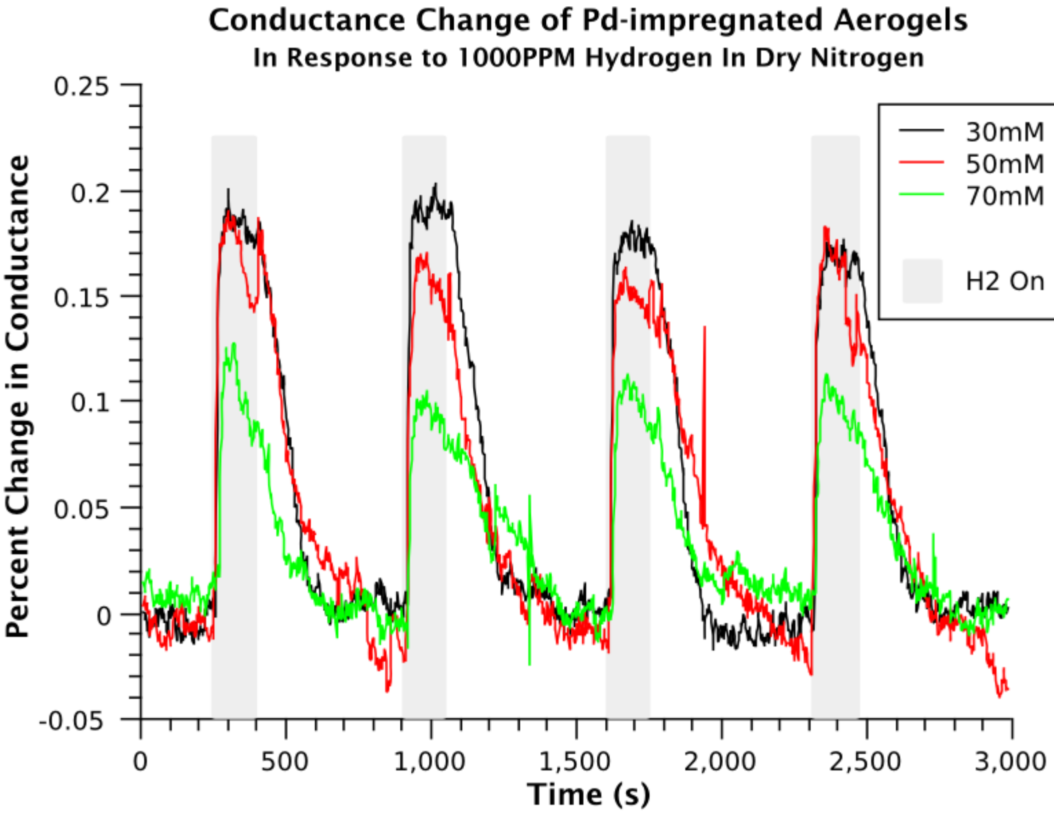
Composite Graphene Aerogels for Hydrogen-Sensing

Joseph Zuyus, Matthew McInnis, Dr. Lei Zhai

University of Central Florida

Graphene oxide (GO) has garnered recent interest because it allows single layers of graphene to be processed in the solution phase. Natural graphite is oxidized; producing negatively charged GO sheet surfaces in the form of carboxylate groups. The GO suspensions are stable due to electrostatic repulsion between these groups. We found that lyophilization of GO suspensions results in free-standing monolithic structures that, after reduction, convert into black, electrically conductive aerogels. Addition of multivalent metal ions to GO suspensions induces gelation due to electrostatic cross-linkage, but these hydrogels collapse during lyophilization. We found that careful selection of metal ligands can shield the electrostatic charge between GO and Pd and Pt ions to facilitate simple loading procedures. The present study reports a novel and facile method for synthesis of low-density (<2 g/cm^3), high surface-area (> 1400 m^2/g), semiconducting reduced graphene oxide aerogels functionalized with metal nanoparticles and their use in conductometric hydrogen sensing at room temperature. By regulating the degree of oxidation, we modify the surface state density, generating a material that ranges from a near zero band-gap semimetal to a large band-gap semiconductor. Aerogels containing Pd or Pt metal nanoparticles demonstrated a

reversible change in conductance in response to hydrogen as a result of Fermi-level pinning at the metal-semiconductor interface. We correlate nanoparticle size, mass loading, aerogel pore size and metal identity with hydrogen sensitivity, selectivity and response time. The described system enables the loading of a wide variety of other materials for sensing other analytes and catalyzing reactions.



PB-03

The Use of Graphene as a Solid-State Diffusion Barrier

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Single crystals of graphene are the strongest material measured to date. However, large area graphene produced by chemical vapor deposition (CVD) is polycrystalline. Perfect graphene domains are impenetrable to all atoms except hydrogen. Grain boundaries of graphene although defective, still retain high strength. In this study we investigate the barrier properties of single layer polycrystalline graphene and bi-layer graphene to copper diffusion into thermally grown 300nm SiO_2 layers on silicon. We calculated through Raman, XPS and Four Point Probe measurements the diffusion coefficients of copper into graphene at temperatures up to 800°C and assess the effectiveness of graphene as a copper solid-state diffusion barrier.

PB-04

Electrochemical Characterization of Hydrogel-Graphene Networks for Enzyme Immobilization

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Agricultural & Biological Engineering Department
Institute of Food and Agricultural Science
University of Florida

Use of catalytic nanomaterials in biosensors is known to increase performance (sensitivity, response time, limit of detection). Real-time, non-invasive biosensors have been utilized to measure intracellular and extracellular analytes in living cells and tissues, including molecules relevant to metabolism and cell signaling. Hydrogels are biocompatible materials that are commonly used to immobilize proteins in biosensors. *This research presents a high fidelity hydrogel created from sustainable materials (waste products from a paper pulp mill).* Various hydrogels (including the hydrogel produced from waste material) were immobilized on a graphene-modified platinum electrode and biosensor performance was characterized using cyclic voltammetry (surface area) and *DC potential amperometry (sensitivity, selectivity, response time and operating range).* When laponite and saponite hydrogels were immobilized on the platinum probe, electron transport decreased by 65-73%; while the lignin-saponite composite had no significant impact on the electroactive surface area. These improvements were attributed to the interaction of lignin with saponite. FTIR analysis confirmed the association of lignin within the clay galleries of the saponite hydrogel. Characteristic C=C stretching was observed at 2861 cm-1 in the composite samples. Improvements in sensitivity to hydrogen peroxide can also be attributed to the presence of lignin in this hydrogel composite. Performance of this hydrogel makes it a candidate for use as an encapsulant that will have minimal impact on biosensor performance compared to other common encapsulants such as glutaraldehyde. In future studies, enzymes will be assembled in graphene-hydrogel composites to detect any interactions between hydrogels and enzymes that would encourage denaturing or hinder performance.

PB-05

Fabrication of Graphene nanoribbons from laser unzipped multiwalled carbon nanotubes

Hai Hoang Van, Kaelyn Badura, Mei Zhang

Graphene has become one of the most attractive materials due to its excellent mechanical robustness and configurable electronic characteristics. Many methodologies have been developed to synthesize graphene and graphene nanoribbons (GNRs). The fabrication process which uses carbon nanotubes (CNTs) as the starting material appears to be one of the most promising methods. Basically, CNTs consist of concentric graphitic shells. GNRs can be fabricated by unzipping the CNTs along their cylindrical axes. Various approaches have been practiced to “cut” the C – C bonds along the tube axis. Most of the methods utilize the chemical reaction between the carbon atoms and other chemical compounds or metal catalysts in liquid phase. These require further purification processes to remove the contaminants. Additionally, these methods make it difficult to obtain the large and flat GNRs.

Our approach is to utilize laser technology to unzip CNTs in a freestanding multiwalled CNT sheet and to modify the GNRs in the solid state. Because the CNTs in the sheet are aligned and uniformly distributed, the GNRs fabricated are freestanding. The continuous scan of the laser beam on the sheet causes the local temperature to instantly rise up and then cool down very fast due to the nanostructure. We are able to produce GNRs and modify their structures through proper control of the laser scan. Our methodology

yields pure and freestanding GNRs, which are large in size and have a flat 2D structure. The detailed results will be presented and the mechanism will be discussed.

PC - CARBON NANOTUBES

PC-01

Do single walled carbon nanotubes decrease nutrient uptake during fish feeding studies?

Bisesi, JH[1], Ponnavolu, S[1], Liu, K[2], Afrooz, N[3], Saleh, N[3], Ferguson, PL[2], Sabo-Attwood, T[1].

[1]Center for Environmental and Human Toxicology, Department of Environmental and Global Health, University of Florida, Gainesville, FL, USA.[2]Department of Civil and Environmental Engineering, Nicholas School of the Environment, Duke University, Durham, NC, USA. [3]Department of Civil and Environmental Engineering, University of South Carolina, Columbia, SC, USA.

The hydrophobic nature of Single Walled Carbon Nanotubes (SWNTs) suggests that in the aquatic environment, these materials will associate with organic matter and sediments. Therefore, foodborne exposure represents a likely route for these contaminants to impact fish. We have previously shown in gavage exposures that SWNTs are not overtly toxic to fish or absorbed in the intestine using near infrared fluorescence (NIRF) imaging to track distribution. However, due to their highly sorptive nature, SWNTs may limit nutrient availability in the presence of food within the digestive system. To examine this phenomenon, we cloned a suite of genes relevant to nutrient transport and processing; peptide transporters 1 and 2 (PEPT1, PEPT2), cholecystokinin (CCK) and lipoprotein lipase (LPL). In preliminary studies, the expression levels of each gene were measured by qRT-PCR in the liver as well as proximal, middle and distal section of fathead minnow intestines. Each gene revealed a specific expression profile where PEPT1 was most highly expressed in the proximal intestine whereas LPL showed the greatest expression in the liver. We are currently exposing fathead minnows to a diet of fish feed laced with SWNTs for 7 days. We will measure expression levels of CCK, LPL, PEPT1 and PEPT2 as well as track and quantify SWNT by NIRF. We hypothesize that SWNTs will not be absorbed in the intestinal tract, but sorption of nutrients by the SWNTs will cause changes in gene expression profiles that mirror those of starved fish, representing a nutritional deficiency during exposure.

PC-02

Synthesis of silicon nanowire on carbon nanotubes by thermal chemical vapor deposition and its application on energy storage

Teng Liu, Mei Zhang

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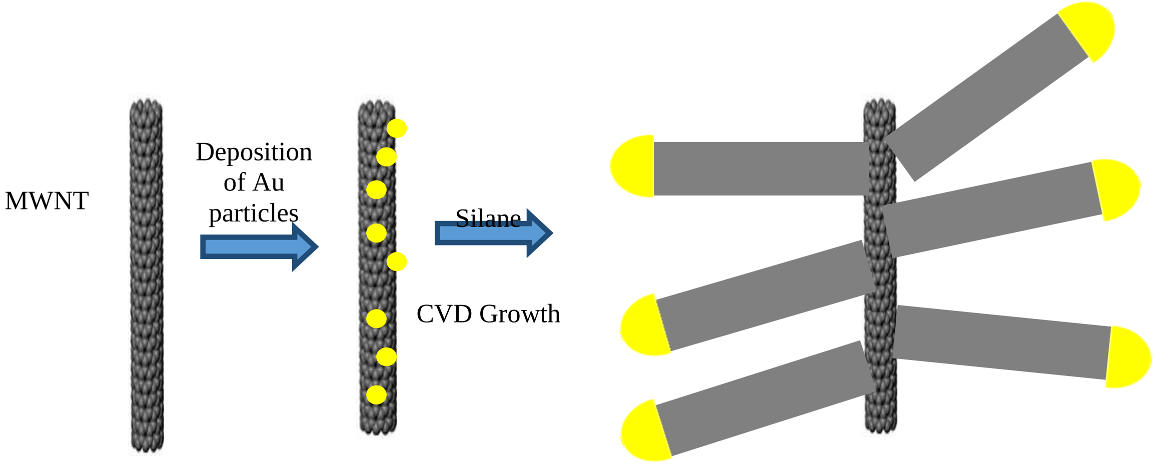
In this work, we show that Au film deposited on MWNT through the method of E-beam served as the substrates to fabricate the Si NWs. This design has several main advantages, firstly, Au could form relatively uniform discrete nanoparticles, eliminating the random diameter distributions of the film breakup on silicon substrates as did previously. Secondly, some recent research showing novel 1D heterostructures comprising vertically aligned multiwall CNTs (VACNTs) containing nanoscale amorphous/nanocrystalline Si droplets deposited directly on VACNTs exhibits impressive reversible stable capacities and good rate capability used as anode materials for Lithium – ion battery gave us excuse (reason) to use the MWNTs / SiNWs hybrid structure as an alternative choice to be applied in anode use, since Si nanoporous 3D structure here could support enough space for the expansion of Si NWs after cycling. Thirdly, here the successful fabrication of Si NWs on free standing MWCNTs sheet can form high mass load of Si NWs by stacking the several layers of MWCNTs together. Through this

design, we successfully achieved the MWNTs/Si NWs hybrid structure, statistical results of diameter distributions of Au particles and SiNWs suggest a more accurate control of diameter of Si NWs is limited in small range of particles, a more uniform control of diameter of Si NWs is under bigger thickness.
This work includes the fabrication of the MWNTs/SiNWs nanostructure and applying such structure into the battery anode fabrication use.



Schematic illustration of the mechanism shows the fabrication of silicon nanowires / multiwall carbon nanotubes nanostructure using CVD (Atomate Inc.)

PC-03

Single-Chirality Separation of Carbon Nanotubes by a simple, rapid single-column separation method

Tianyu Yuan,[1] Justin Clar,[2] Jean-Claude Bonzongo[2] and Kirk J. Ziegler[3]

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[3] Department of Chemical Engineering
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Single-walled carbon nanotubes (SWCNTs) are materials with a large number of potential applications, including biological sensing, electronics and optoelectronics. However, it is necessary to overcome the challenges posed by SWCNT polydispersity to take advantage of their outstanding physical properties in most applications. The separation of metallic and semiconducting fractions of SWCNTs can be obtained by gel chromatography. This large-scale separation process drives the dispersed SWCNTs solution through a column with packed agarose gel. A single surfactant or combinations of them are then used as eluent to release the adsorbed SWCNTs from the agarose gel. Although single SWCNT species have been obtained, the mechanism of separation is still not fully understood. Furthermore, typical single-chirality SWCNT separation by gel chromatography involves the use of multiple columns and repeated iterations, which makes the process slow and unscalable. Here we developed a single-column separation method by which several types of SWCNT species are collected. The technique is easy, rapid and scalable, providing a significant advance to the large-scale production of single SWCNT species. By taking advantage of our understanding of the selective adsorption of semiconducting SWCNTs onto agarose gels, we have improved separation efficiency of SWCNTs.

PC-04

Modulation of Toll-like Receptor Activity and Expression by Single-walled Carbon Nanotubes

Xiao Zheng, Pallab Sanpui, John Lednicky, Julia Loeb, Tara Sabo-Attwood

College of Public Health and Health Professions, Department of Environmental and Global Health, University of Florida

Despite advancement in manipulating nanomaterials and their growing application in a variety of fields, sound understanding regarding the toxicity associated with potential exposures is urgently needed. Single-walled carbon nanotubes (SWNTs) have raised concern about potential adverse health consequences. One area of concern is the ability of inhaled SWNTs to influence the behavior of the immune system that may lead to increased susceptibility to pathogenic infections. We are interested in understanding if SWNTs of distinct chiralities modulate the pulmonary immune response, and if so, whether these effects impact viral infections. Out investigations primarily focus on toll-like receptors (TLRs), which recognize moieties of pathogens as a first line of defense. Our hypothesis is that SWNTs alter TLR activity and expression resulting in the production of cytokines through activation of nuclear factor kappa beta. Furthermore, co-exposures of SWNTs and influenza A virus H1N1 will synergistically activate TLR pathways leading to enhanced inflammation.

Our results produced to date demonstrate that while SWNTs failed to induce activation of TLR2/3 alone, theyenhancedTLR2/3 activity in the presence of their respective agonists. These results suggest that SWNTs may promote TLR responses to pathogens. Using lung cells, we have shown that pre-treatment of cells with SWNTs increases the infectivity of H1N1 while enhancing expression of TLR7, a receptor that recognizes single stranded viral RNA and plays a critical role in virus infection. Overall, these data support the role for SWNTs in modulating TLRs and viral infectivity and is important for assessing safety regimes of engineered nanomaterials.

PC-05

CNT Buckypaper Cross-section Microstructure Study

Andrew Moench, Dr. Richard Liang

High Performance Materials Institute
FAMU-FSU College of Engineering

This work is to explore the processing-structure-property relationships of carbon nanotube Buckypaper. Buckypaper is a freestanding network of carbon nanotubes, between 5-50um in thickness, and has potential applications in aerospace, electronics, filtration, and biosensing. Buckypaper utilizes carbon nanotubes, and their amazing properties, to act as a multifunctional material. Buckypaper is made by mixing carbon nanotubes, water, and a surfactant followed by dispersion techniques and filtration over a microporous membrane. The Buckypaper is then peeled of the membrane to form the freestanding carbon nanotube network. Utilizing ion beam milling techniques for cross sectioning Buckypaper, the nanostructure of the Buckypaper is revealed for studying CNT dispersion, packing, and alignment. The result is used to study processing-structure-property relationships of Buckypaper materials. The goal of

this research is to understand these relationships, and use this information to design and produce higher quality Buckypaper.

PC-06

Interaction of Single-Walled Carbon Nanotubes with Hydrogels: Toxicological Implications.

Justin G Clar[1], Carlos A. Silvera-Batista[2], Jean-Claude J Bonzongo[1], Kirk J Ziegler[2]

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The separation of metallic and semiconducting fractions of as prepared single-walled carbon nanotubes (SWCNT) suspensions is of great interest for their inclusion in a wide variety of devices. A commonly used method to produce high quality separations of the two fractions is through interaction with agarose gels in a packed column. While the production of highly pure fractions is possible using this method, the quantities of nanotubes collected are minimal, requiring further processing before use; making this approach both labor intensive and costly. In addition, current studies of the potential toxicity of SWCNTs have produced conflicting results, in that for the same model organism, both toxic and non-toxic effects are detected. These inconsistencies in observed biological responses may be due to the heterogeneous characteristics of tested SWCNT suspensions as they contain both metallic and semiconducting types. Within we report our findings on the ability to increase the size and scale of the above mentioned separation technique. A successful separation of the two SWCNT fractions was accomplished with a degree of purity similar to that obtained under small scale conditions. Additionally, speciated SWCNT fractions are currently being used in preliminary eco-toxicity studies to discriminate between the biological impacts induced by either metallic or semiconducting SWCNT fractions. Preliminary data indicates interesting differences in test organism response (*P. subcapitata*) when exposed to the identical concentrations of the speciated SWCNTs.

PC-07

Using Photoluminescence and Proton NMR as probes to understand the interaction of surfactants and other adsorbents with single walled carbon nanotubes

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The ability to understand and control the surface structure of nanomaterials is a difficult barrier that must be overcome for their practical application in biology and medicine. Single walled carbon nanotubes (SWCNTs) have a large specific surface area and, thus, a high adsorption capacity. The high adsorption capacity can be utilized for practical applications in drug loading but also has important implications on their fate and toxicity as the materials enter natural systems during production and disposal. The changes that occur to the localized region surrounding individual SWCNT can be tracked by photoluminescence (PL), which has been proven to be a quick and reliable probe of SWCNT surfaces. In this approach, the SWCNTs act like a chemical sensor that qualitatively detects the adsorption of molecules around itself, such as drugs, chemicals, or environmental species. While PL provides information about direct contact

with the SWCNT, Proton NMR is another probe that we have started to use to track the specific interaction of surfactants with SWCNTs and other molecules adsorbed onto their surface. Changes to the NMR chemical shift of the surfactant molecules provides information about their interaction with either the SWCNTs or other molecules. These changes are shown to correspond to molecular structural changes. By combining PL and Proton NMR analysis, we aim to understand the formation and morphology of both surfactant and solvent structures around SWCNTs. We find characteristic trends in the PL and Proton NMR changes that help elucidate the different interactions occurring between SWCNTs, surfactants, and adsorbents. The ability to understand and control the structure around SWCNTs while interacting with different adsorbents has novel applications in drug delivery and will also improve our understanding of the fate and transport of SWCNTs in natural systems.

PD - NANOSCALE PHYSICS

PD-01

Improvement of Microtome Cutting Process to Obtain Ultra-thin Samples for TEM Analysis

Sarah Trayner, JG Park, Yi-Feng Su, Richard Liang

High-Performance Materials Institute
Department of Industrial and Manufacturing Engineering
FAMU-FSU College of Engineering

As research progresses towards nanoscale materials, there has become a need for a more efficient and effective way to obtain ultra-thin samples for imaging under the transmission electron microscope (TEM) for atomic resolution analysis. There are various methods used to obtain thin samples (<50 nm in thickness) for TEM, however, most of the resulting TEM images of soft materials, such as CNT/epoxy composites, are of poor quality due to the sample quality. Such poor quality samples are characterized by uneven sample thicknesses, objective overlapping, overall darkness due to large thickness, and defects such as cutting scratches. In this research, we will study and improve the ultra-microtome cutting technique to provide a repeatable and reliable approach of obtaining an ultra-thin (25-50 nm) cross section of a CNT-polymer composite for high resolution TEM analysis. The improvement will be achieved through design of experiments (DOE) to deduce the relationship between the chosen parameters and sample material. Also, both the thickness and quality of the cut sample will be confirmed through TEM experiments. As a result, we will create a cutting protocol so that ultra-thin sample slices can be achieved by different microtome operators for high resolution TEM analysis and more information can be extracted on the interface of the CNT-polymer composite. Figure 1 illustrates a TEM image of a carbon fiber polymer composite.

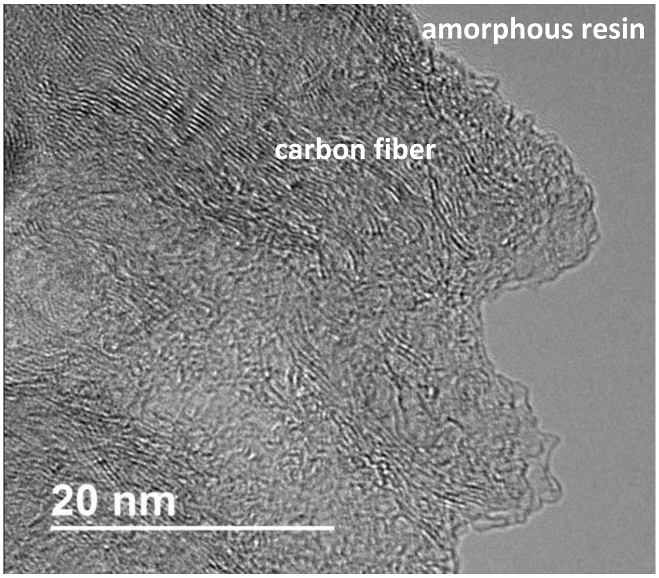

Figure 1: TEM image of carbon fiber polymer composite cut using the ultra-microtome

PD-02

Surface Driven Flows in Ferrofluids

Bhumika Sule[1],Isaac Torres-Diaz[2], and Carlos Rinaldi* [1 2]

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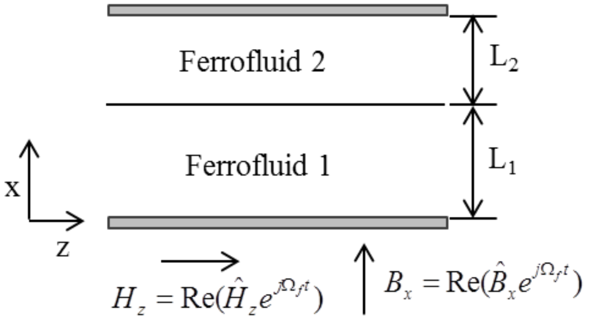
We have obtained the first analytical solutions for the most general case of flow of two layers of immiscible ferrofluids of different thickness between two parallel plates. The flow is mainly driven by the interfacial stress imbalance generated at the ferrofluid-ferrofluid interface due to the application of a uniform rotating magnetic field. Dimensional translational (v_z) and spin velocity (ω_y) profiles were obtained for zero spin viscosity and non-zero spin viscosity cases at different field frequencies and amplitudes. The magnitude of velocity increases with increase in field frequency at a constant field amplitude and increases with the square of magnetic field amplitude at a constant field frequency. The translational velocity varies linearly with distance from the plate and the spin velocity is a constant within each ferrofluid for the zero spin viscosity case. Addition of a pressure gradient causes the translational velocity to acquire a parabolic shape and the spin velocity to vary linearly. In the non-zero spin viscosity case, velocities are in the form of hyperbolic cosine and sine functions. The spin velocity is always in the positive y-direction and addition of a pressure gradient does not significantly change its magnitude. At higher magnitudes of pressure gradient, the pressure gradient dominates the effect of coupling between body torques causing the ferrofluid to flow in the direction of the pressure gradient, thus the direction of translational velocity depends on the magnitude and direction of the applied pressure gradient. This project has the potential of modeling the flow of ferrofluids for microfluidic applications.



Flow of immiscible ferrofluids in a parallel plate channel

PD-03

Complex dynamics of sheared DNA in capillary electrophoresis

Mert Arca[1], Anthony J. C. Ladd[1] and Jason E. Butler[1]

[1]*Department of Chemical Engineering, University of Florida*

Simultaneously applying a parallel electric field and pressure gradient causes migration of DNA in micro-capillaries in the directions perpendicular to the fields. Migration arises from a coupling of electrically driven hydrodynamic interactions between segments of the DNA that is distorted by the shearing flow. This behavior defies common assumptions regarding the electrophoretic motion of DNA, which are based upon observations of the length-independent mobility of DNA in free-solution electrophoresis. The experimental results quantifying the migration will be compared with a theory capable of predicting the migration of the DNA as a function of DNA size and shear rate. The results enables us to determine the effects of the electrically induced hydrodynamic interactions on the migration of DNA and a calculation also demonstrates that the theory is consistent with the observation of length-independent electrophoresis of DNA in free-solution. Technological possibilities of the phenomenon, including the possibility of separating DNA by length in free solution, are also presented.

PD-04

Activatable (OFF/ON) CdS:Mn/ZnS quantum dots (Qdots): spectroscopic studies to investigate interaction of Qdots with quencher

Jeremy Tharkur[1,3], Andrew Teblum[1], Srijita Basumallick[1,2], Rikhav Shah[1], Karishma Cantarero[1], Niharika Maity[1], Sara Rifai[1,2], Mona Doshi[1,2], Andre J. Gesquiere[1,2,4] and Swadeshmukul Santra[1,2,3]

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In recent years, activatable Quantum Dots (AQdots) are gaining popularity in a number of chemical and biological sensing applications. A basic design of AQdot probes involves a suitable quencher which is capable of negatively altering the optical properties of the Qdots. Ideally, upon removal of the quencher, the optical properties of the Qdots should restore. In our previous studies we have shown that CdS:Mn/ZnS fluorescence can be effectively quenched using small molecule quenchers, (such as dopamine, chemotherapeutic drug) as well as iron oxide nanoparticles via an electron/energy transfer process. We have also shown that the quenched Qdot fluorescence can be restored when the Qdots are separated from the quencher. Using this system, we detected an intracellular drug release event. Qdot fluorescence was restored upon interaction with the intracellular glutathione (GSH). In this paper, we sought to understand the effects of GSH on unquenched Qdots. We report a GSH induced quenching of water-soluble N-Acetyl Cysteine (NAC) surface-conjugated CdS:Mn/ZnS Qdots. Quenching of NAC-Qdots was due to aggregation of Qdots in solution. This aggregation induced fluorescence quenching phenomenon resembles the self-quenching phenomenon of traditional organic fluorescence dyes at high concentrations. UV-VIS and fluorescence emission spectroscopy data support the interaction and binding of GSH with the NAC-Qdots. Increase in particle size due to GSH induced aggregation of NAC-Qdots was confirmed by the Dynamic Light Scattering (DLS) data.

PD-05

Superhydrophobicity of biomimetic structures

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Superhydrophobic materials, which possess high contact angles(CA) and low contact angle hysteresis(CAH), have various potential applications, such as self-cleaning surfaces, de-icing coatings, oil-water separation, and drag force reducing surfaces. Additionally, to make water easily roll off a surface, typically generated by surface chemistry and topography is considerably important for superhydrophobicity. Previous studies on superhydrophobic patterned surfaces rarely reported the effect

of mechanical properties, which plays an important role in some water-repellent hairy insects. Here the relationship between the mechanical properties and water repellency was explored by studying the droplet bouncing on pillar-structured soft substrates. Water droplets impacted the polydimethylsiloxane (PDMS) substrate with various velocities. The PDMS substrates were prepared by membrane casting where we controlled the stiffness by varying the ratio of curing agent. The results showed that the softer PDMS, the water is likely to be rolling off more easily. The droplets bounced off more vigorously on soft substrates_regardless the surface structure. We argued that the mechanical response may hinder the transition from the Cassie-Baxter state to the Wenzel regime. The dynamic impact behavior is of fundamental importance in the design of robust superhydrophobic surfaces.

PD-06

Nanotechnology Through Web-Assisted PBL

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A project involving the development web-assisted multimedia modules for problem-based learning (PBL) in nanotechnology will be discussed in this presentation. With funding three interactive multimedia modules were developed to engage students in problem-based learning in nanotechnology related to real world applications. The modules dealt with Consumer choice in health products (*Catching the Rays)*, Clean energy (*Going Green)*, and Ethics and societal issues (*Friend or Foe)*. Each module followed a cognitive learning cycle with a context-based Challenge, a sequence of instruction to stimulate students to generate Thoughts, Research involving data collection, formative feedback for Assessment, and sharing solutions with others through Wrap Up. The modules were field-tested among elementary grade students (N = 40).Results showed a significant ($p< 0.05$) pre- to post-test gain in student conceptual understanding. Post-test interview showed application to consumer decision-making, health and ethics, and scientific process etc. A follow up study of the *Catching the Rays* module showed significant ($p<0.05$) gains in science conceptual understanding, attitude towards science, and perception of science in society of elementary students (N = 46).Web-based PBL in nanotechnology seems to be an effective way of learning science among elementary students. Recently K-12 standard specific science literacy strategies were incorporated into the three modules with appropriate teaching resources. Policy and curriculum implications will be discussed.

PD-07

Decoherence-assisted Electron Trapping in Quantum Dot

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We present a theoretical model for the dynamics of an electron that gets trapped by means of decoherence in the central quantum dot (QD) of a semiconductor nanoring (NR) made of five QDs, between 100 K and 300 K. The electron's dynamics is described by a generalized master equation with a Hamiltonian based on the tight-binding model, taking into account electron-LO phonon interaction (ELOPI). Based on this

configuration, the probability to trap an electron with no decoherence is almost 58 %. In contrast, the probability to trap an electron with decoherence is 83% at 100 K, 74% at 200 K and 67% at 300 K. Our model provides a novel method of trapping an electron at room temperature, which could be used to implement an electrically driven single photon source (SPS) operating in the wavelength range of lambda = 1.3 - 1.5 μm between 100 K and 300 K.

PD-08

Impact of Atomic Layering on Surface Composition and Activity of Pt-Ru Bilayer Catalyst

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Understanding the relation between the surface composition of a catalyst and its catalytic activity toward species is essential in enhancing the science of catalysis. Present literature suggests that a Platinum-Ruthenium alloy in a 1:1 ratio exhibits the highest catalytic activity. Here, we correlate the activity of a bilayer Pt-Ru catalyst to its surface composition. We show that the catalytic activity is independent of the material of the exposed surface, and that a surface with a fixed number of layers of either one of the metals on the other exhibits the highest activity level. The studies were conducted on Ru-Pt catalysts with a varying number of Pt layers, and on Pt-Ru catalysts with a varying number of Ru layers, prepared using the atomic layer deposition (ALD) process. Measurement of the surface catalytic activity and composition were conducted using cyclic voltammetry (CV) and copper under potential deposition (Cu-UPD) techniques. CV studies show a change in catalytic performance with a variation in the number of surface metallic layers. Cu-UPD showed the presence of only one metal on the catalyst surface. This change is perceived to be due to the underlying metal, affecting the Fermi level and lattice parameter of the surface metal, and hence influencing its catalytic properties. The results of this work enhance our understanding of bimetallic catalytic systems and facilitate the fabrication of more efficient catalysts.

PD-09

Plasmon-Enhanced CO Oxidation in Au-$SrTiO_3$ Nanostructures

Brendan C. Sweeny,[1] Qian Kun, [1] Joseph S. DuChene, [1] Jingjing Qiu, [1] Aaron C. Johnston-Peck,[2] Dong Su,[2] and Wei David Wei[1*]

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The engineering of visible-light responsive photocatalytic materials remains a considerable challenge for the realization of efficient visible-light photocatalysis. Irradiation of noble metals at their plasmon resonance frequency leads to a “hot” electron distribution capable of facilitating a variety of catalytic reactions. By integrating Au nanospheres, an active plasmonic material, with $SrTiO_3$ nanocubes, a catalytically active metal-oxide support, the optical response of the hybrid photocatalyst is broadened into the visible range. A wavelength-dependent enhancement of CO oxidation activity that reflects the plasmon resonance frequency of the Au nanostructures is observed, indicating the utility of plasmonic nanostructures for photocatalysis. These results demonstrate the merits of using visible-light to manipulate the electronic structure of plasmonic nanostructures for aerobic oxidation reactions.

PD-10

Optical field enhancement in coupled multi-material nanoparticle trimers

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Coupled plasmon resonances have attracted great attention in nanophotonics due to their ability to provide stronger optical field enhancement factors compared to those observed in isolated plasmonic resonators. This enhanced optical field can improve the sensitivity of surface-enhanced Raman spectroscopy (SERS), improve the performance of certain nonlinear optical processes and enhance spontaneous emission and stimulated emission rates. Li and et. al, demonstrated that even higher optical field enhancement factors can be obtained in a specific type of coupled plasmon resonance in a self-similar chain of metal nanospheres [1]. This effect has been investigated experimentally and theoretically in several studies, most of which focused on coupled resonators made with a single material. In this study, we demonstrate a novel approach in which the near-field coupled resonators consist of different materials. We investigate internal and external field enhancement of multi-material trimer structures consisting of a small gold nanoparticle located between two large silver nanoparticles as shown in Figure 1. Numerically calculated polarization-dependent field enhancement and scattering spectra of the trimers as a function of nanoparticle size and inter-particle spacing show that strong field enhancement inside and around gold nanoparticles can be obtained due to the mutual coupling in a multi-material trimer. The internal field enhancement in the gold nanoparticle exceeds that of isolated Au nanoparticles by up to a factor 15. The presented approach is compatible with chemical synthesis and assembly methods making it a viable candidate for high sensitivity biochemical sensors and nonlinear optical materials.

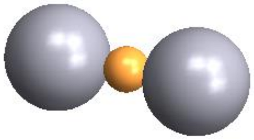

Fig.1.*Schematic of Ag-Au-Ag trimer structure.*

[1] Li. K.; Stockman. M. I.; and Bergman. D. J.; "Self-Similar Chain of Metal Nanospheres as an Efficient Nanolens", Phys Rev Lett 91 (22), 227402 (2003).

PD-11

Many-photon NOON states in a cavity with multiple quantum dots

Michael N. Leuenberger, Mikhail Erementchouk

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Optical devices employing interaction of photons with semiconductor quantum dots (QD) are the object of permanent interest due to their promising features: small size and the fast control of their properties. There are several obstacles, however, which complicate significantly application of physical properties of such systems. The major difficulties arise from effects of decoherence of various origins: interactions of electrons in QDs with phonons and the nuclear spins and the lack of precise control over positions of QDs inside the cavity and their characteristics. We show that these obstacles can be avoided in the off-resonant photon-QD interaction regime, while preserving the benefits of such interaction. In this regime the dynamics of photons is shown to be governed by an effective photon Hamiltonian yielding the non-linear birefringence and the formation of many-photons NOON (GHZ) states. The parameters of the Hamiltonian are determined by characteristics of individual QDs averaged over the ensemble of QDs in the cavity. Thus, slight variations of properties of QDs do not affect the dynamics of the photon state. The effects of decoherence, in turn, are subsided due to the weak excitation of the QDs. The effective photon-photon interaction, of course, is also reduced leading to prolonged time of formation of the NOON state but at the same time in a multiple dot case the interaction is enhanced by the number of *pairs* of QDs. This makes cavities with multiple QDs a promising candidate for implementing a dynamical formation of completely entangled many-photon states.

PD-12

Dynamical formation of entangled photon states in a cavity

Mikhail Erementchouk, Michael N. Leuenberger

NanoScience Technology Center, University of Central Florida

Understanding of the dynamics of the photon state in a cavity with semiconductor quantum dots (QD) is an important component of developing novel optical devices and sources of light with highly nonclassical properties. This problem succumbs to a straightforward analysis in simple cases when there are only few photons or only few QDs. Slightly increasing the number of either photons or QDs leads to highly nontrivial dynamics. We show that in the limits when either the number of photons significantly exceeds the number of dots or the number of dots is much larger than the number of photons the contribution of effects complicating the dynamics diminishes yielding a simple picture of evolution of the photon state. In the first case with large number of photons we show that mediated by QDs the system acquires an effective photon-photon interaction, which leads to the polarization entanglement of initially disentangled photon states. Because the interaction is shared among many photons the characteristic entanglement time is proportional to the square root of the number of photons and inversely proportional to the number of quantum dots. We pay the special attention to the cases when the photons are initially in the Fock state and in a coherent state. We show that the structures of the photon entangled states are different in these cases.

PD-13

The Effect of Surface Electronic Structure on Sonophotochemical Reactions

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In this work, the mechanisms of the synergistic effect of sonophotoctalysis were studied. TiO_2 catalysts with three different electronic structures, namely neutral TiO_2 in dark, negatively charged TiO_2 under visible irradiation and positively charged TiO_2 under UV irradiation have been created by coupling with Au nanoparticles. Sonophotochemical reduction of water was selected as a model reaction. No discernible differences of the reaction rate of water reduction over these three electronic structures were observed, indicating that neither electrons nor holes-enriched semiconductor surface could enhance the formation of free radicals under sonication. Therefore, the surface charge has negligible contribution to the synergistic

effect in sonophotocatalysis. The synergistic effect could only arise from acoustic cavitations-facilitated removal of intermediates from the active surface reaction site and the subsequent regeneration of active sites.

PD-14

Solution-processed Hole Injection and Transport Materials for Small Molecule Organic Light Emitting Diodes

Szuheng Ho, Rui Liu, Franky So

Department of Materials Science and Engineering, University of Florida, Gainesville, FL-32611

Polyethylene dioxythiophene polystyrene sulfonate (PEDOT:PSS) has been widely used as the material for hole injection layer (HIL) in organic light emitting diodes (OLEDs) due to its high work function and thereby enhanced injection efficiency. However, OLEDs that contain PEDOT:PSS suffered from its poor injection stability caused by the acidity, moisture damage and de-doping effect. In this work, Plextronics® HIL and hole transport layer (HTL) were used to compare with conventional PEDOT:PSS OLEDs. The Plextronics HIL was able to yield improved stability and higher power efficiency over the whole brightness range. The detailed investigations were performed with both bipolar and single carrier devices. Furthermore, the Plextronics® hole transport layer (HTL) is a crosslinkable material. Crosslinkable HTL has high resistance to solvent wash from the following solution-processed device fabrication. The morphology, trap states and transport properties were characterized as a function of crosslinking conditions. These two HIL/HTL together will make solution-processed OLEDs with high stability while maintaining high efficiency.

PD-15

Microscopic Self-Diffusion Studies of Carbon Dioxide in Samaria Aerogel Catalyst via Diffusion NMR

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Aerogels containing rare-earth metal oxides represent a promising class of porous catalysts exhibiting high porosity and high surface area with active catalytic sites integrated directly into the porous framework. These catalysts have potential for interesting applications in the areas of energy, environmental control and chemical production. One advantage of aerogels is that they can be easily prepared into macroscopic monoliths or in the beds of particles. Here, we present selected experimental results of microscopic self-diffusion studies of a product gas species, carbon dioxide, in alumina promoted samaria aerogel catalyst prepared as macroscopic monoliths and as beds of particles with sizes around 200 microns. This investigation was enabled by a unique C-13 pulsed field gradient (PFG) NMR technique employing a high magnetic field of 17.6 T. This technique provides a direct measurement of CO2 diffusion in the porous catalyst samples on microscopic length scales. The reported results are described using a commonly used two-domain exchange model developed for zeolites and other microporous materials.

PD-16

Faraday rotation due to Pauli exclusion principle in 3D topological insulators

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Experiments using ARPES, which is based on the photoelectric effect, show that the surface states in 3D topological insulators (TI) are helical. Here we consider Weyl interface fermions due to band inversion in narrow-bandgap semiconductors, such as $Pb_{1-x}Sn_xTe$. We find strict optical selection rules of electron-hole pair excitation by means of the solutions of the 3D Dirac equation and band structure calculations. In contrast to graphene's pseudospin helicity operator $\hat{h}_g = -\left(1/\left|p_\perp\right|\right)\boldsymbol{\sigma}\cdot\mathbf{p}$,we define the spin helicity operator in 3D TI as $\hat{h}_{\mathrm{TI}} = \left(1/\left|p_\perp\right|\right)\beta\left(\boldsymbol{\sigma}_\perp \times \mathbf{p}_\perp\right)\cdot\hat{\mathbf{z}}$ where β is a Dirac matrix and $\hat{\mathbf{z}}$ points perpendicular to the interface. Using our selection rules, we propose a scheme of using 3D TIs as a quantum memory, which is read out by means of the Faraday effect due to Pauli exclusion principle in a slab of 3D TI.

PE - MICRO/NANO DEVICES

PE-01

Ultrathin Organic Capping Layer on Solution-processed Metal Oxides to Suppress Light Quenching in Organic Light Emitting Diodes

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1 Department of Materials Science and Engineering, University of Florida, Gainesville, FL-32611

Metal oxide has been a potential candidate for hole transport layer (HTL) or hole injection layer (HIL) in organic or hybrid optoelectronic devices in recent years. When combined with a sol-gel process, roll-to-roll technique can be used in device fabrication. Compared with their organic counterparts, solution-processed metal oxides can be used for fabrication of heterostructure with improved stability. However, many organic light emitting diodes (OLEDs) suffered from strong light quenching effect when the solution-processed metal oxide layer was deposited next to the emitting unit. In our report, the solution-processed p-type nickel oxide (NiO_x) and n-type electron accepting vanadium oxide (V_2O_5) are fully studied as HTL and HIL respectively. The light quenching effects are explored with Photoluminescence (PL) measurement and we proved that by applying an organic capping polymer on top, light quenching on both NiO_x and V_2O_5 can be greatly suppressed with little sacrifice of hole injection/transport. With the existence of the ultrathin polymer between HTL/HIL and EML, the OLED device shows an overall better performance with reduced efficiency roll-off. As a result, our hybrid OLED devices perform a good efficiency with further improvement of the stability. Furthermore, due to the high triplet energy (E_T) and efficient exciton-blocking ability of the polymer film, this passivation method can also be extended to blue/deep blue OLEDs which are usually limited by the choices of HTL/HIL with high triplet energy.

PE-02

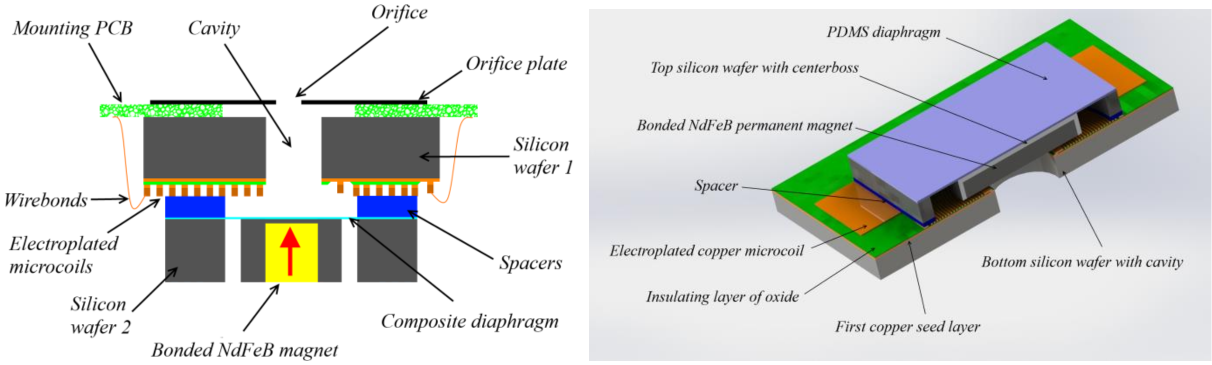
Microfabricated Electrodynamic Synthetic Jet Actuators

Shashank Sawant and David P. Arnold

Interdisciplinary Microsystems Group, Dept. Electrical and Computer Engineering, University of Florida

We present the design and fabrication of micro-scale synthetic jet actuators (also known as zero-net-mass-flux actuators). Synthetic jet actuators are used for active flow control [1] such as flow separation over an airfoil. The actuators will be batch fabricated using silicon micromachining techniques. As shown in Fig. 1, the actuator design consists of three constituent components: the composite diaphragm, the cavity, and the orifice. The 2.2 mm diameter composite diaphragm is made on a silicon wafer and has a PDMS membrane attached to a center-boss holding a bonded NdFeB micromagnet. Another silicon wafer, having electroplated copper micro-coils and an orifice, will be joined with a spacer forming a cavity in between. When AC current is passed through the coil, the diaphragm oscillates at the frequency of the input signal because of the electrodynamic Lorentz force. The diaphragm's motion creates ingestion and expulsion of air, forming a directional jet [2].Using a lumped element approach, the various components of the actuator design are modeled [3] and the output velocity of the synthetic jet is calculated. The design presented here has an estimated output velocity of about 20 m/s, with a total device volume of less than 0.25 cm^3, representing the highest known jet velocity per device volume.

[1] Glezer, A., and Amitay, M.,“Synthetic Jets,” Annual Review of Fluid Mechanics, Vol. 32, 2002, pp.503–29.
[2] Y. Utturkar, R. Holman, R. Mittal, B. Carroll, M. Sheplak, and L. Cattafesta, “A jet formation criterion for synthetic jet actuators," 41st Aerospace Sciences Meeting and Exhibit, Reno, Nevada, Jan. 2003,AIAA 2003-0636.
[3] S. G. Sawant, M. Oyarzun, M. Sheplak, L. N. Cattafesta, and D. P. Arnold, “Modeling of electrodynamic- zero-net mass-flux actuators," AIAA, vol. 50, no. 6, pp. 1347{1359, Jun. 2012.



(*a*) (*b*)

Figure 1: Schematic of ueZNMF actuator: (a) inverted structure of the actuator attached to test PCB and an orifice plate and (b) cross-section of a 3D schematic without the PCB and the orifice plate.

PE-03

Microneedle Based EKG – Glucose Sensor

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[1]*ECE department, University of Florida, Gainesville, USA*

The propose design of a portable MEMS system for mobile phones that measures body electrical signals as well as extracts transdermal biological fluid(ISF)for *in vivo* analysis is presented. This system integrates two sensing methods: electrocardiography (EKG) and glucose monitoring in one painless electrode using a microneedle fabrication variation. The working principle of the EKG is the dry measurement of electrical signal using two electrodes and one reference electrode. The working principle of the glucose sensor is the ISF reaction with glucose oxidase (GOX). Then oxidase the hydrogen peroxide produced by this step to generate electrons. Current between working and reference electrode is related to the glucose concentration. After processing the signal outside the electrode, the concentration of glucose in their interstitial fluid can be obtained.

This work presents the modeling for the EKG signal analysis and Glucose sensor characterization. Every component was modeling independent because the ISF will be static inside the channel during the glucose measurement. The link between both electrical sensors is the reference signal. Both sensors will share this common electrode inside the system. By solving the capillarity model inside the microneedles and optimizing the problem using fmincon function via Matlab we obtained design parameters and geometries. Detailed micro-fabrication process proposed for the microneedles is presented as well as the testing plan for system components. A circuit for amplifying, eliminating noise and filtering is proposed in both systems to connect them to a TI microcontroller MSP430FR5739 in a system in package (SiP) solution.

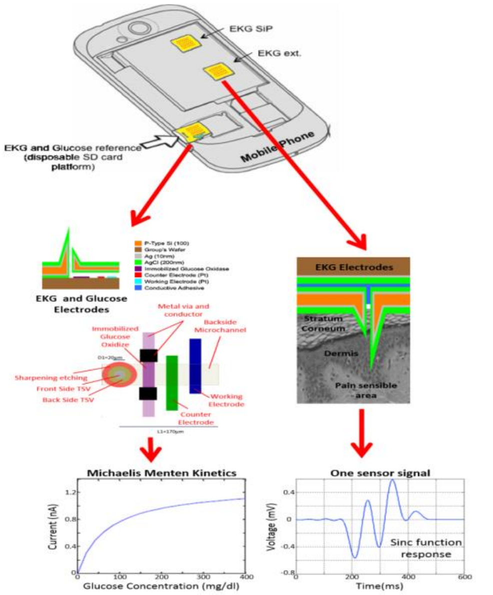

Figure1: Distribution of the proposed EKG and Glucose sensors on the mobile phone, proposed fabrication structure and simulate signals for every electrode.

PE-04

Development of a sonoelectrodeposition platform for biosensor development

M. Taguchi[1,2], Burrs, S. [1,2], Vanegas, D. [1,2], Sondhi, S., McLamore, E.S. [1,2]

[1]Agricultural and Biological Engineering, University of Florida
[2]Institute of Food and Agricultural Science

The field of biosensors is in constant demand for a more sensitive platform. Electrochemical biosensors are based on monitoring the electrical signals produced or consumed by proteins immobilized on metal electrodes. One method of achieving higher sensitivity for electrochemical biosensors is to increase electroactive surface area on the working electrode. This can be accomplished via electrodeposition of various nanomaterials on the working electrode. In addition to diffusion limitations, gaseous by-products of the reaction limit reproducibility when depositing thin films. To resolve this problem, we have developed a custom simultaneous sonication/electrodeposition system. The sonoelectrodeposition system was created using an Arduino™ microcontroller system connected to a bath sonicator and a DC power source. The sonication procedure removes gaseous products formed at the surface of the working electrode, and provides mixing to enhance the electrodeposition process. Sonic energy removes unstable nanostructures and improves control over which would lead to a much more ordered and consistent deposition scheme. A custom MatLab program was developed to allow the user to define cycle frequency, duration, and quiet time. After nanomaterial deposition, electrode surface area was analyzed using cyclic voltammetry. Visual inspection with a microscope indicated that nanoplatinum films formed using the sonoelectrodepsotion technique were uniform yielding a surface area of 0.0632 ± 0.0075 cm^2. The ability to control nanometal deposition and dispersal in a time resolved fashion is a simple technique for improving control over nanostructure formation in the development of biosensors.

PE-05

3D Inkjet Printing towards Organ-on-a-Chip Micro-device Fabrication

Changxue Xu, Zhengyi Zhang, Patrick Hickey, Kyle Christensen, Yong Huang

Department of Mechanical and Aerospace Engineering, University of Florida, Gainesville, FL 32611

Drug discovery and development involves a series of *in vitro* and *in vivo* studies to screen compounds based on efficacy and toxicity. Most drug studies are first conducted by using two-dimensional (2D) cell cultures in Petri dishes or test tubes; unfortunately, they lack multi-organ interactions and therefore cannot reproduce the pharmacokinetic understanding of drug compounds. By combing the unique properties of microfabricated cellular constructs and cell-based biological assays, we aim to develop three-dimensional (3D) *in-vitro* organ-on-a-chip micro-devices to simulate the relevant human organ systems for drug screening.

Vascularization is often identified as a main technological barrier for building 3D organs. As such, the fabrication of 3D biological vascular trees is of great importance for the overall feasibility of the envisioned organ-on-a-chip micro-device. Using drop-on-demand inkjet technology, we have successfully fabricated 3D zig-zag 3T3 fibroblast-based alginate tubular structures which mimic the simple anatomy of blood vessels. The post-fabrication cell viability was above 85% even after a 24-h incubation period. As a proof-of-concept study, the resulting fabrication knowledge helps fabricate organ-on-a-chip micro-devices with complex geometries.

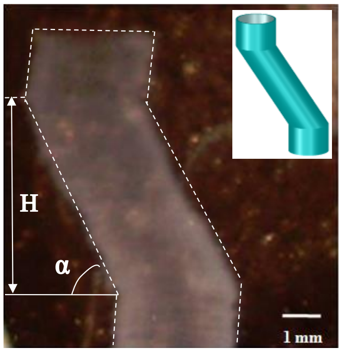

Figure 1. Fabricated 3D 3T3 fibroblast-based alginate tubular structures

PE-06

Fabrication of tunable plasmonic platforms for nonlinear optical enhancement

Panit Chantharasupawong[1], Binh Duong[2], Debashis Chanda[1,2,], Jayan Thomas[1,2,3]

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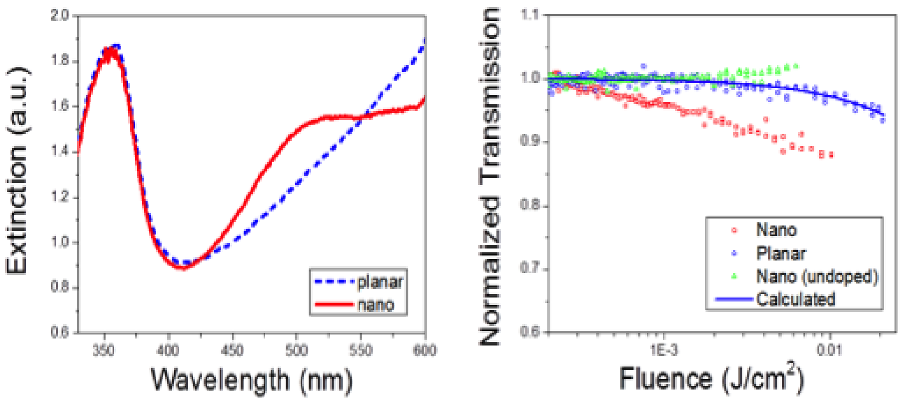
[2]*NanoScience Technology Center, University of Central Florida, Orlando, FL 32826, USA*
[3]*Department of Material Science and Engineering, University of Central Florida, Orlando, FL 32816, USA*

Plamon resonance wavelengths of metal nanostructures are geometrically dependent. Conventional fabrication methods have limited flexibility in changing the size and shape of the fabricated nanostructures with respect to both cost and processes. In this presentation, we demonstrate the use of spin-on-nanoprinting (SNAP) technique developed in our lab to in fabricate plasmonic nanostructures. A simple additional fabrication step is introduced in the fabrication process for tuning the size and the plasmon resonance peak of the imprinted nanohole structures. The use of concentrated electromagnetic field around the structure to enhance optical nonlinear process is also demonstrated. It is found that the nonlinear absorption coefficient of nonlinear dye doped polymer near the plasmonic structure is enhanced by approximately 256 folds.



PE-07

A 3D topological insulator quantum dot for optically controlled quantum memory and quantum computing

Hari P. Paudel, Michael N. Leuenberger

NanoScience Technology Center, University of Central Florida

We present the model of a quantum dot (QD) consisting of a spherical core-bulk heterostructure made of 3D topological insulator (TI) materials, such as PbTe/$Pb_{0.31}Sn_{0.69}Te$, with bound massless and helical Weyl states existing at the interface and being confined in all three dimensions. The number of bound states can be controlled by tuning the size of the QD and the magnitude of the core and bulk energy gaps, which determine the confining potential. We demonstrate that such bound Weyl states can be realized for QD sizes of few nanometers. We identify the spin locking and the Kramers pairs, both hallmarks of 3D TIs. In contrast to topologically trivial semiconductor QDs, the confined massless Weyl states in 3D TI QDs are localized at the interface of the QD and exhibit a mirror symmetry in the energy spectrum. We find strict optical selection rules satisfied by both interband and intraband transitions that depend on the polarization of electron-hole pairs and therefore give rise to the Faraday effect due to Pauli exclusion principle. We show that the semi-classical Faraday effect can be used to read out spin quantum memory. When a 3D TI QD is embedded inside a cavity, the single-photon Faraday rotation provides the possibility to implement optically mediated quantum teleportation and quantum information processing with 3D TI QDs, where the qubit is defined by either an electron-hole pair, a single electron spin, or a single hole spin in a 3D TI QD. Remarkably, the combination of inter- and intraband transition gives rise to a large dipole moment of up to 450 Debye. Therefore, the strong-coupling regime can be reached for a cavity quality factor of $Q=10^4$ in the infrared wavelength regime of around 10 μm.

PE-08

Three-Dimensional Electron Microscopy of Nanoscale Structure and Deformation via Nanopatterning

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Cross-sectional transmission electron microscopy (TEM) provides essential atomic scale imaging and probing for unmatched characterization of nanoscale structures, interfaces, alloy phases, subsurface damage, and more. The most common way to prepare site-specific TEM cross sections is via focused-ion-beam (FIB) lift outs. FIB lift outs of nanoscale features can be extremely challenging. This is because it is difficult to properly position the FIB slice with a specific feature or row of features, particularly if the < 100 nm features cannot be resolved in the FIB/SEM. In this work, a straightforward approach allowing three-dimensional visualization of subsurface deformation beneath nanoindents using reconstructed cross-sectional transmission electron microscopy (TEM) data is demonstrated. This approach is applicable to any array of nominally identical features that can be patterned with regular spacing and included in a single lamella prepared using focused ion beam milling. It was also found to significantly enhance the throughput of preparing routine site-specific TEM samples. The approach is applied to visualize the plastic zones beneath nanoindents in GaAs (001), for loads of 50-1000 μN.

PF - BIO-MAGNETICS

PF-01

Enhancing Magnetic Nanoparticle Based DNA Transfection: Intracellular-Active Cassette Features

Matthew M. Vernon[1], David A. Dean[2], Jon Dobson [1,3,4]

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[2]School of Medicine and Dentistry, University of Rochester Medical Center, Rochester, NY 14642, USA2
[3]Department of Materials Science & Engineering, University of Florida, Gainesville, Florida 32611, USA3
[4]Institute for Cell Engineering & Regenerative Medicine (ICERM), University of Florida, Gainesville, Florida 32611, USA4

Efficient plasmid DNA transfection of embryonic stem cells, mesenchymal stem cells, neural cell lines and the majority of primary cell lines is a current challenge in gene therapy research. Magnetic nanoparticle-based DNA transfection is a gene vectoring technique we have developed that is promising because it is capable of outperforming most other non-viral transfection methods in terms of both transfection efficiency and cell viability [1].Improvements to this technique have occurred mostly with particle functionalization and transfection parameter optimization, which cannot assist the nuclear translocation of delivered plasmid DNA and influence subsequent gene expression. In this study, features incorporated into the plasmid DNA sequence such as a cell-appropriate promoter, kozak sequence and a DTS sequence demonstrated the most significant improvements in observed transfection efficiency. Utilization of a cell-appropriate promoter and kozak sequence increased transfection efficiency by ~400% in HeLa cells. Incorporation of a DTS sequence enhanced the proportion of transfected differentiated SH-SY5Y cells by ~450% . Incorporation of cell-appropriate features in the delivered plasmid DNA improves transfection efficiency in the tested cell types.

PF-02

High energy dissipation from iron oxide superparamagnetic nanoparticles through optimization of their intrinsic loss power (ILP)

Tapomoy Bhattacharjee*,Ana C. Bohorquez+, Lorena Maldonado-Camargo*, Maria E. Hernandez*, and Carlos Rinaldi+*

**Department of Chemical Engineering, University of Florida*
+ J. Crayton Pruitt Family Department of Biomedical Engineering, University of Florida

Iron oxide magnetic nanoparticles have the capacity to dissipate the energy of an alternating magnetic field (AMF) in the form of heat. Heat is generated either due to Brownian relaxation, i.e., due to physical rotation of particles under AMF or due to Néel Relaxation, i.e., rotation of magnetic dipole only. This physical property can be used effectively for inducing local hyperthermia. For suitable application of hyperthermia superparamagnetic nanoparticles are required that possess Néel Relaxation. Previous work has been done to characterize the ILP of commercially available magnetic nanoparticles as well as production of high energy dissipating metallic iron nanocubes. The goal of this work is to produce iron oxide (IO) superparamagnetic nanoparticles with high ILP. Heat generation increases with increase in magnetic core diameter of nanoparticles. However, larger diameter nanoparticles often possess Brownian relaxation. Therefore we seek to find the optimum diameter that results in maximum energy dissipation

solely through the Néel mechanism. Iron oxide nanoparticles were synthesized by the thermal decomposition iron oleate using a high boiling point solvent. Particle size was characterized using Dynamic Light Scattering (DLS) and Nanoparticle Tracking Analysis (NTA) system. Relaxation properties of the nanoparticles were determined by AC susceptibility measurements. Energy dissipation rate measurements were conducted under a range of magnetic fields (10-37.5 kA/m) at a frequency of 340 kHz. The resulting nanoparticle diameter dependence of the energy dissipation rate will be compared to the predictions of the theory by Rosensweig [Ann. Rev. Fluid Mech., 19(1987) 437-463].

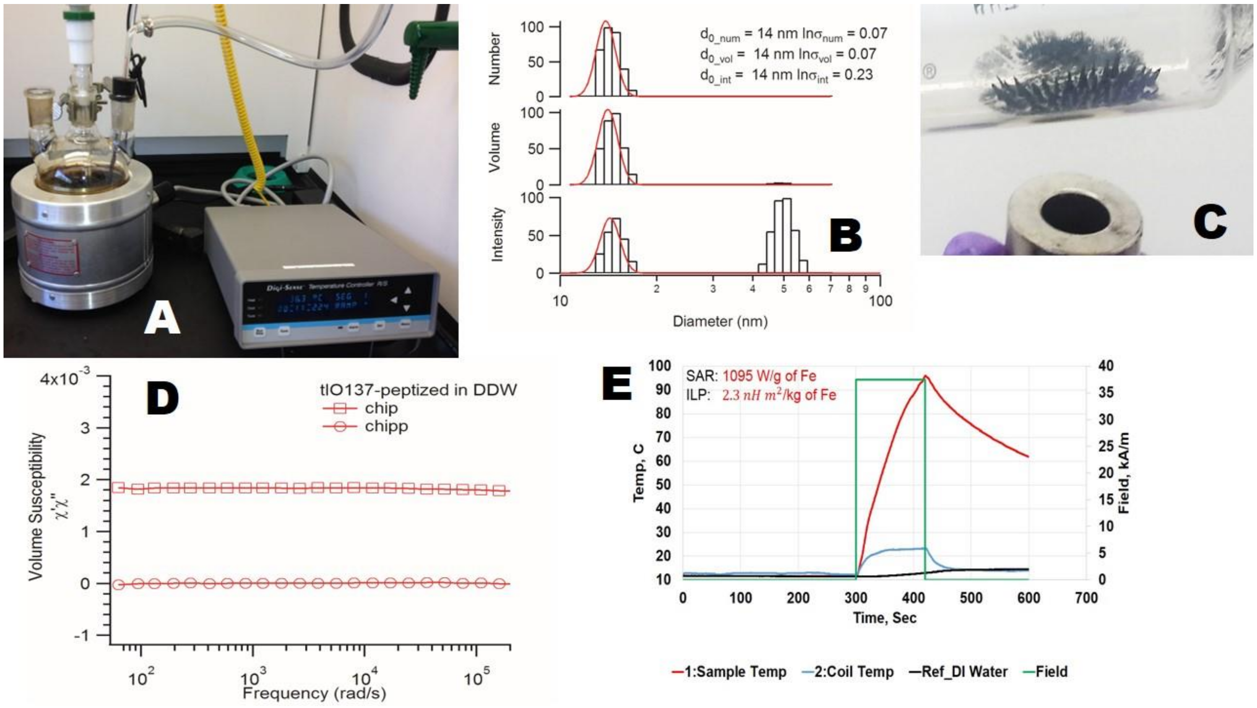

Fig 1: A) Reaction set-up; **B)** DLS analysis of Diameter; **C)** Nanoparticles after production; **D)** AC susceptibility of Néel particles; **E)** Nanoparticle heating under AMF

PF-03

Rotational Diffusion of Magnetic Nanoparticles in Synovial Fluid

Lorena Maldonado-Camargo[a], Elena Yarmola[b], Kyle D. Allen[b] and Carlos Rinaldi [a, b*]

[a]*Department of Chemical Engineering, University of Florida.*
[b]*J Crayton Pruitt .Family Department of Biomedical Engineering, University of Florida.*

Synovial fluid (SF) is an essential part of the functioning of joints, allowing bones to freely articulate. SF consists primarily of hyaluronic acid (HA) and blood plasma proteins (albumin and globulin). Prior studies have established a correlation between changes in SF rheology and joint diseases. Most commonly, a decrease in viscosity is observed, which has been related to changes in the molecular weight of the HA component. These observations suggest that routine analysis of the physicochemical properties of synovial fluid could be a valuable tool for diagnosis of joint disease. However, the large volumes of fluid needed for rheological characterization limit this application. Here, we report a promising non-destructive technique suitable to obtain information on the physico-chemical properties of small volumes (20µL) of SF through measurement of the rotational diffusivity of magnetic nano- and sub-micron particles. Our measurements demonstrate the technique can distinguish between normal SF and SF treated with an enzyme that digests HA as a mimic of degradation SF in joint diseases. Using our measurements deviation from Stokes-Einstein behavior were found, thus viscosity values obtained from conventional rheological methods are different from those measured with the nanoparticles.

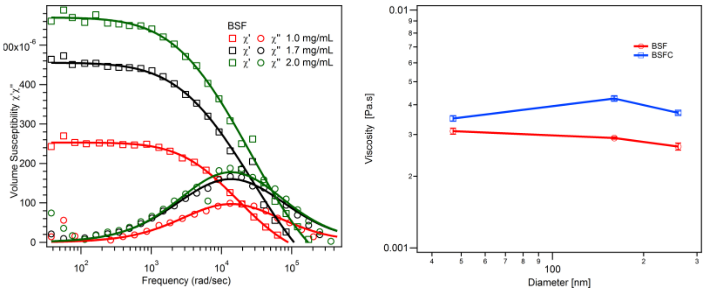

Figure 1. Viscosity of BSF (circles) and centrifuged BSF (squares) using different particles size at 298 K with values χ”, errors bars are based on regressions error .

PF-04

Quantification of the Brownian and Néel relaxation fractions of magnetic nanoparticles using dynamic magnetic susceptibility measurements.

Maria E. Hernandez+, Lorena Maldonado-Camargo*, and Carlos Rinaldi*+

+J. Crayton Pruitt Family Department of Biomedical Engineering, University of Florida
**Department of Chemical Engineering, University of Florida*

Magnetic nanoparticles are often obtained as mixtures of particles that relax by either the Brownian or Néel relaxation mechanisms, depending on their crystallinity and size. It is often desirable to estimate the relative fractions of particles that respond to a magnetic field through each mechanism, for example when characterizing samples for hyperthermia and sensor applications. Dynamic magnetic susceptibility measurements are often used to characterize the response of magnetic nanoparticles to time-varying magnetic fields and allow measurement of the distribution of relaxation times in a collection of magnetic nanoparticles. We hypothesized that such measurements could be used to determine the relative fractions of particles relaxing by the Néel and Brownian mechanism. To test our hypothesis we prepared iron oxide (which relax by the Néel mechanism) and cobalt ferrite (which relax by the Brownian mechanism) nanoparticles with narrow size distribution through the thermal decomposition method. Suspensions of these particles were mixed at different mass ratios to obtain samples with known fractions of particles that relax by each of the two mechanisms. Dynamic magnetic susceptibility measurements were made and interpreted using an extended Debye model to calculate the relative fractions of the two types of particle. These estimates were compared to the known fractions.

PF-05

Magneto Bio-Mechanical Actuation of Cell Surface Proteins Using Superparamagnetic Iron Oxide Nanoparticles: Implications for Cell Engineering and Regenerative Medicine

Adam Monsalve[1,3], Bettina Kozissnik[2,3], Zachary A. Kaufman[3], David P. Arnold[3] and Jon Dobson[1,2,3]

University of Florida, Department of Materials Science and Engineering[1], Department of Biomedical Engineering[2],Department of Electrical and Computer Engineering[3], Institute for Cell Engineering and Regenerative

Medicine (ICERM)[3], BMS J312, Centre Drive, Gainesville, FL, 32611.

Chemical agents play vital roles in the control of cells and tissue growth, however, mechanical forces also affect cell signaling. These processes span the entire spectrum of cellular pathways including apoptosis, proliferation, differentiation, and migration. On the macroscopic scale, muscle atrophy and bone loss occur during prolonged periods of inactivity when cells are no longer receiving important mechanical cues. This demonstrates the crucial role that mechanical forces play in healthy tissue maintenance. Current strategies aiming to investigate mechanical forces for cell engineering tend to use elastomeric substrates, which apply mechanical loads to cells upon deformation. One drawback of this method is that the applied forces cannot be localized to specific cell surface receptors, making it difficult to elucidate specific signaling pathways.

We have developed novel technology for targeted mechanical actuation of surface receptors using magnetic nanoparticles with applied magnetic fields as a “remote control”. Nanoparticles composed of superparamagnetic iron oxides can be biofunctionalized to target and activate specific receptors. Once the particles bind to the membrane, a NdFeB magnetic needle with a diameter of ~200 µm was positioned to within 100 - 200 µm of cells using an electronic micromanipulator. The needle tip generates the strong magnetic field gradient required to actuate the particles bound to the receptors. The cells were loaded with a Ca^{++} reactive dye, which increase their fluorescence when bound to Ca^{++}, allowing for the visualization of pathway induction via magnetic actuation. We are now focusing on larger scale studies moving forward using a novel magnetic force bioreactor (Figure 1).

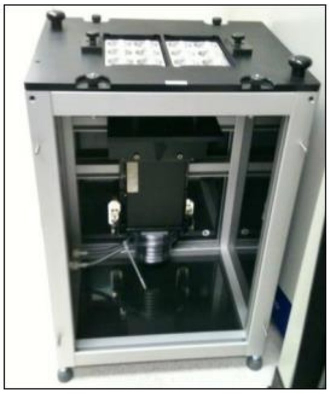

Figure 1: Magnetic Force Bioreactor

PF-06

Magnetic-nanoformulation for treatment of morphine-induced neuropathogenesis and neuroAIDS

Sagar V.[1, 2], Pilakka-Kanthikeel S. K.[1], Atluri, V.S.R[1], Ding, H.[1], Priestap, H.[2], Yndart, A.[1], and Nair, M.[1]

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Magnetite (Fe_3O_4) is the most commonly and extensively explored magnetic nanoparticles (MNPs) in the field of biomedicine. Nevertheless, its potential application as safe and effective drug-carrier for brain associated anomalies is very limited. We herein report magnetic nanoformulation of a highly selective and potent morphine antagonist, CTOP, which is impenetrable to the brain. Currently, drug addiction is at its peak of all time and poses serious global threat. It speeds up the spread of many blood-borne diseases and, as such, recreational drug-addicted patients account one-tenth of HIV-infected population. Opiate such as morphine, heroine, etc. are used frequently and share common target-areas in the brain with HIV. Interestingly, intensity of disease progression and HIV-associated neuropathogenesis is remarkably enhanced due to exposure of these recreational drugs. Existing treatments to alleviate the action of opioids or other abusive drugs are less effective at CNS level, basically due to impermeability of therapeutic molecules across brain barriers. Thus, development of an advanced nanomedicine based approach may pave the way for better treatment strategies. In this context, transmission electron microscopy was used to characterize the size of synthesized MNPs and formation of MNPs-CTOP nanoformulations were established by FTIR spectroscopy and fluorescent detection. Flow-cytometry analysis showed that biological efficacy of this nanoformulation in prevention of apoptosis induction by morphine in peripheral blood mononuclear cells remains equivalent to that of free CTOP. Importantly, confocal microscopy reveals that MNPs-CTOP nanoformulation have comparable efficacy to that of free CTOP in protecting morphine-induced modulation of dendrite and spine morphology in neuronal cells during HIV infection. Thus, in line with our previous reports, this developed nanoformulation could be effective in targeting brain by application of external magnetic force and thereby treat the individual and/or concerted effect of morphine and HIV on neurotoxicity.

PF-07

Superparamagnetic Ferrofluid Induced Hyperthermia for Treatment of Liver Cancer

Kevin Kircheval and Steve Roberts

Center for Environmental and Human Toxicology, University of Florida

Liver cancer remains one of the most prominent and deadliest malignancies facing the human population. The aim of this research is to develop an improved, targeted hyperthermia therapy system to replace classical treatments for hepatocelluar carcinoma (HCC). Ferrous magnetic nanoparticles (MNPs) coated with surfactant to stop agglomeration are suspended in an organic solvent to create the ferrofluid. Ethiodol, used mainly as a contrast agent for computed tomography (CT) scans, serves as the vehicle and targeting device by depositing in the capillary bed of the HCC. Healthy hepatic lymphatic and Kupffer cells are able to process the lipophilic coating and clear the MNPs, resulting only in concentration of the doses in the cancerous cells. When placed in the appropriate, alternating magnetic field (AMF), the particles heat up and cause the induction of cell death. The ferrofluid is a combination of magnetite (Fe_3O_4) and maghemite (Fe_2O_3), coated in oleic acid, and suspended in the ethiodol. Transmission electron microscopy (TEM) will be used to characterize the shape and size distribution of the particles. The ferrofluid will first be analyzed in *ex vivo* tissue samples to study the heating capacity of the particles. *In vivo* studies will be done in carcinogen-induced liver cancer mouse models where small animal MRI will be used to image the ferrofluid post-intravenous tail-vein injections. AMF induced hyperthermia will be monitored by optic temperatures probes.

PF-08

Trapping of magnetic nanoparticles using high-field-gradient permanent magnet microstructures

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[2]*J. Crayton Pruitt Family Department of Biomedical Engineering*
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There is a growing number of biomedical research applications where the need arises to trap or actuate magnetic nanoparticles (MNPs) with high spatial precision [1,2]. This can be accomplished using permanent magnet (PM) structures presenting high magnetic field gradients, since the magnetic force acting on a MNP is directly proportional to the magnetic field gradient. In this abstract, we present two different types of magnetic microstructures and demonstrate their capability to efficiently collect MNPs from fluid suspensions. We also present a model that predicts the time-of-flight and collection volume for these particle capture experiments.

The first structure is a magnetic needle tip laser-machined from a bulk NdFeB magnet. It has an 800-µm-tall, square pyramidal structure with a 50 µm square at the top and a 500 µm square at the base. This geometry creates a large magnetic field gradient at the needle tip. The efficiency of particle capture is assayed by introducing the micro-needle into suspensions of varying concentrations of 1.9-µm-diameter magnetic fluorescent microspheres. The experimental time-of-flight results from microscale video analysis confirm the applicability of the analytic model. Figure 1(a) shows the collection of the magnetic fluorescent microspheres in a 5 min time span. The second structure is a flat Co-Pt PM film (~10 µm thick), which is impressed with north/south magnetic pole patterns via a selective magnetization process reported in [3]. The high field-gradient is located at the boundaries between the north and south magnetic poles. Figure 1(b) demonstrates the ability of this technique to successfully trap MNPs.

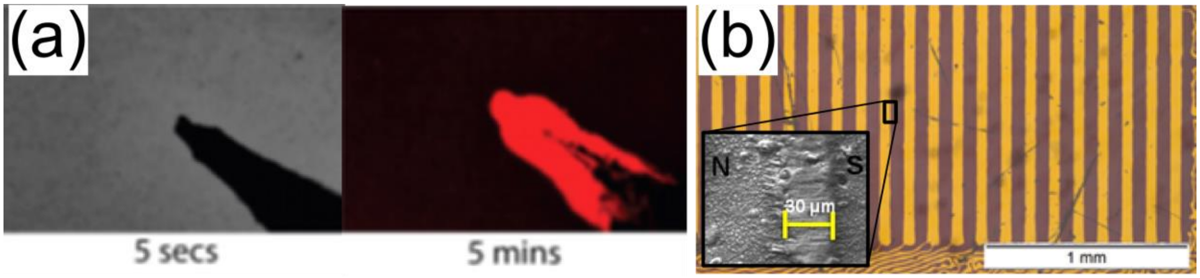

Figure 1: (a) Collection of fluorescent magnetic nanoparticles binding to the magnetic needle tip, (b) Magneto-optical image of a patterned Co-rich Co-Pt film (120 µm wide period), inset: Scanning Electron Microscope picture of trapped MNPs at the maximal field-gradient location.

[1] Dobson, J (2008) Nature Nanotech. 3: 139-143.
[2] Mannix, RJ et al. (2008) Nature Nanotech. 3: 36-40
[3] Oniku, O (2013) IEEE Trans on Magn, *vol. 49, no. 7, pp. 4116-4119*

PF-09

Brownian dynamic simulation of soft magnetic ellipsoidal particle suspensions

Isaac Torres-Diaz and C. Rinaldi

Suspensions of sub-micron magnetic particles composed of soft magnetic materials are recently being considered for various applications, such as in cancer treatment. In these suspensions the static and dynamic behavior of the particles depends on both the magnitude of the applied magnetic field and the relative orientation of the particles with the applied magnetic field, in addition to hydrodynamic and thermal effects. Here, the rotational motion of magnetically-soft tri-axial ellipsoidal particles suspended in a Newtonian fluid was studied using rotational Brownian dynamics simulations. The approach considers the stochastic angular momentum equation (Langevin equation) in an orientational space described by quaternion parameters.

The algorithm quantifies the magnetization of a monodisperse particle suspension in dilute limit conditions under applied steady and time-varying magnetic fields. The algorithm also takes into account the field-dependent relative permeability of the particle's bulk material. We have considered the equilibrium magnetization at different dimensionless field amplitudes and dynamic susceptibility in response to an oscillating magnetic field at different dimensionless frequencies for ellipsoidal particle suspensions with different geometric aspect ratios and different particle sizes, as shown in Fig. 01.

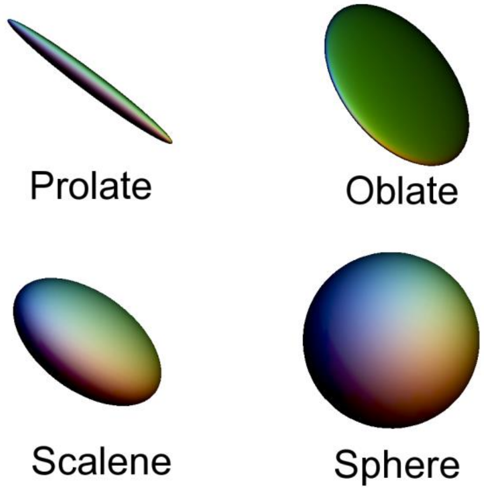

Fig. 1. Different ellipsoid aspect ratios used in simulations.

PF-10

Simulation of Magnetic Particle Imaging

Rohan Dhavalikar[1] and Carlos Rinaldi*[1, 2]

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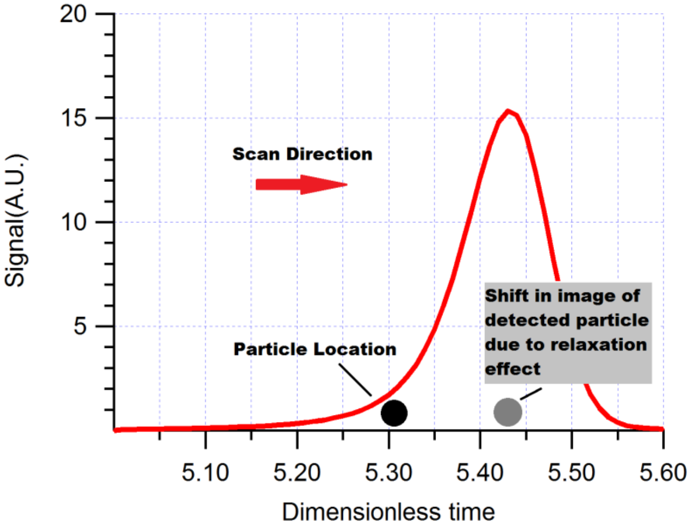
Magnetic Particle imaging (MPI) is a new tomographic imaging technique which utilizes static and oscillating magnetic fields to map the spatial distribution of superparamagnetic iron oxide (SPIO) nanoparticles used as tracers. This technique overcomes the disadvantage of host tissue background signal encountered in MRI as it directly images the tracer particles and is a safer imaging alternative especially for Chronic Kidney Disease (CKD) patients for whom the iodine contrast agents are toxic. The non-linear magnetization of SPIO nanoparticles is the principle by which Frequency domain and X-space MPI obtain millimeter scale resolution images. The imaging process uses a strong field gradient creating a Field Free Point (FFP) where the magnetic field magnitude is weaker than the saturation field of the SPIOs. The change in magnetization of the SPIO is detected by an induction receiver coil and yields an image. Present models developed to describe this imaging process neglect the effect of finite magnetic relaxation of the SPIO, limiting their use in predicting the MPI signal. With the help of Brownian dynamics simulations, we have incorporated the effects of finite relaxation dynamics and non-linear magnetization into models for the MPI contrast signal of magnetic nanoparticle tracers, allowing us to predict the effect of particle properties and MPI magnetic field conditions on the signal strength and resolution of SPIO tracers used in MPI.



PF-11

Magnetic field effects on dielectrophoresis in microstructured thin film manganites

Dan Grant, Galin Dragiev, Amlan Biswas

Perovskite-type manganese oxides (manganites) are of interest for many of the different properties they possess, including colossal magnetoresistance (CMR) and ferroelectric behavior. With the application of an electric field, large resistance decreases have been noted near the insulator-to-metal transition temperature in samples of $(La_{1-y}Pr_y)_{1-x}Ca_xMnO_3$ (LPCMO). Two proposed models have emerged to explain the behavior, dielectric breakdown and dielectrophoresis, with experimental evidence showing some aspects of the dielectrophoresis model to be correct. However, neither model accounts for magnetic interactions among the ferromagnetic metallic regions and the effects of a magnetic field applied in conjunction with an electric field. We have performed measurements on LPCMO samples by varying the strength and orientation of the magnetic field and the applied voltage. Cross-shaped microstructures have been made on LPCMO samples to allow us to investigate the effects of sample size on dielectrophoresis. We will present resistance and magnetization data obtained on LPCMO samples at various magnetic field strengths, magnetic field orientations, and sample sizes to elucidate the effect of magnetic interactions on dielectrophoresis induced transport and magnetic properties.

PG - BIO-MEDICINE

PG-01

Facile Isolation and Detection of Rare Cancer Proteins with Aptamer-Conjugated Silver Microspheres

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Early diagnosis is the most challenging part of the cancer treatment. Since the recognition of the changes in the rare cancer protein abundances or structrures can lead the early diagnosis of cancer, capturing these rare proteins has a great significance. Until now, various types of aptamer conjugated nanoparticles have been used to isolate the biomarker proteins from the corresponding cancer cell lines. The most commonly used isolation techniques depending on the intrinsic properties of those nanoparticles are centrifugation and magnetic separation upon the capture of target protein. In this work, silver microspheres offer a novel separation metdhod, *gravitational separation* owing to their heavy nature. In this way, there is no need for an external stimuli to separate the captured proteins and protein isolation can take only seconds. On the other hand, silver microspheres can be relatively easily synthesized compared to other nanoparticles without using any surfactants as templates. The combination of specificity provided by the aptamers towards the target cancer proteins and the easy separation provided by the silver microspheres would ease the separation and detection of the biomarker proteins.

PG-02

Estrogen Anchored multifunctional micelles Designed for Site-Specific Delivery of Doxorubicin prodrug in Breast Cancer Therapy

Juanjuan Yin, Shu-Feng Zhou*

Department of Pharmaceutical Sciences, College of Pharmacy, University of South Florida, Tampa, FL 33612

The efficacy and applicability of anticancer drugs are greatly restricted by severe systemic toxicities and drug resistance. Targeting drug delivery strategies is an active area of research and it has been developed to prevent the shortcomings of chemotherapy. Nano-scaled drug delivery systems hold tremendous potential for the treatment of neoplasms. In this study, multifunctional estrogen anchored polymer micelles have been designed and prepared, and it is aimed to deliver therapeutics as well as accessorial agents such as antioxidants to estrogen positive cancer cells, the polymer micelles were constructed by covalent and non-covalent interactions to release the drug in a controlled way. The multifunctional micelles are expected to enhance the drug uptake by cancer cells and spare normal tissues compared to conventional chemotherapy.

The PEG-PLA di-block co-polymer was functionalized with gossypol in the PEG terminal through reductive amination. Adamantane were also conjugated to the PEG terminal to serve as a guest molecule moiety for the estrogen targeting cyclodextrin which were synthesized and characterized through multi-step reactions and spectral methods. Adamantane doxorubicin prodrug was prepared and encapsulated the polymer micelles. *In vitro* competition experiment of ER positive (MCF-7) for the targeting and non-targeting micelles was at varying concentrations were assessed. The *in vitro* drug release profile was determined by dialysis and fluorescence measurement, and targeted drug binding *in vitro* was quantitated by flow cytometry and confocal microscopy. The cytotoxicity of the different micelles was measured and the biomarkers related to free Dox-induced cardiotoxicity were also examined at the cellular level.

PG-03

Synthesis and Characterization of a Non Color-Forming, Silver Complex Based Antimicrobial Surface Coating

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University of Central Florida, 12424 Research Parkway, Suite 400, Orlando, FL 32826

The antimicrobial properties of silver have been utilized for hundreds of years in a variety of applications, including food and water storage, sanitation of touch surfaces and implements, and wound care. The high efficiency of silver as an antimicrobial agent, with effective concentrations as low as .1 ppm, makes it an attractive method of imparting antimicrobial properties to a variety of surfaces. While ionic silver forms a colorless, transparent coating when applied to surfaces at levels providing antimicrobial activity, the reduced form of silver, which occurs upon exposure to the atmosphere, will form aggregates, and the resulting nanoparticles exhibit strong surface plasmon absorption, giving the coated object a distinct greyish brown discoloration. This discoloration is not a desirable trait if the silver is acting as a surface coating on a light colored object, necessitating the dark coloration of silver doped plastics. One approach to remedying this issue is to fix the silver into a complex that retains the antimicrobial activity of ionic silver, while providing the stability of complexed silver. This silver complex can be trapped within a silica matrix, which can be applied to any surface to give it enduring antimicrobial properties. The overall goal of the project is to produce a silver complex trapped within a spray-on matrix, capable of imparting a durable, long lasting antimicrobial coating on any surface that would normally require regular cleaning in order to remain hygienic. We will present the details of silver/silica composite material synthesis, characterization and antimicrobial results.

PG-04

Enhanced blood-brain barrier transmigration using a novel Transferrin-conjugated fluorescent magnetoliposome nanoformulation

Hong Ding, Vidya Sagar, Marisela Agudelo, Sudheesh Pilakka-Kanthikeel, Venkata Subba Rao Atluri, Andrea Raymond, Samikkannu Thangavel, Madhavan P. Nair*

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Blood-brain barrier (BBB) is considered as the primary impediment preventing delivery of almost all drugs into the brain. In our study, a dual mechanism, consisting of receptor mediation and non-invasive magnetic force, was co-incorporated into magnetite-based liposomal nanocarriers for BBB transmigration enhancement. The magnetic nanoparticles (MNPs) with homogenous size of ~ 10 nm were synthesized and its morphology and crystal structure was confirmed by TEM and XRD respectively. The classical magnetism assay showed presence of characteristic superparamagnetic property. These MNPs were encapsulated in the PEGylated fluorescent liposomes as magnetoliposomes (ML) with uniquely mono-dispersed of ~ 130 nm diameter using lipid-extrusion technique, determined by DLS, was obtained. Remarkably, magnetite encapsulation efficiency of nearly 60% was achieved and luminescent stability and hydrodynamic size of ML could be maintained for over two months. Additionally, the structural integrity of ML remained unaffected through 120 equivalent blood-circulations. These highly biocompatible fluorescent ML was peripherally conjugated with Transferrin and applied for *in vitro* BBB transmigration study in presence or absence of external non-invasive magnetic force. In compare to the individual effect of magnetic force- or Transferrin receptor- mediated transportation, their synergy resulted in 50-100% increased transmigration without affecting the BBB integrity. Consequently, confocal microscopy showed higher cellular uptake of fluorescent liposomes due to synergic effect, which was further confirmed by respective presence of iron concentration in BBB-composed cells. Thus, the formulated nanocarriers possess enhanced transmigration ability across BBB which could be utilized for more effective brain drug-delivery.

PG-05

Integrating metabolomics application and ingenuity pathway analysis to explore the response of non-small-cell cancer cells to DMXAA and plumbagin

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Non-small-cell lung cancer (NSCLC) is major type of lung cancer which is the leading cause of cancer-related death worldwide. DMXAA and plumbagin are new promising anticancer drugs but their mechanism of action is unclear. This study aimed to examine the intracellular metabolic response to DMXAA and plumbagin in human NSCLC A549 and H23 cells and the possible molecular mechanisms involved. Cells were treated with DMXAA and plumbagin and intracellular metabolites were analyzed using liquid chromatography (LC) coupled with electrospray ionization-time-of-flight-mass spectrometry (ESI-TOF-MS). The profile of intracellular metabolites were identified using reference library, interpreted and visualized by applying principal components analysis (PCA). The metabolomics analysis showed differential response in carbonyl metabolites, fatty acid and cholesterol turnover, which caused metabolic pathways disturbances in the cell energy production. Consequently, it leads to alteration in redox status and cell proliferation. These results indicate that the disturbance in cell energy metabolism is, at least partially, responsible for the anti-cancer effect of DMXAA and plumbagin via regulation of redox balance and cell apoptosis in A549 and H23 cells.

PH - BIO-APPLICATIONS

PH-01

Tumor cell imaging in-vivo by a fiber optic microscope using gold nanorods

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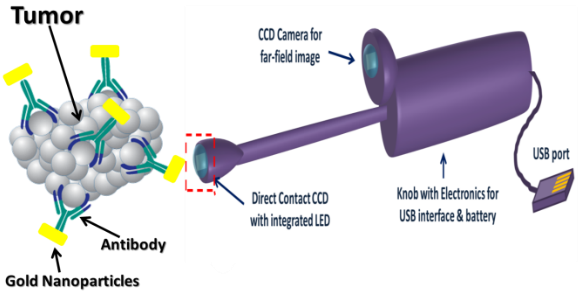
Department of Pathology[1], Department of Electrical and Computer Engineering[2] - University of Miami; Dr. John T. Macdonald Foundation Biomedical Nanotechnology Institute of University of Miami (BioNIUM)[3]

Endoscopic techniques are utilized as a minimally invasive tool for detection of various diseases including cancers. However, white light endoscopic observation typically hinges on macroscopic morphologic assessment of lesions, and the ability to detect cancer at a molecular level during both advanced and early stage of development is far from feasible. Fiberoptic endomicroscopy has the flexibility to reach into organ systems for cellular imaging within both hollow and solid tissue. To maximize the potential of a fiberoptic microscope, an equally advanced technology is necessary that surpasses the capabilities and shortcomings that limit the use of conventional dyes and contrast agents. Gold nanorods (GNR) have proved to be the reagents with ideal characteristics that include a strong two photon photoluminescence and biocompatibility, making them excellent contrast agents to be used in endoscopy as efficient probes for cancer detection. Due to its large cross section, the luminescence strength of a GNR is two orders of magnitude higher than a molecular dye. We are developing an assay using functionalized GNR for cancer-specific molecular recognition. Cancer cells that are positively identified using GNR based endoscopy can also be highly susceptible to localized photothermal damage when excited at a plasmon resonance wavelength. In comparison, a conventional endoscope based on white light source is unable to deliver a source of power capable to induce photothermal damage. Thus, a fiberoptic endomicroscopy, coupled with GNR as the contrast agent, has a potential to be used as a minimal invasive tool for simultaneous detection and therapy of cancers.



PH-02

Noncanonical self-assembly of multifunctional DNA nanoflowers for biomedical applications

Guizhi Zhu, Rong Hu, Weihong Tan

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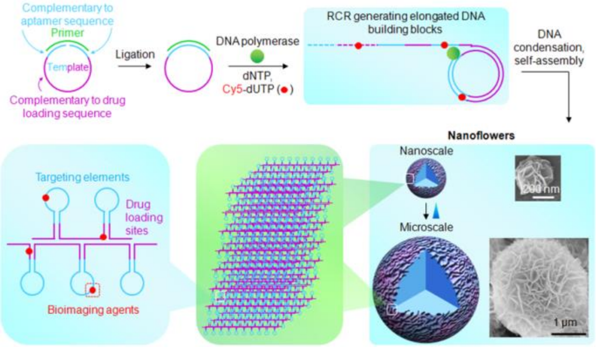
DNA nanotechnology has been extensively explored to assemble various functional nanostructures for versatile applications. Mediated by Watson-Crick base-pairing, these DNA nanostructures have been conventionally assembled through hybridization of many short DNA building blocks. Here we report the noncanonical self-assembly of multifunctional DNA nanostructures, termed as nanoflowers (NFs), and the versatile biomedical applications. These NFs were assembled from long DNA building blocks generated via Rolling Circle Replication (RCR) of a designer template. NF assembly was driven by liquid crystallization and dense packaging of building blocks, without relying on Watson-Crick base-pairing between DNA strands, thereby avoiding the otherwise conventional complicated DNA sequence design. NF sizes were readily tunable in a wide range, by simply adjusting such parameters as assembly time and template sequences. NFs were exceptionally resistant to nuclease degradation, denaturation, or dissociation at extremely low concentration, presumably resulting from the dense DNA packaging in NFs. The exceptional biostability is critical for biomedical applications. By rational design, NFs can be readily incorporated with myriad functional moieties. All these properties make NFs promising for versatile applications. As a proof-of-principle demonstration, in this study, NFs were integrated with aptamers, bioimaging agents, and drug loading sites, and the resultant multifunctional NFs were demonstrated for selective cancer cell recognition, bioimaging, and targeted anticancer drug delivery.

Scheme: Schematic illustration of noncanonical self-assembly of multi-functional DNA NFs.



PH-03

Programmable DNA Nano-Walker for Molecular Interaction Study on Living Cell Surface

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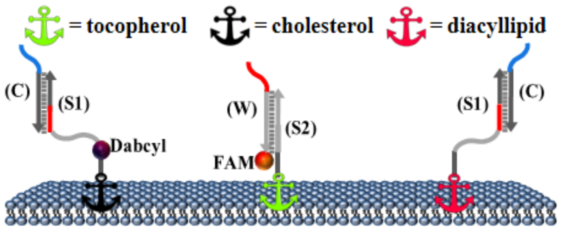
The dynamic nature of membrane plays critical roles in the cell growth, adhesion, trafficking, and signaling. The better understanding of dynamic cellular membrane motions and lateral molecular interactions will shed light on both the basic working principles of cells and the pathogenicity of human diseases. However, due to the complicated cell surface composition, small geometry-scales of membrane structures and relatively fast time-scales of the dynamic events, molecular motion and interaction on the cell membrane are still difficult to be studied.

In this study, we demonstrate the feasibility of studying living cell membrane molecular interactions by recently developed dynamic DNA “nanorobots”. To illustrate, cellular surface and membrane compounds (*e.g.*, lipids or proteins) were employed as the track and anchorage sites, respectively, for the construction of a designable DNA walker system to study the natural molecular interactions on the living cancer cell surface.

We expect the dynamic DNA walker system could be quite useful in studying membrane molecular interactions, because (1) The initiation of DNA walking can be precisely controlled by programmably designed “caging” strands, preventing non-membrane signal; (2) The fluorescence signal intensity is an accumulative result of encounter events of DNA-attached membrane anchors, only routine flow cytometry and fluorescence microscope are needed to study such fast dynamic events; (3) The prerequisite of DNA toeholds encounter (in <10nm range) overcomes the diffraction-limited resolution (hundreds of nanometers) of conventional optical microscopy or FCS, which are proved in this study feasible for the critical lipid domain (generally tens of nanometers in size) studies.



Schematic illustration of “CTL”

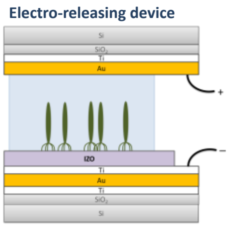
PH-04

Inorganic Binding Peptides with Electroactivated Properties for Biosensor Devices

Ya-Wen Yeh[1], Chih-Wei Liao[2], Seonhoo Kim[2], David Norton[2], Laurie Gower[1, 2]

[1.] *J. Crayton Pruitt Family Department of Biomedical Engineering, University of Florida,*
[2.] *Department of Materials Science and Engineering, University of Florida*

For biosensor devices, functionalizing the surface using covalent linkers is usually employed. However, it is difficult to avoid the loss of activity following the bioreceptor-analyte binding event, which limits the lifetime of the device. The goal of this research is to use phage display to biopan for inorganic binding peptides which are reversible upon application of an electric field. This could provide dynamic functionalization of surfaces, with one potential application being self-cleaning devices. For example, when the bioreceptors become clogged, the peptide linkers may be released by triggering an electric field to generate a non-binding state. A fresh surface of bioreceptors can then be applied via a flow through setup. Our group has been panning for peptides that bind strongly to indium zinc oxide (IZO), a transparent conducting oxide, which makes it an attractive electrode for biosensors. An electro-releasing device is being used to collect the strong binding peptides that are released upon application of an electric field. In an alternative method, because a strong-binding peptide might have reversible binding characteristics, our group has developed a novel phage display biopanning protocol with an electro-elution process instead of the regular chemical elution. Current studies include the comparison of the peptides selected by these two different approaches.



PI - TOXICOLOGY AND HEALTH SCIENCE

PI-01

Advances in trapping bedbugs

Y.C. Hung, R. Qing, W. Sigmund,

Department of Materials Science and Engineering, University of Florida

An increasing number of Bedbugs (Cimex lectularius) is found to be resistant to pesticides. These pests are no longer limited to just homes, they also invade office buildings. Literature reports indicate that plants may trap bedbugs via hooks and sharp needles. The poster will present features found on leaves of plants that may trap bedbugs as well as surface features of bedbugs that may be hooked. Biomimetic hook designs that may be able to trap bedbugs in mechanical ways will be discussed.

This research involves optimizing the surface which biomimetic hooks are embedded on by controlling the diameter and area density of hooks and the quantitative analysis was conducted through the relationship between parameters (aspect ratio, density, sizes of bedbug) and average time bedbugs staying on the surface. In doing so, we will sort out the relationship between the size of bedbugs and experimental parameters.

Additionally, Base on previous paper review, the attraction of human body for bedbug is carbon dioxide, therefore, this research will design an equipment, which could emit carbon dioxide and compare the effect of bedbug attraction between the surface with CO_2 emitter and without CO_2 emitter.

To conclude, this research would improve the living environment and decline the Infestation of bedbug.

PI-02

Synthesis and Characterization of Gadolinium@C_{82} Polyhydroxy Fullerenes

Taylor Maxfield, Zhao Han, Neha Saxena, Angelina Georgieva, Parvesh Sharma, Vijay Krishna, Ben Koopman, Brij Moudgil

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Polyhydroxylated fullerenes (PHF), particularly those containing an endohedral gadolinium atom within the fullerene cage (Gd@C_{82}), have promising potential in biomedical applications, such as photo acoustic MRI contrast agents, and also agents for the thermal ablation of tumors. The present research focuses on the synthesis, characterization, and quantification of purity of Gd@C_{82} PHF for subsequent cancer research in animal trials. Synthesis of Gd@C_{82} PHF is accomplished by hydroxylation of Gd@C_{82} with sodium hydroxide, using a toluene as a solvent and tetrabutyl ammonium hydroxide as a catalyst. The number of hydroxyl groups on the Gd@C_{82} PHF particle is characterized with XPS, and the final Gd@C_{82}PHF purity is quantified using capillary electrophoresis.

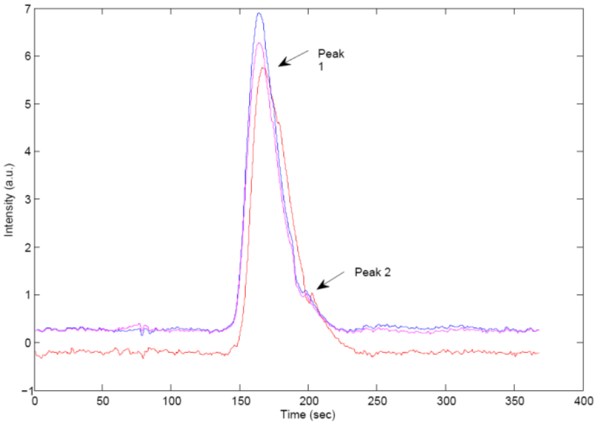

Figure 1: *Electropherogram of PHF, purity 98.8%. Peak 1- pure PHF, Peak 2- impurities.*

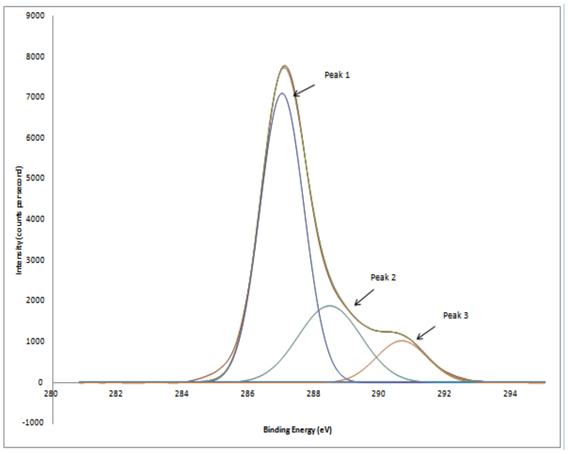

Figure 2: *XPS graph of Gd@C_{82} PHF showing oxygenated (Peak 2), non-oxygenated carbons (Peak 1), and impurities (Peak 3). Number of hydroxyl groups calculated from area under peak 2 is 22 groups, versus 60 non-oxygenated carbons.*

PI-03

Foaming and Frothing of Green Surfactants and Fine Particulate Systems

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Green chemistry is a new and rapidly expanding field of research focused on environmental sustainability. Petroleum-based chemicals are traditionally used as defoamers, but the market for environmentally benign defoamers is increasing by 5.3% per year, and is expected to reach a $2.77 billion total in 2015. The presence of fine particles in industrial processes can alter the properties of surfactants, including their foaming and defoaming capabilities. This project aims to explore the foaming and defoaming properties of modified fine particle and green surfactant systems, and provide enhanced understanding of the antagonistic and/or synergistic effects of such systems. The particles used are environmentally benign minerals, including silica, kaolinite, and ferric (hydr)oxides. The preliminary results indicate that lauryl amido propyl betaine (main component in ECOS) foam stability is enhanced in the presence of silica particles.

Green surfactant mixtures show similar properties compared to petroleum-based surfactants and are good candidates for replacement of petroleum-based surfactants in the future. The defoaming properties of silica particles display the same effects in green surfactants mixtures as in petroleum-based surfactants.

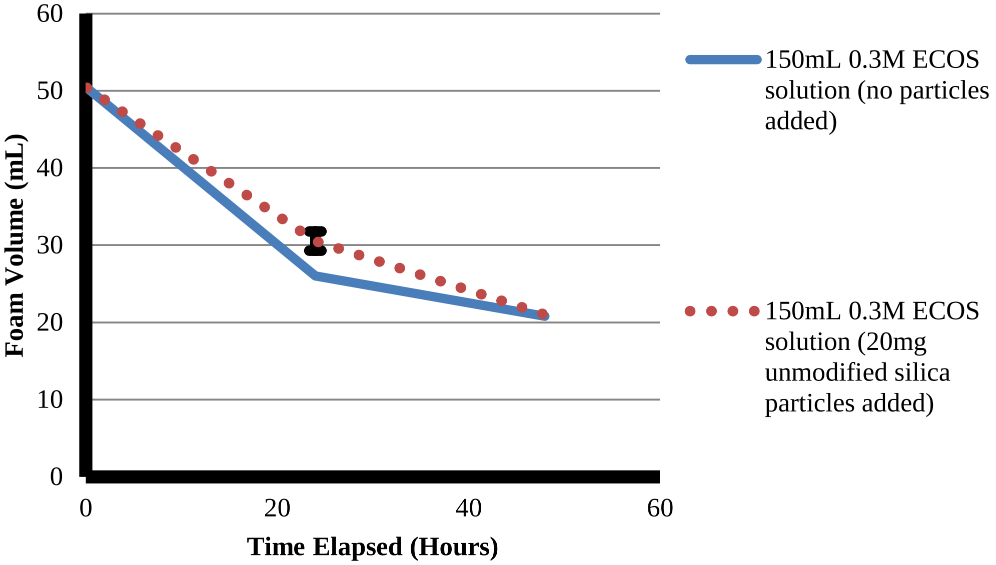

Figure 1.Effect of non-modified silica particles on the foam stability of green surfactant mixture ECOS® with main component lauryl amido propyl betaine.

PI-04

Zebrafish Toxicology – Study of the Effect of Polyhydroxy Fullerenes

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Exposure to chemicals in the environment can lead to adverse effects on the health of living organisms, from subtle biochemical changes to disease and death. Fullerenes and polyhydroxy fullerenes (PHF) were selected as Nanomaterial for the toxicological study due to expectation of their increased release into the environment through future products and their disposal. PHFs are fully water soluble derivatives of fullerenes with multiple applications, including medical applications such as MRI imaging. PHFs studied were synthesized and characterized in our laboratory and their uptake by aquatic animals *Danio Rerio*(Zebrafish) was examined subsequently. An understanding is sought of their environmental fate by determining their uptake characteristics in aquatic organisms. Test results of 6 days exposure to 500 ppm polyhydroxy fullerenes showed that PHF had no acute adverse effect on these aquatic organisms.

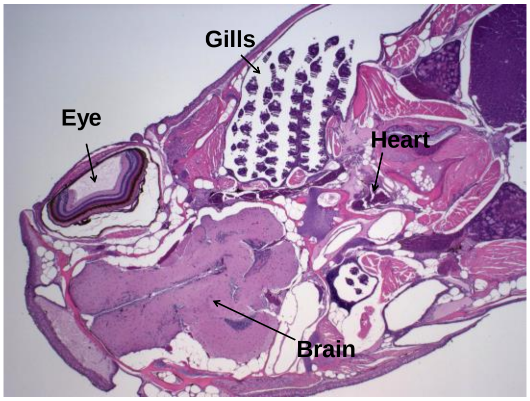

Figure 1. Healthy brain, gills and heart of zebrafish after exposure to PHF, H&E stain (paraffin block section) scan at 1.5mm

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PI-05

Computational Ecology: Elucidating novel chemical defense mechanisms of Antarctic Sea Sponges

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A novel secondary metabolite, erebusinone, was isolated in 2001 from the Antarctic sea sponge, *Isodictya erinacea*, by the Baker group. This small molecule demonstrated anti-molting properties in bioactivity studies against the crustacean, *Orchomene plebs*. It has been hypothesized that erebusinone inhibits the production of the molt inducing hormone, 20-hydroxyecdysone (20E), and thus functions as chemical defense for the sponge. Xanthurenic acid (XA), a known endogenous molt inhibitor, and erebusinone share many similar structural features as well as experimentally exhibit similar effects on *O. plebs* molting. Two cytochrome P450 enzymes (CYP315A1 and CYP314A1) are responsible for the two final hydroxylations in 20E synthesis and experimental studies predict these are inhibited by XA. The purpose of this current study is to propose a mode of action by which erebusinone and XA - as well as the XA metabolic precursor, 3-hydroxy-L-kynurenine (3HK) - inhibit the activity of CYP315A1 and CYP314A1 via computational means. Such knowledge may aid optimizing pesticides targeting arthropod species or developing drugs that might target certain active site motifs. In this work we have employed Prime Homology Modeling and Structure Prediction computational methods as well as MD Simulations, Glide SP/XP Docking and Induced Fit Docking protocols to understand electrostatic and steric interactions between our small molecules and the heme-based active sites of interest. Current data suggests: aromatic rings and conjugated systems of both XA and erebusinone allow for highly favorable and varying π-π interactions between the small molecule and the heme and with key active site residues.