9:10 AM - Dr. Christopher R. Lambert  
clambert@wpi.edu  
Worcester Polytechnic Institute - Bioengineering Institute

**Self-Assembled Monolayers as chemical and biological sensors**

A toolbox of chemistries has been developed that allows surfaces to be efficiently modified a molecular film. These films have a wide range of sensor applications and some examples of this work are given here: Acetylcholinesterase Inhibition Sensing: Acetylcholinesterase (AChE) inhibitors are potentially lethal nerve agents and are found in pesticides, chemical weapons as well as pharmaceuticals. DNA Sensing: We have used SPR to detect unlabeled DNA oligonucleotides. A thiol modification on the probe DNA strand allowed for its attachment to the surface via self-assembly. Potentially the device could be used to detect micro RNAs, oligonucleotides that are now known to play a role in gene expression within cells. They are important in the diagnosis of disease and have potential roles as therapeutic agents. The technology we are developing will potentially be a powerful diagnostic tool both in research and in the clinic. Blood analytes sensing: We are developing a microfluidic device that will measure urea, potassium ions and ammonium ions in biological fluids. Based on our current work it is thought that the device will be capable of sampling biological fluids other than whole blood and will provide a platform for other surface based chemical sensors. The long-term goal of this program is to move the analysis of biological samples to point-of-care devices.

9:30 AM - Dr. Evelyn A. Kurt-Jones  
evelyn.kurt-jones@umassmed.edu  
University of Massachusetts Medical School - Medicine

**Size and shape matter: Studying the immune response to synthetic microparticles**

The human immune system is poised to recognize and respond to foreign particulate substances, like crystals, pollen, bacteria or fungal spores. While some particles can induce significant inflammation others are relatively non-inflammatory. The physical and chemical characteristics that determine the response to different particles are unclear. Our studies aim to systematically examine the roles that particle size, shape, and surface texturing play in uptake efficiency and subsequent immune cell activation. Microparticles were generated using a novel micro-capillary flow focusing technique. We tested the immune response to different particles of similar composition but varying in shape from spherical to budding. We discovered that particles with high surface curvature (budding particles) were associated with and phagocytosed by macrophages at higher frequency than particles with low surface curvature, i.e., smooth particles. Remarkably, budding particles induced stronger immune activation than smooth particles measured by inflammasome activation and IL-1β secretion. These findings demonstrate a pronounced and underappreciated role for particle shape and surface curvature in immune cell activation. Elucidation of the mechanisms by which size, shape, and surface texturing of particles dictates an immune response will increase the understanding of particle technology to create targeted vehicles for delivery of vaccines, drugs, proteins, and siRNA therapeutics.

9:50 AM - Prof. Gerard D'Souza  
gerard.dsouza@mcphs.edu  
Massachusetts College of Pharmacy & Health Sciences, Boston - Pharmaceutical Sciences

**Organelle-Targeted Intracellular Delivery**

Growing evidence suggests that pharmaceutical nanocarriers can be used to control the biodistribution of potentially therapeutic molecules. Control over biodistribution that allows the organ-specific and in many cases cell-specific delivery of therapeutic molecules offers much promise for improved therapy of a variety of diseases. The next logical step in this delivery paradigm is to assess the role of nanocarriers in controlling the disposition of drug molecules in sub-cellular structures. This technology is especially applicable to drug molecules that act on intracellular targets and is a major focus of research in my lab. In the course of the talk I will introduce the concepts behind current approaches to organelle-targeting and share some data from various projects aimed at the development of organelle-targeted nanocarrier platforms as well as research models and tools to study the specific distribution of nanocarriers in physiologically relevant environments.
Nanomanufacturing of Polymers and Composites

The goal of research in Nanomanufacturing is understanding the fundamental science of not only how to manipulate structures or features at the nanoscale, but also how to do so in ways that can be scaled up to high rates, high volumes, and large areas, with the reliability needed for commercial products. Many early manufacturing processes approaching the nanoscale were incremental advances in industrial microelectronics processes – e.g., the ability to push lithography and etching down to finer and finer resolutions. A different approach is combining the methods used in the plastics industry – extrusion, fiber spinning, molding – with new ways of achieving control at the nanoscale. Such integrated nano-micro-macro processes, utilizing mechanisms such as chemical, electrical, and rheological responses, enable a completely different range of structures that can be formed. This presentation will give examples of several nanomanufacturing methods, as well as the results of some research on the fundamental mechanisms affecting repeatability, reliability, and functionality of the fabricated structure.

Imaging at the Nanoscale

Aberration correction has enabled unprecedented imaging at the nano-scale using High-Angle-Annular-Dark-Field/Scanning Transmission Electron Microscopy (HAADF/STEM), a technique uniquely suited for detailed studies of the structure and composition of compositionally and structurally complex materials. The HAADF detector collects electrons which have interacted closely with the nucleus of the atoms in the specimen and therefore resembles the better known Z^2 (Z is atomic number) Rutherford scattering. In the first part of my talk I will briefly introduce the concept of aberration corrected STEM and then focus on molybdenum-based oxides that have been subject of extensive research for several decades due to their enormous catalytic potential for the selective oxidation of light paraffins and olefins. I present HAADF-STEM investigations of various complex oxide phases and show that we can reliably distinguish metal-containing sites within these structurally and compositionally complex-oxides through the analysis of Z-contrast. I will contextualize these results and show how chemistry at the nano-scale gives rise to ‘rationale exuberance’ with respect to synthesis and tailoring of properties. I will close by describing new approaches using the mathematical concept of ‘sparsity’ to analyze STEM images.

Molecular Motors and Force Microscopy

The three-dimensional analysis of thermal position fluctuations can reveal mechanical properties, for instance of molecular motor proteins like Kinesin by recording the fluctuations of an optically trapped bead tethered to a microtubule by a single Kinesin molecule. This became possible by a novel three-dimensional scanning probe microscope, the Photonic Force Microscope (PFM), providing nanometer 3-D spatial and microsecond temporal resolution. The position fluctuations can be transformed into three-dimensional energy profiles using the Boltzmann equation. Energy profiles and their changes are both accessible with a resolution of one tenth of the thermal energy. From such profiles, force versus extension or stiffness versus extension profiles can be calculated along arbitrary paths in three dimensions. Atomic Force Microscopy (AFM) can complement such measurements. In these experiments a step size of 8.0±0.4 nm for Kinesin molecules could be confirmed and the presence of backwards steps of the same size could be demonstrated for the first time. Due to the high torsional spring constant of the lever it became obvious in these experiments that native Kinesin does not require any rotational degree of freedom of the cargo in order to process. Relating these results to studies using PFM validates the results of both techniques and provides a new complementary view on the mechanics of the molecular motor Kinesin.
**Bachelor's Level Abstracts**

1. **Robert Cakounes, Michael Judelson**, Rose Roy, Nancy Burnham, Drew Brodeur, Jianyu Liang  
   (Contact: rcakounes@wpi.edu)  
   Worcester Polytechnic Institute - Chemistry, Mechanical Engineering, Physics

**Adhesion of Silver Nanoparticles**

Nanoparticles demonstrate unique and novel properties, compared to bulk counterparts, due to their large surface area per unit volume as well as quantum confinement. Some applications require attaching nanoparticles to substrates such as semiconductors, carbon materials and polymers. In addition, with the increased use of nanoparticles, society is becoming more concerned with the environmental impact of released nanoparticles. To help understand the life-cycle it is important to understand how nanoparticles adhere to substrates. Currently, no quantitative analysis of nanoparticle adhesion exists due to difficulties of implementation on the nano-scale. This project uses two different methods to study the adhesion strength of silver nanoparticles to various substrates. TEM categorized the silver nanoparticles to show little size distribution and agglomeration. They have an average particle radius of 8 to 15 nm. IR showed proper functionalization of the substrates with a carboxyl and amine ligand. Qualitative AFM analysis showed adhesion forces of hundreds of nano-newtons. Comparing these forces to traditional bulk removal techniques showed that those methods are not applicable to the nano-level. A new test, involving brushing the substrate and AAS analysis of the concentration of silver deposited on the substrate, addresses the problem of bulk removal. With minor refinements, these methods are applicable to the study of adhesion and forces at the nano-level.

2. **Manish Chawla, Tony Chou**, Kevin McCarthy, Xi Geng, Ravindra Datta, Jianyu Liang  
   (Contact: tchou90@wpi.edu)  
   Worcester Polytechnic Institute - Chemical Engineering

**Synthesis and Characterization of Tin Oxide-Supported Platinum for Direct Methanol Fuel Cells**

It is imperative to reduce society’s reliance upon the limited supply of fossil fuels. Direct methanol fuel cells (DMFC) possess immense potential as an alternative to current energy generation methods, especially in portable applications because of their high energy density, low operating temperature, and ease of handling. Several obstacles, however, are preventing wide-spread adoption of the technology. Such obstacles encountered by contemporary carbon-supported catalysts include prohibitive materials cost and relatively abbreviated life cycles due in part to inefficient Pt-catalyst loading and cathode degradation resulting from methanol crossover. The following research investigated the potential of tin oxide as a DMFC electrocatalyst support due to metal oxides’ high electrical conductivity, good corrosion resistance, and resistance to the effects of methanol crossover. In this paper, two synthesis methods to prepare tin oxide-supported platinum are reported: the impregnation process and the colloidal process, relying primarily on ethylene glycol as the reduction solvent. Platinum particle size, loading, and surface distribution on the tin oxide support were characterized by TEM, SEM, and XRD, while its electrochemical properties were determined by electrochemical tests. It’s properties were compared with conventional Vulcan XC-72 carbon black-supported platinum. Promising samples were used as cathode catalysts in DMFC in order to investigate their single-cell performance.

3. **Rebecca Gaddis**, Evan Anderson, Terri Camesano, Nancy Burnham  
   (Contact: rlgaddis@wpi.edu)  
   Worcester Polytechnic Institute - Physics

**Getting to the Root of Bacterial Hairs**

An atomic force microscope (AFM) was used to measure the steric forces of bacterial lipopolysaccharides (LPS) on Pseudomonas aeruginosa. These forces were characterized with a modified version of the Alexander and de Gennes (AdG) model for polymers, which is a function of equilibrium brush length, probe radius, temperature, separation distance and an indefinite density variable, $s$. This last parameter was originally distinguished by de Gennes as the root spacing or mesh spacing depending upon the type of polymer adhesion, however since then it has been commonly thought of as the root spacing. This study aims to clarify the ambiguity of this parameter. This is done by varying the temperature at which the steric forces of the LPS are measured at and by changing the pH value of the imaging fluid. Preliminary data suggest that the LPS extend with increasing temperature and [vary according to the fluid pH], thus using the AdG model the $s$ parameter will next be characterized. If it is the root spacing it should remain constant regardless of the changing polymer lengths, on the other hand if it is the mesh spacing it will be proportional to the temperature or pH change. Preliminary data shows the LPS length to be on the scale of several hundred nanometers while $s$ is on the scale of tens of angstroms and is varying with temperature and pH.
Satya Shivkumar, Melanie Li Sing How
(Contact: min.8mik@wpi.edu)
Worcester Polytechnic Institute - Mechanical Engineering

Cross-linked Sodium Alginate-Calcium Chloride nanostructures using Template Infiltration Technique

Alginates are natural polyacids, which in the presence of ions form pH-sensitive gels with reswell abilities. They are widely used in the food industry as thickening agents due to their non-toxicity, as tissue membranes and as drug carriers in pharmaceutical research. The use of nanoparticles enhances the uptake of the drug by appropriate cells, which make alginate nanotubes a promising structure for orally delivered drugs. In the present study, a template-assisted technique was used to fabricate cross-linked sodium alginate and calcium chloride gel nanostructures. Commercial anodized aluminum oxide templates were infiltrated with calcium chloride and cross-linked with sodium alginate to form the sols. After dissolution of the template, the nanostructures were characterized in Scanning electron microscope and Transmission electron microscope to analyze the effects of dipping cycle, dipping time, concentration of Sodium Alginate and concentration of Ca2+ ions on the morphology. Typical diameter, length and thickness of the nanostructures were of the order of 200-300nm, 10-30μm and 60-75nm respectively. Optimum concentration of alginate to produce distinctly formed nanotubes was 1wt% and template dipping time of less than 4h. Rheological techniques were used to assess the gel strength and behavior with pH and temperature. Low concentrations resulted in long nanostructures with relatively low mechanical strength while high concentrations resulted in short fully-formed nanotubes.

Jeffrey Kleinschmidt, Judy Long, Thandi Buthelezi
(Contact: kleinschmidt_jeffrey@wheatoncollege.edu)
Wheaton College - Chemistry

Temperature Sensing Using Cyclodextrin-Spiropyran Fluorescent Based Nanothermometer

Nanothermometers are important for measuring temperature of systems at the nanoscale level such as a single cell. Here, we have measured the temperature sensitive absorption and fluorescence spectra of the cyclodextrin-spiropyran based nanothermometer. The colorless cyclodextrin-spiropyran complex in aqueous binary solvents change reversibly to a colored cyclodextrin-merocyanine complex as a function of temperature. At lower temperatures, 25 °C or less, the colorless cyclodextrin-spiropyran complex is favored. The colored cyclodextrin-merocyanine complex in DMSO-water is favored at higher temperatures and ranges from pink → red → orange → yellow. The complex undergoes a transformation from MC to MCH+ conformation at temperatures greater than 65 oC which contribute to the different solution colors. The working range of this nanothermometer is from 25 to 95°C.

Fei Huang, John Bladon, Ross Lagoy, Peter Shorrock, Anne Rittenhouse, W. Grant McGimpsey
(Contact: rosslagoy@wpi.edu)
Worcester Polytechnic Institute - Biomedical Engineering

Photostimulation of Neurons

It is estimated that roughly 6.3 million people worldwide are blind as a result of age related macular degeneration and retinitis pigmentosa. Current treatments target the progression of the disease but cannot address the loss of vision. A promising line of research involves the use of photodiodes coupled to a microelectrode array to stimulate the remaining photoreceptor neurons in the retina, restoring a certain degree of vision. As an alternative we have proposed a flexible, plastic, printed array that promotes the growth and attachment of neurons and is photovoltaic. This device could be inserted into the eye using a minimally invasive procedure, it would promote the growth of neurons to it in an ordered array and would and would allow for the photostimulation of those neurons. In this way an image could be created with a minimal pixel size of one neuron. Preliminary work has shown that we can create this surface on an indium tin oxide substrate and that it will photostimulate the electrical activity of NG108 neurons.

Benjamin McCarron, Xiaokong Yu. Mingjiang Tao, Nancy Burnham
(Contact: bmccarron@wpi.edu)
Worcester Polytechnic Institute - Physics, Civil and Environmental Engineering

Investigating ‘Bee-Structures’ in Asphalt Binders

Asphalt binders, otherwise known as bitumen, are crucial in modern construction. Bitumen has been found to possess a complex microstructure. In 1996, Loebet al. coined the term ‘bee-like structures’ to describe a main feature in their studies of bitumen at the nano-scale. Other literature suggests that the structures are composed of a wax, which has been observed to melt at high temperatures. For this project, an atomic force microscope was used to analyze the microstructure of bitumen. All experiments were performed with cantilevers with a nominal spring constant of ~27 N/m and a frequency of ~198 KHz, and were performed in intermittent contact mode. Initial experiments were also performed on a glass slide and a pressed CD sample attached to a slide via double stick tape in order to anticipate problems with thermal drift involving the
increase of temperature at a steady rate during continuous imaging. Graphs of displacement vs. temperature for the glass and pressed CD samples show that despite the difference in thermal expansion coefficients, their thermal drifts were comparable. Future experiments will be performed on bitumen and used to compare the thermal drift to that of glass and pressed CD samples. During these heating experiments, the dissolution of the structures during heating and the evolution of them during cooling will be observed. These data might lead to better asphalt performance and the reduction of potholes.

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Gawain Thomas, Christopher Lambert, Nancy Burnham
(Contact: gawainthomas@wpi.edu)
Worcester Polytechnic Institute - Physics, Bioengineering Institute

Does Controlled Roughening of a Surface Increase its Capacitance?

Miniature electrodes are in growing demand in several areas of science, including medicine, alternative energy, and nanotechnology. The investigation into the effects of surface roughness on the electrical properties of these electrodes could lead to improvements in their efficiency or applicability, particularly for monitoring glucose levels in diabetics or by potentially increasing the efficiency of fuel cells and solar panels. We use gold microscope slides that are cleaned and electrochemically coated with gold nanoparticles, and then coated with dodecanethiol. The surface roughness and characteristics are determined using atomic force microscopy (AFM), and the electrical properties are measured using electrochemical impedance spectroscopy (EIS). The electrodes are modeled by the Randles-CPE circuit, and a numerical fitting algorithm is used to determine the magnitude of the capacitance. AFM images show successful growth of various-sized nanoparticles on the gold surface. Preliminary EIS results have shown a decreased capacitance for smaller roughness features, in agreement with literature. The literature also predicts that a surface coated with spherical particles should have twice the capacitance of a truly flat surface, which we have been thus far unable to observe due to difficulties in obtaining a flat surface. The remainder of research will focus on various polishing techniques so that we may have a true comparison between rough and smooth surfaces.

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Zhixin Wang, Christopher Lambert, Nancy Burnham
(Contact: hara.zhixin.wang@wpi.edu)
Worcester Polytechnic Institute - Chemical Engineering, Bioengineering Institute, Physics

Nanoparticle-Roughened Photoelectrodes for Efficient Dye-Sensitized Photovoltaic Systems

Gold nanoparticles were used to roughen gold substrates of photoelectrodes using NK5962 photoelectric dyes, in order to increase the substrate surface area for dye deposition. Nanostructured gold substrates were fabricated using seed-mediated growth approach and characterized using atomic force microscopy (AFM). NK5962 dye attachment onto the substrates was achieved through self-assembled monolayer formation. The nanoparticle and dye coverage of the gold substrates were studied using electrical impedance spectroscopy (EIS) and UV/Vis absorption spectroscopy. The photovoltage and photocurrent produced by the photoelectrodes in an electrochemical cell were measured using a lock-in amplifier. AFM imaging displayed photoelectrode substrates roughened by moderately covered 200 nm nanoparticles. Such particle size was achieved after a minimum of 5-day gold growth period. The EIS spectra of the roughened photoelectrodes, fitted into a Randles-W-CPE model, showed -1.3% change in capacitance, meaning that no significant surface area change occurred. It coincided with the UV/Vis spectra, where differences in NK5962 peak intensity between unmodified and nanoparticle-modified photoelectrodes are minimal. Photovoltage and photocurrent measurements demonstrated similar results, where no significant change was observed for nanoparticle roughened photoelectrodes. Therefore, gold nanoparticle roughening is inadequate to significantly improve dye deposition for dye-sensitized solar systems.

MASTER’S and PHARM.D
LEVEL ABSTRACTS

Amal Abdulghani, Reema Zeineldin
(Contact: amal.abdulghani@my.mchs.edu)
Mass. College of Pharmacy & Health Sciences – Pharmaceutical Sciences

Employing Inflammatory Environment for Drug Release from Supported Lipid Bilayers in Ovarian Cancer

The environment of ovarian carcinoma (OVCA) is an inflammatory environment and has immune cells that can generate reactive oxygen species (ROS). It was discovered that antibodies can catalyze the formation of peroxide (H2O2) and a species with a chemical signature similar to that of ozone through the oxidation of water. The ozone-like species is associated with activated human neutrophils found in inflammation. Our goal is to create a nanocarrier made of a ROS sensitive lipid bilayer that is supported on porous silica nanospheres. Dye-loaded silica spheres were encapsulated with different lipids and
incubated in vitro with activated macrophages and OVCA. Our results show disruption of the supported lipid bilayer on spheres and the release of the fluorescent dye encapsulated inside the carriers as detected by flow cytometry. In conclusion, the lipid bilayer is sensitive to ROS produced by macrophages. The significance of being ROS sensitive is that its therapeutic content can be released exclusively within the inflammatory peritoneal microenvironment of OVCA. At the same time having the lipid bilayer supported on silica spheres will stabilize them when facing lower ROS concentrations.

11 Evan Anderson, T. Esformes, S. Chakraborty, D. Eggiman, C. DeGraf, K. Stevens, D. Liu, N. Burnham
(Contact: evan09@wpi.edu)
Worcester Polytechnic Institute – Physics

Shape-Independent Lateral Force Calibration

Lateral force microscopy is a discipline of atomic force microscopy used to measure friction on micro- and nanometer scales. The cantilever used must be calibrated in order to determine the magnitude of the lateral force twisting it. Current methods used for lateral force calibration of cantilevers suffer from several limitations. These limitations include: i) specialized samples or equipment are required, ii) repeated measurements are necessary, causing excess wear to the tip, iii) calibration is done on a cantilever other than the one that will be used, iv) calibration is performed ex-situ, v) the method is time-consuming, vi) the equilibrium diagrams of the forces acting on the tip are incorrect. Here, a new method is proposed which alleviates these problems. This procedure is shown to be independent of scan parameters and sample topography. The local geometry is calculated from the topography images so that the average lateral force in Newtons can be plotted against the average lateral force in Volts. The slope of this plot gives the calibration factor, the lateral force required to cause one volt of movement on the photodiode. This method is shown to be accurate within a factor of five of torsional spring constants calculated using the dimensions given by the manufacturer, and its precision is a few percent. With the validation of this method comes a simple, quick, and precise method for lateral force calibration. ACS Appl. Mater. and Interfaces 3, 3256-3260 (2011)

12 Jeffrey Bibeau, Luis Vidali
(Contact: jpbibeau@wpi.edu)
Worcester Polytechnic Institute – Biology and Biotechnology

Fluorescence recovery after hotobleaching analysis of the molecular motor myosin XI

The study of polarized tip growth has provided important insights into the mechanism of plant cell growth. It is well accepted that during tip growth, growth machinery deposits new cell wall material at the apex of the cell. The central components of this machinery are filamentous actin (F-actin) and myosin XI (the plant homologue of myosin V), which are believed to polarize and transport Golgi derived secretory vesicles. Nevertheless, the precise dynamics and binding partners of myosin XI are unknown in plant cells. To elucidate the binding partners of myosin XI fluorescent recovery after photo bleaching (FRAP) techniques were used. Experiments were conducted with a moss line expressing fluorescently labeled myosin XI. FRAP analysis indicated that the dynamics of myosin XI at the cell’s apical region differed from those measured at the sub-apical region. Specifically, the rate of fluorescent recovery was found to be more rapid at the sub-apical region. When treated with the F-actin inhibitor, Latrunculin B, apical myosin XI recovery hardened and resembled that of sub-apical myosin XI. This strongly suggests that myosin XI is binding to F-actin at the cortex of cell and provides essential insight into the process of moss tip growth.

13 Lisa Ferreira, Anna Liang, Khaled Elsaid, Gerard G.M. D’Souza
(Contacts: lisa.ferreira@my.mcphs.edu, gerard.dssouza@mcphs.edu)
Mass. College of Pharmacy & Health Sciences – Pharmaceutical Sciences

Evaluation of Micelles and Liposomes in an In-Vitro Articular Cartilage Explant Model

Osteoarthritis (OA) is a degenerative joint disease. OA is ideally suited for direct administration of drugs at the disease site, but a major challenge to this approach is the short residence time of bioactives in the joint tissues. Pharmaceutical carriers like micelles and liposomes could potentially improve the efficiency of drug delivery and retention in joint tissues. The aim of this project is to evaluate the time-dependent association, dose dependent, penetration and chondrocyte uptake of micelles and liposomes using an in-vitro bovine cartilage explant model. Results from the time-dependent association of micelle- and liposome-treatments show higher fluorescence intensity in the micelle-treatment as compared to the liposome- treatment over time. Histological slides stained with Hoescht suggest the micelles are able to penetrate into cartilage and associate with the chondrocytes as compared to liposomes. Data also suggests association and penetration of micelles is dose dependent. Overall, bovine articular cartilage explants can serve as an in-vitro model to evaluate the distribution of nanocarrier platforms within articular tissue. Liposomes showed a measurable uptake and association with articular tissue. Micelles showed significantly greater tissue penetration and chondrocyte uptake as compared to the liposomes. Micelles therefore represent a
promising platform for the improved delivery of poorly soluble disease modifying drugs for the treatment of OA.

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Xi Geng, Jieying Jing, Yuqin Yao, Jianyu Liang
(Contact: xigeng@wpi.edu)
Worcester Polytechnic Institute – Mechanical Engineering & Taiyuan University of Technology (People’s Republic of China) – Mechanical Engineering

Construction of Hierarchical Structured Carbon Fiber/Carbon Cloth Hybrid for Effective Immobilization of TiO2 Nanoparticles

Hierarchical structured TiO2/CNFs-CC nanocomposite was synthesized via a combination method of chemical vapor deposition (CVD) and sol-gel fabrication. In-situ growth of coil-like carbon nano fibers (CNFs) on carbon cloth (CC) was first achieved through catalytic pyrolysis of acetylene. Anatase TiO2 nanoparticles with average particle size of 15nm were subsequently immobilized onto the CNFs-CC film by impregnation and calcination at 450°C in nitrogen. The physicochemical properties of the as-synthesized nanocomposite were investigated using transmission electron microscopy (TEM), scanning electron microscopy (SEM) and X-ray diffraction (XRD), respectively. This synthetic strategy provided an efficient route towards the integration of functional nano-scale entities, such as photoactive TiO2 nanoparticles onto the porous nanocarbon substrate, which may open potential for the enhanced photocatalytic degradation of hazard materials.

While the Cr2O3 is a common industrial catalyst, due to charge compensating mechanisms associated with the LiNbO3, its ferroelectric properties are relevant in determining the behavior of this material system. In addition to showing evidence for epitaxial Cr2O3 thin films on LiNbO3, our results give insight into the origin of the charge compensation mechanism of the ferroelectric substrate.

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James Kingsley, Erkan Tüzel
(Contact: jkingsley@wpi.edu)
Worcester Polytechnic Institute – Physics

Capillary Waves on Binary Droplets in a Particle-Based Fluid Simulation

Stochastic Rotation Dynamics (SRD) is a particle-based simulation method that can be used to model fluids. It has many of the benefits of direct simulation methods, while still being computationally inexpensive. With hydrodynamic interactions and thermal fluctuations built-in, it can be used in the simulation of complex fluids. Starting with a simple, ideal fluid, the method was verified for theoretical consistency and extended to support non-ideal equations of state. As expected, the non-ideal fluid demonstrated freezing behavior at low temperatures. It has been shown that by employing these repulsive interactions, the model can be applied to binary mixtures. Droplets in these mixtures show the expected characteristic capillary waves, which can be used alongside Laplace pressure to calculate the droplet line tension.

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Abedin Koshi, Peter Bradley, Daniel Schmidt, Emmanuelle Reynaud
(Contact: abedinkoshi@gmail.com)
Worcester State University – Biology

Biocompatibility testing using VERO cells cultured on some polyamide clay nanocomposites

In this study, several polyamide plastic samples were tested for biocompatibility by studying the growth of mammalian tissue culture cells on them. These included chemically analogous amorphous Grilamid TR90 and microcrystalline Trogamid CX7323 plastics with and without organically modified montmorillonite nanoparticles (Cloisite 30B at a concentration of 1% inorganic by volume). Cells were counted with a Coulter counter at several time points. Changes in the appearance of cells were examined with phase contrast microscopy and scanning electron microscopy. At first, the cells did not adhere to any of the test plastics and were rounded instead of spreading onto the plastic and growing normally. After about 10 days the cells on the Grilamid TR90 nanocomposite did recover and increased in number. Cells on unfilled Grilamid TR90 did
not grow, nor did cells on either the Trogamid CX7323 or its nanocomposite. In sum, the presence of these clay nanoparticles appears to have rendered one plastic more compatible with Green Monkey kidney (VERO) cells than when the clay nanoparticles were absent from the same plastic.

**Combined Atomic Force Microscopy and 3-D Optical Microscopy of Cells and Biomaterials**

Atomic force microscopy (AFM) and 3-D Optical Fluorescence Microscopy are uniquely combined to measure the static, dynamic, and even living response of cells and biomaterials to mechanical loading. For example, in the case of MH-S macrophage cells, living cells are observed to actively adhere to an impinging AFM tip when loading the cell with <10 nN. Known for scavenging nano- to micro-scale structures from their surroundings via phagocytosis, a 50% local increase in fluorescence intensity of GFP-Actin at the tip apex is resolved in 3-D. Signifying F-actin polymerization, the resulting cytoskeletal structure either attaches to the tip, or assembles to capture and consume the probe. Following retraction of the AFM load, depolymerization signifies that this living structure is dis-assembled. On the other hand, with fibrous-gel cell scaffolds for tissue engineering, 3-D tracking of embedded microbeads during nanomechanical loading can reveal local as well as ensemble mechanical properties for these complex networked systems. This combined hardware therefore provides unique opportunities to investigate passive and active materials properties at the interface between nanotechnology and biomedicine.

**Silver (Ag) - Carbon Nano Tube (CNT) Composite for Wastewater Treatment**

Particles used on the nano-scale are much more reactive than their conventional macro-scale counterparts, due in part to their greater surface area per weight. The optimization of a silver-CNT composite with strong adhesive properties is expected to provide an effective means at treating industrial wastewater in a simple and cost effective manner. Preliminary results exhibit strong support of this investigation. A bottom-up chemical reduction approach is used to produce silver nano-particles without aggregation at high yield and low-cost. By controlling various synthesis parameters such as concentration, pH, and additives, silver nano-particles can be created at the desired diameter. Preliminary results show an average stable particle size of 8nm of silver on the CNT's. Adhesion properties have also been improved by specially treating the CNT surfaces. Through further adjustment of the synthesis conditions, Ag nanoparticles with desirable morphology are tested in the treatment of industrial wastewater. Optimizing this nanocomposite is the first step in creating a more complex and more effective nanocomposite that can treat a broader range of containments.
Domain formation in multicomponent lipid bilayers coupled to elastic substrate

We will discuss the physics that governs the lipid localization and domain formation in multicomponent lipid bilayers coupled to an elastic substrate. Lipid localization and domain formation has been studied extensively in biological cell membranes. In this talk we will extend a previous model for membrane energetics to account for the coupling between the bending and the local lipid composition of the two leaflets. Our aim is to determine the relationship between the localization and domain formation in the presence of lipid flip-flops between the two leaflets and the effect of intrinsic curvature of the lipids. Using a lattice model for the membrane, we simulate the system and study the effect of lipid flip-flop on lipid organization in the membrane.

Coarse-grained model of chloroplast transport in moss

In eukaryotes organelle motility plays an important role in cell function. Microtubule (MT) network is an intercellular structure that consists of polarized filaments, namely “tracks” allowing cargoes to be transported via molecular motors. In the moss Physcomitrella patens, reorganization of the chloroplasts to adapt to changes in light intensity and quality is essential. In this work, we analyze the chloroplast transport in protonemal moss cells, and show that their transport is facilitated by the microtubule cytoskeleton. Recently, lattice models of microtubule network have been used to explain cargo transport in animal cells. Here, we discuss a similar model that we developed for chloroplast transport in moss. In particular, we show results on the effect of the length distribution of MT tracks, and the porosity of the network on the observed motility.

High-Speed Atomic Force Microscopy Techniques for the Efficient Study of Nanotribology

As mechanical devices scale down to micro/nano length scales, it is crucial to understand friction and wear at the nanoscale (nanotribology) especially at technically relevant sliding velocities. Accordingly, three novel techniques have been developed to study nanotribology leveraging recent advances in high speed AFM. The first method utilizes high line scanning rates
coupled with sinusoidal scanning along the AFM fast scan, enabling rapid friction measurements as a function of velocity up to 20 mm/sec. The second method rapidly acquires friction versus force curves through disabling the feedback loop during scanning and relating the resulting lateral data with the correspondingly varying normal loads. As a result, ‘images’ of the coefficient of friction, friction at zero load, and/or load for zero friction (typically adhesive) can be uniquely determined for heterogeneous surfaces. This work includes measurements on graphite, mica, diamond, and Au/SiOx microfabricated structures, and is applicable for wear of sliding or rolling components in MEMS, biological implants, contact lenses, or data storage devices, etc.

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Moumita Dasgupta, Arshad Kudrolli, Michael Berhanu, Bin Liu, Thomas Powers, Kenneth Breauer, Henry Fu
(Contact: mdasgupta@clarku.edu)
Clark University – Physics; Brown University

Speed of a Taylor swimmer in Newtonian and Viscoelastic fluids

We discuss a mechanical experimental model of a flexible sheet swimming with a prescribed wave pattern through a fluid. We are motivated by a need for a fundamental understanding of microorganism locomotion through non-Newtonian fluids. To simplify the problem, we suspend a tall flexible cylindrical sheet concentric within a cylindrical tank filled with the fluid; we call this a Taylor swimmer. The design is based on similar principles as formulated theoretically by G. I. Taylor in ‘Analysis of swimming in microscopic organism, Proc. R. Soc. A 209, 447 (1951)’ for a planar geometry. We impose torque free boundary conditions by supporting the flexible sheet and the tank with friction-free ball-bearings. A traveling wave is imposed on the sheet with a pair of rollers in the azimuthal direction. We observe an increasing trend of swimming speed as wave speed increases. Decrease in swimming speed is observed with increase in viscoelasticity of the fluids. We then discuss the dependence of swimming speed on the Deborah number of the fluids.

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April D. Jewell, E. Charles H. Sykes
(Contact: april.jewell@tufts.edu)
Tufts University – Chemistry

Determining the Effect of Head Group Chemistry on Surface Self-Assembly

Surface molecular self-assembly is a fast advancing field with broad applications in sensing, patterning, device assembly and biochemical applications. The vast majority of practical systems utilize alkane thiols supported on Au surfaces. While a strong S-Au bond facilitates robust self-assembly, the interaction is so strong that the surface is reconstructed, leaving etch pits that render the monolayers susceptible to degradation. By adjusting the molecule-surface interaction and using different head group elements, a vast array of new systems with novel properties may be formed. Here we use a carefully chosen set of molecules to make a direct comparison of the self-assembly of thioether, selenoether and phosphine species on Au(111). Using Au’s native herringbone reconstruction as a sensitive readout of molecule-surface interaction strength we correlate head group chemistry with monolayer properties. We demonstrate that the simple hard/soft rules of inorganic chemistry can be used to rationalize the observed trend of interaction strengths i.e. P > Se > S. We find that the structure of the monolayers can be explained by the geometry of the molecules in terms of dipolar, quadrupolar or van der Waals interactions between neighboring species driving the assembly of distinct ordered arrays. As this study directly compares one element with another in simple systems, it may serve as a guide for design of self-assembled monolayers with novel structures and properties.

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Rudra Kaifle, Eddy Timmermans
(Contact: rpk101@wpi.edu)
Worcester Polytechnic Institute – Physics; Los Alamos National Laboratory

Berry-gauge tuned Bose-Einstein condensate gyroscope

If stable, the many-body ground state of a dilute gas of ultracold, bosonic atoms occupying a superposition of two internal (hyperfine) states is a Bose-Einstein condensate (BEC) of effective spin $1/2$ bosons. The superfluid BEC dynamics admits long-lived quantized vortex states in which the complex phase of the superfluid order parameter, which we call the charge phase, undergoes an integer number of $2\pi$ windings along a multiply connected path - a closed trajectory that encloses a region in which the superfluid density vanishes. In response to an overall rotation of the ring, a quantization event can occur that can be used to sense rotation. Unfortunately, the sensitivity of the ring BEC gyroscope would be limited as the quantization...
event sets in at a rotation frequency that is not as low as the frequencies measured by other devices such as ring laser gyroscopes. We show that the recently realized synthetic magnetic fields, in which the controlled position dependence of the spin results in an effective gauge field, can tune the BEC ring gyroscope to trigger a quantization event at much smaller rotation frequency. In addition, the effective gauge field can undergo its own quantization events in which the spin vector undergoes an integer number of $2\pi$ or $4\pi$ windings.

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P. Kalakonda, G.S. Iannacchion, R. Basu, C. Rosenblatt, R. P. Lemieux
(Contact: parvathalu@wpi.edu)
Worcester Polytechnic Institute – Physics; Case Western Reserve University – Physics; Queen’s University (Ontario, Canada) – Chemistry

Effect of CNT and Induced Chirality on I-N and N-A Liquid Crystal Phase Transitions

High-resolution calorimetry is presented on the phase transitions of nano-colloidal dispersions of multi-wall carbon nanotubes (CNTs) and the liquid crystal 9OO4 as a function of temperature, scan rate, and CNT concentration (0, 0.008, 0.025, 0.01 0.05, 0.20 wt%). The CNT used have an enantiomeric excess that has been shown to induce chirality into this LC. The pure LC exhibits the phase sequence I-N-SmA-SmC-SmB-Cr on cooling with the expected heat capacity Cp signatures. The introduction of CNTs results in the I-N, N-SmA, Cp features to all shift to higher temperatures by 1 K and remains sharp. The order of the transition remains the same being the I-N first-order and the N-SmA second-order. The temperature-dependent but $\phi$,w-independent change in thermal transport properties is observed due to the surface ordering and disordering interaction of CNT with LC molecules. A slight change in enthalpies is alsoobserved in the samples due to the addition of CNT. These effects of incorporating the CNT with LC are likely due to mainly surface anchoring for $\phi$,l-Pi$,rPi$, electrons and the thermal anisotropic properties of CNT. Continued ex-perimental eorts probing the homogeneity of the sample, frequency-dependent-dynamics, analyzing other phases.

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Paul. G. Kassebaum, L. R. Ram-Mohan
(Contact: pkassebaum@gmail.com)
Worcester Polytechnic Institute – Physics

The adiabatic bond charge model of phonons in diamond

The dispersion relation between wave vector and frequency of atomic vibrations, or phonons, can be succinctly described by the adiabatic bond charge model, first developed by Werner Weber, which employs as few as four parameters to fit experiment. We investigated this model in order to better unify the description of the technologically relevant group IV elemental semiconductors (e.g. diamond, silicon, germanium, and gray tin) by replacing an ad hoc parameter introduced by Weber with one arising from quadrupolar interactions between the bond charges, and by fitting the parameters to density functional theory calculations. We also illustrate constant frequency surfaces embedded in wave vector space for the various modes of vibration for the first time. The bond charge model allows for rapid calculation of various quantities related to the interaction of phonons with electrons and photons as compared to density functional theory, especially in structures with little symmetry and for macroscopic structures, thus enabling the design of complicated electronic and photonic devices much more accurately. Future work will involve adapting the bond charge model tot zincblende- and wurtzite-structured group III-V alloys.

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Aung Khaing, Aung H. Lynn, Christopher R. Lambert
(Contact: aungmk@wpi.edu)
Worcester Polytechnic Institute – Biomedical Engineering

Covalently linked antibiotics for biofilm resistant surfaces

Invasive and chronic infection from biofilm formation is one of the main causes of failure of medical implants. Once biofilms have formed, removal of the implants is often the only viable medical option to prevent its spread and further infection. Our approach to address this problem is to attach a single molecular layer of an antimicrobial agent that attacks the membrane of the bacterium. This film does not change the physical properties of the material but only the surface behavior. The antibiotic chosen is an example of a cyclic lipopolypeptide and may be attached through the use of peptide coupling chemistry. Preliminary experiments have shown that the system limits the colonization of bacteria on the surface and resists the formation of biofilm. The proposed mechanism of this activity will be presented and details of how it might be applied to wide variety of materials discussed.
An atomic-scale study of the reactivity of methanol with model Cu, O/Cu and Pd/Cu alloy surfaces with STM and TPD

Hydrogen is green fuel capable of producing electricity. Methanol is a promising hydrogen storage molecule with a high hydrogen-to-carbon ratio (4:1). My research examines methanol oxidation and decomposition on model catalysts via variable temperature scanning tunneling microscopy (VT-STM) and temperature-programmed reaction (TPR). Methanol desorption on Cu(111) was studied from 130 K (multilayer desorption) to 165 K (monolayer desorption) with STM. Analysis of STM images reveals several structures that are governed by hydrogen-bonding interactions. From the STM images, hexamers are the most thermodynamically stable structure on Cu(111). Hydroxyl-proton localization on the hexamers leads to two enantiomers. The Cu surface was chemically modified in two ways to alter methanol reactivity. First, the effect of oxygen at various temperatures on Cu(111) was studied with STM. STM and XPS of a Cu(111) surface pre-adsorbed with oxygen after exposure to methanol show methoxy forms at the interface of the oxide-like domains and bare Cu. The second avenue was a Cu-based bi-metallic alloy containing small amounts of Pd. The TPD studies on model Pd/Cu catalysts interestingly reveal partial decomposition of methanol to formaldehyde and hydrogen. STM images acquired reveal that at temperatures above MeOH desorption, molecules only occupy sites near Pd atoms, suggesting these are the active sites.

Adsorption of Gases on Metal Oxide Powders and Films

The adsorption of reactive gases, including sulfur dioxide and methanethiol, on a variety of metal oxide and hydroxide nanoparticle powders has been studied using X-ray photoelectron spectroscopy (XPS), Raman spectroscopy, and thermal gravimetric analysis. The effect of moisture on adsorption has been evaluated either by pre-drying the metal oxides or hydrating them prior to gas exposure. In the case of zinc oxide, dramatic differences in the amount of adsorbed gas have been observed due to morphology changes, as measured by transmission electron microscopy. Many of the metal oxides studied are photoluminescent, and changes in their emission spectra have been monitored during gas exposure. In addition to exposing metal oxide powders to reactive gases, inkjet printed films of zinc oxide and zirconium hydroxide have been fabricated on different substrates. It is demonstrated that photoluminescence changes of the films may be used to monitor adsorption, and these may have sensor applications.
of nanocarrier formulations in solid tumors in a high-throughput manner. OVCAR-3 (ovarian carcinoma) and LLC (Lewis Lung Carcinoma) spheroids were generated by a liquid-overlay technique on agar matrices in a 96-well plate. The cytotoxicity of different formulations (liposomes with different surface modifications, micelles, nanoparticles) on the spheroid was assessed by the MTS assay while apoptosis was determined by a luminescence assay following treatment. The penetration and accumulation of the formulations into the spheroids were determined by imaging spheroid sections under a fluorescence microscope followed by analysis with Image J. Spheroids, 0.8 mm in diameter, were produced reproducibly. The high-throughput cytotoxicity assay in spheroids was useful in determining the effect of different treatments on the spheroid while the apoptosis assay identified the cell death mechanism of the treatments. Differences in the penetration and accumulation of the formulations into the spheroid were observed. Screening formulations in the spheroid model in a high-throughput manner could potentially improve the optimization and selection of nanocarrier formulations for evaluation of antitumor effect in solid tumors in vivo.

35 Morgan M. Stanton, W. Grant McGimpsey, Christopher R. Lambert
(Contact: mmstanton@wpi.edu)
Worcester Polytechnic Institute – Chemistry and Biochemistry

A Modified Surface for Optimized Cell Culture

In vitro studies of cell behavior are an essential prerequisite in accessing the biocompatibility of a surface. Multiple studies have been done that show changes in cell morphology with varying surface roughness. These unique surfaces have applications in tissue engineering and biomedical devices. Using a simple templating technique, a super-hydrophobic, adhesive surface was fabricated used to control cell morphology and adhesion. The final surface has applications in bioengineering and high throughput assays for a polymer substrate. The surface presented behaves as a pseudo three dimensional scaffold, for fibroblast cell growth, allowing the expression of in vivo morphology.

36 Ilyas Unlu, James E. Whitten
(Contact: ilyas_unlu@student.uml.edu)
University of Massachusetts, Lowell – Chemistry; Center for High-Rate Nanomanufacturing

Light-Induced Transfer of Nanoparticles

Titanium dioxide surfaces are known to undergo a hydrophobic-to-hydrophilic transition upon irradiation with ultraviolet (UV) light. Efforts are underway to use this phenomenon for light-induced transfer of nanoelements for nanomanufacturing applications. In one approach, nanoparticles are placed on the tip of an atomic force microscope (AFM). When the tip is brought into proximity with a TiO2(110), the tip/surface combination is irradiated with UV light in order to induce hydrophilicity on the surface and to attract nanoparticles from the tip via dipole-dipole forces. In the second approach, a nanoscale trough is formed on a quartz substrate. Nanoparticles functionalized with polar ligands are placed into the trough, and this assembly is covered with a TiO2(110) surface. Transfer may be initiated by irradiating the TiO2 surface through the quartz substrate. Progress on these projects and their advantages over competing transfer techniques will be presented.

37 Vikrant Yadav, Jean-Yonnel Chastaings, Arshad Kudrolli
(Contact: vyadav@clarku.edu)
Clark University – Physics; ENS de Lyon

Experiments on ordering transitions in mechanically stable structures of granular rods

We investigated the evolution of granular rods from mechanically stable disordered to crystalline states in response to vibrations. We obtained positions and orientations of the rods in three dimensions using micro-focus X-ray Computed Tomography. Above a critical aspect ratio, we find that rods align vertically in layers with hexagonal order within a layer, independent of the shape of the container and details of the form of vibration. We also quantitatively study the evolution of local and global ordering using density pair correlation function $g(r)$ and orientational order parameter $q_{6}$ as a function of aspect ratio. As the system compacts, local structures emerge and grow, their size and orientation being dependent on volume fraction. Although the initial nucleation of order occurs along the boundaries, we show that the geometry of boundaries have little overall effect on the observed ordering transition. Finally we show that configuration entropy arguments do not play a significant role in the observed ordering, and the system evolves towards increasing stability under small perturbations.
Synthesis of Graphene Nanosheets

As a 2-D carbonaceous material with monoatomic thick layer and honeycomb network, graphene nanosheet (GNS) has attracted extensive attention since its discovery in 2004. Various synthesis methods have been developed, such as mechanical exfoliation, chemical vapor deposition, thermal decomposition, unzipping carbon nanotubes and wet chemical synthesis. Among them, wet chemical synthesis method is considered to be one of the most controllable methods. Typically, wet chemical method includes three steps: oxidizing natural graphite with concentrated sulfuric acid, dispersing graphite oxide in organic solvent and reducing graphene oxide to GNS. Most of the chemicals used in this method are toxic, and powerful sonication is required. In this paper, we report on a novel synthesis method which consists of two facile steps to obtain stable GNS suspensions and does not rely on strong reagent or powerful sonication. This method also enables us to tailor the functional groups on the basal planes and the edge of GNS. Materials characterization techniques, including SEM, TEM and XRD were employed to investigate the morphology and crystal structure of graphite, graphene oxide and GNS. AFM and SEM studies indicate that the average thickness of synthesized GNS is around 2nm, i.e. ~5 graphene layers. Besides, the GNS suspension is proven to be stable for at least a month, which is desirable for future fabrication of graphene-based composites.

Microscopic morphology and mechanical properties of bitumen

Bitumen, also known as asphalt binder, is a complex mixture of hydrocarbons and one of the main construction materials. Previous study suggested that some bitumen is a multi-phase system exhibiting bee-like microstructure, and different phases varied in stiffness were resulted from different chemical components in bitumen. However, the origin of the bee-structure of bitumen is debatable and quantitative understanding of its micromechanical properties is incomplete. This project aims to build the link between chemistry and mechanics of bitumen in micro scale using atomic force microscopy (AFM). Preliminary experiments performed on heat cast and solution cast samples showed that great technical challenges (e.g. opacity and stickiness) existed in this study. Clear topographic image could not be obtained at room temperature by contact AFM mode due to the sticky surface. Bumps were formed at the points of force-curve acquisition and they shrunk gradually as time increased, which indicated that adhesion might be dependent on the maximum load and the shrinkage of the bump could be an indicator of bitumen’s viscosity. Other factors such as approach and retraction velocity as well as tip radius also played a role in adhesion measurement. Currently, force modulation mode AFM is being considered on bitumen with the hope to obtain its elastic modulus, viscosity and damping property, which would be connected to the microstructure of bitumen obtained in intermittent contact AFM mode.

Professional Abstracts

Nancy A. Burnham, Jon Pratt, Gordon Shaw, Lee Kumanchik
(Contact: nab@wpi.edu)
Worcester Polytechnic Institute – Physics; National Institute of Standards and Technology, Gaithersburg, MD; University of Florida, Gainesville – Mechanical Engineering

Quantitative Assessment of Sample Stiffness and Sliding Friction from Force Curves in Atomic Force Microscopy

The angular deflection of an atomic force microscope (AFM) cantilever under “normal” loading conditions can be profoundly influenced by tip-sample friction. We show here that a remarkably quantifiable hysteresis occurs in the slope of loading curves whenever the normal flexural stiffness of the AFM cantilever is greater than that of the sample. This situation arises naturally in cantilever-on-cantilever calibration, but also when trying to measure the stiffness of nanomechanical devices or test structures, or when probing any type of surface or structure that is much more compliant along the surface normal than in transverse directions. Expressions and techniques for evaluating the coefficient of sliding friction between the cantilever tip and sample from normal force curves, as well as relations for determining the stiffness of a mechanically compliant specimen are presented. The model is experimentally supported by the results of cantilever-on-cantilever spring constant calibrations. The cantilever spring constants agree tally supported by the results of cantilever-on-cantilever spring constant calibrations. The cantilever spring constants agree.
Composites

Bounds for Effective Conductivity in Nanoionic Composites

This presentation discusses upper and lower bounds for the effective conductivity of a composite material where nanoparticles are embedded in a background material. The effective conductivity of the composite material is enhanced because of the work function mismatch between the two materials; the nanoparticles themselves are nonconducting. This presentation will focus on how the geometry of particle distribution affects (or does not affect) effective conductivity.

Controlled Templating of Porphyrins by a Molecular Command Layer

The ability to generate well-defined two-dimensional architectures of functional molecules on a surface is a prerequisite for their possible application in nanodevices. In ongoing research to build, in a bottom-up fashion, well-defined arrays of metalloporphyrins at a solid/liquid interface, self-assembled molecular command layers of a phenylacetylene derivative at the graphite/1-phenyloctane interface were studied by Scanning Tunneling Microscopy (STM). This revealed that these monolayers existed in a “face-on” orientation, with the aromatic rings of the molecules parallel to the surface. The command layers were subsequently used to template copper porphyrin molecules in a highly distinct and well-defined organization on top of the template. The molecular command layer templates the porphyrins in a specific arrangement of single, isolated species. Very subtle structural features of the command layer, like the presence of a superstructure, were found to have a profound effect on the final ordering of the porphyrins in the top layer.

Drag and lift forces on intruders moving in granular beds

We present experiments and 2D simulations for the drag and lift forces acting on simple geometric objects that are slowly dragged through granular beds. We first consider the case of a semi-infinite sheet, and find that the drag can be modeled by a modification of Coulomb’s classical treatment involving shearing wedges. The next intruder shape is a vertical cylindrical post, which we model by applying lithostatic theory to the surfaces and edges. 2D DEM simulations also confirm that particles transmit non-negligible forces on edges. We find that most of the lift forces arises from the bottom edge. Finally we consider a vertical square bar, and find very similar behavior to that of the posts: drag forces are primarily due to the frontal surface and edges, whereas lift arises primarily from interactions with the bottom edge.

Transport and deformations of cargo tracks in cells

Organelle motility is essential for the functioning of the eukaryotic cell. Actively modifying intracellular structures allows cells to change and adapt to different conditions. One of these cellular structures is the microtubule cytoskeleton, which is comprised of polarized filaments that function as tracks to transport cargo via molecular motors. While there is a great deal of work on the cooperative motility of organelles over microtubules (MTs), less is known about the deformations and transport of the microtubules themselves. Recent experiments on LLC-PK1 epithelial cells provide strong evidence for motor driven buckling of microtubules, suggesting that the cell is regulating the MT array via active force generators. The corresponding MT curvature distribution is non-Gaussian, with a pronounced exponential tail. Curvature distributions measured in gliding assays are similar to these in vivo distributions. Motivated by this remarkable similarity, we performed coarse-grained simulations of MT deformation and buckling on gliding assays. Our Brownian dynamics simulations recapitulate experimentally observed curvature distributions, and our analysis reveals the dependence of the scaling relation for curvature on the properties of the microtubules and molecular motors.
Understanding Adhesive Properties of Nanostructured and Polymeric Surfaces

Atomic Force Microscopy (AFM) based force mapping and force spectroscopic investigations can help us to understand intermolecular interactions between two surfaces or molecules. Here one can measure affinity between two functional groups or between two biomolecules like an antibody and an antigen. With the development of various force mapping protocols one can use standard and modified probes for physico-chemical mapping of surfaces. Previous investigations on nanostructured-nanopatterned surface with silicon nitride tips, has helped us infer biochemical behavior of titanium dioxide thin films. In this study, we would like to investigate hydrophobic and hydrophilic interactions of various bioactive polymers and other nanostructured materials against the surface of interest. Using modified AFM probes, one can understand mechanism and chemistry behind adhesion of polymer and different functional moieties on any biocompatible material. Here, we would also like to elucidate the role of aqueous medium where pH and concentration of various ionic species influences the bond formation between two interacting surfaces.