Cooperative International Science and Engineering Internships

Cooperative International Science and Engineering Internships(CISEI)
Summer 2009 - Student Projects

Student/School	Mentor	Faculty Sponsor	Site Abroad	Student Project
Katelyn Cahill-Thompson Biomedical Engineering, University of California Davis	Darragh Crotty and Dr. Adriele Prina-Mello	Dr. JMD Coey	Physics Department, Trinity College Dublin, Ireland	Microelectrode Array for Measuring Magnetic Stimulation of Neurons
Chris Cantaloube Mechanical Engineering, University of Florida	Dr. Francisco Garcia	Dr. Francisco Garcia	Chemical Engineering, CIMAT, Santiago, Chile	Synthesis of Novel Porous Copper Containing Silica Nanocomposite Thin Films for the Catalytic Reforming of Methanol
Ryan Chan Chemistry, Brown University	Prof. Dongyuan Zhao	Prof. Dongyuan Zhao	Chemistry Department, Fudan University, Shanghai, China	Magnetic Silica Filtration of Microcystins
Natalie Concors Chemical Engineering, UCSB	Dr. Ingrid Weiss	Prof. Eduard Arzt	Dept of Biomineralization, Leibniz Institute for New Materials, Saarbruecken Germany	Growth and Development of *Dictyosteliumdiscoideumon* Gecko Adhesive Surfaces
Duc T. Duong Chemistry, University of California, Santa Barbara	Matthew Carnes and Erik Berda	Prof. Bert Meijer	Department of Macromolecular and Organic Chemistry, Eindhoven University of Technology, Netherlands	Synthesis of C-3 Symmetrical Discotic Triamides Derivatives for Reciprocal Catalysis
Kate Fountaine Chemical Engineering, University of California Santa Barbara	Dr. Michael Brandon	Professor John M. Kelly	Chemistry Department, Trinity College Dublin, Ireland	Nanofabrication of Zinc Oxide and Nickel Oxide for Solar Cells
Sharice Handa	Marleen	Prof.	Functional Surfaces research group at the	Exploring Actuation

Mechanical Engineering, UCSB	Kamperman	Eduard Arzt	Leibniz Institute for New Materials, Saarbrücken, Germany	Systems for Gecko Inspired Surfaces
Cade Markegard Chemical Engineering, UCSB	Aileen O'Mahony and Dr. Ian Povey	Professor Martyn Pemble	Advanced Materials and Surfaces, Tyndall National Institute, Cork, Ireland	Atomic Layer Deposition of Copper on Oxide Seed Layers and Porous Materials
Ricardo Martinez Electrical Engineering, UCSB	Dr. Isabelle Ferdin and Kiyeol Byun	Prof. Dr. Cindy Colinge	Microsystems Group, Tyndall National Institute, Cork, Ireland	Low Temperature Direct Wafer Bonding
Laura Paulsen Biomedical Engineering, Johns Hopkins University	Alec Junyan Liu	Hualong Xu	Chemistry Department, Fudan University, Shanghai, China	HPLC Use in Proteomics and Traditional Chinese Medicine
Max Ramirez Computer Engineering, UCSB	Dr. Francisco Vivanco	Dr. Francisco Vivanco	Departmment:Advanced Materials Physics, CIMAT, Santiago, Chile	Analysis of Granular Material under Shear Stress
Erik Zinn Chemical Engineering, UCSB	Erik Berda and Matthew Carnes	Prof. E. W. Meijer	Department of Macromolecular and Organic Chemistry, Eindhoven University of Technology, Netherlands	Multi-Stimuli Responsive Supramolecular Polymer Nanoparticles Via Intramolecular Collapse Of Single Polymer Chains

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Cahill-Thompson's Project Page - CISEI summer 2009

Intern: Katelyn Cahill-Thompson, Biomedical Engineering, University of California Davis
Mentors: Darragh Crotty and Dr. Adriele Prina-Mello
Faculty Supervisor: Dr. JMD Coey
Physics Department, Trinity College Dublin, Ireland

Microelectrode Array for Measuring Magnetic Stimulation of Neurons

Transcranial magnetic stimulation of neurons has been established as a successful treatment of depression symptoms, with great potential for alleviating other neurological disorders such as multiple sclerosis and Parkinson's disease. Pulsed magnetic stimulation induces an electric field according to the principles of Faraday's Law; this field initiates action potentials, the propagating electrical signals by which neurons communicate. Although this principle is well established in vivo, until recently there have been no studies on the phenomenon in vitro. The ultimate objective is therefore to demonstrate magnetic stimulation of neurons in a controlled in-vitro environment. Towards that end, this project has been concerned with the fabrication of a device capable of measuring and quantifying the electrical activity of neurons cultured directly on its surface. The microelectrode array was produced with three photolithography steps, three deposition steps, and a milling step. It consisted of indium tin oxide (ITO) leads, Au contact pads, and an arc of Au electrodes concentric with the induced electric field, onto which excitable neurons may be patterned with microcontact laminin printing.

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Cantaloube's Project Page - CISEI summer 2009

Intern: Chris Cantaloube,
Mechanical Engineering, University of Florida
Mentor: Dr. Francisco Garcia
Faculty Supervisor: Dr. Francisco Garcia
Chemical Engineering, CIMAT, Santiago, Chile

Synthesis of Novel Porous Copper Containing Silica Nanocomposite Thin Films for the Catalytic Reforming of Methanol

The production of hydrogen for use in fuel cells has been an area of intense research in recent years. Of the methods available, steam reforming of hydrocarbons over highly activated catalyst has received considerable attention due to high theoretical yields of hydrogen. Typical catalysts include an active transition metal deposited on a ceramic support which offers high surface area as well as favorable metal-support interactions. One of the main drawbacks of these catalysts is the tendency of the active metals to sinter at high reforming temperatures, thereby decreasing surface area, dispersion, and reactivity. This project involves the synthesis of mesoporous and microporous silica-copper nanocomposite thin films. Incorporating the active metal, copper, into porous silica films allows for both good metal dispersion as well as reduced sintering. The thin films were prepared using the sol-gel process during which TEOS is hydrolyzed and heat treated to form silica. Doping of copper into the silica matrix was conducted either by addition of copper acetate to the prehydrolyzed TEOS or dispersion of already-synthesized copper nanoparticles into the prepared silica sol. Both samples were reduced under hydrogen so as to contain the active copper(0) species. It is hoped that these nanocomposite thin films will prove to be stable effective catalysts.

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Chan'sProject Page - CISEI summer 2009

Intern: Ryan Chan, Chemistry, Brown University
Mentor: Prof. Dongyuan Zhao
Faculty Supervisor: Prof. Dongyuan Zhao
Chemistry Department, Fudan University, Shanghai, China

Magnetic Silica Filtration of Microcystins

Composite silica microspheres have shown promise in many applications due to their easily tuned porosity, size, and low cost. One interesting usage is in water filtration, using a bed of composite mesoporous spheres to trap contaminants while allowing water to flow through. This project aims to synthsize magnetic mesoporous silica spheres in order to further facilitate filtration handling. We will have a particular interest in filtering microcystins, a toxic protein produced by several aquatic life forms. We seek to create multicomponent spheres, starting from a Fe_3O_4 nanoparticle seed, adding a base silica layer, then finishing with a template mesoporous top shell. We will vary the size of the silica layer via reaction conditions, the porosity via a variety of templating agents, and the surface chemistry through a variety of chemical treatments, testing which combination of methods allow for the most complete extraction of microcystins.

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Concors' Project Page - CISEI summer 2009

Intern: Natalie Concors, Chemical Engineering UCSB
Mentor: Dr. Ingrid Weiss
Faculty Supervisor: Prof. Eduard Arzt
Dept of Biomineralization, Leibniz Institute for New Materials, Saarbruecken Germany

Growth and Development of *Dictyosteliumdiscoideumon* Gecko Adhesive Surfaces

Gecko inspired adhesives are surfaces with many microscale pillars that form van der Waals forces with other surfaces to which they are applied. These adhesives are given this name because they are inspired by the adhesive structures on the bottom of geckos' feet. They differ from conventional tape in that they have directional adhesion and have the potential for switchable adhesion. These properties make gecko adhesives ideal for various biomedical applications. It is therefore important to understand how these structured surfaces interact with biological systems. The two main objectives of this project were to determine the most suitable way to sterilize the surfaces and how the surfaces affect cell development. The first objective was achieved by using various methods to sterilize the surfaces and noting the effect they had on the pillar structures. The second objective was accomplished using the model organism Dictyosteliumdiscoideum. Dictyostelium was chosen because of its simplicity and the extensive literature available studying its lifecycle. The slime mold Dictyosteliumdiscoideumaccumulates and differentiates from single celled organisms to multi-cellular stalks with spore capsules using signal transduction pathways when introduced to a starvation media. The development of the slime mold on the surfaces was observed using time-lapse photography on a stereo binocular microscope.

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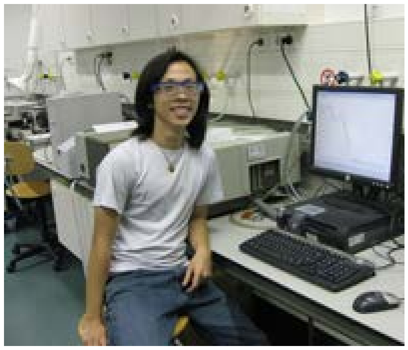
Duong'sProject Page - CISEI summer 2009



Intern: Duc T. Duong, Chemistry, UCSB
Mentors: Matthew Carnes and Erik Berda
Faculty Supervisor: Bert Meijer
Department of Macromolecular and Organic Chemistry, Eindhoven University of Technology, Eindhoven, Netherlands

Synthesis of C-3 Symmetrical Discotic Triamides Derivatives for Reciprocal Catalysis

Benzene-1,3,5-tricarboxamides (BTA) have been shown to self-assemble into helical columnar stacks with lengths in the nanometer scale. The supramolecular structure is stabilized by ð-ð interactions between aromatic rings and hydrogen bonding between corresponding amide hydrogens. Interestingly, when these discotic triamides contain chiral side chains the columnar structures preferentially formed either right-handed or left-handed helices, which can be detected via Circular Dichroism (CD) spectroscopy. In our project, we aimed to synthesize BTA derivatives that would template the formation of ring-like aromatic structures by acting as a geometrical directing agent via ð-ð stacking and hydrogen bonding. The products of such type of reaction would then provide the template for the next reaction. These mutually catalyzing systems had been previously observed in inorganic chemistry and were categorized as reciprocal catalysis. Through Atomic Force Microscopy (AFM), CD spectroscopy, and NMR spectroscopy, we characterized the syntheses and self-assemblies of new BTA derivatives that have potential for reciprocal catalysis. Sergeant-and-soldiers and majority rules experiments were also carried out to observe the chirality of the columnar structures but the results were inconclusive. Finally, discotic molecules containing alkyl side chains of various lengths and branching were synthesized to optimize their solubility and intermolecular interactions.

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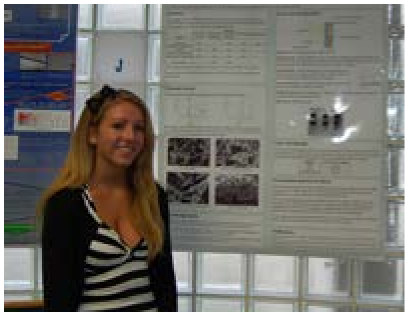
Fountaine'sProject Page - CISEI summer 2009



Intern: Kate Fountaine, Chemical Engineering, UCSB
Mentor: Dr. Michael Brandon
Faculty Supervisor: Professor John M. Kelly
Chemistry Department, Trinity College Dublin, Ireland

Nanofabrication of Zinc Oxide and Nickel Oxide for Solar Cells

Dye-sensitized solar cells (DSSCs) are one of the most promising answers to the world energy crisis due to the low cost of materials and easy assembly. Currently, DSSCs can achieve up to 11% efficiency. However, to attain commercial appeal, their price-performance ratio must be improved. One potential way to do this is to replace the standard semi-conductor material, titanium dioxide, with another metal oxide such as zinc oxide and/or nickel oxide. The metal oxides are promising because they are chemically stable, wide band gap semiconductors like titanium dioxide, but are significantly lower in cost. The main research goal was to synthesise nano-structured zinc oxide and nickel oxide with high surface area and photocatalytic activity for application as semi-conductors in dye-sensitised solar cells. Nanowires are specifically of interest for photocatalysts in solar cells because they can increase the rate of electron transport. Pure zinc oxide and zinc oxide/nickel oxide composite nanowires were successfully synthesized. The composite material is particularly intriguing because the inclusion of nickel oxide could potentially minimize the photocorrosion effect that often plagues zinc oxide. The synthesized nanowire materials were then incorporated into solar cells, and their performance was tested, revealing definitive photocatalytic activity. Furthermore, a novel technique for synthesizing nickel oxide with a rose-like morphology was developed. This material is an ideal catalyst because of its high surface area. Thus, nickel oxide and zinc oxide materials show promise for application in dye-sensitized solar cells.

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Handa's Project Page - CISEI summer 2009

Intern: Sharice Handa, Mechanical Engineering, UCSB
Mentor: Marleen Kamperman
Faculty Supervisor: Eduard Arzt
Functional Surfaces research group at the Leibniz Institute for New Materials, Saarbrücken, Germany

Exploring Actuation Systems for Gecko Inspired Surfaces

Geckos can naturally adhere to a variety of rough and smooth surfaces. Tiny, fibrillar hair arrays on their toe pads enable them to do so. Although other creatures such as beetles are also capable of this feat, geckos are the largest animal with this ability. They have the smallest adhesive surface area to weight ratio. Their adhesive pads are also self cleaning and do not become dirty as in traditional adhesives. Yet another interesting aspect of gecko adhesion is that geckos are able to adhere by choice. If it wishes to stick to a surface, they will contract their toes. Gecko adhesives can be applied to a variety of commercial applications such as medical stitches, tapes, gloves, and more. The actuation system, turning adhesion on and off, was the focus of my project. We wished to explore a way of creating an actuation system for gecko pillar structures. We sought to create a bi-layer structure vertically on nano-scale pillar structures. When the pillars swelled with increased humidity or absorption of a solvent, the pillars would bend, due to the rigidity of the metal on one side of the pillar, essentially turning off adhesion capabilities. When the substrate dried, the pillars would once again be in the upright position and thus adhesion would be possible. We explored different substrates-metal combinations, swelling, and metal deposition techniques.

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Markegard's Project Page - CISEI summer 2009

Intern: Cade Markegard, Chemical Engineering, UCSB
Mentors: Aileen O'Mahony and Dr. Ian Povey
Faculty Supervisor: Professor Martyn Pemble
Advanced Materials and Surfaces, Tyndall National Institute, Cork, Ireland

Atomic Layer Deposition of Copper on Oxide Seed Layers and Porous Materials

Transistors grow exponentially on microchips according Moore's Law; however, there is currently a 22 nm node limitation. It has become increasingly necessary to investigate new methods to overcome this size restriction. Recently, metal atomic layer deposition (ALD) has become an area of interest for the fabrication of metallic nanowires and interconnects. ALD also has the potential to overcome the 22 nm limitations. In this study, ALD copper growth was observed using sequential pulsing of copper(II)-hexafluroacetylacetonate hydrate (Cu(hfac)2•xH2O), and formalin. Initially, the infiltration of copper into photonic opals and porous anodic alumina was investigated. However, the research began to focus on the ability to use oxide layers, such as magnesium oxide (MgO), zinc oxide (ZnO) and aluminum oxide (Al_2O_3), as seeds to promote copper growth. Currently, seed layers are used as a template for interconnects which copper is electrolessly deposited onto. The goal of this work is to investigate the feasibility of using ALD as a way of depositing the copper for interconnects. Previous work has shown that Cu(hfac)2 does not grow readily on a pure Si surface. AFM and SEM results revealed the copper did not grow as the thin films usually characteristic of ALD. On MgO and ZnO the copper grew as islands, typical of a chemical vapor deposition (CVD) process. In contrast, SEM images indicate copper growth was achieved on the Al_2O_3 seed layer in the (100) direction of the silicon wafer. From the obtained EDX spectra, it can be inferred pure aluminum seeded the copper growth. Interestingly and unexpectedly, SEM and EDX analysis also confirmed sparse copper growth on an unseeded silicon wafer. Future studies should include an investigation on the effects of temperature and other potential seed layers.

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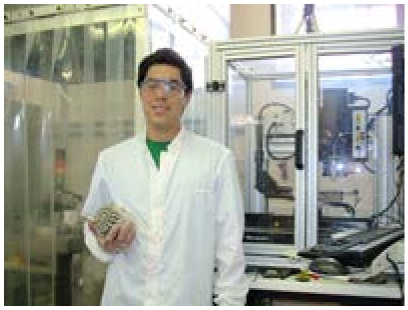

Intern: Ricardo Martinez, Electrical Engineering, UCSB
Mentors: Dr. Isabelle Ferdin and Kiyeol Byun
Faculty Supervisor: Prof. Dr. Cindy Colinge
Microsystems Group, Tyndall National Institute, Cork, Ireland

Low Temperature Direct Wafer Bonding

Through a process of direct wafer bonding which includes activation of the wafer surfaces through radical plasma exposure by remote plasma, we were able to significantly increase the bond strength of homogeneous and heterogeneous structures such as Si-Si. With this new method of remote plasma activation, bond strengths as high as 2500mJ/cm2 could be realized. The radical exposure also led to increased bond strengths without the need of a high temperature annealing step. Annealing the samples at high temperatures can cause certain problems: due to differences in thermal expansion coefficients the wafers can crack or, depending on the initial bond quality, the wafers can de-bond. To understand what was leading to this increase in bond strength we needed to characterize the buried oxide in the interface. An increase in buried oxide would lead to increase in bond strength however this would greatly degrade electrical properties of the bond, which is not a desired effect.

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Paulsen's Project Page - CISEI summer 2009

Intern: Laura Paulsen, Biomedical Engineering, Johns Hopkins University
Mentor: Alec Junyan Liu
Faculty Supervisor: Hualong Xu
Chemistry Department, Fudan University, Shanghai, China

HPLC Use in Proteomics and Traditional Chinese Medicine

High performance liquid chromatography, or HPLC, is a type of column chromatography where a compound and two buffers are pumped through a chromatography column. A UV-light or fluorescent light detector then records the retention times of the molecules making up the compound. These retention times are then outputted onto a graph showing the intensities of the molecule detections in the form of peaks. From these peaks it is possible to determine the appropriate adjustments to make to the buffers and compounds. HPLC was used to study and quantify protein on tissue by labeling the proteins with OPA, a reagent that reacts with free amino acid groups, and then detect these amino groups with the fluorescence detector. Adjustments were made to the OPA-protein reactions as well as the buffers that the proteins were immersed in to obtain better results. The OPA-protein experiments included varying the OPA-protein reaction time, the temperature of this reaction environment, and the pre and post-OPA-protein reaction conditions. The buffers were also varied by testing the effect of pH on the fluorescence intensity as well as the effects of TFA (trifluoroacetic acid), TEA (triethyl amine), and salts such as H_3PO_4, K_3PO_4, KH_2PO_4, and Na_2 HPO_4 in the buffer solutions. In addition to working with HPLC to study proteins, it was also used to analyze a Traditional Chinese Medicine (TCM) that is known to have curative properties for breast and liver cancers. From the separations of the TCM and future cell culture studies, it will be possible to determine which specific molecules or combinations of molecules have a curative effect on the cancers.

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MATERIALS RESEARCH LABORATORY at UCSB: an NSF MRSEC
the innovation engine for new materials

Ramirez'sProject Page - CISEI summer 2009

Intern: Max Ramirez, Computer Engineering, UCSB
Mentor: Dr. Francisco Vivanco
Faculty Supervisor: Dr. Francisco Vivanco
Departmment:Advanced Materials Physics, CIMAT, Santiago, Chile

Analysis of Granular Material under Shear Stress

Composite silica microspheres have shown promise in many applications due to their easily tuned porosity, size, and low cost. One interesting usage is in water filtration, using a bed of composite mesoporous spheres to trap contaminants while allowing water to flow through. This project aims to synthsize magnetic mesoporous silica spheres in order to further facilitate filtration handling. We will have a particular interest in filtering microcystins, a toxic protein produced by several aquatic life forms. We seek to create multicomponent spheres, starting from a Fe_3O_4 nanoparticle seed, adding a base silica layer, then finishing with a template mesoporous top shell. We will vary the size of the silica layer via reaction conditions, the porosity via a variety of templating agents, and the surface chemistry through a variety of chemical treatments, testing which combination of methods allow for the most complete extraction of microcystins.

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Zinn's Project Page - CISEI summer 2009

Intern: Erik Zinn, Chemical Engineering, UCSB
Mentors: Erik Berda and Matthew Carnes
Faculty Supervisor: Prof. E. W. Meijer
Department of Macromolecular and Organic Chemistry, Eindhoven University of Technology, Eindhoven, Netherlands

Multi-Stimuli Responsive Supramolecular Polymer Nanoparticles Via Intramolecular Collapse Of Single Polymer Chains

Polymeric nanoparticles have become a topic of interest in the creation of well-defined controllable nanoscale architectures. Covalent cross-linking has been utilized to create discrete polymeric nanoparticles. Through the intramolecular collapse of single polymer chains it has been shown that this strategy can be applied using non-covalent cross-linking of ureidopyrimidinone (UPy) moieties. Acidification of UPy nanoparticles disrupts the cross-linking resulting in the expansion of the nanoparticles back into random coils. In this project, we aim to synthesize and characterize nanoparticles which combine covalent and non-covalent cross-links that are responsive to both UV irradiation and acidification. Non-covalent cross-links will be provided by UPy and covalent cross-links by the reversible photodimerization of Coumarin. Gel permeation chromatography (GPC), ultra violet absorption (UV), and atomic force microscopy (AFM) were used to monitor the formation, collapse, and re-expansion of the nanoparticles.

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