The 2001 NNUN

Research Experience for Undergraduates

Convocation

at

The 2001 NNUN REU Convocation

Wednesday, August 8th:

Everyone arrives at the Washington Plaza, 10 Thomas Circle, Washington, DC. Pizza in Diplomat Room, 6pm.

Thursday, August 9th:

8:30am — **Bus takes us from WP to Blackburn Center on Howard Campus.**

9:00-9:30 — **Registration & Continental Breakfast**

9:30-9:45 — **Welcome: Gary Harris, Howard University**

(Facilitator: Gary Harris, Howard U)

9:45-9:57 — **Ms. Sara Alvarez, UCSB** — **page 7**
Engineering of Protein Molecules for the Ordered Structuring of Silica

9:57-10:09 — **Ms. Anna Bacon, CNF** — **page 7**
Characterization of Nano-Imprinting Processes Using the EV-520 Embosser

10:09-10:21 — **Ms. Nitasha Bakhru, UCSB** — **page 8**
The Effects of Penetration Point on Quantitative Drug Delivery by Jet Injection

10:21-10:33 — **Mr. Lukmaan Bawazer, UCSB** — **page 8**
Evaluation of Novel Growth Techniques for Dislocation Reduction in Gallium Nitride

10:33-10:45 — **Mr. Noah Beck, SNF** — **page 9**
Electron Beam Lithography of Nanoscale Hall Probes for Scanning Microscopy

10:45-11:15 — **Break**

(Facilitator: Al Flinck, UCSB)

11:15-11:27 — **Ms. Teresa Bixby, PSU** — **page 9**
Study of Γ-Aminopropyltriethoxysilane Coatings on Glass Substrates for DNA Microarray Testing

11:27-11:39 — **Mr. Julio Bracero Rodriguez, HU** — **page 10**
Characterization of Peptide Sorption onto GaAs (100) Surfaces by AFM, Optical Microscopy and Fourier Transform-Infrared (FT-IR) Spectroscopy

11:39-11:51 — **Ms. Mary Brickey, UCSB** — **page 10**
Transdermal Drug Delivery

11:51-12:03 — **Mr. Arthur Carter, PSU** — **page 11**
Selection of Compatible Films for Hepatocyte Differentiation and Adhesion

12:03-12:15 — **Ms. Fatou Maiga, CNF** — **page 21**
Studies of the Formation of Sub-Surface Voids in Silicon Substrate Induced by Silicon Surface Migration

12:15-2:15 — **Lunch & Photographer**

(Facilitator: Melanie-Claire Mallison, CNF)

2:15-2:27 — **Mr. Philip Choi, CNF** — **page 12**
VLSI Interconnect Characterization

2:27-2:39 — **Mr. Matthew Daniels, CNF** — **page 12**
Novel Method for Large Scale Nanopatterning

2:39-2:51 — **Mr. Andrew Davenport, SNF** — **page 13**
Alignment System for Distributed Multi-Axis Electron Beam Lithography

2:51-3:15 — **Mr. Peter Ercius & Ms. Linh My Tran, UCSB** — **page 14**
Development of a C++ Program to Study Five-Layer, Thin-Film Systems using Multiple Beam Interferometry

Friday, August 10th:

8:30am	**Bus takes us from WP to Blackburn Center on Howard Campus. (Bring with you a change of clothes for the baseball trip later.)**	
9:00-9:45	**Registration & Continental Breakfast**	
(Facilitator: Mark Horn, PSU)		
9:45-9:57	**Ms. Aileen Chang, SNF** *Controlled Growth of Single-Walled Nanotubes (SWNTs) Using Electric Fields*	page 11
9:57-10:09	**Ms. Caitlin Devereaux, CNF** *Fabrication and Optimization of Organic Thin Film Transistors*	page 13
10:09-10:21	**Ms. Unyime Eshiet, HU** *The Growth and Characterization Processes of Gallium Nitride (GaN) Nanowires*	page 14
10:21-10:33	**Ms. Jamie Fontaine, PSU** *Mass Analysis using Silicon Films with Amino Acid Additives*	page 15
10:33-10:45	**Ms. Danna Freedman, CNF** *Fabrication of a Galium Phosphide Semiconductor on a Silicon Wafer*	page 15
10:45-11:15	**Break**	
11:15-11:27	**Ms. Ashley Harness, CNF** *Chemical Mechanical Polishing Characterization and Process Development*	page 16
11:27-11:39	**Mr. Damon Hebert, UCSB** *Photoluminescence and AFM on Strain-coupled, Self-assembled InAs Quantum Dots*	page 16
11:39-11:51	**Ms. Sondra Hellstrom, SNF** *Lipid Bilayers and Microfluidic Systems*	page 17
11:51-12:03	**Ms. Samar Hubbi, SNF** *Formulating DNA "Inks" for Microarrays*	page 17
12:03-12:15	**Mr. Noel Jensen, SNF** *Containment of Reactions on Microchips for DNA Sequencing*	page 18
12:15-2:15	**Lunch**	
(Facilitator: Mike Deal, SNF)		
2:15-2:27	**Mr. Matthew Kittle, UCSB** *Atomic Force Microscopy on Synthetic Spider Silk Protein*	page 18
2:27-2:39	**Ms. Kate Klein, SNF** *Analysis of Thin Film Diamond Using an E-beam Micro-column*	page 19
2:39-2:51	**Mr. Robert Klein, HU** *InGaAsN Solar Cells*	page 19
2:51-3:03	**Ms. Hayley Lam, UCSB** *Porous Silicon MicroElectroMechanical Systems*	page 20
3:03-3:15	**Ms. Joy Liu, PSU** *Fabrication and C-V & I-V Characteristics of Metal-Insulator-Metal Structure*	page 20
4:00pm	**Bus to Baltimore baseball!!**	

Saturday, August 11th:

8:30am	**Bus takes us from WP to Blackburn Center on Howard Campus.**	
9:00-9:33	**Registration & Continental Breakfast**	
(Facilitator: Evelyn Hu, UCSB)		
9:33-9:45	**Ms. Natalie Lui, SNF** *Minimum Line-width Features for Cryogenic Optical Photon Detectors*	**page 21**
9:45-9:57	**Mr. Brian Manuel, CNF** *Investigation of Filtration Properties of Collagen On Silicon Wafer*	**page 22**
9:57-10:09	**Ms. Meredith McElroy, CNF** *Construction of Thin Optical Microcuvettes*	**page 22**
10:09-10:21	**Mr. Nathan Morris, SNF** *The Integration of Carbon Nanotubes into Electronic Devices*	**page 23**
10:21-10:33	**Ms. Laura Moussa, CNF** *Development of Ultramicroelectrode Arrays for Microfluidic Biosensor Devices*	**page 23**
10:33-10:45	**Ms. Linda Ohsie, SNF** *Characterizing the Viscosity of Concentrated Solutions of DNA with Cationic Agents*	**page 24**
10:45-11:15	**Break**	
11:15-11:27	**Mr. Nagesh Rao, CNF** *Processing of Next Generation Resist Materials Using Supercritical* CO_2	**page 24**
11:27-11:39	**Mr. Gregory Roman, CNF** *Process Characterization of LPCVD Silicon Nitride and the Consequential Fabrication of Low Stress Microcantilevers*	**page 25**
11:39-11:51	**Ms. Heather Russell, PSU** *Superconductivity of Ge/Ag/Ge Nanowires*	**page 25**
11:51-12:03	**Ms. Kathleen Schaefer, UCSB** *Asymmetric Diblock Copolymer Films for Nanopatterning*	**page 26**
12:03-12:15	**Mr. Jonathan Schuller, SNF** *Microfluidics for DNA Pyrosequencing*	**page 26**
12:15-2:15	**Lunch**	
(Facilitator: Dan Woodie, CNF)		
2:15-2:27	**Mr. Metages Sisay, UCSB** *Spectroscopy of the* Ir^{3+} *Organo-Metallic Complexes*	**page 27**
2:27-2:39	**Ms. Marina Sofos, SNF** *Magnetostrictive Thin Films for MEMS Applications*	**page 27**
2:39-2:51	**Mr. Chau Tang, UCSB** *Synthesis of Dialkoxy-Substitutes Oligophenylenevinylenes*	**page 28**
2:51-3:03	**Mr. Court Wilson, HU** *Fabrication of 3C-SiC Nanofiltration Membranes*	**page 28**
3:03-3:15	**Mr. Alexander Wissner-Gross, PSU** *Directed Formation of Nanosphere Monolayer Domains*	**page 28**
3:15	**Final Words from Melanie-Claire**	

Free time — get your Metro pass from Yvette!

Sunday, August 12th:

Everyone must check out by 11am. We pay the room charge — interns pay any room bill (movies, rental games, phone calls, etc) and get to their planes/trains/cars.

2001
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Convocation
Abstracts

in alphabetical order

Engineering of Protein Molecules for the Ordered Structuring of Silica

Sara Alvarez, Microbiology, University of California, Santa Barbara

REU Site: UCSB

PI: Dr. Daniel E. Morse, Molecular, Cellular, and Developmental Biology, UCSB

Mentor: Dr. Jan Sumerel, Marine Science Institute, UCSB

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The control of nanofabrication of biosilica structures in many instances exceeds the present capabilities of human engineering. Analysis of occluded proteins from the biosilica spicules produced by the marine sponge, *Tethya aurantia,* has revealed that these proteins act catalytically in directing the condensation of polysiloxanes from silicon alkoxides under mild physiological conditions whereas chemical synthesis of these materials typically requires acid or base catalysis or extreme temperatures and pressure. Silicatein a has been isolated from the protein axial filament of the marine sponge, *Tethya aurantia*. Its respective cDNA has been cloned. Sequence analysis has shown that this protein is related to Cathepsin L family members, a group of proteins that hydrolyze peptide bonds during protein degradation. Dr. Morse and his laboratory members have shown that recombinant silicatein a catalyzes the hydrolysis of tetraethoxysilane (TEOS) to form $(SiO_2)_n$ at neutral pH *in vitro*. In my studies, I am genetically engineering a chimeric protein between silicatein a and green fluorescent protein. This chimera will allow monitoring of the coupling of silicatein a to surfaces and assist in further investigation of the structure-directing properties of silicatein a during synthesis-directed activities of the protein.

Characterization of Nano-Imprinting Processes Using the EV-520 Embosser

Anna Bacon, Material Science Engineering, Michigan State University

REU Site: CNF

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Nano-Imprinting has to potential to greatly improve throughput in the micro- and nanoprocessing industries by providing a method to create features by parallel processing that formerly were only possible by serial processing. The EV-520 is a new machine to the Cornell Nanofabrication facility and will provide access to this technique for future research.

In order to explore the functions of the EV 520 hot embossing machine, processing recipes based on the variables of embossing temperature, embossing piston pressure, and hold time were performed. The embossing was done using three different templates and three different plastics. The first template was created using image reversal and photolithography. It had dies with different sized and spaced lines and dots. The smallest size and spacing of which were 1 μm with a 2 μm pitch and were 10 μm deep. This template was used to emboss its patterns into bulk PETG. It was also used to emboss into flexible Mylar. The second template was created using electron beam lithography based on the same pattern. The features were much smaller and were used to emboss into bulk PETG. The second template was used to emboss in 900nm spun PMMA on a SiO_2 wafer. Lastly, a template was created to pattern a microfluidic device using photolithography and transferred into the bulk PETG. The results are shown by SEM microscopy.

The Effects of Penetration Point on Quantitative Drug Delivery by Jet Injection

Nitasha Bakhru, Biological Sciences, Rensselaer Polytechnic Institute

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PI: Samir Mitragotri, Dept. of Chemical Engineering, UCSB

Mentor: Joy Schramm

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Though modern medicine has rapidly improved throughout the years, we are still challenged by one of the most fundamental applications of it, that involving the delivery of drugs to patients. Jet-injectors have proposed an alternative to the use of needles to deliver macromolecular drugs through the use of a high velocity jet that can penetrate the skin. Research focused on observing how penetration point can be correlated with quantitative drug delivery is being undertaken.

A Franz diffusion cell was used to test the conductivity changes in porcine skin at room temperature. The skin was penetrated with needles of diameters ranging from 0.45 to 1.27 mm. It was observed that conductivity linearly escalated with increasing needle area. Fluid dispersion through skin was also observed by injecting a dye into the side of the dermis. By slicing the skin and imaging it, it was noticed that fluid dispersed more significantly in the horizontal direction. In fact, the width of the pooled fluid in skin was approximately 2.5 times greater than the depth. When a jet-injector was used to deliver the fluid, the width/depth aspect ratio remained nearly the same. However, it could be seen that the fluid dispersed more evenly in skin when injected via a jet-injector than through a needle. Further investigations into the mechanics of the penetration point of injection will hopefully aid in gaining more knowledge about quantitative drug delivery and the eventual development of a painless, needleless jet-injector.

Evaluation of Novel Growth Techniques for Dislocation Reduction in Gallium Nitride

Lukmaan Bawazer, Materials Science and Engineering, The Ohio State University

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Mentor: Tom Katona, Electrical and Computer Engineering Department, UCSB

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Gallium Nitride (GaN) is a semiconductor that has important applications for opto-electronic devices such as blue lasers for increased data storage, LED's for electronic displays, and solar blind UV detectors for missile detection. Metalorganic chemical vapor deposition (MOCVD) was utilized to grow gallium nitride thin films on Si (111) substrates. Differences in lattice constants and in coefficients of thermal expansion between GaN and Si (111) cause dislocations to form in the GaN. It has been shown that these dislocations have adverse effects on electronic properties of GaN devices. A novel growth technique known as cantilever epitaxy (CE), where growth is performed on an etched substrate, was employed to reduce the dislocation density of the GaN. X-ray diffraction and scanning electron microscopy were used to characterize the resulting thin films. The dependence of crystallographic tilt on lateral to vertical growth ratio was studied. These results were compared with similar studies using lateral epitaxial overgrowth (LEO), another novel growth technique in which growth is performed on a masked substrate.

Electron Beam Lithography of Nanoscale Hall Probes for Scanning Microscopy

Noah Beck, Physics, Harvey Mudd College

REU Site: SNF

PI: Kathryn Moler, Applied Physics, Stanford University

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The study of magnetism is central to understanding many physical systems. Small, sensitive magnetic probes allow us to study magnetic domains, flux vortices in superconductors, magnetic nanoparticles, and other systems. One non-invasive way of doing so is with a scanning Hall probe, which measures the local magnetic field at many points on the sample surface, producing a magnetic field image. The size of the active region of the Hall probe governs the spatial resolution of the image. We are designing and fabricating the smallest working scanning Hall probe possible on a GaAs/AlGaAs two dimensional electron gas (2-DEG) heterostructure using electron beam lithography. The goal is to reduce the size of the active region from its current micron-scale to around 100 - 200 nm or possibly smaller.

Study of Γ-Aminopropyltriethoxysilane Coatings on Glass Substrates for DNA Microarray Testing

Teresa J. Bixby, Chemistry and Physics, Susquehanna University

REU Site: PSU

PI: Carlo Pantano, Materials Science

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DNA microarrays have the capability of revolutionizing biological research because of the ability to simultaneously test multiple experimental conditions. Small amounts of fluorescently tagged DNA bond to a substrate and after printing, the substrate is thoroughly cleaned to remove all excess or non-specifically bound DNA strands. The degree of DNA immobilization is determined from fluorescence measurements. Therefore, creating a bonding site that will strongly attach the specific strands is advantageous.

Glass substrates were coated with Γ-aminopropyltriethoxysilane (APS) from aqueous solution to create a linker system on the glass surface for DNA immobilization. Several different post-printing conditions, similar to those that the substrates might undergo during DNA testing, were tested and analyzed using x-ray photoelectron spectroscopy (XPS). The nitrogen content on the surface was used to qualitatively measure the retention of the coating because this element is unique to the coating (not in the glass). Atomic force microscopy (AFM) was used to measure the roughness of the surface and to examine the coating morphology and uniformity. Contact angles were measured to determine hydrophobicity of the coating, important when spotting the substrate with the DNA. Finally, fluorescence measurements were made to calculate the DNA retention after each post-printing treatment.

Characterization of Peptide Sorption onto GaAs (100) Surfaces by AFM, Optical Microscopy and Fourier Transform-Infrared (FT-IR) Spectroscopy

Julio Bracero-Rodríguez, Biology, Univ. of Puerto Rico, Mayaguez Campus

REU Site: Howard University

PIs: Gary Harris, Electrical Eng, Mamadou Diallo, Civil Eng and Chem, Howard Univ

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The characterization of peptide sorption onto semiconductor surfaces such as GaAs, Si, and SiC is of critical importance to the development of novel hybrid organic-inorganic nanoscale devices for molecular electronics.

This project focuses on the characterization of peptide sorption onto GaAs (100) surfaces. The first phase of the project consisted of exposing GaAs crystals to aqueous solutions of two model peptides, G1-3 and G12-3 buffered with Tris at pH = 7.8. We exposed the surfaces to the peptide solutions for 16 hours with and without a continuos nitrogen gas flow. The surfaces were also exposed to a Tris-buffered saline (TBS) solution as a control. We then searched for peptide binding on the GaAs (100) surfaces using atomic force microscopy (AFM) and optical microscopy. Preliminary findings using both AFM and optical microscopy showed various patterns on the surface of the semiconductor that suggest possible peptide binding. We will use Fourier Transform-Infrared (FT-IR) spectroscopic studies.

Transdermal Drug Delivery

Mary C. Brickey, Biochemisry, University of Illinois – Chicago

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Mentor: Ahmet Tezel

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Transdermal drug delivery is superior to traditional inoculation and oral ingestion of pharmaceuticals both economically and physiologically. However, the low permeability of the outer surface of the skin to large molecules must be overcome. Exposure of skin to low frequency ultrasound has been shown to greatly enhance transdermal delivery of large molecules, such as insulin, by increasing the permeability of skin. This method is called sonophoresis.

Cavitation, the oscillation of bubbles of vapor collapsing on the surface, is the mechanism by which it is believed ultrasound increases skin permeability. However, how these cavitation bubbles work is still largely unknown. By observing the surface effects of cavitation on aluminum foil, the activity of these bubbles will become further understood. The pits formed on the foil were observed as frequency and intensity were varied. A phenomenon referred to as acoustic decoupling was observed. As intensity increases beyond certain threshold, ultrasound is less effective because fewer bubbles reach the surface. This and other trends will be used to complete our understanding of exactly how sonophoresis increases the permeability of skin. Using this information, an apparatus can eventually be designed to provide painless and continuous absorption of any number of drugs through the skin. This has the potential to revolutionize the pharmaceutical industry and improve the quality of medical care by leaps and bounds.

Selection of Compatible Films for Hepatocyte Differentiation and Adhesion

Arthur F. Carter, Chemistry and Physics, Wake Forest University

REU Site: PSU

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Drug and Product testing will soon be performed on films fabricated through photolithographic patterning instead of at the cost of many animals. Select films were found for a proposed drug testing cell culture and manipulation chip. A series of common and novel films' etching behavior was observed in Ham's media. Of the films initially observed select films were coated with collagen. After collagen coating the films' compatibility with photolithographic methods to pattern the film and collagen was observed. Hepatocyte cells were then deposited on films. Cell growth based on film selectivity was noted while cell adhesion was observed through use of micro-fluidic flow chamber techniques. Films were tested to observe if cell growth was regulated or inhibited by film shape, or if certain films actually stimulate cell growth optimally withstanding constant media and collagen concentrations.

Controlled Growth of Single-Walled Nanotubes (SWNTs) Using Electric Fields

Aileen Chang, Physics, University of California at Berkeley

REU Site: SNF

PI: Hongjie Dai, Chemistry, Stanford University

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Controlled growth of nanotubes is necessary to integrate them into practical devices. We are attempting to grow nanotubes into an array, geometrically and functionally similar to current memory arrays. Using chemical vapor deposition (CVD) and an electric field, single-walled nanotubes (SWNTs) are allowed to grow from an elevated poly-Si surface onto a quartz surface in an aligned manner. Observations of nanotubes using a scanning electron microscope (SEM) and theoretical calculations have shown that alignment is due to the high polarizability of SWNTs and that an electric field of 1-2 V/um is necessary to align suspended nanotubes and overcome randomization from thermal vibrations and gas flow in the CVD process. Varying voltage, distance between voltages, type of current (AC or DC), type of catalyst used, and geometry of chips will hopefully yield successful results.

VLSI Interconnect Characterization

Philip Choi, Electrical Engineering, Cornell University

REU Site: CNF

PI: Professor Edwin Kan, Electrical Engineering, Cornell University

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Successful miniaturization of integrated circuit components has been the driving force behind the booming computer industry. When transistor structures are reduced in size, gate lengths and switching times are reduced, resulting in faster circuits. However, unfavorable results occur when the interconnecting wirings between transistors are made narrower and closer together. As the dimensions for Very Large Scale Integrated (VLSI) circuits are continually reduced, electrical signal distortions and logic failures are imminent.

Primary focus was geared towards the fabrication of copper testing structures which mimic interconnect lines. These samples were used to study proximity effects on the resistance of the wires, and signal cross-talk between neighboring wires. Photolithographic patterning and lift-off processes were used to create the structures. 1.5 µm thick lines, as narrow as 1 µm, as long as 8 mm, and of various layout geometries were successfully fabricated. The transmission line characteristics of these structures were measured using a network analyzer capable of driving signals of up to 40 GHz.

Novel Method for Large Scale Nanopatterning

Matthew Daniels, Physics, Pacific Lutheran University

REU Site: CNF

PIs: Christopher Umbach, Jack Blakley, Materials Science, Cornell University

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The focus of the project is to develop methods to etch features in silicon that are 100 Å high and 200-300 Å apart. A silicon dioxide film with a gradient in thickness is deposited on a silicon wafer. Sputtering the oxide in an ion mill at an off normal angle creates ripples on the oxide surface. These ripples are then used as an etch mask and the ripple pattern is transferred into the silicon by a reactive ion etch. The quality of the pattern transfer depends on the oxide thickness, the degradation of the ripples during the etch and the initial long-wavelength roughness of the deposited oxide.

Alignment System for Distributed Multi-Axis Electron Beam Lithography

Andrew Davenport, Mechanical Engineering, Washington University

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PI: Fabian Pease, Electrical Engineering, Stanford University

Mentor: Dan Pickard, Electrical Engineering, Stanford University

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Large parallel arrays of electron beams may provide orders of magnitude faster production than current single beam systems. One of the primary difficulties with such a system is the alignment of the many adjacent beamlets. Each beamlet must be mechanically positioned to within a few microns accuracy to enable finer electronic alignment. Our system will be complicated by the requirements that all parts must: be non-magnetic to maintain a uniform magnetic field, have no outgassing properties to achieve an ultra high vacuum, and operate in a volume of 27 cubic centimeters. Our goal is to design and integrate a system of commercial piezomotors and drive mechanisms to control the many degrees of freedom required to align the arrays.

Fabrication and Optimization of Organic Thin Film Transistors

Caitlin Devereaux, Chemistry, Harvey Mudd College

REU Site: CNF

PI: George Malliaras, Cornell Center for Materials Research, Cornell University

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Organic thin film transistors (OTFTs) provide a useful alternative to conventional inorganic TFTs. The use of an organic conducting layer (pentacene, in our case) allows for inexpensive, low-temperature processing of the devices. These processing qualities make OTFTs ideal for flexible electronics and disposable electronics applications. The main shortcoming of OTFTs is that their charge mobility is much lower than that of inorganic TFTs.

The goal of the research was to improve OTFT performance by (1) varying the dimensions and spacing of the source and drain electrodes and (2) changing the type of material used for the electrodes. A variety of OTFT devices were fabricated via photolithographic methods and are currently being characterized to determine their electrical properties.

Development of a C++ Program to Study Five-Layer, Thin-Film Systems using Multiple Beam Interferometry

Peter Ercius, Applied and Eng Physics, Cornell University

Linh Tran, Chemical Eng, UCLA

REU Site: UCSB

PI: Jacob Israelachvili, Chemical Eng, UCSB

Mentors: Nianhuan Chen, ChemEng, Rafael Tadmor, Materials Research, UCSB

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Five-layer interferometry can be used to study the coalescence of thin liquid films at the molecular level. Data collected on the process of coalescence could be helpful in improving applications such as liquid-liquid extractions, emulsification, and polymer blending processes. Our project involves using an interferometer to measure the thicknesses of a symmetric, five-layer system. Our five-layer system is comprised of one layer of polydimethylsiloxane (PDMS) between two layers of polybutadiene (PBD), which are coated on cylindrical mica substrates. We wrote a C++ program that solves the five-layer interferometry equations to give the thickness of both interstitial liquid layers using Newton method, a numerical method that finds the roots of equations. The program requires input of the wavelength and order of two successive fringes, three refractive indices (for mica, PBD, and PDMS), and the wavelength of these fringes when no polymer is between the substrates. The five-layer equations have multiple solutions; therefore, the program selects the probable answer by comparing the answers to a guess derived by treating the PBD and PDMS layers as one layer. Our program compensates for refractive index dispersion (wavelength dependence of refractive indices) since the solutions are very sensitive to small changes in these values.

The Growth and Characterization Processes of Gallium Nitride (GaN) Nanowires

Unyime Eshiet, Electrical & Computer Engineering, Temple University

REU Site: Howard University

PIs: Dr. Gary Harris, Dr. Peinzhen Zhou, Dr. Maoqi He, Michael Beyer, MSRCE-Howard University

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Gallium nitride (GaN) semiconductor nanowires were grown and fabricated to show its possible use in making quantum devices. The ability to grow and use nanowires in making quantum devices such as lasers, light detectors, diodes and transistors offers great promise for the future of science and technology. GaN nanowires were grown by reacting 3g of gallium metal with ammonia gas flowing at 100 sccm in a quartz liner inside a tube oven at 900¯C for 4 hours in a vacuum system at 15 Torr pressure.

The characterization process involved categorizing the physical and the electrical properties of the nanowires. The physical properties of the nanowires were determined using the optical microscope, photoluminescence and the scanning electron microscope. Some nanowires were found to be uniform, short and straight and others were found to be curvy, long and non-uniform. Photoluminescence was done to test and determine the band gap of the GaN nanowires, found to be 3.4 electron volts. The electrical properties (I-V characteristic) of the nanowires were tested by extracting an individual nanowire and placing it on an insulated copper circuit board with tweezers and securing a fixed position with conductive silver epoxy, and then testing its conductivity with a programmable curve tracer.

Mass Analysis using Silicon Films with Amino Acid Additives

Jamie Fontaine, Biology, Penn State University

REU Site: PSU

PI: Dr. Stephen Fonash, Engineering Science, Penn State University

PI Email: sfonash@psu.edu

With increasing interest in the emerging field of proteonomics, characterization and detection techniques of proteins are being developed and improved. Mass Analysis using Silicon Films (MASiF) is a matrix-free technique useful in detection and characterization of proteins and molecules ranging between 0-6000 Daltons. The purpose of this study was to develop an additive to enhance signal sensitivity, and specifically enhance large molecule detection for MASiF. Bradykinin (1060.2 Daltons) and Insulin (5777.6 Daltons) solutions were prepared and combined with amino acid additives; these combined solutions were tested on the surface of porous silicon coated glass substrates. Various amino acid additives increased analyte signal sensitivity, detection of large molecules, and were also found to suppress background signal.

Fabrication of a Galium Phosphide Semiconductor on a Silicon Wafer

Danna Freedman, Chemistry, Harvard University

REU Site: CNF

PI: James Engstrom, Chemical Engineering, Cornell University

PI Email: jre@cheme.cornell.edu

The fabrication of 3-5 semiconductors is useful to industry due to the effectiveness of such semiconductors. However, growing a gallium phosphide semiconductor on silicon is difficult because there is a lattice mismatch between the silicon and the gallium phosphide. The solution to this difficulty lies in creating a surface that will accommodate the tension between the two materials. Our project uses sharp silicon tips to relieve the stress.

The focus of my project is to fabricate and analyze the tips before they are inserted in the deposition machine. It is very important that the tips be sufficiently sharp, so the gallium phosphide does not strain and lose its properties. We created the tips with a series of oxidations in the chemical hood. Subsequently, we used the SEM to characterize the tips and determine the correct oxidation times. The final stage of the project involves creating an array of tips with the correct spacing for deposition. This involves using the pattern generator to try many different spacing combinations.

Chemical Mechanical Polishing Characterization and Process Development

Ashley Harness, Chemical Engr, Virginia Commonwealth University

REU Site: CNF

PI: Daniel Woodie, CNF Staff, Cornell University

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Chemical mechanical polishing (CMP) is a current method used to planarize wafers, remove films, and construct damascene circuits. The focus of this project was to characterize the Strasbaugh 6EC CMP instrument located at the Cornell Nanofabrication Facility (CNF). Three, four, and six-inch diameter silicon wafers with a thermal oxide film were studied. Using a Prometrix FT-750 reflectometer, the film thickness was obtained in a specific pattern to provide uniformity data. Wafers were polished for three minutes and the remaining film thickness was measured. Further experiments were performed to acquire etch rates of various types of films and wafers.

The average film removal rate increased with an increasing wafer diameter. Three and four-inch wafers ranged from 15% to 3% non-uniformity. Six-inch wafers consistently polished to a non-uniformity of 3%. Film removal rate and wafer uniformity were affected by pad age, run order, pad conditioning, and carrier head ring attachment.

Photoluminescence and AFM on Strain-coupled, Self-assembled InAs Quantum Dots

Damon Hebert, Department of Physics, Macalester College

REU Site: UCSB

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A quantum dot (QD) is a region of a semiconductor material embedded in a different surrounding semiconductor matrix that allows the three-dimensional, spatial confinement of carriers. Due to the small size of a QD, quantization of the electronic energy states is observed that mimics the behavior of an atom. We study the bulk optical properties of self-assembled InAs QDs by examining photoluminescence spectra. Two closely spaced layers (45Å) of QDs are grown via the Stranski-Krastanow method using molecular beam epitaxy (MBE). We observe inhomogeneous spectral broadening due to a gaussian distribution of sizes of nucleated QDs. We control the energies of the QDs using partially capped islands (PCI) whereby the physical dimensions of the QDs are controlled by changing growth parameters. In this way we are able to tune the energies of adjacent strain-coupled layers of QDs. We also study the size and shape distribution of uncapped InAs islands using the atomic force microscope (AFM). Statistics on QD density, distribution, size, and PCI ratio are recorded.

The goal of this research is to attain control over the MBE growth parameters of self-assembled QDs and investigate the electronic coupling of adjacent QDs. This research has several possible applications including quantum computation and memory bits.

Lipid Bilayers and Microfluidic Systems

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Supported lipid bilayers provide a unique system for modeling biological membranes. Taking advantage of the 2D fluidic nature of these bilayers, we have previously developed electrophoresis-based techniques for microscale separation of membrane-associated biomolecules. Difficulties that have precluded easy methods for collecting lipid fractions induced in such separations include the necessity of applying a continuous electric field over a self-enclosed area to maintain a gradient in a two-dimensional fluid, difficult access perpendicular to that field, and size on the order of microns. Using photolithographic micropatterning, we are currently designing microfluidic systems for collecting fractions of these membranes using passivated poly(dimethylsiloxane) elastomer. After undergoing electrophoresis, we strip the gradated bilayer from the glass using either detergent (such as LDAO) or an appropriate solvent (such as ethanol), channeling different lipid concentrations into separate pipettes for study. We anticipate future use of the system for differentiating and separating lipids with varying protein concentrations for use in complex studies of cell membrane behavior and intercellular interactions.

Formulating DNA "Inks" for Microarrays

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DNA microarray technology, or gene chips, allow for tens of thousands of DNA sequences to be arrayed in an orderly manner on a single chip. Complementary binding of these sequences with cDNA from a biological sample is related to specific genes that are active in the sample. Thus, gene chip technology enables massively parallel acquisition of gene expression data, which allows the study of gene function.

cDNA microarrays can be fabricated by several methods. Inkjetting in microarray technology offers a much more precise, reproducible method though it largely restricted to reagents for DNA synthesis and very short DNA fragments (</=25 bases). Because cDNA molecules are much longer (typically 1-2 kilobases), their solutions are much more viscous and their behavior is less predictable, making them inappropriate for inkjetting.

Cationic compounds (with positive charge >3) interact electrostatically with negatively charged DNA molecules reducing the solution viscosity. We are studying the effect of spermine (with four positive charges) and polylysine (with approximately 200 positive charges) on the surface tension and viscosity of concentrated DNA solutions.

While the research focuses on DNA "inks", the principle of packaging charged polymers with oppositely charged compounds might also be used for inkjetting electroluminescent polymers for light emitting devices and displays.

Containment of Reactions on Microchips for DNA Sequencing

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On a macroscopic level, any DNA sequencing technique is expensive due to the cost of reagents. Sequencing on a micron scale offers the possibility of much cheaper reactions as well as the potential for several parallel reactions on a single microchip. One problem with processing on a microchip is the containment and localization of the sequencing reactions. We are fabricating chips that attempt to deal with this issue using microwells and electrostatic potentials. If it is successful, our technique should significantly reduce the expense of DNA sequencing.

Atomic Force Microscopy on Synthetic Spider Silk Protein

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Atomic Force Microscopy (AFM) is an amazing new technology that allows biologists to image in real time and without the need to damage or manipulate the bio-molecules that are being investigated. My mentor and I are using AFM this summer to view recombinant synthetic spider silk in order to gain insight into its structure. Understanding its structure is the first step in eventually manufacturing this amazing fiber. Synthetic Spider Silk will have an amazing range of applications. Everything from building materials to bulletproof vests.

Part of the problem with AFM, and one that we have run into, is that the tip can distort or convolute the image. This convoluted image does not allow for an accurate measurement of a specimen's size and shape, specifically the diameter. Since we are trying to determine the structure of the spider silk protein an at least approximate diameter of the fiber is required. To work around this problem, I am investigating the use of manufactured gold reference particles. We used incompressible particles in 5 sizes ranging from 5nm to 30nm. They have previously been used to investigate the compressibility of bio-molecules. I'm attempting to de-convolute the image by finding the average amount of width added to the image because of the tip. In addition, I'm trying to characterize the slope of the tip to further enable us to de-convolute the image.

Based on data collected, a certain tip seems to add 16nm to the width of the protein fiber. Based on this we calculated the spider silk protein fiber to be 10nm wide.

Analysis of Thin Film Diamond Using an E-beam Micro-column

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Due to its unique properties, diamond has many potential applications in the electronics industry. The applications range from high temperature transistors to low dark current photo-emitters. In our study, we are investigating the properties of large bandgap materials such as diamond, cubic boron nitride, and aluminum nitride. The electron loss mechanisms within the thin films of these materials can be measured in order to gain insight into the physical properties of semiconductors. The experimental apparatus for these measurements is a modified scanning auger electron microscope, with the major modification being the addition of a second, miniature electron column. This micro-column will focus an electron beam onto the back surface of the sample, transmitting electrons.

InGaAsN Solar Cells

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When building a solar cell, multiple materials with different band gaps better utilize the spectrum of wavelengths in sunlight and thus increase the power conversion efficiency. This project focussed on the creation and optimization of an InGaAsN solar cell. The diode junction and other layers were created by molecular beam epitaxy, and devices were made using lithography, scribing, and metal evaporation.

The basic structure was based on a 1999 paper from Sandia Laboratory, and using this same design we showed an open circuit voltage of 0.195 V and a short circuit current of 0.080 mA at AM1, which translates into an efficiency of 0.4% and a saturation current of 1.4e-6 A/cm^2. We also varied the internal structure to try to increase efficiency. The main difficulty throughout testing was a high leakage current due to exposed edges and incomplete metal contacts.

Porous Silicon MicroElectroMechanical Systems

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MicroElectroMechanical Systems are micron-scale devices that are fabricated similarly to electronic devices. The potential for MEMS in biosensor applications has long been recognized as they have the advantage of small size and easy integration with standard electronics. Electromechanical transducers are one type of MEMS which can interchange electrical and mechanical energy. We attempt to build biosensors with eletromechanical transducer MEMS by modifying the surface of the device. Specifically, basic electrochemical etching techniques are used to form a porous silicon (PS) layer on mobile parts of the device, creating a greater binding area. We then hope to activate the PS surface with various molecules; the device can then be used as a sensor of substances.

Fabrication and C-V & I-V Characteristics of Metal-Insulator-Metal Structures

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Poly(methyl methacrylate) (PMMA), a film similar to molecular films, and Tetraethyl ethoxy silane (Sol-Gel), a form of SiO2, are two well established insulators that can be made into nanometer thin films. Studying the fabrication methods and electric properties of metal-insulator-metal (MIM) structures using these films (1) provides a foundation for the study of electron transfer in metal-molecule-metal structures and (2) explores methods for making ultra thin dielectrics for molecular electronics.

MIM structures were fabricated using a variety of metals and thicknesses of insulator films. A metal layer, of either Cr with Au or Ti with Pt, was evaporated onto Si wafers. 2-8nm films obtained through varying concentrations of PMMA and Sol-Gel solutions were then spun on the wafers. The final structures were created by evaporating metal pads onto the film surface with a shadow mask. Capacitance-voltage (CV) and current-voltage (IV) characteristics were measured in order to find breakdown fields and capacitances. Roughness was also measured using atomic force microscopy (AFM). The method to fabricate and analyze these devices will be discussed.

Minimum Line-width Features for Cryogenic Optical Photon Detectors

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New optical-photon detectors using transition-edge sensors have been developed by the Cabrera group at Stanford University. Low temperature superconducting tungsten and aluminum films, deposited on silicon substrates, are patterned into an array of individual sensors using standard semiconductor manufacturing equipment. The primary application is to determine the energy, time of arrival, and phase of each optical photon from sources in space, such as the Crab pulsar. The instrumentation of a multi-pixel imaging detector array requires ultra-thin read-out lines to maximize detection area and minimize rail events. By using the Hitachi E-Beam Lithography machine, optical photon detectors with more pixels and thinner read-out lines can be produced. Improved optical photon detectors will have higher count rates and better point spread function, and can be used in many new experiments in cosmology and astronomy.

Studies of the Formation of Sub-Surface Voids in Silicon Substrate Induced by Silicon Surface Migration

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The objective of this study is to investigate the formation of sub-surface silicon structures. Photolithographic techniques as well as e-beam lithography are used to create matrices of pores of specific sizes. The patterns are etched and annealed at a high temperature. At high temperature, the surface atoms reorganize themselves in order to minimize the free energy creating sub-structures below the surface.

The sub-surface structures have applications in many areas such as fluid transport, sensor actuators, and MEMS devices. More over, the technique has the capability to change the microprocess for the production of large integrated circuits.

Investigation of Filtration Properties of Collagen On Silicon Wafer

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The use of collagen as a filter and the successful patterning of a collagen structure has numerous biological applications. Some of them include replacement of degraded collagen matrices in teeth, skin, and cartilage as well as insertion of collagen filters in defective kidneys. Soluble Type I collagen was spun on a silicon wafer and a process for patterning collagen, using a photolithography technique, and testing its porous properties was determined. This is the primary investigation of a bio-molecule used in nanofabrication. Because the resist layer, spun on top of collagen, was made to bond to silicon wafer and not to collagen layer, several problems arose. The resist pattern was easily washed off of collagen layer. Changes in techniques of development and development time of resist were tested to ensure total development of exposed resist and to maintain structural integrity of patterned arrangement. Resist was patterned in a series of wells with a barrier of resist of varying thickness between each well. Fluorescent molecules 20 nm and 100 nm in diameter were put into solution and allowed to flow through barriers of collagen acting as a filter. This was done to determine the porosity of the collagen matrix and to rind an optimal thickness that would prevent flow of certain sized molecules.

Construction of Thin Optical Microcuvettes

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A number of important nonlinear spectroscopies, such as sum-frequency generation and third-harmonic generation cannot be phase matched in normally dispersive liquids. If the chromophores in the solution show strong linear absorption, it is necessary to use cuvettes with ultra short path lengths ($< 2\ \mu m$) for these nonlinear spectroscopies. We have pursued two design strategies for the construction of micro-cuvettes using UV grade fused silica wafers. One design is for a de-mountable clamped cell that consists of two wafers sandwiched together. One of the two wafers is masked and subsequently sputtered with Aluminium such that the thickness of the metal deposit matches the required cell spacing. Input and output channels are sonically drilled (sonic drill) into the second wafer in the form of two 500 μm diameter holes.

The second design is for a multi-cell permanently sealed microcuvette. A silicon layer of the desired thickness is first deposited onto one of the fused quartz wafers using plasma vapor deposition, and the liquid chambers are then patterned using standard lithography techniques. Another wafer which has holes drilled into it through the use of a sonic press is then bonded to the first using an EV501 bonding machine. We demonstrate an optical interference method for measuring the path-length of the microcuvettes and hope to demonstrate the utility of the cuvettes by showing some linear UV-Vis absorption spectra obtained from strongly absorbing liquids and solutions.

The Integration of Carbon Nanotubes into Electronic Devices

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There has been much excitement in the potential use of carbon nanotubes in integrated circuits. With an average radius of 2-3 nm and unique electrical properties, single wall carbon nanotubes (SWNTs) represent one of the most promising materials for construction of molecular electronics. Controlled growth of SWNT into arrays, highly oriented interlaced patterns, is however, a challenge to their future use in integrated circuitry. We have achieved production of aligned SWNTs using chemical vapor deposition (CVD) coupled with the application of an electric field. Using the induced dipole-dipole interactions produced by the application of an electric field, we will now attempt to grow aligned carbon nanotubes into interlaced arrays on silicon substrates. Such arrays will mark the first step in the production of circuitry using carbon nanotubes.

Development of Ultramicroelectrode Arrays for Microfluidic Biosensor Devices

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The primary goal of this project is the customization of an interdigitated ultramicroelctrode array (IDUA) for use in a generic pathogen biosensor. The IDUAs are made on three inch, one-millimeter thick wafers. To produce the IDUA, a layer of photoresist is patterned with a CAD drawn design using the 5x g-line stepper. The pattern consists of two leads attached to a row of interdigitated “fingers” which form a channel for substrate to flow through. The width of the fingers and the gaps is five µm. Following an image reversal process, the wafer is descummed and the electrode array patterned in platinum by evaporation followed by lift-off in acetone. A thin layer (100 A) of titanium between Pt and the glass improves adhesion.

Finished wafers are then cut into individual electrode chips and tested with a multimeter. The percentage of working electrodes after cutting is 81.3%. Sample chips are then tested amperometrically with varying concentrations of ferri and ferrocyanide.

Characterizing the Viscosity of Concentrated Solutions of DNA with Cationic Agents

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Concentrated solutions of free DNA are extremely viscous and are characterized by unpredictable surface tension. The fluid behavior of DNA solutions is largely influenced by its highly charged nature. Studying the fluid behavior of DNA solutions has important applications in many areas. However, there has not been a systematic study of the viscosity of concentrated DNA solutions since the 1960's. In the manufacturing of DNA microarrays, inkjets can dispense smaller, more reproducible drops, producing better quality, higher density arrays. Currently, the unusual fluid behavior of concentrated cDNA solutions makes inkjetting difficult. Also, in cystic fibrosis patients, the characteristic and unusually thick mucus in the lungs is largely comprised of free DNA - the resultant cell debris after bacterial infection. The thick mucus is particularly susceptible to bacterial colonization, launching a vicious cycle of repeated infections. This results in scarring and reduced lung function. Our research concerns the study of the viscosity and surface tension of DNA solutions in complexes with cationic agents such as spermine and polylysine. Multivalent (>3 charges) cationic compounds are known to complex electrostatically with the negatively charged DNA. Because DNA can become tightly packaged in these complexes, solution viscosity and surface tension are expected to decrease dramatically.

Processing of Next Generation Resist Materials Using Supercritical CO_2

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Supercritical CO_2 (SC CO_2) has become an important medium of fluids technology for environmentally benign semiconductor processing. The solvent has received attention for processing and cleaning abilities of various photoresist materials, specifically chemically amplified fluorinated photoresists. Some resist materials were designed for next generation 157 nm photolithography, and have the potential to be developed in a nontoxic environment and reduce hazardous chemical waste. The focus of the project was divided into three main areas: (1) Studying development of THP-(r)-F7MA photoresists with and without a Au/Pd substrate coating for optimal processing and sample preparation conditions for other photoresists dissolved by SC CO_2; (2) Development of a chemical process to convert negative toned resists into positive toned resists, through Diffusion Enhanced Silylated Resist (DESIRE); (3) Using a Dissolution Rate Monitor (DRM) to study polymer film thickness changes within a SC CO_2 medium. The behavior of this curve depends on polymer dissolution rate and extent. It is expected to see an approximate sinusoidal curve when processing conditions were ideal.

Photoresist processing and characterization included a SC CO_2 film development chamber, SEM, and AFM. Results obtained included feature sizes of sub-micron width on THP-(r)-F7MA photoresist, fractional sinusoidal curves for an arbitrary block co-polymer film, and creation of DESIRE processing apparatus.

Process Characterization of LPCVD Silicon Nitride and the Consequential Fabrication of Low Stress Microcantilevers

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Low Pressure Chemical Vapor Deposition (LPCVD) of silicon nitride (Si_3N_4) is an important process in the construction of micromachined devices that depend upon low stress thin films. This paper presents a logical method for modifying the deposition parameters of a hot wall type reactor to obtain desired stress levels for use in micromachined devices.

The primary parameters of investigation are: total gas flow of dichloro silane (DCS) and ammonia, gas chamber pressure, and the gas ratio of DCS to ammonia. At a fixed point inside the reactor these parameters were found to have significant effects on the thin film that was formed. We found that by varying one or more of the specified variables that we could lower the stress of our silicon nitride film to 1.4 +-11 MPa. Trends for each of the adjustment parameters were identified and explained. The results of this optimization process allowed us to form a low stress film for the construction of microcantilevers.

Superconductivity of Ge/Ag/Ge Nanowires

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Multilayer structures of Ge/Ag/Ge have been previously found to exhibit superconducting fluctuations at liquid He temperatures. As neither Ge nor Ag is superconducting at atmospheric pressure, it is likely that any effects of superconductivity is due to phenomena occurring at the Ag-Ge interface. Such a truly two-dimensional (2D) superconducting system would make it a unique structure in which to study the nature of the superconducting state in one-dimension (1D).

In this study, structures of Ge/Ag/Ge were fabricated using electron beam lithography, and characterized using atomic force microscopy (AFM). As a comparison, larger 2D Ge/Ag/Ge films were also fabricated simultaneously. Initial electrical transport studies of the larger films indicate that the conductance is highly dependent on the thickness of the Ag layer. Low temperature (Tmin = 0.3K) electrical transport studies on both nanowires and 2D films are currently under way.

Asymmetric Diblock Copolymer Films for Nanopatterning

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Through the process of self-assembly, block copolymers can be used to produce various morphologies on a size scale unachievable through conventional patterning techniques. By controlling the chemical composition of these polymers, structures such as nano-scale lamellae and arrays of cylinders or spheres can be produced. Although the ordering process is relatively well understood for lamellar and cylindrical morphologies, the factors that affect ordering of spherical domain block copolymers have been less extensively studied. Through a detailed understanding of how these polymers reach an ordered state, we will be better able to control long-range patterning and generate specifically designed structures. Two techniques, dynamic secondary ion mass spectrometry (SIMS) and optical microscopy on a heat stage, were used to investigate the process of self-assembly of poly(styrene-b-2vinylpyridine) (PS-PVP): SIMS depth profiles of samples annealed under various conditions demonstrate how annealing can be optimized to produce the highest degree of order perpendicular to a substrate. Optical microscopy of films on patterned substrates provides a more detailed picture of the mobility of the polymers and how they reach an ordered state. Arrays of nanometer sized ordered spheres could ultimately prove useful in numerous applications such as nanolithographic templating and the fabrication of membranes.

Microfluidics for DNA Pyrosequencing

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Due to the cost of manufacturing biological chemicals, Pyrosequencing is an expensive procedure. Miniturizing the process could decrease the cost and timescale of gene sequencing. At present, accurate sequencing on microchips is limited to short DNA molecules (approx. 40 base pairs) because of enzymatic buildup. Microchannels and. microsieves were designed to contain DNA molecules while allowing buffer solution to flow through a microchip. We hope to increase the length of accurately sequenced DNA molecules by an order of magnitude or more. This method has the potential to make gene sequencing and identification quicker, more accurate, and less costly.

Spectroscopy of the Ir^{3+} Organo-Metallic Complexes

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We present a basic spectroscopy study of three organo-metallic complexes containing phenyl-pyridine ligands with a varying number of phenyl groups attached. Such compounds are known to be potent electro-luminescent materials used in organic light emitting diodes (OLEDs). There are two important excitations, which determine the electro-luminescent spectrum of these complexes: the first excitation involves only organic part of the complex while the other involves metal-to-ligand energy transfer. To this point we collected absorption, emission and photoluminescence (PL) spectra of the three Iridium complexes in solution and solid thin films at 77 and 300K. The following are the observations we gathered so far:

- We observe a red-shift of the absorption and emission bands with the increase of the ligand conjugation length.
- The most red-emitting complex (the one with the longest ligands) is sensitive to photo-oxidation while the others are not.
- The PL spectra of Ir^{3+} complexes shift to the red at lower temperatures.
- There are two types of emission bands that can be distinguished by their emission life-times: the weak ones which have the life-time of about 80 ns and the strong ones which last for about 1 μs.

With this and some additional experiments planed for the near future, we hope to understand photo-physics of these important organo-metallic complexes.

Magnetostrictive Thin Films for MEMS Applications

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Magnetostrictive thin films offer an attractive approach for remote actuation of micro-electro-mechanical systems (MEMS) devices. Among the candidate materials are TbFe compounds and amorphous alloys, which can exhibit large magnetostrictive effects. In thin film form, however, their magnetostrictive and mechanical properties are a function of deposition conditions, and can differ significantly from bulk values. We investigated the magnetostrictive performance of amorphous $TbxFe1^{-x}$ (with x ~ 0.33) using thin films sputter-deposited onto free-standing silicon nitride cantilever beams with dimensions optimized for thin film magnetostrictive actuation. The coercive fields, magnetization and magnetic anisotropy of the $TbxFe1^{-x}$ thin films were determined by vibrating sample magnetrometry, and the magnetostrictive actuation was examined by optical microscopy in the presence of a magnetic field. This approach can be used to rapidly explore new materials and material systems for magnetostrictive MEMS.

Synthesis of Dialkoxy-Substitutes Oligophenylenevinylenes

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Synthesis and spectroscopic analysis of two oligophenylenevinylenes is described herein. Oligophenylenevinylene molecules constitute a fundamental basis for studying intermolecular interactions and charge transfer within conjugated polymers. Single molecule fluorescence and conformationally selective mass spectroscopy are used to determine the shape of 4,4'-Distyryl-(2,2',5,5'-tetraethyloxystilbene) and 1,4-Bis[2',5'-dioctoxy-4'-(4"-(3'",5"'-dihexyloxystyryl) styryl) styryl) styryl)]benzene. A model of their conformations is constructed to determine the relative amount of *cis*- defects within the bulk. This model can further be used to define *cis*- defects in polyphenylene- vinylene polymers. These novel molecules are synthesized using Heck, McMurry, and Wittig coupling reactions.

Fabrication of 3C-SiC Nanofiltration Membranes

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Silicon Carbide, due to the semiconductor's high breakdown voltage threshold, allows for strong permanent electric fields to exist across large voltage differentials. Thus, when used as a Nanofiltration Membrane in conjunction with voltage differentials created by way of Ion Implantation, the result would be a static electric field within the membrane pores. Interaction of the resultant electric field with charged particles would help counter membrane fouling from colloidal and particulate matter.

This experiment was designed to fabricate and test Silicon Carbide Nanofiltration Membranes, and investigate the effects of Ion Implantation on the efficiency of such devices. Using Metallization and Lithography techniques, 1 μm pores were etched into 1 to 6 μm layers of Silicon Carbide on a Silicon backing. Silicon Carbide Nanofiltration Membranes were then implanted with Chloride and Fluoride ions, and compared to identical unimplanted membranes by way of flux, percent rejection of contaminants, and amount of membrane fouling from prolonged use. A significant reduction in fouling characteristics in such a membrane would translate into more reusable and less costly membrane technologies that would require much less maintenance.

Directed Formation of Nanosphere Monolayer Domains

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Nanosphere monolayers have been previously used as lithographic masks for regular arrays of sub-100nm metal nanoparticles. Patterns produced by nanosphere lithography have interesting applications for optics and the efficient manufacture of magnetic storage media. However, the technique lacks positional specificity and is restricted to making periodic patterns. In this paper, we present a method for adding local positional control to nanosphere lithography. Patterned gaps in an oxidized silicon layer etched by standard photolithography were used to align the orientations of defect-free monolayer domains. Positional control over domain walls is demonstrated, as well as controlled formation of "strings" of gold nanoparticles by metal evaporation through the domain walls.