A Welcome from the Program Directors

August 31, 2006

Dear IM-SURE Fellows, Faculty Mentors, and Guests:

Research has traditionally been performed within the boundaries of a single discipline. However, those boundaries have begun to loosen: researchers in many fields are discovering the value of interdisciplinary and multidisciplinary collaboration. Micro/nano technology brings together researchers from a wide range of backgrounds to explore the nearly limitless possibilities of design and creation on a sub-microscopic scale.

This summer, the Integrated Micro/Nano Summer Undergraduate Research Experience (IM-SURE) brought 22 undergraduate researchers together from 16 institutions, out of 174 applicants from 81 institutions across the country. The 2006 IM-SURE Fellows were selected to study the very small under the guidance of 18 nationally-distinguished faculty mentors from the Henry Samueli School of Engineering, School of Medicine, and the School of Physical Sciences. Students chose from a variety of challenging and original research projects, each exploring a diverse and exciting range of topics in biomedical, physical and engineering micro/nano technology. Faculty mentors and their teams of graduate students and post-doctoral fellows provided personalized mentoring and training to the IM-SURE Fellows, giving them the unique opportunity to explore the future of micro/nano research, learn about how research is conducted, and to become immersed in the collaborative research culture of the Integrated Nanosystems Research Facility (INRF) at UC Irvine.

The IM-SURE Fellows dedicated themselves to full-time work on their research throughout the ten weeks of the program. In addition to their research, the students explored their own futures as well, looking into the vast array of possibilities that lie before them. They attended seminars on a wide variety of topics relevant to their research and futures. They toured state-of-the-art labs and local industries. And, weekly coffee hours and other mixers provided them opportunities to develop new contacts within this rapidly growing field. Throughout the program, they have been immersed in both research and learning.

The IM-SURE Program is a collaborative effort between the INRF and the Undergraduate Research Opportunities Program (UROP), in the Division of Undergraduate Education, with funding from the National Science Foundation. UROP is committed to supporting faculty-mentored undergraduate research and creative activities in all disciplines. UROP’s programs include advising students through the pursuit of on- and off-campus research opportunities, providing funding for project-related expenses, sponsoring the annual UCI Undergraduate Research Symposium, and publishing The UCI Undergraduate Research Journal. UROP also collaborates with various schools and research units to develop specialized research opportunities. Last summer, these collaborations resulted in the introduction of the IM-SURE program, as well as the Inter-Disciplinary Summer Undergraduate Research Experience (ID-SURE), and the Summer Undergraduate Research Fellowship in Information Technology (SURF-IT).

Thank you for participating and for showing your support for the IM-SURE Fellows presenting here today. A special note of appreciation also goes out to the faculty mentors who have devoted much time and effort mentoring these students. We look forward to following up with the continued achievement of these outstanding individuals, and hope that you leave today’s program with a renewed sense of wonder and excitement.

Sincerely,

G. P. Li
IM-SURE Principal Investigator
Professor & Director, INRF

Said M. Shokair
IM-SURE Managing Director
Director, UROP

IM-SURE Symposium
Schedule of Events

Friday, August 25, 2006
Calit2 Auditorium

4:00 p.m. – 4:10 p.m.  Welcome
4:10 p.m. – 5:10 p.m.  Presentations

Thursday, August 31, 2006
Calit2 Auditorium

8:00 a.m. – 8:45 a.m.  Continental Breakfast
8:45 a.m. – 9:15 a.m.  Welcome
9:20 a.m. – 11:00 a.m.  Presentations
11:00 a.m. – 11:20 a.m.  Break
11:20 a.m. – 12:40 p.m.  Presentations
12:40 p.m. – 1:40 p.m.  Lunch
1:40 p.m. – 3:20 p.m.  Presentations
3:20 p.m. – 3:40 p.m.  Break
3:40 p.m. – 5:20 p.m.  Presentations
## Schedule of Presentations

Each presentation is allotted 15 minutes followed by a 3-minute question and answer period.

Electronic copies of Students’ abstracts, PowerPoint presentations and papers are available on the IM-SURE Web site (http://www.urop.uci.edu/im-sure.html). Click “Participants,” then the name of an individual student.

### Friday, August 25, 2006

<table>
<thead>
<tr>
<th>Time</th>
<th>IM-SURE Fellow</th>
<th>Project Title</th>
<th>Faculty Mentor(s)</th>
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</table>
| 4:10  | Scott Roberts  
*Materials Science and Engineering*  
Carnegie Mellon University | Nickel Titanium Nanowire Growth Using Electrochemical Step Edge | Reginald “Reg” Penner  
*Chemistry* |
| 4:30  | Yaniv Scherson  
*Mechanical Engineering, Materials Science*  
University of California, Berkeley | Effects of Defects in MEMS (Micro Electro Mechanical Systems) Mass Distributed Gyros | Andrei Shkel  
*Mechanical & Aerospace Engineering* |
| 4:50  | Julius Oatts  
*Neuroscience and Behavioral Biology*  
Emory University | Optimal Conditions for Cell Viability on SU-8 Adherent Cell Sorting Microstructures | Mark Bachman  
*Electrical Engineering & Computer Science* |
## Thursday, August 31, 2006

<table>
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<th>IM-SURE Fellow</th>
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<tr>
<td>9:20</td>
<td>Anthony Davis</td>
<td>Optimization of Electrochemical Wet Etching of Silver STM Tips</td>
<td>Wilson Ho</td>
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<td>Electrical Engineering</td>
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<td>Hampton University</td>
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<td>9:40</td>
<td>Michael Sullivan</td>
<td>Voltage-Gating in Synthetic Nanopores Induced by Cobalt Ions</td>
<td>Zuzanna Siwy</td>
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<td>Computer Engineering, Mathematics</td>
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<td>George Mason University</td>
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<td>10:00</td>
<td>Jeevitha Martin</td>
<td>Nanoscale Electrode Development for Fundamental Studies of Mixed Ionic and Electronic Conductors as High Temperature Fuel Cell Components</td>
<td>Daniel Mumm</td>
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<td>Chemical Engineering, Materials Science Engineering</td>
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<td>University of California, Irvine</td>
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<td>10:20</td>
<td>Scott Wilhour</td>
<td>Solid State Approach of La(<em>{9.33})Si(</em>{6})O(_{26}) as a Replacement Electrolyte for Y(_2)O(_3) Stabilized ZrO(_2) in Solid Oxide Fuel Cells</td>
<td>Martha Mecartney</td>
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<td>Pennsylvania State University</td>
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<td>Aminah Rumjahn</td>
<td>Sol Gel Approach: Lanthanum Silicates as a Replacement for Yttria Stabilized Zirconia (YSZ) in Solid Oxide Fuel Cell (SOFC) Electrolytes</td>
<td>Martha Mecartney</td>
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<td>University of California, Davis</td>
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<td>11:00</td>
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<td>20-Minute Break</td>
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<td>11:20</td>
<td>Scott Cromar</td>
<td>Properties of Suspended Nanowire Field-Effect Transistor</td>
<td>Jia “Grace” Lu</td>
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<td>Michael DiNezza</td>
<td>Thermal Characterization of Light Emitting Diode</td>
<td>Henry Lee</td>
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<td>University at Buffalo</td>
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<td>12:00</td>
<td>David Tseng</td>
<td>All-Fiber Acousto-Optic Spectrometer</td>
<td>Henry Lee</td>
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<td>12:20</td>
<td>Georges Siddiqi</td>
<td>Study of Self Assembled Nanoparticle Arrays on Diblock Copolymer Templates</td>
<td>Regina Ragan</td>
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<td>David Arndt</td>
<td>Using a Microplasma for Propulsion in Microdevices</td>
<td>John LaRue</td>
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<td>Mechanical Engineering</td>
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<td>Richard Nelson</td>
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<td>2:00</td>
<td>Sanda Cea</td>
<td>Electrical Characterization of Semiconducting Polymers</td>
<td>John LaRue</td>
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<td>Brian Higa</td>
<td>Fabrication of Electrodes with Nano-Size Gap</td>
<td>Peter Burke</td>
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<td>Minh Guong Nguyen</td>
<td>Single-Cell Platforms for Microbiomechanics</td>
<td>William Tang</td>
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<td>3:00</td>
<td>Elizabeth Nettleton</td>
<td>Simulation and Experimental Studies of Biomechanics at the Micro-Scale</td>
<td>William Tang</td>
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<td>3:40</td>
<td>Anurag Gupta</td>
<td>Swept Source Fourier Domain Endoscopic Optical Coherence Tomography</td>
<td>Zhongping Chen</td>
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<td>University of Rochester</td>
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<td>4:00</td>
<td>Shehreen Dheda</td>
<td>Fabrication and Design Considerations for Microfluidics-Based Tactile Sensors</td>
<td>Abraham Lee</td>
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<td>4:20</td>
<td>Lindsay Picket</td>
<td>Droplet Gradient Array for Parallel Experimentation via Microfluidic Device</td>
<td>Abraham Lee</td>
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<td>4:40</td>
<td>Dallas Reilly</td>
<td>Cell Migration in Microfluidic Devices</td>
<td>Noo Li Jeon</td>
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<td>Carthage College</td>
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<td>5:00</td>
<td>Brian Sa</td>
<td>Integrated Compact Disc (CD)-Based Microfluidic Device for Cell Lysis and DNA</td>
<td>Marc Madou</td>
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<td>Stanford University</td>
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**Thursday, August 31, 2006 (Continued)**
David Arndt

Major: Mechanical Engineering
Home Institution: University of California, Irvine
UCI E-mail: darndt@uci.edu

Project Title: Using a Microplasma for Propulsion in Microdevices
Faculty Mentors: John LaRue & Richard Nelson

Abstract:
It has been shown in various studies that plasma pumps can be used to create unidirectional fluid motion and even to delay flow separation in fluid flows over airfoils or helicopter blades. The goal of this project is to use the pumping capabilities of plasma pumps at the MEMS level to move air through microchannels. Eventually, photolithographic techniques will be used to create the plasma pump on a chip, but a macro-scale plasma pump was created first to characterize the effect on pumping velocities for variables such as electrode geometry, dielectric thickness, and input voltage and waveform of the plasma generator. Copper tape was used for the electrodes and Kapton tape was used for a separating dielectric. The electrodes were placed in a glass chamber that was then filled with smoke to show the flow produced by the plasma. Video of the smoke flow was taken for multiple electrode geometries and analyzed frame by frame to calculate rough velocities at positions along the length of the chamber. The effect of dielectric material and thickness was also studied. It was found that neither changes in electrode width nor small changes in dielectric thickness had a noticeable effect upon flow velocity. Control over flow direction and path was demonstrated by using multiple plasma generators connected in parallel. A microplasma pump has not yet been created, but design parameters have been established based upon results obtained. Overlapping electrodes and a glass dielectric will be used due to ease of use.

Sanda Cea

Majors: Electrical Engineering/ Information and Computer Science
Home Institutions: Saddleback College/ University of California, Irvine
E-mail: sandac310@yahoo.com
UCI E-Mail: scea@uci.edu

Project Title: Electrical Characterization of Semiconducting Polymers
Faculty Mentors: John LaRue & Richard Nelson

Abstract:
The study of organic electronics is relatively young, yet they are thought to be the key to the advancement of microelectronics manufacturing due to their durability and ease of low-cost processing. This project attempts to characterize semiconducting polymers with respect to their electrical properties. Two compounds, consisting of a conductive polymer and a soluble viscous additive (PEDOT with PVA and Polyaniline with SU-8), were prepared as thin films by spin coating onto a substrate with an insulating layer. These were cut into thin strips to measure resistance using a collinear four-point probe. Films with a higher proportion of conductive material exhibited higher conductivity countered by less thickness. A previous study involving a different formulation of PEDOT showed a conductivity of $10^{-5}$ S/cm at the 50%wt level while this one indicated a much higher $10^{-2}$ S/cm. This difference supports the need to compile more comprehensive resumes of organic substances. Future work involves finding Young’s Modulus using resonance methods on a micromachined cantilever beam.
**Scott Cromar**

**Majors:** Electrical Engineering/ Computer Engineering  
**Home Institution:** University of California, Irvine  
**UCI E-mail:** scromar@uci.edu

**Project Title:** Properties of Suspended Nanowire Field-Effect Transistor  
**Faculty Mentor:** Jia “Grace” Lu

**Abstract:**  
As II-VI compound semiconductors with a wide and direct band gap of 3.37 eV, ZnO nanowires have attracted an intensive research effort due to their unique properties and potential application as transistors, light-emitting diodes, photodetectors, and chemical sensors. Recent reports have documented studies of the electrical transport characteristics, as well as the optical properties and mechanical properties of individual ZnO nanowires. In this project, the characteristics of suspended nanowires were investigated. Single-crystalline ZnO nanowires were synthesized by a vapor trapping chemical vapor deposition method. They were configured as field-effect transistors (FET) with a suspended ZnO nanowire channel. Contacts between the ZnO nanowire and metal electrodes were improved through annealing and metal deposition using a focused ion beam. Gate dependence of the suspended nanowire FET was observed to be weak. The gas sensing characteristics were studied and compared to those of the nonsuspended structure. In addition, the surface potential distribution of the suspended nanowire was investigated using scanning probe microscopy to characterize the uniformity of the nanowire. Continued work is underway to reveal the intrinsic properties of suspended ZnO nanowires and to explore their device applications.
**Anthony Davis**

**Major:** Electrical Engineering  
**Home Institution:** Hampton University  
**E-mail:** RydaT2000@aol.com  
**UCI E-Mail:** ardavis@uci.edu

**Project Title:** Optimization of Electrochemical Wet Etching of Silver STM Tips  
**Faculty Mentor:** Wilson Ho

**Abstract:**  
Various Scanning Tunneling Microscope (STM) experiments have insinuated that enhanced light coupling can be achieved with the use of silver STM probing tips. More efficient light coupling from a silver tip yields stronger electric fields, resulting in better signals from individual molecules than the more commonly used tungsten tips. The challenge presented is to optimize the procedure and parameters for etching silver tips to ensure efficiency and reproducibility. Voltage is one of the parameters of etching silver tips; we have used different levels of potential difference to see which have produced an ideal apex. We have tested various chemical recipes and monitored evaporation rates of these solutions to gain data on how they affect the shape of the apex. Results have shown that, by applying higher DC voltages during etching, the process becomes more expedient. We have found that the concentration of the etching solution changes due to evaporation, which can affect the shape of the apex. Circuitry has been designed and used with LabVIEW® software for means of monitoring the current flow through the electrochemical etching system to allow for more accurate and efficient means for monitoring etching. A more ample supply of silver tips that can be easily replenished will serve as a significant assistance to those pursuing STM experimentation. One of the major strengths of the STM is its unique capability to examine individual molecules; discovering eccentric characteristics of these molecules is essential to the development of nanostructures and nanotechnology.
**Shehreen Dheda**

**Major:** Biomedical Engineering  
**Minor:** Material Sciences  
**Home Institution:** University of California, Irvine  
**UCI E-mail:** dhedas@uci.edu

**Project Title:** Fabrication and Design Considerations for Microfluidics-Based Tactile Sensors for Prosthetic Hand  
**Faculty Mentor:** Abraham Lee

**Abstract:**  
Many variations of the prosthetic hand exist today. However, only a few exhibit tactile sensing facility. In the skin of the human hand, there are four main types of mechanoreceptors. Each plays an important role in detecting the different types of stimuli that are present in everyday life. The objective here is to develop the first microfluidics-based synthetic tactile sensor array to be embedded within the artificial skin of a prosthetic hand. Two synthetic sensor types were designed to mimic two of the biological tactile sensors. The key components of the project considered here are the fabrication process and the design. The fabrication process includes selectively filling the array with fluid and preventing permeation of fluid out of the device, while the design includes computer modeling of the transduction of mechanical stimuli to measurable volume changes within the microfluidic sensor array. Three techniques were investigated for filling the devices. It was found that all three of the techniques have drawbacks, although modifications are being developed and tested for one of the methods. Some of the filled devices were kept for monitoring the pervaporation of fluid from the devices. Over a period of weeks it was observed that pervaporation had taken place from the devices and its rate was determined to be approximately constant. Lastly, a simulation of part of the device was developed and tested in order to quantify the transduction of pressure applied to changes in volume of the sensor.

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**Michael DiNezza**

**Major:** Electrical Engineering  
**Home Institution:** University at Buffalo  
**E-mail:** mdinezza@eng.buffalo.edu  
**UCI E-Mail:** mdinezza@uci.edu

**Project Title:** Thermal Characterization of Light Emitting Diode  
**Faculty Mentor:** Henry Lee

**Abstract:**  
Light emitting diodes (LEDs) are becoming increasingly popular, and are now being used as light sources for general lighting applications. Unfortunately the output intensity of an LED is largely dependent on the operating temperature. As the device temperature increases, light intensity and efficiency decrease. The sensitivity of the light intensity with respect to a change in temperature is given by the temperature coefficient $T_o$. A new method and experimental setup that takes self-heating into account has been developed to find $T_o$. Results show that $T_o$ depends on the band gap of the material and the forward current. Ultimately this method will allow newer and more efficient LEDs to be tested and compared to current LED technology.
Anurag Gupta

**Major:** Biomedical Engineering  
**Home Institution:** University of Rochester  
**E-mail:** agupta@mail.rochester.edu  
**UCI E-Mail:** anurag@uci.edu

**Project Title:** Swept Source Fourier Domain Endoscopic Optical Coherence Tomography  
**Faculty Mentor:** Zhongping Chen

**Abstract:**
In Optical Coherence Tomography (OCT), a broadband light source is used to create high-resolution cross-sectional images of biological samples non-invasively. The advantage of the compact fiber-based endoscopic system is that it can create images with approximately 10 µm resolution. Currently, this is accomplished using the time-domain technique; however, the acquisition of images is slow and the ability to control the optical dispersion is not very easy. To correct these problems, we use the Fourier domain technique, which allows us to create cross-sectional images of live tissue, blood vessels, and the eye at up to 25 frames per second (theoretically), while allowing us to control optical dispersion by the combination of the fast Fourier transforms and subtracting out the appropriate non-linear phase. We are also using a bandpass filter to select for the positive Fourier transform followed by a phase modulator (LiNbO3 crystal) driven by an Arbitrary Waveform Generator to increase the signal to noise ratio. The ideal outcome is to detect cancer and other diseases at a much earlier stage, while decreasing the amount of time needed to insert an endoscope into the human body for the acquisition of medical images.

Brian Higa

**Major:** Electrical Engineering  
**Home Institution:** University of California, Irvine  
**E-mail:** bhiga001@yahoo.com  
**UCI E-Mail:** bhiga@uci.edu

**Project Title:** Fabrication of Electrodes with Nano-Size Gap  
**Faculty Mentor:** Peter Burke

**Abstract:**
Intense study in nanotechnology suggests that electronic devices must be developed to measure the electrical properties of atoms and molecules. Current fabrication methods of these devices require abstruse techniques and expensive equipment. We propose a simple and inexpensive method of fabrication by electroplating metal onto electrodes with a large gap (0.25 microns) between them. We hypothesized that the deposition rate can be controlled by monitoring the electronegativity of the electrodes and the electrolyte concentration. We found that during a specific stage in metal deposition there were increases in the conductance between electrodes by increments of $2e^2/h$. This shows the quantization of conductance, which can be interpreted as the first atoms closing the gap between electrodes. With this result, we conclude that metal deposition can be controlled, and can be used as an alternative fabrication method for electrodes with nano-size gap.
Jeevitha Martin

Majors: Chemical Engineering/ Materials Science Engineering

Home Institution: University of California, Irvine

UCI E-mail: emartinj@uci.edu

Project Title: Nanoscale Electrode Development for Fundamental Studies of Mixed Ionic and Electronic Conductors as High Temperature Fuel Cell Components

Faculty Mentor: Daniel Mumm

Abstract:
Electrostatic Spray Deposition (ESD) is used in the study of electrode morphology to fabricate La$_{0.8}$Sr$_{0.2}$MnO$_3$ (LSM), an electrode layer, over the stainless steel substrate in Solid Oxide Fuel Cells. ESD has recently been shown to provide controlled porosity to achieve reticular structures. By varying the porosity of the cathode, and thus increasing the surface area of the cathode layer, the effect of a triple phase boundary can be observed. Various parameters were changed and the procedures were repeated. These experimental procedures can be used to learn about the so-called triple phase boundary, where most of the chemical activity is believed to occur. ESD results are analyzed through SEM and X-ray diffraction.

Elizabeth Nettleton

Major: ACS Chemistry

Home Institution: University of South Dakota

E-mail: enettlet@usd.edu

UCI E-Mail: enettlet@uci.edu

Project Title: Simulation and Experimental Studies of Biomechanics at the Micro-Scale

Faculty Mentor: William Tang

Abstract:
Micro-structured biomechanical devices, specifically sensors, offer great potential in the medical field. For instance, bone strain sensors may possess the capacity to provide information on disease progression in bone tumors, osteoporosis, and similar cases. Prosthetic heart valves offer new life to patients, but the valves weaken as they age, threatening a fatal breakage. By adhering a micro-sensor for measuring strain to the prosthetic tissue, one could potentially track the weakening of the valve and consequently design a better prosthesis based upon acquired real-time data. Multiple Biomedical Engineering labs have worked on projects involving bone strain sensors, but the heart valve project is unique. The William Tang Microbiomechanics Lab is pursuing both projects. Multi-faceted problems include such issues as device characterization using computer modeling and physical experiments, and the testing of biological adhesives and their effects on the biological tissue. Further modeling can predict the tolerable level of heat dissipated from the sensor electronics to avoid thermal damage to surrounding tissue. Use of the MEMS module of COMSOL Multiphysics provided simulations modeling the spring constants of the cantilever sensors, which will ultimately be used to map the compliances of the heart valve. Calibration of the fabricated devices was achieved using a Wheatstone bridge to measure the relative change in resistance with respect to the cantilever deflections. The simulated values will be compared to data collected by taking physical measurements with the fabricated device. Ongoing work involves the evaluation of biological adhesives, modeling the resonant frequencies of the device, and performing COMSOL simulations to map the heat transfer from our sensor into biological tissues.
Project Title: Single-Cell Platforms for Microbiomechanics

Faculty Mentor: William Tang

Abstract:
It is known that physical changes in an individual cell can play an important role in the cause of diseases; nano-biomechanics aims to illustrate nanotechnology’s increasing contribution to the understanding and treatment of diseases. Because many of the mechanical properties of a cell are defined by cytoskeleton morphology—which can be represented by viscosity and stiffness—it is hypothesized that viscosity and stiffness measurements of the cytoskeleton can be used to produce a fresh understanding of diseases. The correlation has not been determined yet, but this research holds great promise in improving parallel drug screening, cancerous cells identification and qualification, and single-cell physiologies. This idea led to the development of a micro-platform with massive arrays of micro chambers, each with a resonant transducer capable of interrogating the mechanical properties of a cell down to micro scale, bringing greater accuracy to the measurements. We use implemented piezoelectric transducers to serve as the resonant transducers, and the micro-platform can be used to investigate any kind of cell morphology related to the cell’s cytoskeleton. When the piezoelectric transducer is treated with different media, the resulting graphs show lower resonance frequencies and wider bandwidths than piezoelectric transducers treated without the media. The frequency shift and changes of quality factor are related to the weight and viscosity of water and silicone oil. This result is very promising, as it demonstrates that the micromachined piezoelectric transducer is working. By using such a piezoelectric transducer, we can apply nano-measurement techniques to living cells to test and measure the mechanisms of the cells’ cytoskeleton.
Julius Oatts

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**Project Title:** Optimal Conditions for Cell Viability on SU-8 Adherent Cell Sorting Microstructures  
**Faculty Mentor:** Mark Bachman

**Abstract:**  
Sorting and distinguishing individual cells from a heterogeneous population is extremely useful in promulgating biomedical research. The most common technology currently used for this purpose is flow cytometry, in which a detector sorts cells flowing through a tube based on the interaction between the fluorescently labeled cellular constituents and a laser beam designed to excite these dyes. Although this method is effective, it falls short in terms of analysis based on cell morphology and growth rate. The development of a new technology called Micro Pallet Arrays offers a promising alternative that not only uses fewer cells, but is also capable of classifying cells according to different and applicable criteria. Pallet Arrays are designed to separate individual adherent cells in a population on tiny biocompatible microstructures composed of SU-8, which can be released with a laser from the array and grown out into separate colonies for further analysis. Before introducing this technology into the field, it is important to find the optimal conditions for cell growth on these microstructures. This includes finding the ideal cell density and evaluating critical components such as surface proteins, which allow adherent cell attachment. Data discussed in this paper shows promising results that varying cell density between 1,000 and 10,000 cells/mL does not affect cell growth. This is an important discovery considering the low density at which cells are required to grow on micropallets. Also, different surface proteins had drastically dissimilar effects on cell growth, requiring further research to create ideal Micro Pallet Array conditions.

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**Project Title:** Droplet Gradient Array for Parallel Experimentation via Microfluidic Device  
**Faculty Mentor:** Abraham Lee

**Abstract:**  
The aim of this study is to generate a gradient array consisting of monodispersed aqueous droplets in oil as a platform for parallel experimentation in a microfluidic device. The droplets are approximately 50 µm in diameter and serve as picoliter reaction chambers. Formation of droplets is accomplished by shearing two aqueous reagent streams (dispersed phase) with a constant oil stream (continuous phase) at a junction of high shear stress. The flow rates of the reagents and the oil phase are in the range of 1–2 µl/min. The aqueous inlet at the shearing junction is 12 µm and the shearing orifice is 7.5 µm. The droplet array is captured in serpentine channels after the shearing junction to allow imaging and characterization. This platform not only offers the ability to reduce reagent consumption during parallel experimentation; it can also be easily adapted for a variety of other applications.
Dallas Reilly

Project Title: Cell Migration in Microfluidic Devices
Faculty Mentor: Noo Li Jeon

Abstract:
In recent years, microfluidic devices have been used to obtain valuable information about cells, especially cancer cells. It is important to study the true value of these devices in their usefulness in cancer research and other fields. Also, the main chambers of microfluidic devices can provide us with an area from which to obtain important information on the various migrations of cancer cells towards or away from specific gradients composed of various chemicals (chemo-attractant or chemo-repellent gradients). With proper sterilization techniques to culture MDA-MB 231 breast cancer cells, and by following the proper protocols to create the devices, we can use a 10x microscope (with mercury lamp), fluorescence/growth factor (epidermal growth factor) solution, and various computer programs to monitor the cells and quantify their migrations accurately. Varying the conditions can provide further depth the study of these cells (i.e. different concentrations of growth factor, starving the cells, and eventually using chemo-repellants to study cancer fighting drugs). In this project I discovered that metastatic cancer cells migrate towards gradients containing natural amounts of growth factor, and I concluded that other conditions affect these cells as well. These results show promise in the study of cancer cell migrations due to different positively or negatively stimulating chemicals.

Scott Roberts

Project Title: Nickel Titanium Nanowire Growth Using Electrochemical Step Edge
Faculty Mentor: Reginald “Reg” Penner

Abstract:
With the increased popularity of using nanowires for complex sensing applications, it has become desirable to create a more rudimentary switching mechanism. A simple temperature-activated mechanical switch can be created with shape memory alloys. To date, no attempts have been made to grow nanostructures with a shape memory effect, leaving open the question of whether the effect will scale down to such small sizes. Ti or TiOx were first synthesized; it is unknown exactly which was formed as photoluminescence measurements were inconclusive. We have not yet successfully grown NiTi wires, although a series of closely nucleated particles along the step edges of HOPG has been achieved. They were determined to contain both Ni and Ti via EDAX analysis. The atomic ratio of the NiTi wires is roughly 30:70, outside of the range of a shape memory effect, although evening the ratio should be simple. The remaining work is to increase nucleation density and test for the shape memory effect.
Aminah Rumjahn

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Project Title: Sol Gel Approach: Lanthanum Silicates as a Replacement for Yttria Stabilized Zirconia (YSZ) in Solid Oxide Fuel Cell (SOFC) Electrolytes

Faculty Mentor: Martha Mecartney

Abstract:
New material systems must be considered to achieve high ionic conductivity for Solid Oxide Fuel Cells (SOFC) at operating temperatures in the range of 600–800 °C. Recent studies have shown that oxy-apatites, such as La_{9.33}(SiO_4)_6O_2, exhibit higher oxygen ion conductivity at lower temperatures than the traditional YSZ, which typically operate around 1000 °C. Among these apatites, lanthanum silicates exhibit the highest ionic conductivity. This study focuses on the development and characterization of lanthanum silicates, specifically through a sol gel route to ensure a homogenously mixed product that has a lower crystallization temperature than that of solid state methods. Hydrated lanthanum nitrate and TEOS (tetraethylorthosilicate) were used as polymer precursors, and were heat treated to obtain a fine-grained powder composed of lanthanum silicate (La_{9.33}(SiO_4)_6O_2). A unique cryomilling process was then used in hopes of decreasing the grain size to the nanometer scale. X-ray diffraction was used to study the phases present in our samples and enabled the use of the Scherrer formula to calculate the crystallite size; scanning electron microscopy gave us approximate grain sizes. Future work with impedance spectroscopy will determine the material’s ionic conductivity.
Brian Sa

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**Project Title:** Integrated Compact Disc (CD)-Based Microfluidic Device for Cell Lysis and DNA Purification  
**Faculty Mentor:** Marc Madou

**Abstract:**  
The compact disc (CD) as a microfluidic platform offers unique advantages, including low cost and parallel processing, that make it optimal for miniaturizing and expediting laboratory tests. The purpose of this project is to design and fabricate an integrated solution for PCR sample preparation—from cell lysis to DNA purification—on one CD. Sample preparation is an ideal candidate for the CD platform because it has multiple steps, including centrifugation, that can be consolidated on a single CD and automated. This is a clear improvement over traditional sample preparation kits, which are often inconvenient, time-consuming, and require extensive handling. Prototypes of the sample preparation CD were drafted in AutoCAD and machined out from polycarbonate sheets using a CNC (computer numerically controlled) milling machine. Channels with micrometer dimensions were fabricated in the adhesive layers joining the central polycarbonate disc to top and bottom discs. Tests using a computer-controlled servomotor with an attached laser-triggered strobe light imaging system have shown that cell lysis, clarification, and the bulk transport of solutes between reservoirs can be successfully accomplished. An improvement in fluid gating control that is integral to the design is a novel chamber design that uses negative feedback to self-regulate fluid outflow. This allows for increased reagent volumes, because fluid can be discharged in a regulated manner. Furthermore, this self-regulatory element allows for deterministic fluid flow in complex designs that incorporate multiple reservoirs and flow sequencing.

Yaniv Scherson

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**Project Title:** Effects of Defects in MEMS (Micro Electro Mechanical Systems) Mass Distributed Gyros  
**Faculty Mentor:** Andrei Shkel

**Abstract:**  
Defects in the fabrication of micro electro mechanical systems (MEMS) gyros used for sensing angular motion cause inaccurate and poor performance. Through a paralleled use of both finite element modeling (FEM) and experimental measurements, a model can be made of the deviation from ideal behavior that is caused by imperfections. FEM provides a theoretical deviation in the natural frequency of the resonators in the gyro, while the use of a scanning electron microscope (SEM) to measure the changes in feature dimensions indicates the experimental deviation in natural frequencies of the gyro’s resonators. Through mesh analysis, an adequate density of elements used in the FEM was obtained and used to determine theoretical shifts in the resonant frequencies of the gyro’s resonators. SEM measurements that indicate actual deviations in feature dimensions were followed by testing, which provided information on the actual variation in the resonators’ natural frequency. A model that relates the shift in the natural resonator frequencies due to variations in feature dimension from the original design can provide insight into enhancing the gyro’s performance and improve future gyros design.
**Georges Siddiqi**

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**Project Title:** Study of Self Assembled Nanoparticle Arrays on Diblock Copolymer Templates  
**Faculty Mentor:** Regina Ragan  
**Abstract:**  
This project seeks to attach noble metal nanoparticles (NPs) to the PMMA domain of the diblock copolymer PS-b-PMMA. Several factors influencing the attachment of NPs have been investigated, as well as factors influencing surface damage to the diblock copolymer template. It has been found that two methods of controlling the surface damage to the PS-b-PMMA are to reduce the amount of time the template is immersed in the NaOH solution and to treat larger pieces of Si wafer coated with PS-b-PMMA. For controlling the thickness of the PS-b-PMMA template, it was found that the weight percent of the PS-b-PMMA in toluene is the largest factor. In dealing with NP aggregation, dipping times must be kept at less than 1 hour, and spotting times must be kept to less than 30 minutes. Care must also be taken to remove all EDC-MES and sulfo-NHS-PBS solution from the surface. NPs were successfully attached exclusively to the PMMA domain, but further work is needed to better control the extent of the NP attachment, size and density.

**Michael Sullivan**

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**Project Title:** Voltage-Gating in Synthetic Nanopores Induced by Cobalt Ions  
**Faculty Mentor:** Zuzanna Siwy  
**Abstract:**  
The study of ion transport through synthetic nanopores has attracted the interest of researchers from various scientific fields. Nanopores have many potential uses, such as serving as the basis for sensors of a variety of biological molecules. Also, nanopores and channels that exist in biological cells are fundamental to the physiological processes found in living organisms. The purpose of this study was to investigate the transport properties of a single nanopore in a polymer film with the presence of sub-millimolar concentrations of cobalt ions. These nanopores were produced by the track-etching technique whereby a polymer film (in our case polyethylene terephthalate) is irradiated with energetic heavy ions, and the resulting tracks are etched with various chemicals to form an asymmetric nanopore. We worked with single conical nanopores obtained by etching one side of the irradiated films with 9 M NaOH. Once the pores were etched, current-voltage (I-V) curves and signals of ion current over time were recorded in the range of voltages from -1V to +1V. The results show that cobalt acetate in sub-millimolar concentrations consistently produces characteristic ion current fluctuations and oscillations in certain voltage ranges. These ion current fluctuations are voltage-dependent, and resemble those found in biological voltage-gated channels. Current-voltage curves taken from the pores show a region of voltage with negative incremental resistance that is not observed without divalent cations present in the solution. The result of cobalt producing controlled current instabilities is important, because it indicates a possible potential for single polymer nanopores to be used as sensors for different molecules in the future.
David Tseng

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**Project Title:** All-Fiber Acousto-Optic Spectrometer  
**Faculty Mentor:** Henry Lee

**Abstract:**  
Dual Acousto-Optical Tunable Filter (AOTF) is an element of an optical system that serves as a filter in the optical domain. AOTF can be configured to behave like a notch filter in that all frequencies except one will be transmitted. As a transducer, the radio frequency voltage signal is converted to mechanical energy (acoustic wave), which propagates through a fiber. A gradient is then created, which selectively reflects a specific frequency of a broadband light passing through the optical fiber. Characterization and optimization of the efficiency of the transducer in the AOTF must be defined and optimized so that future work with AOTF will not be restricted by poor coupling of acoustic energy to the fiber.

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**Project Title:** Solid State Approach of La$_{9.33}$Si$_6$O$_{26}$ as a Replacement Electrolyte for Y$_2$O$_3$ Stabilized ZrO$_2$ in Solid Oxide Fuel Cells  
**Faculty Mentor:** Martha Mecartney

**Abstract:**  
Research into the materials governing solid oxide fuel cell (SOFC) electrolytes has expanded a great deal in recent years. This project involves a study into the apatite structure to produce a high-conductivity electrolyte as an alternative to yttria-stabilized zirconia (YSZ). Most of the electrolytes currently used in SOFCs are 8YSZ, but studies have shown that apatite is more desirable than YSZ due to the lower sintering temperatures used in processing. More specifically, the electrolyte chosen for this study is an apatite-type lanthanum silicate, La$_{9.33}$Si$_6$O$_{26}$. Powder form raw materials of lanthanum oxide (La$_2$O$_3$) and silicon oxide (SiO$_2$) were combined in a 4:5 ratio and specially milled to make La$_{9.33}$Si$_6$O$_{26}$. The milling process was used to impede grain growth, which is important because smaller grains increase the overall surface area and improve conductivity. Once milled, the powders were sieved to obtain the finest-sized particles. These powders were then pressed and sintered at 1450 ºC for 2 h to produce lanthanum silicate. From previous studies, it was believed that the link between the conductivity of lanthanum oxide and the silicate network would provide insight into the interstitial mechanism of oxide ion conduction. The results of an X-ray diffraction (XRD) analysis indicate that almost all of the diffraction peaks of the sample can be assigned to La$_{9.33}$Si$_6$O$_{26}$. Scherrer’s Method of peak broadening was used to determine grain sizes of the sintered sample. Impedance spectroscopy of the solid state lanthanum silicate powders was to follow XRD investigation, but was not conducted due to time constraints. This last step is crucial, however, to determine if lanthanum silicates do in fact have a higher ionic conductivity than 8YSZ as a fuel cell electrolyte.
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The Integrated Micro/Nano Summer Undergraduate Research Experience (IM-SURE) at the University of California, Irvine (UCI), provides a unique 10-week summer research opportunity for undergraduates to become fully immersed in cutting-edge micro/nano research and applications. Participants have the opportunity to choose from a variety of challenging and original research projects that explore a diverse and exciting range of topics in biomedical, physical and engineering micro/nano-technology. The IM-SURE Program is designed to help students fully develop the knowledge and skills that will propel them into graduate studies or careers in the fields of micro/nano technology. Students will even receive ongoing support after the program ends to help them further pursue their research and career goals.

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