

2005

IM-SURE Integrated Micro/Nano Summer Undergraduate Research Experience



Symposium

UCI

University of California, Irvine

❧ A Welcome from the Program Directors ❧

September 2, 2005

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

The world is getting smaller. Advances in communication and other technologies have brought faraway places almost to our doorstep. And, things that once seemed large have now been reduced to miniature scale. As the world gets smaller, we explore the very small as well. Research in micro- and nano-technology is taking us down to a scale that was considered unthinkable only a few decades ago. Today, engineers are designing machines that can fit on the head of a pin, and they are going smaller still.

This summer, the Integrated Micro/Nano Summer Undergraduate Research Experience (IM-SURE) brought 21 undergraduate researchers together from 14 institutions, out of 173 applicants from 78 institutions across the country. The 2005 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 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. This 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

❧ Schedule of Events ❧

Thursday, August 25, 2005

Calit2 Building, Room 3008

12:00 p.m. – 12:10 p.m.	Welcome
12:10 p.m. – 2:00 p.m.	Presentations

Friday, September 2, 2005

McDonnell Douglas Engineering Auditorium

8:00 a.m. – 8:50 a.m.	Continental Breakfast
9:00 a.m. – 9:15 a.m.	Welcome
9:20 a.m. – 10:40 a.m.	Presentations
10:40 a.m. – 11:00 a.m.	Break
11:00 a.m. – 12:20 p.m.	Presentations
12:20 p.m. – 1:20 p.m.	Lunch
1:30 p.m. – 2:50 p.m.	Presentations
3:10 p.m. – 3:30 p.m.	Break
3:30 p.m. – 4:50 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' PowerPoint presentations and abstracts 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.

Thursday, August 25, 2005

<u>Time</u>	<u>IM-SURE Fellow</u>	<u>Project Title</u>	<u>Faculty Mentor(s)</u>
12:10	Eudean Sun <i>Electrical Engineering & Computer Science</i> University of California, Berkeley	Induced DC Signals Due to RF Excitation of the Scanning Tunneling Microscope	Wilson Ho <i>Physics & Astronomy</i>
12:30	Manuel Aldrete <i>Materials Science and Engineering</i> University of California, Berkeley	Thermal Measurements to Evaluate GaN LED Performance	Henry Lee <i>Electrical Engineering & Computer Science</i>
12:50	Kathleen O'Hara <i>Biological Sciences, Psychology</i> Virginia Polytechnic Institute and State University	Optimizing Usage of Microfluidic Chemotaxis Chambers for Cancer Research	Noo Li Jeon <i>Biomedical Engineering</i>
1:10	Michael Thompson <i>Chemistry</i> University of California, Irvine	Nanowire "Thinning" by Kinetically Controlled Electrochemical Stripping: A New Route to Ultra-Small Metal Nanowires	Reginald "Reg" Penner <i>Chemistry</i>

Friday, September 2, 2005

<u>Time</u>	<u>IM-SURE Fellow</u>	<u>Project Title</u>	<u>Faculty Mentor(s)</u>
9:20	Owen Finch <i>Electrical Engineering</i> University of California, Irvine	Automation of an All-Fiber Acousto Optic Spectrometer	Henry Lee <i>Electrical Engineering & Computer Science</i>
9:40	Evan Brown <i>Material Science Engineering</i> University of California, Irvine	Vertical ZnO Nanowire Field Effect Transistor	Jia “Grace” Lu <i>Chemical Engineering & Materials Science</i>
10:00	Daniel Strickland <i>Mechanical Engineering</i> Seattle University	Nanocrystalline Materials for Solid Oxide Fuel Cell (SOFC) Electrolytes	Martha Mecartney <i>Chemical Engineering & Materials Science</i>
10:20	Bryan Comis <i>Chemical Engineering</i> Princeton University	Nanoscale Electrode Development for Fundamental Studies of Mixed Ionic and Electronic Conductors as High Temperature Fuel Cell Components	Daniel Mumm <i>Chemical Engineering & Materials Science</i>
10:40	20-Minute Break		
11:00	Vince Nguyen <i>Biochemistry, Astrophysics</i> Oxnard College	Passivation of Carbon Nanotube Chips for Biosensing Applications	Philip Collins <i>Physics & Astronomy</i>
11:20	Dolly Creger <i>Biological Engineering</i> Utah State University	Assembly and Testing of MEMS Mirror for Endoscopic OCT	William Tang <i>Biomedical Engineering</i>
11:40	Jessica Reddy <i>Biological Sciences</i> University of California, Irvine	The Advanced Prosthetic Hand Project—Artificial Muscle	William Tang <i>Biomedical Engineering</i>
12:00	Delaram Sahebzamani <i>Biological Sciences</i> University of South Florida	Fabrication of Microfluidic Devices for 3D Chemotaxis Studies	Noo Li Jeon <i>Biomedical Engineering</i>
12:20	One-Hour Lunch		

Friday, September 2, 2005 (Continued)

<u>Time</u>	<u>IM-SURE Fellow</u>	<u>Project Title</u>	<u>Faculty Mentor(s)</u>
1:30	Alok Vij <i>Materials Science and Engineering</i> Northwestern University	Cell Encapsulation for Tissue Engineering	Abraham Lee <i>Biomedical Engineering</i>
1:50	Liana Alston <i>Biochemistry</i> University of California, Riverside	Optimizing the Net Fluorescence of Droplets in a Microfluidic System to Detect the Prevalence of a Disease in a Biosample	Abraham Lee <i>Biomedical Engineering</i>
2:10	Joon Kim <i>Electrical Engineering, Mathematics</i> University of Maryland, College Park	Frequency Domain Optical Coherence Tomography (FDOCT)	Zhongping Chen <i>Biomedical Engineering</i>
2:30	Justin Little <i>Aerospace Engineering</i> University of California, Irvine	The Resistive Properties of Thin Carbon Films from Pyrolyzed SU-8	John LaRue and Richard Nelson <i>Mechanical & Aerospace Engineering</i>
2:50	Lindsay Rogers <i>Mechanical Engineering</i> University of Wisconsin, Platteville	Simulation and Analysis of Equally Distributed Microfluidic Flow for Use in Ultrasonic Atomization	Chen Tsai <i>Electrical Engineering & Computer Science</i>
3:10	20-Minute Break		
3:30	Michael Helmeste <i>Computer Engineering, Switching to Electrical Engineering</i> University of California, Santa Barbara	Passive RFID Sensors	Mark Bachman <i>Electrical Engineering & Computer Science</i>
3:50	Chia-Jung Yu <i>Electrical Engineering</i> University of California, Irvine	The Steady Fluidic Characteristics in Virtual Wall Micro Channels	Guann-Pyng "G.P." Li <i>Electrical Engineering & Computer Science</i>
4:10	Brandon Johnson <i>Computer Engineering</i> University of California, Irvine	Analyzing the Properties of IrOx Derived Electrochemical Sensors	Marc Madou <i>Mechanical & Aerospace Engineering</i>
4:30	Carlos Jimenez <i>Electrical Engineering</i> California State Polytechnic University, Pomona	Investigation of Multi-Layer Electrostatic Actuation	Andrei Shkel <i>Mechanical & Aerospace Engineering</i>

IM-SURE Fellows

Manuel Aldrete



Majors: Materials Science, Engineering

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Project Title: Thermal Measurements to Evaluate GaN LED Performance

Faculty Mentor: Henry Lee, *Electrical Engineering & Computer Science*

Abstract:

High power light emitting diodes have become popular in many applications. The performance of LEDs typically degrades with increased temperature. This project uses thermal measurements to evaluate the LED performance at increasing temperatures and high current operation. With these measurements T_0 , a parameter dependent on the material bandgap and LED design, can be accurately calculated. The LED performance was determined through I-V curves and light versus current curves, using a semiconductor parameter analyzer, optical spectrometer, and laser diode controller. After obtaining T_0 , LED susceptibility to temperature effects should be easier to predict and GaN LEDs with lower performance degradation can be designed.

Liana Alston



Major: Biochemistry

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Project Title: Optimizing the Net Fluorescence of Droplets in a Microfluidic System to Detect the Prevalence of a Disease in a Biosample

Faculty Mentor: Abraham Lee, *Biomedical Engineering*

Abstract:

Astronauts, specifically, are in need of a more sensitive and conservative method for disease testing during spaceflight, especially with longer-term spaceflight on the horizon. Our goal is to develop a microfluidic system that will require only picoliter droplets of saliva and systematically combine them with droplets of a viral-specific molecular beacon for DNA analysis, which will be quantified by the fluorescence signal of the mixed droplets. We will use existing droplet generation technology for the bio-sensing of an oligonucleic acid sequence via a salivary sample. This kind of system will eventually lead to the more immediate diagnosis of a viral infection along with more general applications; producing solutions not only in clinical patient-care, but also for domestic use, in curbing the spread of pandemic diseases. There will be biochemical and physical challenges in the development of this microfluidic system: the characterization of a hybridization “working” buffer for the optimum signal-to-background fluorescence ratio, as well as analyzing mixing properties within droplets for a homogenous buffer-saliva-molecular beacon solution within microfluidic channels.

Evan Brown



Major: Material Science Engineering

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Project Title: Vertical ZnO Nanowire Field Effect Transistor

Faculty Mentor: Jia “Grace” Lu, *Chemical Engineering & Materials Science*

Abstract:

To fully utilize the scaling advantage of quasi-one-dimensional nanostructures, vertically grown ZnO nanowires have been successfully fabricated, using DC and pulsed electrodeposition methods in a highly ordered anodic aluminum template. An evaporated layer of titanium on one side of the template serves as the working electrode in a standard three electrochemical cell. It is found that pulsed electrodeposition grows Zn nanowires with a much higher filling factor and uniformity. The ZnO nanowires were formed by thermally oxidizing the Zn nanowires. XRD spectra of increasing oxidation time show that the as-grown Zn was gradually converted to ZnO. The electrical transport property of individual nanowires was characterized with an atomic force microscope using conductive probes. Vertically-aligned field effect transistors will be constructed, which will serve as the building blocks for nanoscale memory and logic devices.

Bryan Comis



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

Faculty Mentor: Daniel Mumm, *Chemical Engineering & Materials Science*

Abstract:

The goal of this project is to better understand what micro-structural features influence the reduction of oxygen and the transportation of oxygen ions through the cathode/electrolyte bilayer in solid oxide fuel cells. Past studies have used averages of specific micro-structural features, such as cracks, over an entire sample in an attempt to extract meaningful structure-property relationships. This study, however, takes the unique approach of synthesizing a regular, repeating cathode structure. In doing so, accurate measurements of variables, such as triple phase area and bulk contact between the cathode and the electrolyte, will be possible. Specific processes, such as the glycine-nitrate process (GNP), anodization of aluminum, and pulse-laser deposition, will be used in the synthesis of this well-defined cathode. This project is not an attempt to discover a new way to synthesize cathodes for mass production purposes. The inherent complexity and high cost of creating such well-ordered cathodes makes the commercialization of such a process impractical. Rather, this project is intended to gain a better understanding of the way in which micro-structural properties in the cathode/electrolyte interface correlate with the electrical and ionic conductivities of that bilayer.

Dolly Creger



Major: Biological Engineering

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Project Title: Assembly and Testing of MEMS Mirror for Endoscopic OCT

Faculty Mentor: William Tang, *Biomedical Engineering*

Abstract:

The rising technologies of Micro-Electro-Mechanical Systems (MEMS) and Endoscopic Optical Coherence Tomography (OCT) can be combined to facilitate internal imaging without invasive procedures. A 360° rotating mirror is required for imaging tubular structures within the body, such as the esophagus, trachea, and artery walls. The size limiter for these rotary probes is the motor used for actuation. A fully rotating MEMS mirror is presented, which will allow for the production of a probe only 1 millimeter in diameter, making it nearly half the size of those on the market today. This device consists of a rotary scratch drive motor and a polysilicon mirror. Several methods were tested to assemble the mirrors. It was found that the surface tension underneath the mirrors was greater than forces applied to lift the mirrors. More effective eradication of stiction forces will allow this and other MEMS devices to become more commercially viable.

Owen Finch



Major: Electrical Engineering

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Project Title: Automation of an All-Fiber Acousto Optic Spectrometer

Faculty Mentor: Henry Lee, *Electrical Engineering & Computer Science*

Abstract:

Spectrometry and spectroscopic methods have applications in many fields, such as chemistry and astronomy. A compact all-fiber spectrometer with .01 nm resolution has previously been demonstrated using an Acousto Optic Tunable Filter (AOTF) and a Frequency Shift Key (FSK) signal. In this paper we will demonstrate a completely automated spectrometer using a Motorola 68HC11E9 microcontroller and AD9834 Direct Digital Synthesizer. By automating this system, its practicality as a measurement tool can be realized.

Michael Helmeste



Major: Computer Engineering, Switching to Electrical Engineering

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Project Title: Passive RFID Sensors

Faculty Mentor: Mark Bachman, *Electrical Engineering & Computer Science*

Abstract:

Passive RFID technologies are becoming increasingly commonplace and inexpensive. Used in the supply chain for inventory tracking and management, the potential for value added RFID tags with passive sensors is enormous. By integrating MEMS sensor technology with RFID tags, the existing infrastructure of RFID can be utilized to passively acquire environmental data. Ideally, sensors would be integrated with the digital logic of the RFID chips themselves. However, existing solutions are not ready for mass production, and the key selling point of RFID is low cost. Elegant, low cost solutions result from modifying the configuration of the tag's antenna, and can easily be manufactured. RF MEMS switches are used in the modification of the tag's antenna to provide ancillary data. Two solutions of modifying the tag were investigated. One solution involves using the activation of a sensor to modify the tag's resonant frequency, detected by a change in reflected power at the reader. The reader must be modified to emit two carriers. The other solution involves a simple encoding scheme using two RFID tags, where only one tag is connected to a sensor. The two carrier solution is technically complex and requires modifications to the reader, the price of which is high to begin with. The two tag solution results in a higher per unit cost, but requires no modification of the reader and can be easily integrated with existing infrastructure.

Carlos Jimenez



Major: Electrical Engineering

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Project Title: Investigation of Multi-Layer Electrostatic Actuation

Faculty Mentor: Andrei Shkel, *Mechanical & Aerospace Engineering*

Abstract:

Electrostatic forces are commonly used for actuation of micro-scale devices ranging from gyroscopes to precision systems. Parallel offset combs can be an alternative way of actuating Micro-electrical-mechanical-systems (MEMS). Many MEMS use parallel combs to drive internal structures in-plane, parallel to the wafer. Several MEMS devices, such as gyroscopes and micro mirrors, require out-of-plane actuation. However, when devices are built using a single mask Silicon-on-Insulator (SOI) fabrication, out-of-plane actuation cannot be easily achieved. This study explores an opportunity for driving masses out-of-plane using a planar fabrication process. The concept is to fabricate parallel combs with different heights with respect to the top of the wafer. It is expected that with such an offset, the net electrostatic forces in the vertical, z-direction will generate forces large enough to drive a structure out-of-plane in the presence of a differential applied potential across the different combs. The FEMLAB 3.1 with MATLAB modeling package is used to predict which comb geometries will maximize this out-of-plane force. Modeling shows that by making the short electrodes half the size of the tall ones, the force in the z-direction is higher. Using these optimized geometries, lithographic masks are designed and test structures are fabricated. The first attempt to make short combs requires opaque combs in the mask to let some UV light go through, exposing only half as much as the fully covered comb with photo resist. The second technique uses a two-mask deposition, which leads to unexpected roughness in the small combs. While the fabrication was rough and not fully explored, computer models show that offset parallel combs offer promising ways of actuating the next generation of gyroscopes and other devices requiring out-of-plane actuation.

Brandon Johnson



Major: Computer Engineering

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Project Title: Analyzing the Properties of IrOx Derived Electrochemical Sensors

Faculty Mentor: Marc Madou, *Mechanical & Aerospace Engineering*

Abstract:

Electrochemical sensing is extremely important in many aspects of engineering, science and industrial applications, and pH sensing is among the most utilized and necessary functions of electrochemical sensing. The present standard, a glass pH electrode, is fragile, expensive, and cannot be used in certain environments. In recent years the development of IrOx electrochemical sensors has attempted to supplement the problems created by these standard glass pH electrodes. A method of creating IrOx sensors by baking an iridium wire at high temperatures in a Li_2CO_3 melt bath was claimed to produce very small IrOx sensors with excellent mechanical stability, very fast response times, and stability in a wide variety of mediums. However, for some time, these results were not able to be reproduced in industry. Recently however SensIrOx, a company producing these sensors, has made progress in their manufacturing of IrOx. Tests were done on IrOx sensors acquired from SensIrOx which have proven to support many of the initial claims regarding producing IrOx from a Li_2CO_3 bake. Fast response times, stability in a variety of pH buffers and in the presence of Ferricyanide, and fairly good mechanical stability were all observed. However, some contradictions with initial claims were also observed. The sensors require a several day break-in period of being fully soaked in a pH buffer before they are usable, and the sensors must be fully hydrated to maintain good readings with quick response times. It is uncertain why this discrepancy exists, however, the general progress thus far seems to support the initial claims made regarding the creation of IrOx in a lithium carbonate melt bath.

Joon Kim



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Project Title: Frequency Domain Optical Coherence Tomography (FDOCT)

Faculty Mentor: Zhongping Chen, *Biomedical Engineering*

Abstract:

An optical coherence tomography (OCT) is a noninvasive imaging technology in which an amplitude and a phase of electromagnetic wave undergone backscattering are used to extract properties and microstructure of a material medium such as biological tissues by providing a cross-sectional view of the sample being scanned. In an OCT experiment, the precise control of laser source plays a crucial role in obtaining accurate data. Reflecting this point, the use of high-tech hardware and control software, ranging from a voltage controlled laser generator to the high speed digitizer, which maintains a consistent and precise triggering of rapidly evolving information-bearing signal, are pervasive and thus, an integral part of OCT experimentation.

Justin Little



Major: Aerospace Engineering

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Project Title: The Resistive Properties of Thin Carbon Films from Pyrolyzed SU-8

Faculty Mentors: John LaRue, *Mechanical & Aerospace Engineering*, and Professor Richard Nelson, *Mechanical & Aerospace Engineering*

Abstract:

Carbon formed by pyrolysis of the negative photoresist SU-8 has many diverse applications in the fields of MEMS and electrochemistry. Its ability to achieve high aspect ratios, exceptional strength, small dimensions, large electrode potentials, as well as diverse levels of conductivity makes SU-8 a strong option for uses in micro batteries and many other cutting-edge MEMS devices. The research group is studying the material properties of these pyrolyzed polymers. This part of the research designed, fabricated, and evaluated an apparatus for measuring electrical resistivity as a function of temperature. Unwanted electrode and contact effects associated with resistance measurements are eliminated through the use of a four-wire Kelvin bridge measurement. A relatively large aluminum mass is used to heat a silicon die containing the carbon strips, and will assist in reducing temperature gradients. Temperature is measured using two displaced thermocouples. The experiment takes place under two quartz shrouds to minimize free and forced conduction as well as create a nitrogen environment to avoid oxidation of the copper measuring contacts at high temperatures. The apparatus is designed to measure the resistance across the carbon strips accurately and with a high level of repeatability. Given the measured resistance and the dimensions of the carbon, the resistivity of the pyrolyzed SU-8 is determined.

Vince Nguyen



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Project Title: Passivation of Carbon Nanotube Chips for Biosensing Applications

Faculty Mentor: Philip Collins, *Physics & Astronomy*

Abstract:

Carbon nanotubes, and specifically single-walled carbon nanotubes (SWNTs), have unique electronic properties that may allow electronic biosensor applications in protein and virus sensing and detection. One advantage of carbon nanotubes is the enabling of electronic sensing without, or in addition to, fluorescent labelling. This project focuses on creating passivating windows on carbon nanotube electronic chips by optical or electron-beam lithography. The purpose of these windows is to protect some portions of a chip from conductive electrolytes and biological material while the active nanotube portion remains in contact. The electron-beam lithography used in this project has followed standard techniques but is performed in a shutterless system with no beam blanker. Simple beam control allows squares, rectangles and points on the SWNT chip to be exposed and developed. Important factors to be controlled include the exposure time and the electron beam spot size. By changing these parameters, we have created fully developed windows in a range of sizes and shapes, though the smallest window dimensions to date remain at a width of 0.64 microns. Atomic force microscopy inside the windows clearly resolves the exposed SWNT section that will be in contact with the biological fluids. This technique will allow us to perform electrochemical and biochemical experiments on carbon nanotube biosensors with minimal interference. Future research may shrink the window sizes further if the measured interference is found to be unacceptable.

Kathleen O'Hara



Majors: Biological Sciences, Psychology

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Project Title: Optimizing Usage of Microfluidic Chemotaxis Chambers for Cancer Research

Faculty Mentor: Noo Li Jeon, *Biomedical Engineering*

Abstract:

The use of microfluidic chemotaxis chambers provides environments in which to study directed cell migration as never before. Specifically, observation of chemotaxis in a chemoattractant gradient, which has been documented to be a cause of cancer metastasis, is possible. Despite the obvious value of this technology, the field still lacks a simple and consistent protocol for the use of this equipment. Previous techniques have failed to produce maintainable gradients, have relied upon complex procedures and did not offer the ability to isolate individual cells. This study introduces a new microfluidic H-channel device and explores the protocol necessary to study MTLn3 CFP, rat adenocarcinoma, cell migration based on linear epidermal growth factor (EGF) gradients. By experimentally varying the collagen I and bovine serum albumin coating, cell culture, EGF concentration and cell density requirements, the study has produced a preliminary foundation for continued work on this cell line and device. Behavior of MTLn3 cells can now be observed and evaluated to determine optimal testing conditions. Once a protocol for this device is established, further experiments including drug therapy and cell isolation work can occur.

Jessica Reddy



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Project Title: The Advanced Prosthetic Hand Project—Artificial Muscle

Faculty Mentor: William Tang, *Biomedical Engineering*

Abstract:

The application of an advanced prosthetic hand becomes increasingly significant as our soldiers continue to face the inevitabilities of wartime. Current artificial muscles use myoelectric prostheses, in which residual muscle remnants send EMG signals to electrode sensors in the prosthesis socket. This method is used to design prosthetic hooks, in which amputees are allowed a “thumb-index finger pinch” movement. The advanced prosthetic hand would replace the myoelectric process with neural prostheses implanted in the cortical region of the brain. Also, the advanced prosthetic hand would mimic skeletal muscle, giving patients functionalities beyond a “pinch,” to movements analogous to a normal functional hand, with tactile sensors included. At the same time, the artificial limb must be lightweight and consume low amounts of energy. To build this, we are investigating the optimal artificial muscle and arrangement. McKibben artificial muscles are double-bladder pneumatic actuators, in which a braided shell surrounds an elastic inner bladder. When pressure is applied to the actuator, the outer braided shell constrains longitudinal expansion of the internal bladder, thereby causing perpendicular volume production. This decreases the longitudinal length of the actuator, which can cause tension when the actuator is attached to a load. Some drawbacks of the McKibben artificial muscle are hysteresis between the two membranes, membrane deformation and failure, and low total displacement values. Pleated pneumatic artificial muscle (PPAM) is an improved design capable of contracting with increased total displacements. When pressure is applied to the single-membrane cylindrical PPAM, it contracts by expanding the many pleats that are folded along the longitudinal axis. The high elastic modulus of the membrane allows the cross-sectional surface area of the membrane to remain constant throughout contraction, thereby eliminating the concern of tensile stress and membrane deformation. We are modeling the action of these muscles in FEMLAB and are currently testing McKibben artificial muscle to further characterize an artificial muscle with the optimal shape, size, and material properties.

Lindsay Rogers



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Project Title: Simulation and Analysis of Equally Distributed Microfluidic Flow for Use in Ultrasonic Atomization

Faculty Mentor: Chen Tsai, *Electrical Engineering & Computer Science*

Abstract:

The need for fine, uniform sprays of atomized particles is gaining importance in the medical, nanoelectronic, and Micro-Electrical-Mechanical-System (MEMS) fields. A silicon-based, high-frequency ultrasonic nozzle has recently been constructed by the research group of Professor Chen S. Tsai, with the ability to produce uniform drops in the vicinity of seven microns. Creating an array of such nozzles will provide the ability to greatly increase the production of monodisperse drops for spray applications. To analyze an array of nozzles, a microfluidic channel manifold, which will supply equally dispersed fluid flow to each nozzle, was studied. This flow was analyzed using commercial finite element software and computer programming to simulate and analyze microfluidic flow and acoustical vibrations to design the most optimal channel profile.

Delaram Sabezamani



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Project Title: Fabrication of Microfluidic Devices for 3D Chemotaxis Studies

Faculty Mentor: Noo Li Jeon, *Biomedical Engineering*

Abstract:

Microfluidics has played a vital role in the study of cell-molecule interactions. One area in particular is the investigation of chemotaxis of metastatic cancer cells. Studying and understanding the migration of these cancer cells will allow for improvement in the diagnosis and treatment of this disease. Previous studies of metastatic breast cancer cells (MDA MB 231) in 2-dimensional microfluidic devices have enabled the characterization of chemotaxis in response to specific chemoattractants. While providing important information about the chemotactic response of these cancer cells, this approach is limited in its ability to model the 3-dimensional movement of *in vivo* cells. The objective of this research project is to fabricate microfluidic devices capable of producing concentration gradients in 3D Collagen Type 1 gels. Since the tissues and organs of the human body are abundant with Collagen, these devices will better mimic the tissue microenvironments. A simple technique of fabricating 3D collagen gels in microfluidic devices was developed. Future studies of cell migration within these new devices will lead to a better understanding of cancer cell chemotaxis *in vivo*.

Daniel Strickland



Major: Mechanical Engineering

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Project Title: Nanocrystalline Materials for Solid Oxide Fuel Cell (SOFC) Electrolytes

Faculty Mentor: Martha Mecartney, *Chemical Engineering & Materials Science*

Abstract:

Increased ionic conductivity has been reported in nanocrystalline zirconia, as compared with zirconia at the micro-scale, making such materials of interest for applications such as Solid Oxide Fuel Cells (SOFCs). A comprehensive study of such materials, however, has not previously been accomplished. This research project focuses on the fabrication and characterization of nanocrystalline yttria and scandia-stabilized zirconia thin films, using a sol-gel process. Isopropoxides of yttria, scandia, and zirconia were selected as precursors, and spin coated onto silicon wafers. The resulting thin films are expected to have grain sizes less than 100 nm, and are approximately 200 nm thick. Characterization techniques include glancing angle X-Ray Diffraction (XRD) for crystal structure characterization, Scanning Electron Microscopy (SEM) to determine grain size and surface morphology, and Impedance Spectroscopy (IS) to measure ionic conductivity.

Eudean Sun



Majors: Electrical Engineering, Computer Science

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Project Title: Induced DC Signals Due to RF Excitation of the Scanning Tunneling Microscope

Faculty Mentor: Wilson Ho, *Physics & Astronomy*

Abstract:

Experimental data demonstrated that a direct current (DC) bias between the tip and sample in a scanning tunneling microscope (STM) could be induced by a radio frequency (RF) signal passed through a copper coil placed around the tip of the STM. A resonant response to the RF signal, indicated by an increase in the measured DC bias, was discovered at certain frequencies, including 800MHz, 1.3GHz, and 2.0GHz. This project was intended to verify the experimental data by modeling the STM, including the scanner and radiation shields, in Ansoft's High Frequency Structure Simulator (HFSS), and then testing this model for resonance at excitation frequencies from 500MHz to 2GHz in 100MHz steps. Results indicated that resonance is due strongly to the radiation shields (inner and outer) in the model, as the model showed insignificant resonance in the absence of the radiation shields. Further, plots of the electric field across the sample were made in relation to the distance between the tip and sample, varying from 10^{-6} in to 10^{-3} in, which indicated a strong relation between the magnitude of the electric field and the tip-sample distance as well as an extremely strong localization around the tip. Trends seen in results were generally consistent with expectations, but certain inconsistencies did exist in resonant frequencies and electric field magnitudes on the tip, and could be tied to various approximations made in the construction of the model.

Michael Thompson



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Project Title: Nanowire “Thinning” by Kinetically Controlled Electrochemical Stripping: A New Route to Ultra-Small Metal Nanowires

Faculty Mentor: Reginald “Reg” Penner, *Chemistry*

Abstract:

Nanowires of many different metals and semiconductors have been deposited on highly oriented pyrolytic graphite (HOPG) in the Penner group, using a three-step electrochemical process called electrochemical step edge decoration (ESED). Typically, the wires created by this process can be no smaller than 80 nanometers in diameter. A fourth step has been proposed that thins the wires by oxidizing them at a slightly anodic potential to induce kinetically controlled stripping of the metal. The method has been refined with antimony nanowires, which have interesting transport properties when the wires are below 40 nm in diameter. Using the three step ESED method, the antimony nanowires can only be as small as 125 nanometers in diameter. The application of the stripping method has given a 75% size reduction in the antimony wires with retention of the length and morphology of the original wires. We can now synthesize parallel arrays of 50-micron long antimony nanowires with diameters as low as 35 nm. Kinetically controlled electrochemical stripping also allows for close control of the diameter of the wires, because the change in wire diameter is linearly proportional to the stripping time. The method has also proven successful with gold and bismuth telluride nanowires, and extensive data has been taken to prove the viability of the method.

Alok Vij



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Project Title: Cell Encapsulation for Tissue Engineering

Faculty Mentor: Abraham Lee, *Biomedical Engineering*

Abstract:

The widespread adoption of poly(dimethylsiloxane) (PDMS) based microfluidic devices is based on both the ease of using the material system as well as the enormous range of capabilities of microfluidic systems, including the creation of micro-total analysis systems (μ TAS) or “lab-on-chip” systems, immunoprotective capsules for implants and cell encapsulation for biological assays or for the creation of tissue engineering scaffolds. A novel three-dimensional microfluidic device for the continuous encapsulation of cells in alginate droplets and the in-channel polymerization of the droplets is presented. Due to the reduction of volume and the associated reduction of the surface-area-to-volume ratio of these microbeads, as compared to previously reported alginate beads, the microbeads offer improved mechanical stability as well as increased diffusion capabilities for the influx of nutrients to as well as the efflux of biologically active molecules and waste products from the encapsulated cells. Furthermore, the continuous creation process afforded by the microfluidic device allows for standardized droplet polymerization conditions for uniform mechanical properties of all beads in a batch as well as the ability to combine other components, such as growth factors, gene promoters or other cell types, with the cells downstream of the encapsulation region.

Chia-Jung Yu



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Project Title: The Steady Fluidic Characteristics in Virtual Wall Micro Channels

Faculty Mentor: Guann-Pyng “G.P.” Li, *Electrical Engineering & Computer Science*

Abstract:

Many fundamental issues of Micro-Integration Technology, such as adsorption of chemicals, contamination of reagents, and the difficulties of integrated fabrication, are challenging researchers. Several studies have been done on reducing surface adsorption by permanent or dynamics chemical surface treatment in micro channels. The virtual wall micro channel is a specifically designed geometry channel that uses an air/liquid interface, super hydrophobic surface phenomenon, to reduce waste of reagents and surface adsorption. Virtual wall micro channels are designed to simplify micro-components’ fabrication and integration procedures, reducing cost and time. We hypothesized that fluidic resistance of virtual wall micro channels should have similar or smaller fluidic resistance than reference straight micro channels in PDMS microfluidic chips. The relative velocity method has been developed to take the ratio of pressure driven fluidic resistance between virtual wall and straight micro channel under constant pressure. The fluidic resistance of air-filled virtual wall micro channels is 2.28% higher than the reference channels. The fluidic resistance of oil-filled virtual wall micro channels is 4.67% smaller than the reference channels. The current difference is measured to show the electro-osmotic flow mobility, when Sodium Phosphate with 1.8 μM has been gradually replaced by 2.0 μM in a micro channel. The electro-osmotic flow mobility in virtual wall channels is similar to that in the straight line channel. The result demonstrates steady fluidic characteristics do not alter much for virtual wall channels, which have potential to be applied in multifunctional microfluidic system. The steady fluidic characteristics in virtual wall channels have proved that they are applicable in micro-integration technology.

❧ Thanks & Acknowledgements ❧

Many thanks to the following individuals, institutions and groups for their support in making the IM-SURE Program an outstanding success.

Chancellor Michael V. Drake
Executive Vice Chancellor Michael R. Gottfredson

Vice Chancellor William H. Parker, *Research & Graduate Studies*
Dean Sharon Salinger, *Division of Undergraduate Education*
Dean Ronald J. Stern, *School of Physical Sciences*
Dean Nicolaos G. Alexopoulos, *The Henry Samueli School of Engineering*
Director Bruce J. Tromberg, *Beckman Laser Institute*

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Philip Collins, *Physics & Astronomy*
Wilson Ho, *Physics & Astronomy*
Noo Li Jeon, *Biomedical Engineering*
John LaRue, *Mechanical & Aerospace Engineering*
Abraham Lee, *Biomedical Engineering*
Henry Lee, *Electrical Engineering & Computer Science*
Guann-Pyng “G.P.” Li, *Electrical Engineering & Computer Science*
Jia “Grace” Lu, *Chemical Engineering & Materials Science*
Marc Madou, *Mechanical & Aerospace Engineering*
Martha McCartney, *Chemical Engineering & Materials Science*
Daniel Mumm, *Chemical Engineering & Materials Science*
Richard Nelson, *Mechanical & Aerospace Engineering*
Reginald “Reg” Penner, *Chemistry*
Andrei Shkel, *Mechanical & Aerospace Engineering*
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Robert Gomez, *Career Center*
J. DeWayne Green, *Assistant Graduate Dean*
Rakhi Jain, *Advanced Medical Optics*
Susan C. Jarratt, *Campus Writing Coordinator*
James Jusko, *Aerospace Corporation*
Kathryn Kjaer, *Library*
Abraham Lee, *Biomedical Engineering*
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Marc Madou, *Mechanical & Aerospace Engineering*
Goran Matijasevic, *INRF Research Coordinator*
Martha McCartney, *Chemical Engineering & Materials Science*
David Melitz, *Environmental Health & Safety*
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William Tang, *Biomedical Engineering*

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California State Polytechnic University, Pomona
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University of South Florida
University of Wisconsin, Platteville
Utah State University
Virginia Polytechnic Institute and State University

Additional Thanks to the:

Arroyo Vista Housing
Calit2 Team
Division of Research & Graduate Studies
Division of Undergraduate Education
Graduate Students and Post-Doctoral Fellows
INRF Team
Jazz Semiconductor
UROP Team

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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.



The IM-SURE Program at UC Irvine is an NSF REU
Site funded by the National Science Foundation.