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Research Internships in Science and Engineering

Research Interns in Science and Engineering (RISE)
Summer 2005 - Student Projects

Student Major/School	Mentor	Faculty Sponsor	Department	Student Project
Edgar Algarin Chemistry UCSB	Brian Thibeault	Evelyn Hu	Electrical & computer engineeringCE	Nano-imprint lithography of nanostructures
David Ando Physics UCSB	Rob Knobel	Andrew Cleland	Physics	Nanolithography nanomatching nanoelectronics
Michael Bjorndal Physics Cornell	---	Deborah Fygenson	Physics	DNA melthing and hairpin formation in the presence of intercalating dyes
Krista Ehrenclou Chemistry UCSB	Cara Evans	Joseph Zasadzinski	Chemical Engineering	Encapsulation of Taxol for use in vesicle based drug delivery systems
Edouard Fonck Chemical Engineering UCSB	Ray Tu	Matt Tirrell	Chemical Engineering	Specific drug delivery
Wesley Francillon Engineering SUNY Stony Brook	Rafael Leckie	Carlos Levi	Materials	Study of new thermal barrier coating materials by synthesis of rare earth Oxide-ZrO_2-Al_2O_3
Heather Hoff Materials Engineering Calpoly, SLO	Alex Small	David Pine	Chemical Engineering	Processing of macroporous materials using ordered polystyrene or silica spheres as templates
Kathleen Kolstad Neuroscience Bates College	Michelle Staples	Lincoln Johnson	Neuroscience	Role of Matrix metalleproteinases(MMP) and their inhibitors (TIMP) in age related macular degeneration

Penny Letts Biology Queen's University	Ahmet Tezel	Samir Mitragotri	Chemical Engineering	Sonophoresis of skin with fluorescent polystyrene microspheres
Xerxes Lopez-Yglesias Physics UCSB	Tom King Matt Doty	Mark Sherwin	Physics	Antennae creating for tertahertz radiation sensors
Jaclyn Martinez Biochemistry UCSB	Luke Sherlin	John Perona	Chemistry	Purification and crystallization of GLN-tRNAGln protein COMPLEXES
Worawat Meevasana Physics UCSB	---	Guenter Ahlers	Physics	The ring patterns in the convection of isoproponal
Anthony Morfa Biochemistry UCSB	Larken Euliss	Galen Stucky	Chemistry	Biomineralization of Calcium Carbonate
Sachin Patil Physics UCSB	Matt Doty	Mark Sherwin	Physics	Terahertz tecnologies: radiation detectors for the far infra red
Sara Petrella Math &Physics San Diego State University	David Andeen	Fred Lange	Materials	X-ray analysis on Zinc Oxide
Ashley Sens Chemistry Santa Barbara City College	Ahmet Tezel	Samir Mitragotri	Electrical & Chemical Engineering	Low-frequency sonophoretic transdermal transport of hydrophilic permeants: determination of pore size within porcine skin
Alyson Whitney Chemistry UCSB	Khalid Hanif	Geoffrey Strouse	Chemistry	Doping CdSe quantum dots with Vanadium(II)
Aaron Williams Electrical Engineering UCSB	Wenhua Zhang	Kim Turner	Mechanical Engineering	Porous silicon formation with applications to biosensing microelectomechanical systems

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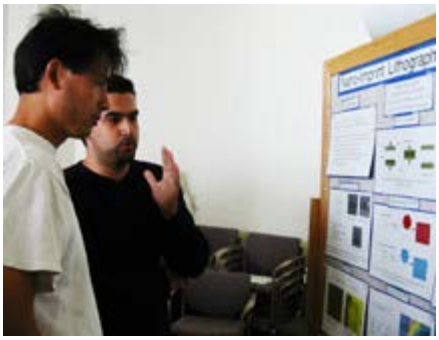
Edgar's Project Page

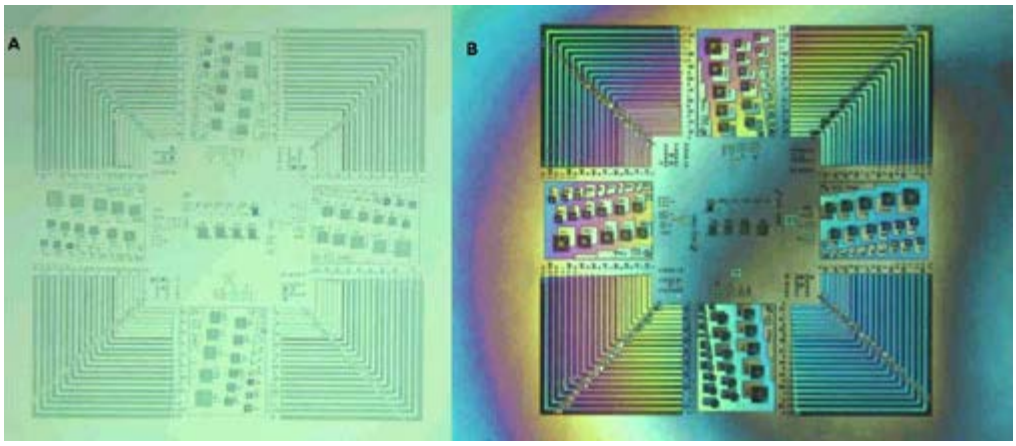


Intern: Edgar Algarín
Mentor: Dr. Brian Thibeault
Faculty Supervisor: Professor Evelyn L. Hu
Department: Electrical Engineering

NANO-IMPRINT LITHOGARPHY OF NANOSTRUCTURES

Nano-imprint lithography is a useful and cheap method to replicate nanostructures and shows potential to replicate structures under the 100 nm scale. Current processes such as e-beam lithography and UV-lithography can be expensive, time consuming, and difficult to reproduce under the 100 nm scale. With imprint lithography, a large number of replicas can be made from one exposed master, insuring research and production throughput.

Nano-imprinting is the molding of a polymer from a prefabricated master. The master can be produced using e-beam or UV lithography to define nm-scale patterns. A durable non-stick layer that can withstand high pressure and high temperature is then applied to the master. This coating is usually composed of hydrocarbon monomers and is important in order to prevent breakage and pull-off of the polymer. In this work the Si master is patterned by UV lithography and reactive ion etching and is coated with a self-assembled layer of octadecyltrichlorosaline for the non-stick layer. Once the master is produced (figure A), it is imprinted onto a host substrate bearing a polymer. The polymer used in this work is poly (methyl methacrylate) or PMMA. Depending on the temperature, pressure, and time, the polymer will flow and fill in the intended structures on the master. After the polymer flow is done, the sample is cooled and then the host is separated from the master to reveal a copy (figure B). In this work, key parameters for process the Si master and PMMA based imprint were determined.



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David's Project Page

Intern: David Ando
Mentor: Rob Knobel
Faculty Supervisor: Professor Andrew Cleland
Department: Physics

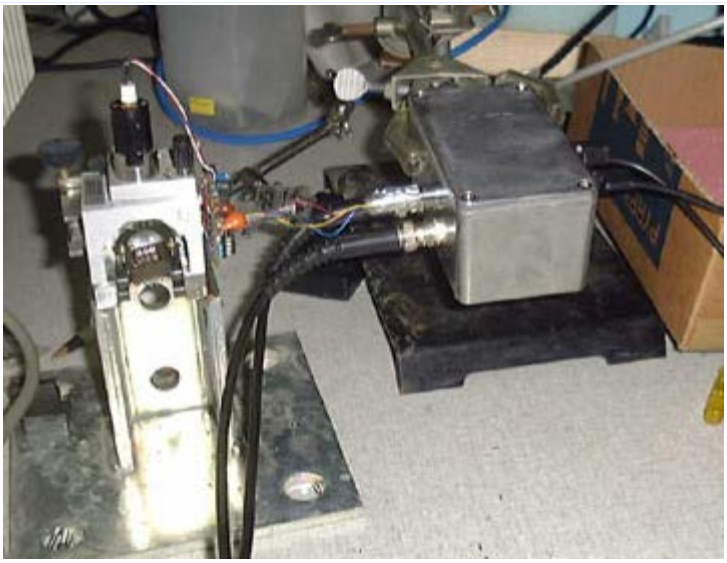
Nanolithography Nanomachining Nanoelectronics

My goal this summer was to detect the vibrations of a freestanding nanometer sized rod, which is made out of silicon. The freestanding nanometer sized rods are made using advanced nanolithography nanomachining techniques in the University of California at Santa Barbara clean room. My approach to the problem of detecting the nano motion was to take an old prototype atomic force microscope and modify it to measure the motion of a nanometer sized rod.

Detecting this nano motion allows access to new experimental regimes at the nanoscale. This nano size brings out new physical properties as the size approaches the length scales set by quantum mechanics. These new physical properties are under intense study by physicists. The immediate benefits of detecting this motion are the ability to characterize the motion of nanoelectromechanical systems built by the Cleland research group. Characterization involves checking that the nanoelectromechanical systems work, what quality factor they have, and what frequency they resonate at.

Although I have not completed my goal of detecting the nano motion, I have completed my modified atomic force microscope. The modifications include a photodiode that can detect reflections of the atomic force microscope laser off the nanomachines at a frequency of 500 million cycles per second. My other major modification was to remove the atomic force microscope head cantilever and to replace it with a sample holder, which is connected to instrumentation. The sample holder holds the nanomachines and is designed to be magnetically positioned in place to allow for greater degrees of freedom in positioning the samples and so that many nanomachines, which have to be on the same sample, can be looked at simultaneously.

This image shows my modified atomic force microscope on the left with associated electronics on the right. At the top of my modified atomic force microscope is the laser and on the bottom is my magnetic sample holder.



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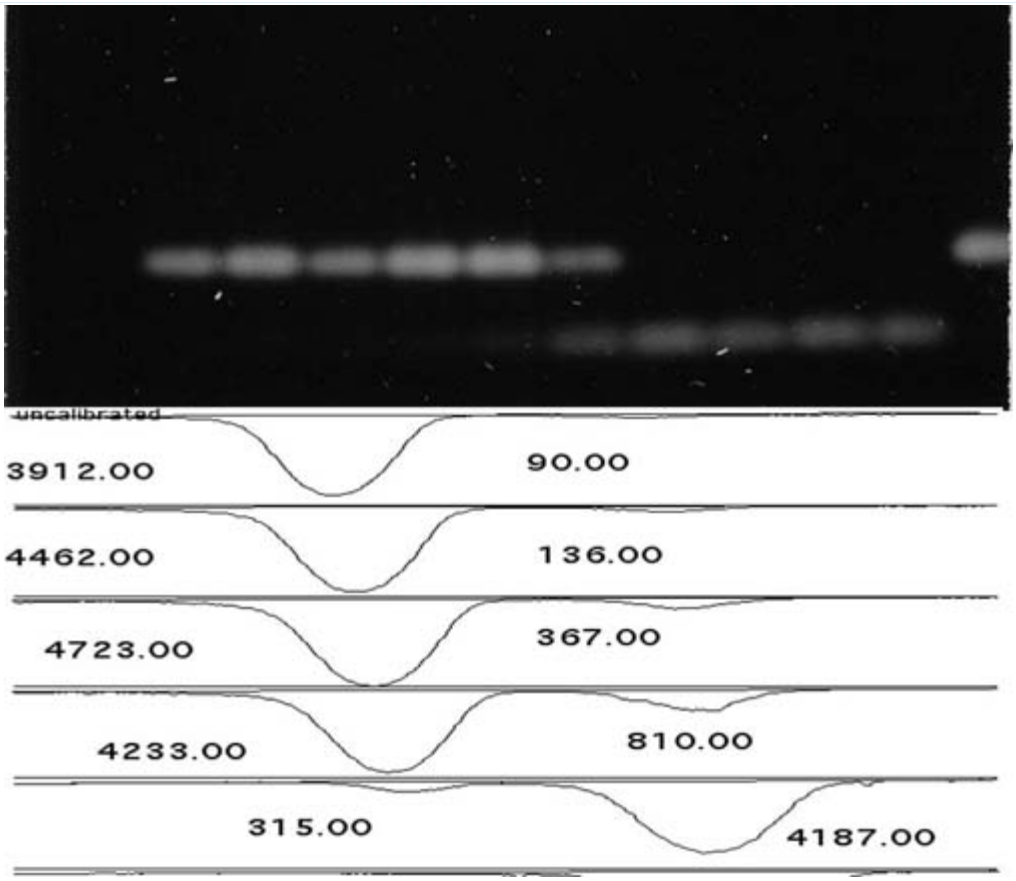
Michael's Project Page

Intern: Michael Bjorndal
Mentor/Faculty Supervisor: Professor Deborah Fygenson
Department: Physics

DNA MELTING AND HAIRPIN FORMATION IN THE PRESENCE OF INTERCALATING DYES

The effect of intercalating dyes on the melting transition of DNA was seen through the use of a new gel electrophoresis assay. The technique studies the duplex to hairpin transition using perfect palindromic oligomers. After raising the temperature of the annealed duplexes and then quenching quickly in a cold water bath, percentages of duplexes and folded hairpins can be seen. One interpretation states that the hairpins represent oligomers that were completely melted at the temperature of interest and then folded quickly during quenching. By comparison to UV-visual absorption melting curves, it is possible to determine the order of the transition. Work is being done to determine if the formation of hairpins has another interpretation: the DNA is not completely melted but can stay in the hairpin state favorably at certain temperatures. Various concentrations of the dyes YoYo and YoPro were used to see their effect on the DNA. The dyes clearly raise the overall melting temperature, with YoYo having about the same effect as twice the concentration of YoPro. This has been of use for people using these dyes to watch DNA at and around its melting temperature. One other chemical commonly used with DNA, Betamercaptoethanol (BME), obscures the UV-visual absorption curves. It is the hope that this new assay will also give a clear estimate of the effect BME has on DNA melting.



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Krista's Project Page

Intern: Krista Ehrenclou
Mentor: Dr. Cara Evans
Faculty Supervisor: Professor Joe Zasadzinski
Department: Chemical Engineering

ENCAPSULATION OF TAXOL FOR USE IN VESICLE BASED DRUG DELIVERY SYSTEMS

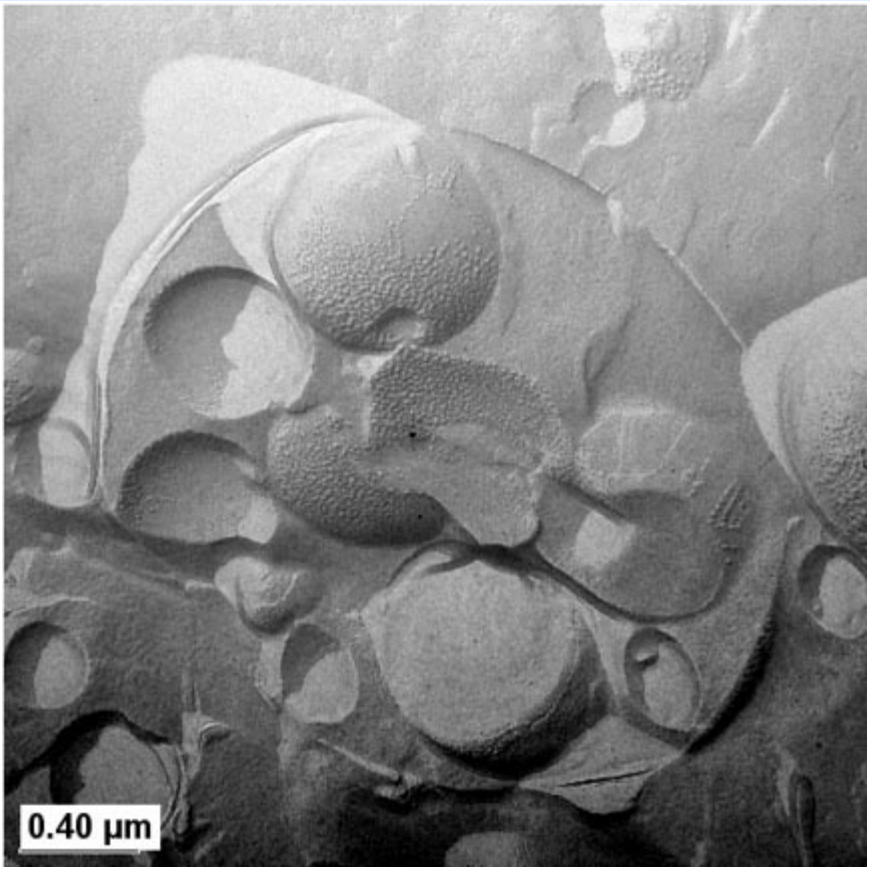
Background: Taxol is an important drug used in the treatment of breast, ovarian, lung, head and neck cancers. However, the drug?s hydrophobic nature has made this drug very difficult to administer. Currently, Taxol is delivered intravenously in a toxic mixture of Cremophore/Ethanol. In addition to harmful side effects, this method of drug delivery has poor drug circulation time and allows uncontrolled circulation of the drug throughout the body.

Encapsulation of Taxol in a phospholipid bilayer vesicle has the potential to greatly improve the current methods of drug administration. The bilayer membrane would eliminate the use of the Cremophore/Ethanol cocktail, provide a protective barrier between the drug and the body increasing drug circulation time and decreasing drug interaction with healthy cells, and provide a vehicle capable of cell targeting and controlled release.

Methods: A solution of Taxol in 100% ethanol was added to L-alpha-Dipalmitoyl phosphatidylcholine (DPPC) then dialyzed and heated past the melting temperature of DPPC. Freeze fracture replicas of the dialyzed product were imaged by a transmission electron microscope for evidence of vesicle formation. Chromatography(SEC), fluorescence and UV/VIS spectroscopy were used to isolate and determine the location of free taxol, encapsulated taxol and encapsulation efficiency.

Results: Freeze fracture images revealed vesicle formation in the presence of Taxol. A rippled phase was observed in vesicles formed from the solution with Taxol. The rippled phase is evidence of a change in lipid phase behavior, possibly due to an interaction with Taxol. Vesicles were isolated from the solution using size-exclusion chromatography (SEC) and identified using fluorescence spectroscopy. UV/VIS spectroscopic data is currently being collected. UV/VIS will be performed on fractions collected by SEC to determine the amount of free taxol. Vesicle containing fractions will then be treated with detergent to liberate any encapsulated taxol and will be measured by UV/VIS.

Future Projects: Future projects will include: the completion of the UV/VIS portion of the experiment, improvement of separation techniques to collect free Taxol, and the refinement of the dialysis method to optimize Taxol encapsulation.



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Edouard's Project Page

Intern: Edouard Fonck
Mentor: Raymond Tu
Faculty Supervisor: Professor Matthew Tirrell
Department: Chemical Engineering

SPECIFIC DRUG DELIVERY

In recent studies, peptides amphiphiles have been shown to be a potential tool for specific drug delivery. Our peptide amphiphile is composed of a hydrophobic tail and a peptide head group. The tail is the hydrophobic part made of two saturated alkyl chains, which promotes inclusion into the lipid membrane of the liposomes. The head group is attached to the tails with a glutanic acid linker and a C2 spacer. The head is derived from a region of type IV collagen that is known to bind to melanoma.

The ability of the peptide amphiphile to specifically bind cells along with their amphiphilic character make them a very good candidate for drug delivery in liposomes (see fig. 1). Liposomes, which are characterized by their spherical geometry and their lipid bi-layers, are able to encapsulate hydrophilic as well as lipophilic molecules. In order to develop a better synthetic peptide amphiphile targeted vesicle, we propose to study the effectiveness of various compositions on vesicles formation. The success of vesicle formation depends on distinct factors such as concentration of DMPC, DMPE, PEG and concentrations of peptide amphiphile, temperature and time.

Our goal is to obtain the specific data to optimize the best possible self-assembled structure. A structure that will not allow the liposomes to aggregate to one to another and that will target the specific cell. We will be able to determine those data by conducting experiments at various mixtures of lipids, molecular weight of PEG and molecular weights of peptide amphiphile. In order to determine if the data obtained are satisfactory (formation of liposome and no aggregation), we will run dynamic light scattering to measure the hydrodynamic diameter of the liposomes formed. Then, we will load the liposome with Texas Red DHPE; concentration<0.1%, a fluorescent dye-lipid, to help show the outcome of the liposomes complexed with mouse fibroblast cells.

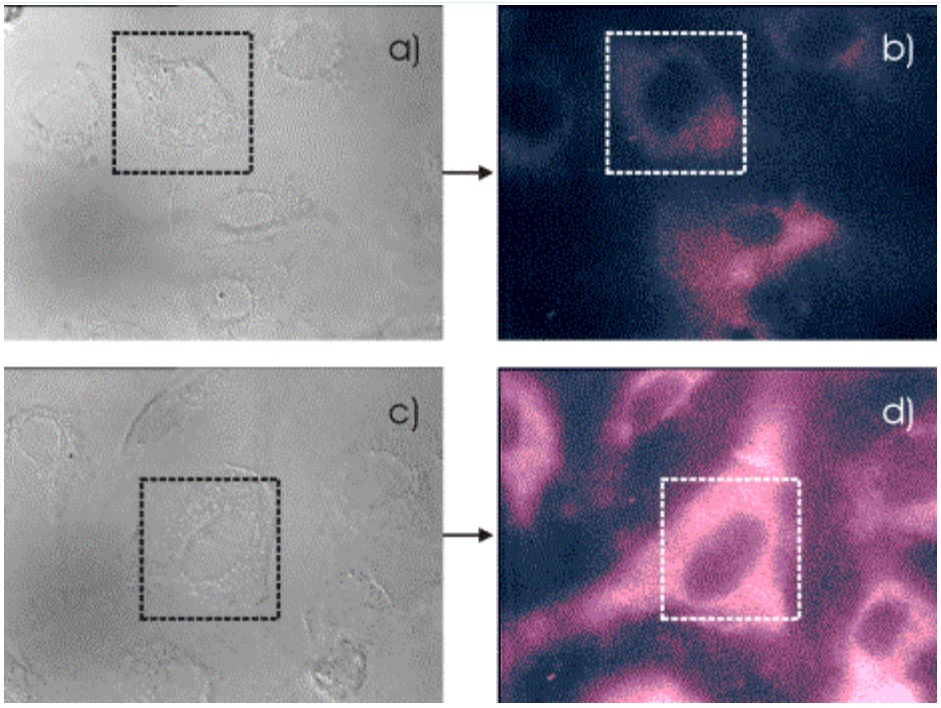

Fig. 1: pictures a & c DIL images of the fibroblast cells (those express similar integrins as of melanoma cells). Picture b represents the fibroblast cells after addition of liposomes without the peptide amphiphile. We see through fluorescent that only few liposomes attached themselves to the fibroblast cells. Picture d shows a high concentration of the liposomes with the peptide amphiphile bind to the melanoma cells.

Pictures made available by Raymond Tu.

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Wesley's Project Page

Intern: Wesley Francillon
Mentor: Rafael Leckie
Faculty Supervisor: Professor Carlos G. Levi
Department: Materials

THE STUDY OF NEW THERMAL BARRIER COATING MATERIALS BY THE SYNTHESIS OF RARE EARTH OXIDE-ZrO_2-Al_2O_3

Thermal Barrier Coatings (TBCs) are a critical component in today?s jet engines. By insulating the turbine blades and other hot zone components from the hot combustion gases TBC?s increase the operating temperature of the engine and extend the life of the components. This improves both the efficiency and reliability of the engines. Key parameters for TBC materials are low thermal conductivity and the ability to operate at high temperatures. The coatings provide an increase in fuel efficiency of the engines of approximately 1% resulting in savings that can extend to the 100s of million dollars.

However, the durability of the coatings is an issue under increasing operating temperatures and extended exposure times. One of the crucial parameters for the design and life-prediction of TBCs is the thermal conductivity. Exposure to the high combustion gas temperatures leads to a decrease in the insulation value of current TBC materials (7 wt. % yttria stabilized zirconia) because of a process called sintering. This increases the oxidation of the metal on the surface of the blade, leading to TBC failure and shorter blade life.

The purpose of this research is to study a class of potential new TBC materials, Rare Earth Oxide-Zirconia ceramics, that show lower thermal conductivity and possibly greater sintering resistance than yttria stabilized zirconia. Specifically I will be doing phase diagram studies looking at lanthanum oxide-zirconia mixtures and their interaction with aluminum oxide. Aluminum oxide is grown as an oxygen barrier on the surface of the turbine blade, underneath the TBC. Any reactions between the TBC and this protective coating are considered undesirable. Virtually no data is available in the literature regarding these ternary systems. Following the synthesis of La_2O_3-ZrO_2-Al_2O_3 compositions, the crystal phases present after different heat treatments will be established using primarily X-Ray Diffraction.

The second portion of this research project involves a kinetic study of two different stabilizers including yittra for comparison at seven weight percent. These stabilizers are Lanthanum and Gadolinium. The kinetic study will give an understanding of the temperature at which phase

segregation occurs that in general unwanted due to ceramic structural changes.

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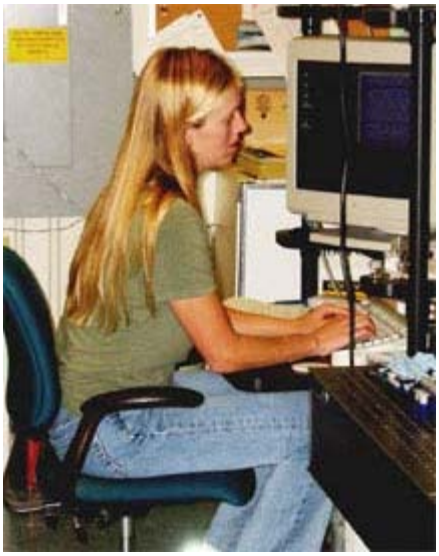
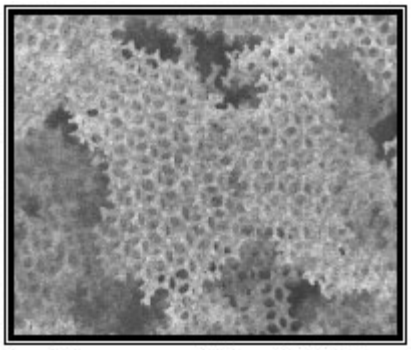
Heather's Project Page



Intern: Heather Hoff
Mentor: Alex Small
Faculty Advisor: David Pine
Department: UCSB Chemical Engineering

PROCESSING OF MACROPOROUS MATERIALS USING ORDERED POLYSTYRENE OR SILICA SPHERES AS TEMPLATES

Two different types of macroporous materials were synthesized for use in electrophoretic applications. The first was a silica matrix templated with polystyrene spheres, the second was a PMMA (poly methylmethacrylate) matrix with silica spheres as templates. Monodisperse polystyrene spheres were synthesized via emulsion polymerisation and dispersed in water. Silica spheres were synthesized using the Stober Process and also dispersed in water. Polystyrene spheres were centrifuged for about 15 minutes at 5,000 RPM inside a .4 x 4 mm capillary tube to achieve ordering of the spheres (close packing). Silica spheres were centrifuged under the same conditions except at a lower speed (2,000 RPM). Samples were dried for 1-3 days in air and 1 day in a furnace at 60C which yielded minimal cracking. Another method to reduce cracking in polystyrene samples was to disperse the polystyrene spheres in methanol before centrifuging. Polystyrene templates were infiltrated with a mixture of TMOS (tetra-methyl-ortho-silicate), water and HCl (catalyst). Gelation of TMOS occurred in atmosphere after 40 hours. Following gelation, the polystyrene spheres were removed by calcination at 525C. The remaining structure was a periodic three-dimensional array of macropores in silica. Sizes can range from 300 nm to 1.5 microns based on the size of the polystyrene spheres used in templating. This method of processing worked moderately well, and final samples were analyzed with SEM. The structure was ordered as well as monodisperse with the expected pore size. Ordered silica spheres were infiltrated with a PMMA precursor rather than TMOS. The precursor was exposed to long range UV light for 2-4 hours to polymerize the PMMA. The silica was etched away (along with the glass capillary tube) in concentrated HF leaving a porous PMMA structure. Difficulties were encountered while etching and recovering PMMA material and analysis of the resulting structure is ongoing work.



Macroporous Silica 10,000X

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Kathleen's Project Page

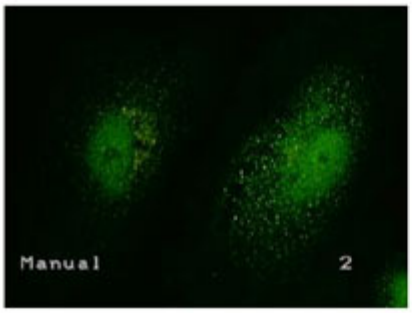
Intern: Kathleen Kolstad
Mentor: Michelle Staples
Faculty Supervisor: Professor L.V. Johnson
Department: Center for the Study of Macular Degeneration Neuroscience Research Institute

THE ROLE OF MATRIX METALLEOPROTEINASES (MMP) AND THEIR INHIBITORS (TIMP) IN AGE RELATED MACULAR DEGENERATION

Age Related Macular Degeneration (AMD) is the most common cause of blindness in adults over 60. Drusen, a plaque like deposit found between Bruch's membrane (the inner layer of the choroid) and the Retinal Pigment Epithelium (RPE) is thought to contribute to the damage of photoreceptors in the macula, thus causing degeneration of eyesight. The purpose of this experiment is to explore the expression of matrix metalleoproteinases (MMPs) and tissue inhibitors of metalleoproteinases (TIMPs) in RPE cells. MMPs are enzymes that break down the Extra Cellular Matrix (ECM), promote angiogenisis (the formations of new blood vessels) and connective tissue turnover. TIMPs regulate ECM turnover and neovascularization by inhibiting MMPs. Under normal conditions TIMPs and MMPs are functionally balanced to maintain an ideal rate of ECM turnover and angiogenisis. When the functions of MMPs and TIMPs become unbalanced (an event thought to occur during the aging process) the result can be excess ECM digestion and neovascularization, resulting in a build up of ECM deposits.

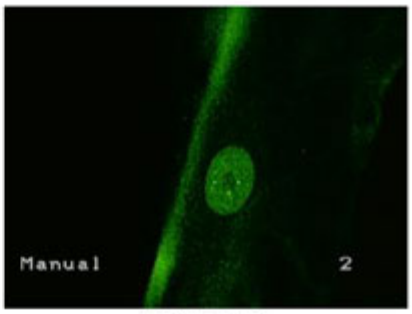
In the present study, we exposed human fetal RPE to oxidative stress (incubation in 100mM hydrogen peroxide) in order to simulate aspects of the aging process. The expression of MMP 1,-2,-3,-7,-9 and TIMP
immunohistochemistry. Each TIMP and MMP was labeled with a primary antibody and a flourescently labeled secondary antibody. The results were analyzed under a confocal microscope. Out of all the proteins analyzed, TIMP -1,-2,-3,-4 and MMP -7 and -9 possessed visible and comparable staining in both the control and the H_20_2 cells. All visibly labeled TIMPs and MMPs exhibited slightly less staining under oxidative stress. These results were inconsistent with previously collected Array data (except for TIMP-4, which showed a decrease under oxidative stress). Because of this inconsistency the next step in the project was to alter the incubation H_20_2 periods to 6, 10, 24, and 48 hours. The stressed cells and growth media will then be analyzed by immunohistochemistry and the ELISA method (Enzyme-Linked Immunosorbent Assays). The ELISA will detect the proteins that have been excreted into the media, and therefore may not of appeared in the initial immunohistochemistry experiments. With this information we will be able to determine more precisely the cellular expression and secretion of TIMP?s and MMP?s under varying levels of oxidative stress.

#1-34 HFRPE 25414 α TIMP-3 DAR Cy-2
Incubation Series



Control T_0

Cytoplasmic TIMP-3 staining



H_2O_2 10 hrs.

Dense nuclear staining, cytoplasmic Staining (TIMP-3)

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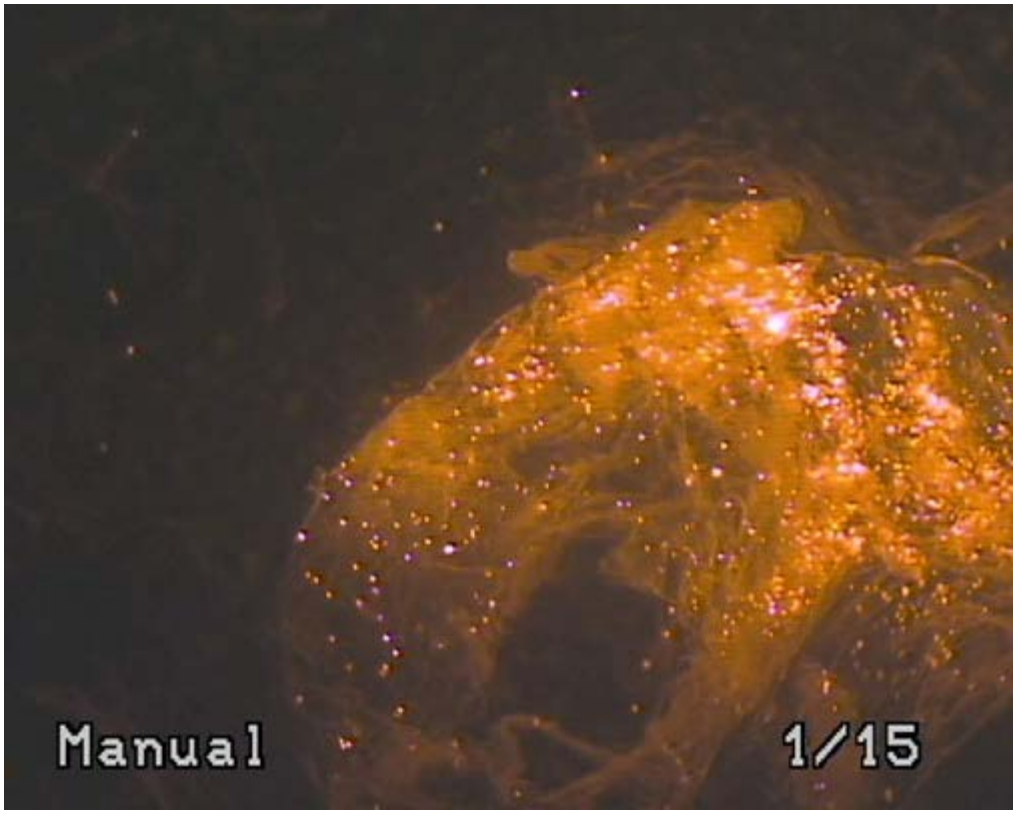
Penny's Project Page

Intern: Penny Letts
Mentor: Ahmet Tezel
Faculty Supervisor: Professor Samir Mitragotri
Department: Chemical Engineering

SONOPHORESIS OF SKIN WITH FLUORESCENT POLYSTYRENE MICROSPHERES

Modern methods of drug delivery have many disadvantages. Intravenous drug delivery often involves patient fear and non-compliance. Long-term oral delivery often results in liver damage since, to overcome first-pass metabolism, oral doses are taken in very high amounts. Oral drug delivery, even for the few drugs that survive gastrointestinal degradation, is not well-controlled because fluctuations in the absorption rates of the digestive system vary the amount of drug actually entering the blood stream. An appealing alternative to intravenous and oral drug delivery is transdermal drug delivery, a painless method with added benefits of possible sustained controlled release and extraction of fluid for samples. Transdermal drug delivery is hindered by the impermeability of the stratum corneum, the outermost layer of the skin. Different methods to overcome this barrier are currently being studied. One of the most promising is sonophoresis, the application of ultrasound to the skin. Sonophoresis enhances skin permeability for a prolonged period of time with no apparent harmful side effects. Unfortunately, its mechanisms are not well understood. The primary sonophoresis mechanism believed to increase skin permeability is transient cavitation. Pressure from ultrasound and the skin forces cavitation bubbles to collapse in on themselves, forming microjets that shoot into the skin like needles, disrupting the stratum corneum and delivering drugs from the liquid medium. Another possible mechanism is physical impact of the particles with the ultrasound transducer, which vibrates at a speed of O(100)m/s. The particles are accelerated and shot into the skin at high velocities. My project involved sonicating skin with fluorescent polystyrene microspheres (~2um and 5um diameters) and determining the number of particles to reach various depths in the stratum corneum by standard tape stripping of the skin and counting the particles under a fluorescent microscope. Comparisons of these results may help in the analysis of sonophoresis mechanisms.

Transient cavitation should deliver smaller particles most efficiently because more particles would become trapped in the microjet. Particle delivery from impact with the transducer should peak since larger particles encounter more resistance from the skin but smaller particles have less momentum. Experiments showed that 2mm microspheres entered the stratum corneum at higher percentages, at all depths, than the 5mm microspheres. While this may suggest that microjets are more responsible for the rise in skin permeability than the impact of the transducer, more particle sizes must be studied before the results can be reliably analyzed.



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Xerxes's Project Page

Intern: Xerxes Lopez-Yglesias
Mentors: Tom King, Matt Doty
Faculty Supervisor: Profesor Mark Sherwin
Department: Physics

ANTENNAE CREATION FOR TERAHERTZ RADIATION SENSORS

The aim of our project was to test the sensitivity of a terahertz radiation detector using the UCSB free electron laser as a radiation source. Unfortunately, many problems arose in the process of preparing the detector for use. The largest problem was creating antennas with a sharp enough tip to contact the detector. For the length of our internship, we focused on ways to chemically etch a sharp point on the tip of a gold wire to be used as our antennae.

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Jaclyn's Project Page

Intern: Jaclyn Martinez
Mentor: Luke Sherlin
Faculty Supervisor: Professor John J. Perona
Department :Chemistry and Biochemistry

PURIFICATION AND CRSTYALLIZATION OF GLN-tRNA^{Gln} PROTEIN COMPLEXES

During protein synthesis, the genetic code embedded in DNA is transcribed and translated to create a protein chain. Messenger RNA (mRNA) contains the genetic code in a series of trinucleotide units or codons. Transfer RNA (tRNA) provides a link between the mRNA sequence and the protein chain by carrying an amino acid that corresponds with the complementary codon of the tRNA. Some structures of tRNA are known but no structures of human tRNA have been determined. Through my research, the kinetic parameters of the human tRNA^{Gln} will be calculated from aminoacylation assays. The tRNA construct will then be crystallized, and x-ray crystallography will be used to determine the molecular structure. The synthesis and purification of tRNA constructs involves first a DNA polymerase, which is used to construct a DNA template from which human tRNA is translated using a Bacteriophage T7 RNA polymerase. Once the correct product is verified, the tRNA^{Gln} is purified through a variety of techniques and dialysized to ensure that the tRNA stays at a low salt concentration and at a constant pH. The techniques have been successful and produced a valid product. In order to evaluate the ability of *E. coli* glutaminyl-tRNA synthetase in acting on the human tRNA construct, aminoacylation assays will be run to determine the rate of aminoacylation. After which the tRNA will be crystallized for further study.

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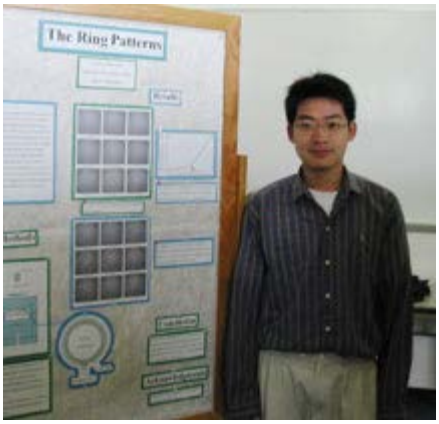
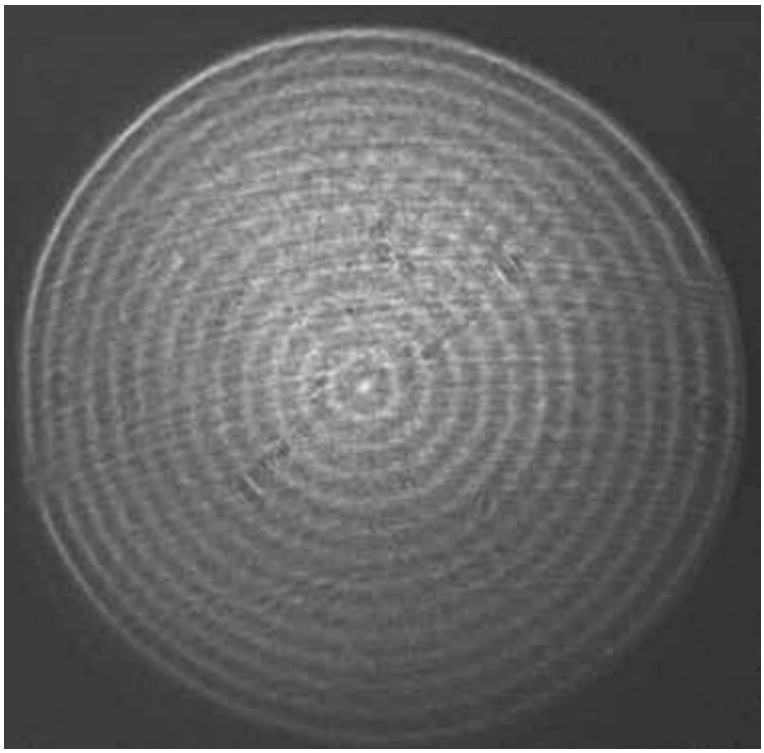
Worawats's Project Page



Intern: Worawat Meevasana
Mentor and Faculty Supervisor: Professor Guenter Ahlers
Department: Physics

THE RING PATTERNS IN THE CONVECTION OF ISOPROPONAL

The purpose of this experiment is to study the ring patterns in the convection of isoproponal. We are interested in the pattern because we wish to experimentally verify a recently proposed theory describing pattern behavior above onset. In this experiment, we attempted to obtain ring patterns in the circular cell by using a sidewall heater. We applied a constant power to the sidewall heater while increasing the temperature difference between the top and bottom plates to above onset. As a result, the ring pattern occured below onset; however, the ring pattern started to disappear close to onset while the square and roll patterns started occurring. We fail to obtain the ring pattern above onset. The failure may be caused by the impurity of the isoproponal which is indicated by the occurrence of the square pattern.



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Anthony's Project Page

Intern: Anthony Morfa
Mentor: Larken Euliss
Faculty Supervisor: Professor Galen Stucky
Department: Chemistry

BIOMINERALIZATION OF CALCIUM CARBONATE

Nature has a profound ability to control crystalline structure in biological systems. Calcium carbonate is being studied because it composes the primary mineral found in the shells of mollusks. The proteins that assemble the shell are able to control the crystalline growth on the nanoscale. In this way the protein activity has become a model for controlling crystalline growth. Utilizing this model for crystalline growth, we are currently organizing calcium carbonate on different length scales by using AB block copolypeptides, which can both nucleate and self-assemble the individual crystals. The primary block used in the block copolypeptides is aspartic acid because it has been found to bind with Ca^{2+} which will help control the way calcium carbonate will form. This research has already found that the addition of the block coploypeptides containing aspartic acid can change the morphology of the crystalline material. It is our hope that by changing the stereochemistry of the amino acids we can cause a polymorph transition in our material. Another goal of this research is to apply this method to other crystalline materials.

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Sachin's Project Page

Intern: Sachin Patil
Mentor: Matt Doty
Faculty Supervisor: Professor Mark Sherwin
Department: Physics

TERAHERTZ TECHNOLOGIES: RADIATION DETECTORS FOR THE FAR INFRA RED

Technologies in the Terahertz frequency range (1-10 THz, or 300-30 µm wavelengths) have lagged technologies in the nearby microwave and infrared frequency ranges. Among the many devices now being developed and improved are radiation detectors. Current ones operate by means of thermal excitation and require cooling to temperatures below 4K - a task which can be very time consuming. At present, the Sherwin Group possesses a protype THz detector that does not require any cooling. Our task thus far has been to learn more about the detector and get it fully operational. Over the last few weeks, we have focused primarily on building antennas for this detector. More specifically, we have been using an etchant consisting of potassium ferro-cyanide, sodium cyanide, and de-ionized water to chemically sharpen the gold wires that will serve as the antennas for this detector.

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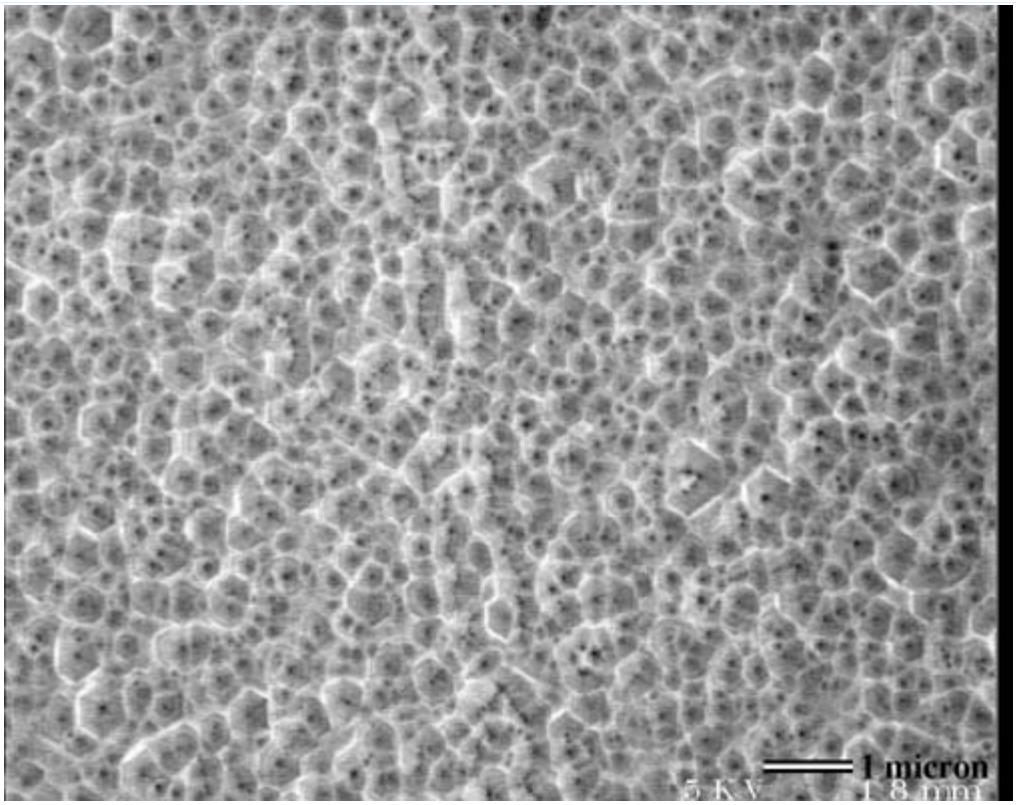
Sara's Project Page

Intern: Sara Petrella
Mentor: David Andeen
Faculty Supervisor: Professor Fred Lange
Department: Materials

X-RAY ANALYSIS ON ZINC OXIDE

X-ray diffraction was performed on hydrothermally deposited zinc oxide films in order to analyze the quality of the film. Methods of analysis employed include the Warren-Averbach method and the Integral-Breadth method. Warren-Averbach analysis requires a Fourier series fit of a diffraction peak to obtain information on grain size and strain for different length scales. The Integral-Breadth Method strictly takes into account width of a diffraction peak. The two methods should agree with each other in order to reinforce the results. Assuming a gaussian peak, we have fit curves to our data by means of a Fourier series typical of Warren-Averbach. In addition we have developed an algorithm for a goodness of fit of our data with the Fourier series.



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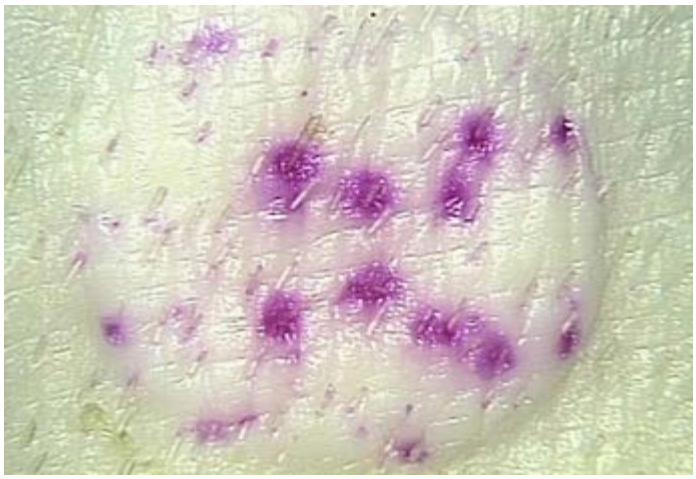
Ashley's Project Page

Intern: Ashley Sens
Mentor and Faculty Supervisor: Professor Samir Mitragotri
Department: Chemical Engineering

TRANSDERMAL DRUG DELIVERY (TDD) REPRESENTS A NONINVASIVE AND PAINLESS METHOD OF ADMINISTERING THERAPEUTIC MOLECULES THROUGH THE SKIN

Transdermal drug delivery (TDD) represents a noninvasive and painless method of administering therapeutic molecules through the skin. However, in the absence of TDD enhancers, the stratum corneum is nearly impermeable to large (>300 Da) and/or hydrophilic drug molecules, such as proteins. The application of low-frequency sonophoresis (LFS) is an enhancement technique that exponentially improves the delivery of these molecules transdermally. The mechanisms by which sonophoresis induces greater skin permeability and increases the flux of drug molecules have only recently begun to be investigated. This research attempts to partially address these mechanistic questions as they relate to the microscopic physical alterations that occur within the stratum corneum. Application of LFS is thought to alter the stratum corneum by three possible mechanisms: (i) increasing pore radii, (ii) increasing the number of pores and/or (iii) decreasing the pore tortuousity. These mechanisms were explored experimentally using full-thickness pig skin and three model drugs of varying molecular weights: water, mannitol and inulin. Permeabilities for these drugs were determined as a result of sonophoresis at an applied frequency of 76 kHz. The steady state permeabilities were calculated over a 29 hour period. Based on these permabilities and drug concentration the flux for each model drug was then determined. Finally, the experimentally determined permeabilities were incorporated into a theoretical model of the transport of hydrophilic permeants during LFS in order to calculate the pore radii within the stratum corneum.



Alyson's Project Page

Intern: Alyson Whitney
Mentor: Khalid Hanif
Faculty Supervisor: Professor Geoff Strouse
Department: Chemistry

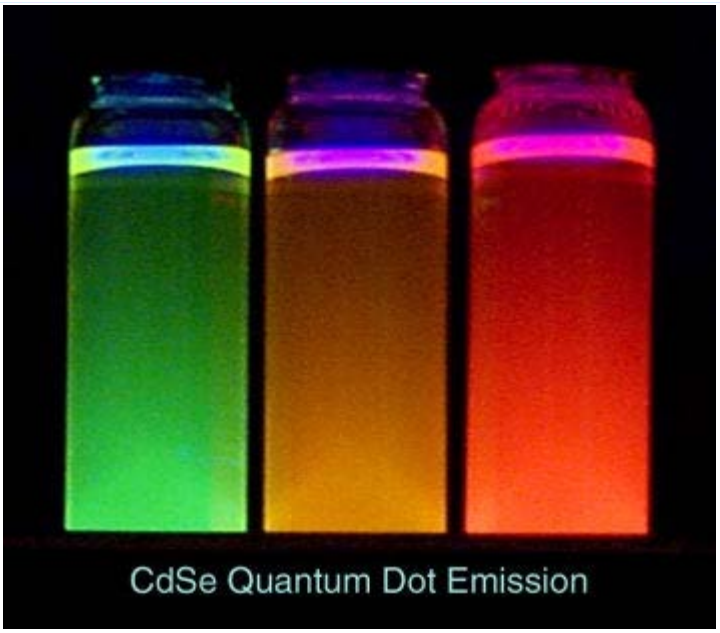
DOPING CdSe QUANTUM DOTS WITH VANADIUM(II)

Quantum dots have optical properties that are based upon their size. By controlling the size of the quantum dots one can control their optical properties. Doping the nano particles with different metal clusters not only enhances the optical properties of the quantum dot but can also add magnetic properties to the material as well.

During the summer I doped CdSe quantum dots with V(II). Vanadium was used because it has a tetrahedral configuration and contains three d orbital electrons. Because the energy gap between the orbitals is small there is more of a chance that and electron could move between the levels, which promotes the idea that the material would act like a switch and could be used for memory.

In order to make CdSe quantum dots I had to first make the precursor cluster, $Li_2[Cd_4(SPh)_{10}]$, which was then combined with selenium to form $Li_4[Se4Cd_{10}(SPh)_{16}]$. The $Li_4[Se4Cd_{10}(SPh)_{16}]$ was then placed into melted hexadecylamine (HDA) and heated. The HDA served to passivate the surface of the CdSe so that the product did not become a bulk material. To ensure that the proper size nano particle was obtained, absorptions had to be taken. Since the optical properties of quantum dots are based on their size one can take absorbances of the quantum dots during their growth to determine how large they have become. The CdSe quantum dots that I worked with absorbed at about six hundred nanometers. The CdSe was to be used as a reference to compare with the vanadium doped CdSe.

The V(II) doped CdSe was achieved by combining $Li_4[Se4Cd_{10}(SPh)_{16}]$ with different amounts of vanadium(II)chloride and then heated in the presence of HDA. Absorbances were again taken so that a uniform absorption of six hundred nanometers could be obtained. Multiple samples of the same size CdSe quantum dot were obtained, each with different concentrations of vanadium. X-ray diffraction was used to determine if the CdSe had actually been doped or if the vanadium was only on the surface of the particle.



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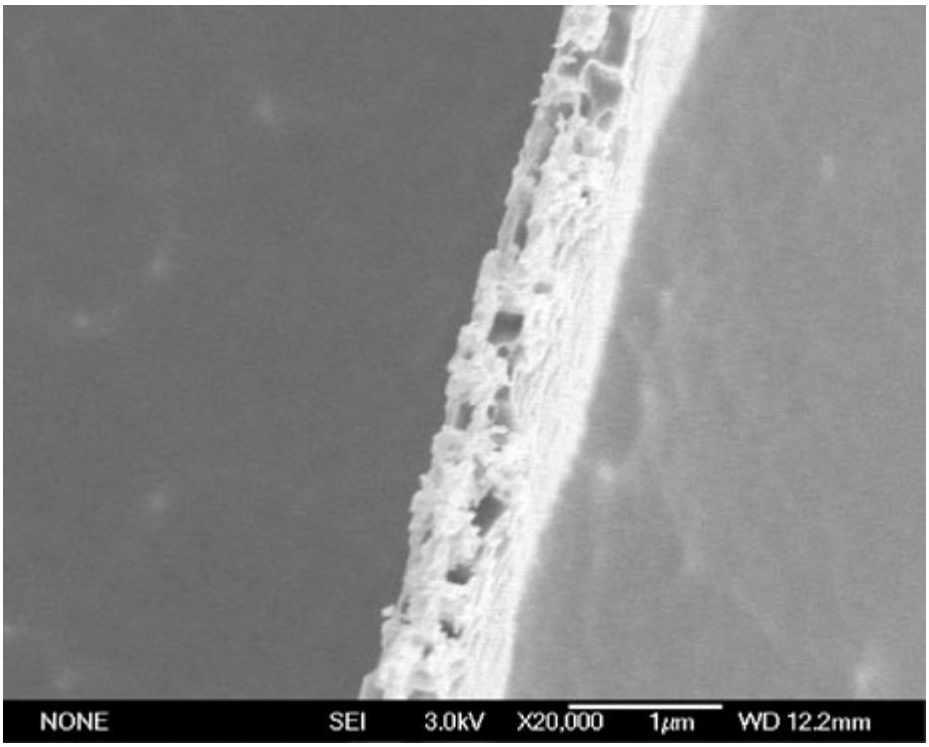
Aaron's Project Page

Intern: Aaron Williams
Lab Mentors: Raji Baskaran, Wenhua Zhang
Faculty Supervisor: Professor Kimberly Turner
Department: Mechanical Engineering

POROUS SILICON FORMATION WITH APPLICATIONS TO BIOSENSING MICROELECTROMECHANICAL SYSTEMS

Formation of porous silicon (PSi) by electrochemical processing was investigated with future plans to use the PSi as part of biosensing MEMS devices. An electrolytic cell was designed and manufactured to suit our specific needs. The electrochemical process we used had four variables, these being; wafer resistivity, concentration of chemical solution used as electrolyte, current density, and process time. These variables were manipulated such that we experienced everything from electro-polishing to the formation of PSi to our only roughing the surface of our samples. Processing was done with a 50/50 (volume) mixture of 50% Hydrofluoric Acid and 90% Ethanol. We used p-type Boron doped wafers with risistivties ranging from .02-.1 cm up to 10-15 cm. Current densities from 2.4 mA/cm^2 up to 50 mA/cm^2 were used during processing of PSi. Processing times ranged from 10-30 minutes. Future plans include using PSi on biosensing devices where the material would be used to attach analyte particles to its surface. PSi would be used specifically because of it extremely high specific area which can reach several hundred square meters per cubic centimeter.



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