1 **Towards Low Cost Organic Solid State Solar Cell**

S. Mohammad Mirvakili, Antonio Fernandes de Lima, Ali Mahmoudzadeh, Bahar Iranpour, Arash Takshi, John D. Madden, J. Thomas Beatty

We are working on the design and fabrication of a low cost, efficient solar cells that employ bacterial reaction centers (RCs), protein complexes involved in the first stages of photosynthesis, as charge generators. The initial questions are what is the maximum efficiency that can be obtained from these devices, and how much material is needed. UV-Vis. Spectroscopy is used to measure the absorption spectrum of the RCs. Knowing the absorbance enables us to find the extinction coefficient of the RC as a function of wavelength. By using the extinction coefficient we can find the amount of light absorbed as a function of thickness. Given the energies of the excited charges the peak efficiency can be determined. These estimates show that a thickness of ~20 μm of RC can absorb almost the entire incident light. Ultimate efficiency of the solar cell is calculated to be between 12% and 18% depending on the choice of reaction center. In principle at least these solar cells can perform as well as other low cost solar technologies, but substantial work is needed now to approach these efficiencies.

2 **Study of plasmonic lenses for superfocusing**

Yongqi Fu, Xiuli Zhou, Yu Liu, Yiwei Zhang (UESTC)

A novel metallic elliptical nano-pinholes-based plasmonic lens was put forth for the purpose of superfocusing. Systematic investigation of the lens from design to fabrication and characterization were described. Surface plasmon polaritons (SPPs) enhanced transmission is theoretically analyzed using finite-difference time-domain (FDTD) algorithm-based computational calculation. Then the designed pattern was fabricated using focused ion beam (FIB) directly milling technique. Focusing of the lens is observed from the results of both theoretical calculation and experimental characterization using near-field scanning optical microscope (NSOM). The experimental results are in agreement with that of the theoretical calculation. Our results demonstrated that the lens can realize subwavelength focusing with enhanced transmission, elongated focal length, and depth of focus.

3 **Controlling photochemistry remotely using near-infrared light and upconverting nanoparticles**

Carl-Johan Carling (SFU), John-Christopher Boyer (SFU), Farahnaz Nourmohammadian (SFU, Organic Colorants Institute for Color Science and Technology, Tehran, Iran), Byron Gates (SFU), Neil Branda (SFU)

We have utilized a nanosystem capable of converting low energy near-infrared light (980 nm) into higher energy visible and UV light and shown how we can use this light to drive important photoreactions. We have applied this system for "drug release" and photoswitching.

4 **Monolithic Integration of AlGaAs Distributed Bragg Reflectors on Virtual Ge Substrates via Aspect Ratio Trapping**

Yiheng Lin, Wei Shi, Mark Greenberg, Lukas Chrostowski, Guangrui Xia (UBC). Jizhong Li, Ji-Soo Park, Jennifer Hydrick, James G. Fiorenza (AmberWave Systems Corp). Ting-Chang Chang (UBC/NSYSU). Zigang Duan (Shenzhen University).

High quality AlxGa1-xAs distributed Bragg reflectors (DBRs) were grown on virtual Ge substrates via the aspect ratio trapping (ART) technique and intermediate GaAs buffer layers. The Ge/Si ART-based DBRs have reflectivity spectra comparable to those grown on conventional bulk offcut GaAs substrates and have smooth morphology. High-resolution X-ray diffraction shows that the residual stress and crystal quality of the Ge films depend on ART oxide trench patterns. Transmission electron microscopy (TEM) images reveal very good periodicity and uniformity that are unaffected by threading dislocations or residual strain. These results are very encouraging for the subsequent growth of vertical cavity surface emitting lasers (VCSELs) on these substrates, and also confirm that virtual Ge substrates via ART technique are effective Si platforms for optoelectronic integrated circuits (OEICs).

5 **Advanced Lithography in the 4D LABS Nanofabrication Facility**

Nathanael Sieb (SFU), Grace Li (SFU), Mary Boysel (SFU)

The Nanofabrication Facility in 4D LABS has a number of tools for advanced lithography processing. We are located at SFU in a class 100 Clean Room facility. Utilizing our lithography tools, a user can fabricate complex structures with dimensions from 20-nm to several mm. These tools are just one component of the suite of fabrication and analytical tools available in 4D LABS. We are always willing to work with users to meet their fabrication needs.

6 **Physical Vapor Deposition in the 4D LABS Nanofabrication Facility**

Nathanael Sieb (SFU), Chris Balicki (SFU), Philip Kubik (SFU), Mary Boysel (SFU)

The Nanofabrication Facility in 4D LABS has several tools for physical vapor deposition (PVD). We are located at SFU in a class 100 Clean Room facility with adjacent laboratory space. A user can deposit a wide variety of metals and oxides with our PVD tools. These tools are just one component of the suite of fabrication and analytical tools available in 4D LABS. We are always willing to work with users to meet their fabrication needs.

7 **A Surface Plasmon Resonance Cellular Antibody Sensor**

Donna Hohertz, Karen Kavanagh, (Physics, SFU), Bonnie Gray, Sean Rominuik, (Engineering Science, SFU), Jamie Scott, Naveed Gulzar (Molecular Biology and Biochemistry, SFU), Alex Brolo, (Chemistry, UVic), Reuven Gordon (Electrical and Computer Engineering, UVic)

Extraordinary optical transmission (EOT) is the transmission of radiation through thin metal films perforated with periodic arrays of sub-wavelength sized holes. EOT is a surface plasmon resonance (SPR) mediated phenomenon. In SPR the surface bound evanescent electric field can only interact with material near the metal surface. Adsorption of a chemical species to the metal surface therefore influences SPR, making it an extremely sensitive probe to changes in surface chemistry. The small size of the EOT elements allows us to monitor chemical binding events in a highly localized environment. EOT nanohole arrays (20 x 20 μm) have been fabricated in thin (100 nm) gold films via focused ion beam milling. The gold surface is functionalized with proteins using well-established methods for the immobilization of biomolecules. The arrays are integrated into a microfluidics package in close proximity to cell traps. Living mammalian immune cells are immobilized in the traps and their anti-body production is studied. White light is used to excite EOT while the integrated signal from the area of the array is monitored using a visible light spectrometer. Monitoring shifts in the SPR signal allows us to watch antibody-antigen binding dynamics from trapped cells.

8 **Template Assisted Synthesis of InSb Nanowires**

M. Beaudoin, H.J. Kim and J. Wang (UBC), A, Ahktari-Zavareh and K. L. Kavanagh (SFU)

InSb nanowires (NW) have been synthesized by pulsed electrodeposition using anodic alumina membranes (AAM) as templates. Two sets of AAMs were used: one set had 150 nm diameter pores and a porosity of 32% with a density of 2x109 pores/cm2 while the other set had 35 nm pores and 12% porosity with a density of 1010 pores/cm2. Both sets of membranes were 50 μm thick. The InSb AAMs were dissolved with a drop of NaOH and rinsed several times in deionized (DI) water and then dispersed in solution in an ultrasonic bath. The NWs were deposited on a native Si wafer with an eyedropper and dried on a hotplate at 120°C. Scanning electron microscopy (SEM) imaging shows that the free standing nanowires had uniform diameters but varied in length although they were all several μm long. Powder X-Ray Diffraction (XRD) shows that the 150 nm diameter nanowires exhibit polycrystalline properties with the <111> and <220> being slightly more prominent than the <331>, <422> and even <333> peaks and also showed the presence of an In metallic phase. However, Transmission Electron Microscopy (TEM) measurements performed on both sets of wires shows that the 35 nm diameter wires are amorphous while the 150 nm diameter wires may have some polycrystalline domains. Current efforts are aimed at improving NW crystallinity and harvesting method.

9	**Analytical Capability in the 4D LABS Nanofabrication Facility**
	Nathanael Sieb (SFU), Michael Wang (SFU), Grace Li (SFU), Tom Cherng (SFU), Mary Boysel (SFU)
	The 4D LABS Nanofabrication Facility is located at Simon Fraser University. We have several tools available for material and device analysis, to complement our extensive fabrication capabilities. These tools are located both outside and inside our class 100 Clean Room Facility. We look forward to discussing with you any of your fabrication needs.
10	**Additional Processing Capability in the 4D LABS Nanofabrication Facility**
	Nathanael Sieb (SFU), Tom Cherng (SFU), Grace Li (SFU), Philip Kubik (SFU), Mary Boysel (SFU)
	The 4D LABS Nanofabrication Facility is located at Simon Fraser University. In addition to our lithography and physical vapor deposition equipment, we have many tools for other fabrication processes. These systems include reactive ion etchers, thermal depositions systems, and robotic processing tools. We have extensive fabrication capabilities within our class 100 Clean Room Facility and we look forward to discussing with you any of your fabrication needs.
11	**Strain Balanced InAs/InAsSb Superlattice Detectors**
	D. Lackner (Physics, SFU), O. J. Pitts (Present address: CPFC, NRC Institute for Microstructural Sciences, Ontario, Canada), E. Plis (Center for High Technology Materials, University of New Mexico, USA), M. Steger (Physics, SFU), A. Yang (Physics, SFU), M. L. W. Thewalt (Physics, SFU), S. P. Watkins (Physics, SFU)
	Currently there is a growing interest in developing III-V alternatives to mercury-cadmium-telluride photo-detectors for the mid to long infrared wavelength regime. We present a concept, suitable for OMVPE growth, based on InAsSb/InAs strain balanced superlattices. We show initial detector results with detectivity at 9 microns at 77 K which prove that the InAsSb/InAs band-lineup is definitely type II, as type I and type II detection is measured within the same sample. One major challenge of this material is surface conduction since InAsSb forms a two dimensional electron gas at the semiconductor-air interface. This surface conduction channel shunts the p-n junction and leads to high dark currents. For the case of an InAsSb homojunction detector we show, that by introducing an InPSb top layer to form a heterojunction detector, this challenge can be overcome. Due to the higher band gap of InPSb, dark currents are lowered and a higher internal field to separate the carriers can be created, which increases the detector performance even further.
12	**Pros and cons of using Ln3+ - doped NaYF4 upconverting nanocrystals as imaging agents in upconversion two-photon upconversion laser (scanning and wide field microscopy)**
	Jothirmayanantham Pichaandi and F.C.J.M van Veggel (Chemistry, University of Victoria, Kerry R Delaney(Biology, University of Victoria)
	The spatial resolution (SR) obtained imaging a mouse from two-photon upconversion (laser scanning microscopy (LSM) and wide field microscopy (WFM)) has been elucidated. Ln3+ ions doped NaYF4 nanocrystals (NCs) were used for imaging and results were further substantiated with experiments using agar-milk gel (artificial phantom). To obtain images with SR (x-y plane) from using 800 nm emission from Tm3+ ions, LSM took a long time in the order of an hour due to the slow photocycle coupled with few number of photons/sec released per NC. The other drawback was SR (z-axis) was not observed due to the high power density required to get enough photons/sec to obtain images with good signal to noise ratio. The sole advantage is that images with SR (x-y plane) could be obtained at a depth of ~ 900 μm which is twice better than the green emission (500 μm) used by organic fluorophores and quantum dots. To reduce the required time for imaging and still obtain images with SR, WFM was employed. When blood vessels inside the brain of a mouse was imaged with 800 nm emission from Tm3+ ions, images showed SR and a stack of images over a depth of 100 μm was obtained in a few minutes. The difficulty encountered with WFM is that we cannot get images with spatial resolution (x-y plane) at depths of more than ~ 500 μm which is twice better than green emission (250 μm).
13	**Ab Initio Calculations of Activation Energies for Diffusion in Mg**
	Liam Huber (UBC), Joerg Rottler (UBC), Matthias Militzer (UBC)
	Ab initio simulations of metals provide an extremely useful tool for collecting information that is challenging to collect from real-world experiments. The results of such calculations—in addition to providing novel insights in their own right—can be used to provide input for continuum models that can be used to describe processing of metals. In our poster we present applications of computer simulations to magnesium, which has recently become of renewed scientific interest but for which there has been surprisingly little computational work done so far. In particular we examine the activation energies of various solutes for bulk diffusion in Mg.
14	**An Achroplanatic TEM for Electron Holography and Electron Vortex Beams**
	Rodney Herring (UVic)
	A forefront, state-of-the-art electron microscope and some exciting, new electron microscopy methods will be presented. This microscope is the first achroplanatic Transmission Electron Microscope. It has sub-50 pm spatial resolution over a wide field of view and an electron energy spread of 0.3 eV. Energy-filtered diffracted electron beams are interfered to measure the spatial coherence of phonons, surface plasmons, and bulk plasmons in crystals and amorphous materials. The angular intensity dependence of the inelastically scattered electrons also enables their filtration from other electron intensities. By combining energy filtering methods, the lateral spatial coherence of phonons responsible for electron scattering to high angle (16 mrad) have been measured (0.095 of the wavevector). Electron vortex beams have recently been created by passing a plane wave beam of the TEM through a phase mask having a dislocation in its center. These spiraling beams, with a high quanta (up to 100) of orbital angular momentum, will be useful for atomic and subatomic scale manipulations of atoms and electrons. They will induce currents in superconductors, apply magnetic fields at the nanoscale, make or break electronic bonds (tweezers), and enable the measurement of new pico-level information about a sample.
15	**Laser Ultrasonics : A new Technique for the in situ Monitoring of the Evolution of Microstructures**
	T.Garcin (UBC), M.Militzer (UBC), A.Moreau (IMI,CNRC), F.Fazeli (UBC), M.Maalekian (UBC), M.Lord (IMI,CNRC), W.Poole (UBC)
	A Laser Ultrasonic Sensor is about to be installed in the Materials Engineering the UBC. As an attachment to the already existing Gleeble 3500 thermomechanical simulator, it will open a variety of new approaches to monitor the evolution of microstructures in metallic materials. In this new technology, lasers are used for the generation and detection of ultrasound in the material. The changes in the acoustic parameters are then correlated to microstructure and material properties. Elastic properties, grain size, texture and phase transformations are examples of features that can be monitored with this technique.
16	**Austenite grain growth studies in Ti/Nb microalloyed steel using laser-ultrasonics**
	M. Maalekian (UBC), M.Militzer (UBC), A. Moreau (NRC-IMI), W.J. Poole (UBC)

Laser-ultrasonics is a state-of-the-art technique for the real time monitoring of grain size evolution in metals and alloys. In particular, the laser-ultrasonic technique offers the opportunity to measure austenite grain growth in low-carbon steels where it is challenging or even impossible to reveal the austenite microstructure with conventional metallographic methods. Using a novel laser ultrasonic technique, in-situ grain size measurements are conducted during continuous heating (10°Cs-1) and subsequent isothermal holding at various temperatures in the range of 950°C -1250°C. Based on the measured limiting grain sizes and using the advanced thermo-kinetic software MatCalc, an approach is developed to estimate the initial distribution of precipitates in the as-received material. Further, a grain growth model is developed, which includes the pinning effect of precipitates present in the steel. The proposed grain growth model successfully describes the observed kinetics of austenite grain growth.

17 **The Detection of Antibodies Secreted by Microfluidically Trapped Biological Cells via Extraordinary Optical Transmission Based Nanoscale Immunobiosensing Arrays**

S.F. Romanuik (SFU), S.M. Grist (SFU), B.L. Gray (SFU), N. Gulzar (SFU), J.K. Scott (SFU), D. Hohertz (SFU), K.L. Kavanagh (SFU), R. Nirwan (UVic), C. Hui (UVic), A.G. Brolo (UVic), and R. Gordon (UVic)

Therapeutic monoclonal antibody (MAb) production typically begins by screening thousands of cell lines to identify those secreting the high-affinity MAbs of interest (requiring 4-6 weeks to obtain 1-10 lines) [1]. We are developing a system to monitor the MAb production by thousands of cells on a single slide, to streamline this process. We previously trapped 17/9 hybridoma cells within biocompatible PDMS microwells [2-4] and detected their secreted MAbs using arrays of nanoholes perforating a gold film [3-4]. When optically excited, these nanoholes produce surface plasmon (SP) polaritons with a resonance (SPR) sensitive to the permittivity near the gold surface. We detect the binding of secreted MAbs to immobilized antigen via the induced SPR shifts observed within the extraordinary optical transmission through the nanohole arrays. This poster presents the SPR shifts of two slides exposed to MAbs secreted by trapped 17/9 hybridoma cells (~200 cells/trap). The specific Bio-HA binding yields a significantly larger shift than the nonspecific Bio-2F5 binding. This work demonstrates significant progress towards our desired system.
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18 **Novel Carboxyl-Amine Bonding Methods for Poly(dimethylsiloxane)-Based Devices**

Eric Ouellet*(1,2,3), Cheng Wei T. Yang*(1,2), Tao Lin(1,2), Lee Ling Yang(1), and Eric T. Lagally(1,2,3)
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1 Michael Smith Laboratories, UBC, 2 Chemical and Biological Engineering, UBC, 3 Biomedical Engineering Program, UBC

We present a novel bonding technique for poly(dimethylsiloxane) (PDMS)-based devices employing chemical surface modifications at room temperature. PDMS surfaces were functionalized to present primary amine groups, and glass or gold substrates were functionalized to present carboxylic acid groups. Irreversible bonding was achieved by bringing the two surfaces in contact and reacting at room temperature to form peptide bonds between the substrates. Shear tests reveal the bond strengths achieved to be comparable to values obtained using conventional bonding methods. We also describe the use of carboxyl-terminated silanes on gold surfaces to bond amine-modified PDMS devices. Water contact angle measurements and X-ray photoelectron spectroscopy (XPS) confirmed the presence of carboxyl-terminated silanes on gold surfaces. Cyclic voltammetry (CV) and concentration-based bonding measurements further examined the conjugation, a novel result that expands the variety of surface chemistries available for such bonding.

19 **Synthesis of Ultra-small NaGdF4 Nanoparticles: Efforts to understand their T1 MRI contrast Enhancement**

Noah J. J. Johnson, Frank C. J. M. van Veggel* (Chemistry, UVIC)

Gadolinium doped inorganic nanoparticles are widely explored for their potential as contrast agents in Magnetic Resonance Imaging (MRI). However, uniform nanoparticles of this class of materials with high relaxivity are yet to be achieved and have greatly impeded the understanding of their contrast enhancement mechanism. The surface to volume (S/V) ratio increases drastically for nanoparticles below 10 nm and this size range is ideal to study the individual contributions of “surface” and “bulk” ions towards MRI contrast enhancement. Uniform NaGdF4 nanoparticles with size tunability from 2.5 – 8.0 nm were developed by a controlled nucleation and growth process in high boiling organic solvents. Phase transfer of the nanoparticles to water was done using a simple ligand exchange strategy with polyvinylpyrrolidone and the size dependent MR relaxivity determined at clinical magnetic field strength (1.5 T). The uniform size and shape allowed for the calculation of relaxivity based on mass of nanoparticle, per nanoparticle and total surface area, to understand the parameters responsible for the T1 relaxivity enhancement. Two parameters are found to be responsible for the contrast enhancement, the surface to volume (S/V) ratio and the nanoparticle tumbling time (τR), showing a counteractive effect along the size range. These nanoparticles are thus promising candidates to be explored as next generation MRI contrast agents.

20 **A Comparison of Grain Morphologies with Phase Field Predictions in Three Dimensions**

I. M. McKenna (UBC), M. P. Gururajan (Indian Institute of Technology – Bombay), S. O. Poulsen (Risø National Lab), D. J. Rowenhorst (Naval Research Laboratory), E. M. Lauridsen (Risø National Lab), P. W. Voorhees (Northwestern University)

We employ phase field simulations to study the evolution of grains in a single phase titanium alloy. In order to understand how the local grain environment effects grains during coarsening we have developed a set of tools to analyze the topology and morphology of individual grains. Furthermore, we have developed a model capable of simulating materials with varying levels of anisotropy in the grain boundary energy with respect to all five macroscopic degrees of freedom. For validation of the predictive capabilities of the model we utilize two experimental datasets: an x-ray tomography sample and a serial sectioned sample. The x-ray tomography data is taken in-situ making it possible to directly compare the morphology of individual grains computed using the phase field method with that observed experimentally. Despite the complex physical phenomenon occurring during grain growth, the comparison between the experiment and phase field simulation reveals clear evidence of regions with excellent agreement. Most importantly we find poor agreement in other regions of the system, confirming that anisotropy of the grain boundary energy and mobility has an important influence on grain evolution.

21 **Microstructure Evolution in Copper Interconnects**

Nidal Alshwawreh (UBC), Matthias Militzer (UBC), Dan Bizzotto (UBC)

In advanced integrated circuit, copper replaced aluminum as the interconnect material of choice due to its better conductivity and higher reliability. However, microstructure evolution process in Cu interconnects that occurs at room temperature (i.e. self-annealing) is still not well understood. Hence, a complete understanding of the microstructure becomes essential for the development of future microsystems. In this work, the microstructure evolution of electrodeposited copper thin films was investigated. The effect of varying the deposition conditions and annealing temperature was studied by in-situ electron backscatter diffraction (EBSD) and resistivity measurements. For completely self-annealed (i.e. recrystallized) 1 micron-thick films, about 20% drop in resistivity was recorded in a period of 10 to 200 hours. The rate of self-annealing increased with the deposition rate. Also, films as thick as 500 nm underwent a very slow self-annealing even when produced at high deposition rate (e.g. 40 mA/cm2). Moreover, the process was found to be thermally activated with 0.93 eV activation energy. A good correlation was observed between the fractions recrystallized obtained from resistivity and EBSD maps. Also, the recrystallized grains appeared to have lower local orientation spread and higher EBSD image quality which may indicate lower dislocation density.

22 **Study of the interaction of solutes with interfaces in iron using density-functional theory**

H. Jin (UBC), I. Elfimov (UBC) and M. Militzer (UBC)

Substitutional alloying elements significantly affect the austenite-ferrite phase transformation rates in steels. However, the detailed mechanisms of their interaction with the moving interfaces are not fully understood. To gain insight into the solute-interface interaction density functional studies have been carried using VASP. Simulations have been performed for a Σ5 grain boundary in bcc-Fe containing important alloying elements, e.g. Mn, Mo, Nb and V, to determine the binding energies of these solutes to the grain boundary and their activation energies for diffusion along and across the boundary. Further, the interactions of different solutes at the grain boundary have been investigated. This study confirms the strong interaction of Nb with interfaces that is consistent with experimental observations of the effects of Nb in solution in delaying the austenite-to-ferrite transformation.

23 **Bosch-like Method for Creating High Aspect Ratio Poly(Methyl Methacrylate) (PMMA) Structures**

Marius Haiducu, Ash Parameswaran (SFU)

This paper presents a method for etching millimetre-deep trenches in commercial grade poly(methyl methacrylate) PMMA using deep-UV at 254 nm. The method is based on consecutive cycles of irradiation and development of the exposed areas, much like a Bosch process for silicon. The method reported here differs from the authors' previous work in that it increases the aspect ratio of the microfabricated devices (trenches deeper than 120 μm were impossible to be made previously) and alleviates the resulting negative sidewall, which is due to the uncollimated nature of the irradiation source. As such, considering the outcomes of this process and the insignificant costs associated with it, this procedure represents a true 'poor man's LIGA.' PMMA exposure for this work was performed using an in-house-built irradiation source equipped with twelve 25 Watt low pressure mercury vapour ultraviolet lamps. The PMMA samples underwent cycles of semi-collimated irradiation followed by development in a mixture of 7:3 IPA:H2O at 28 °C. Light semi-collimation was obtained using a stainless steel honeycomb grate. The outcome of this process can be used as is (for example for creating microfluidic devices) or as a template (or mould) to microfabricate 3-D structures on the micron-to-millimetre scale.

24 **Polarized Light Microscopy Study of Pb(In1/2Nb1/2)O3 - Pb(Mg1/3Nb2/3)O3 -PbTiO3 Ternary Piezoelectric Single Crystal**

Zihe Ren, Alexie A. Bokov, Z-G Ye(SFU)

The complex perovskite solid solution system, PIN-PMN-PT has become one of the most promising high-performance piezoelectric materials for the next generation of electromechanical transducers and actuators applications. In this work, systematic study was carried out on ceramic samples to locate the morphotropic phase boundary (MPB) of the ternary system and to identify the optimum compositions for piezoelectricity. Polarized light microscopy (PLM) was carried out to examine the domain structure and to analyze the phase symmetry and phase component of the grown crystals. In PIN-PMN-PT single crystals, coexistence of rhombohedral, tetragonal and an unknown low symmetry phase are found by PLM. The results will be discussed based on the ternary phase diagram.

25 **Liquid crystalline properties of rigidly linked discs**

Nasim Seifi, E-Johan Foster, Vance E. Williams (SFU)

Discotic liquid crystals (D LC) have attracted much attention for their desirable physical properties for semicoducting applications such as field - effect transistors, OLEDs, and photovoltaic devices[1]. Our research group is interested in developing new class of disc-shaped molecules based on dibenzo[a,c]phenazines which are obtained through modular synthesis and introduced as a versatile precursor to synthesis of more extended structure such as oligomers and dimers. The effect of the molecular shape and functional groups was investigated in order to understand the relationship between the structures and the propensity of these molecules to form columnar mesophases. Our lab efforts to construct extended discotic molecules and the study their self-assembly will be discussed.
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26 **The interplay of surface energy and depolarizing field on the domain evolution of a thin-film ferroelectric materials**

A. T. Wicaksono (UBC, formerly National University of Singapore NUS), N. Ng (Institute of High Performance Computing IHPC, Singapore). R. Ahluwalia (IHPC), S. J. Chua (NUS)

Stability of the polarized-state of a thin-film ferroelectric (FE) material is an important reliability aspect of micro/nanoelectronic devices such as FE memories, FE transistors and FE microwave antenna. In this work, the stability issue of a FE material was examined from a simulation perspective. More specifically, the work studied the behaviour of a strained thin film barium titanate (BaTiO3) under the presence of two factors, surface energy and depolarizing field. When either or both of these factors exist, an initially uni-polarized (monodomain) film may no longer be stable and can switch into multidomain state--a state which is undesired in most practical applications. The work utilized phase-field method to study the evolution of ferroelectric domain. The simulation results demonstrated good agreement with the theoretical model and published experimental data.

27 **Looking into the Nano-Imaging Facility**

Li Yang, and Karen L. Kavanagh, Nano-Imaging Facility, 4D Labs, SFU

The Nano-Imaging Facility is part of the Pacific Centre for Advanced Materials and Microstructures (PCAMM) and 4D Laboratories. Situated at SFU Burnaby Campus, it consists of a collection of electron and scanning probe microscopes. It is our mission to provide hands-on access with user training and technical assistance for nanoscale analysis of composition, phase, and morphology of a wide variety of solids, including: inorganic materials and devices, biological and medical samples, rocks and minerals, and anything else that is compatible with vacuum environments. We welcome all new and old users. This poster highlights some of the recent results from our users from SFU, UBC, U Vic, University of Alberta, and NRC. More examples and full details about the facility are found on our website: http://nanoimaging.sfu.ca. You may also call 778-782-3812 contacting Li Yang to book an appointment or lab tour.

28 **Travelling Heater Method Growth of Telluride and Antimonide Crystals Using Tapered Crucibles**

Jordan Roszmann, Sadik Dost, Brian Lent (UVic)

Tapered crucibles are being used to reduce the cost of travelling heater method (THM) growth of compound semiconducting crystals. THM is a solution based method for producing high quality crystals of binary and ternary compounds. THM is very costly, though, due partly to the high cost of seed crystals, which are typically the same
diameter as the product. Tapered crucibles have been employed to grow GaSb crystals at 25 mm diameter using 10 mm diameter seeds, and at 50 mm diameter using 25 mm diameter seeds. Experiments are underway to repeat these results using CdTe. These 84% and 75% reductions in seed volume are very significant because even 10 mm diameter crystals of CdTe cost well over $1000. The current study aims to maximize the reduction in seed diameter and minimize the axial length of the transition region while maintaining a favourable growth interface shape. Polycrystalline ingots have been produced by unseeded THM and vertical gradient freezing, and seed crystals with <111> orientation are being core-drilled from large grains in these ingots.

29 **Progress Towards Coupling Pb-based Nanocrystal Excitons to Silicon Photonic Circuits at Room Temperature**

Ellen Schelew (UBC), Keith A. Abel (UVic), Haijun Qiao (UBC), Charles Foell (UBC), Simon Dickreuter (UBC), Georg W. Rieger (UBC), Stephen Hughes (Queen's), Frank C.J.M van Veggel (UVic), Jeff Young (UBC)

	It is our goal to efficiently couple the electronic resonance in Pb-based semiconductor nanocrystals to low-loss, single mode waveguides in silicon photonic chips. Applications of such devices include non-classical light sources and coherent transfer of quantum information from electrons to “flying photons”. A major step forward has been the successful fabrication of a 6” silicon wafer with thousands of fully integrated cavities/waveguides/I-O couplers. Facilitated by CMC, the chips were made by IMEC. There has also been significant progress made by the University of Victoria group on improving high-temperature performance of the Pb-based nanocrystals. Much work has been done to better understand the behaviour of the excitons in PbSe nanocrystals. This included a detailed analysis of the temperature dependence of the full emission lineshape of thick film PbSe. The saturation behaviour of the cavity coupled emission has also been experimentally studied and modelled.
30	**Investigation of the Various Impacts of Curvature on the Optical Absorption Properties of Carbon Nanotubes**
	Saloome Motavas (UBC), Andre Ivanov (UBC), Alireza Nojeh (UBC)
	The electronic and optical properties of carbon nanotubes are known to be highly dependant on their diameter. For small-diameter nanotubes, the curvature of the nanotube sidewall has shown to significantly influence their electronic structures. This curvature can result in different effects such as (1) rehybridization of the sigma-pi orbitals, (2) bond length change after geometry relaxation, and (3) rehybridization of d-pi orbitals. In this work, we use first-principles/density functional theory calculations to investigate the effect of each of these phenomena on the electronic structure and consequently the optical absorption properties of carbon nanotubes. For this purpose, we simulate three zigzag nanotubes with considerably different diameters ((4,0), (8,0) and (16,0) nanotubes with diameters of ~0.34, ~0.63, and ~1.27 nm, respectively) and compare their band structures, optical transition energies, transition dipole moments, and optical absorption spectra. We show that while the effect of d-pi rehybridization can be negligible, sigma-pi rehybridization and bond length change after geometry optimization can highly affect the absorption spectra of nanotubes with small diameters. For example, sigma-pi rehybridization results in 64.2% change in the first optical transition energy of a (4,0) nanotube. This change is 6.8% and 5% for (8,0) and (16,0) nanotubes, respectively.
31	**A New Unified Model for SiGe Interdiffusion over the Full Germanium Concentration Range**
	Yuanwei Dong (UBC), Yiheng Lin (UBC), Guangrui Xia (UBC)
	A new model was established for SiGe interdiffusion in tensile or relaxed Si1-xGex over the full Ge content range ($0 \le x \le 1$). The model is based on the correlations between Si and Ge self diffusivity, intrinsic diffusivity and interdiffusivity. It unifies available interdiffusivity models over the full Ge range in the temperature interval from 800 and 900 °C. This model has already been implemented in major process simulation tools to predict SiGe profiles after thermal processing. The simulation results showed excellent consistency with experimental data.
32	**The design of a full photochromic and electrochromic dithienylethene**
	Andreea Spantulescu (SFU), Neil Branda (SFU)
	Dithienylethenes DTE(s) are photochromic molecules: they harvest light (sun light) and isomerise from a colourless to a coloured state. A less advertised property of DTE(s) is their electrochromic behaviour, a colour change can be accomplished by a burst of electricity (in the dark). Due to this dual response, DTE(s) can be incorporated in devices that rely on colour change: ophthalmics and electrochromic windows. Whereas all DTE(s) undergo a bidirectional colour change with light, only one of the states can be achieved with electricity. The isomerisation reaction through oxidation or reduction is therefore unidirectional. To date there is only one example of DTE that exhibits bidirectional electrochromism, through reduction, the coloured state is obtained and oxidation yields the colourless state. This particular DTE does not meet the three requirements necessary for a working device: photochemical stability, electrochemical stability and thermal stability (of the coloured state). In the present work is shown a logic design of a dual response DTE that accounts for each functional group appended the general backbone of the DTE. So far two compounds have been synthesized and studied and the photo-electrochemical behaviour and thermal stability will be presented.
33	**Growth of high quality ZnO by Metalorganic Chemical Vapour Deposition**
	Z.W. Deng, D.C. Li, H. Huang, S.P. Watkins (SFU)
	ZnO is a very challenging material with great potential for optoelectronic applications. Metalorganic chemical vapour deposition is a preferred technique for large scale growth of III-V and II-VI materials. In this poster we review work performed at SFU on the growth and characterization of epitaxial ZnO films. We report the observation of extremely sharp exciton transitions at 4.2K with linewidths as low as 0.2meV, which enable us to identify the sources of residual shallow donors in the material. Photoluminescence spectroscopy is used to identify trends in material quality as a function of growth conditions such as temperature, precursor chemistry, dopant source, and VI:II ratio. Schottky devices with promising rectifying behaviour have been fabricated by a photolithographic process using Au top contacts. Surface morphology remains a key challenge for this material when grown on sapphire substrates.
34	**Vibration Detection Using Zinc Oxide Nanowire Sensor**
	Derek Tsan (UBC), Lisheng Wang (UBC), Konrad Walus (UBC), Boris Stoeber (UBC)
	A vibration-sensitive device based on zinc oxide nanowires is presented. Zinc oxide is a piezoelectric material, which generates a voltage in response to an applied stress, and nanowires of zinc oxide are known to exhibit higher piezoelectric response compared to bulk material [1]. In this device, vertically-aligned nanowires are grown on a copper substrate using a hydrothermal growth method. Electrodes made of conductive polymer PEDOT:PSS are deposited on top of the nanowires to ensure good electrical contact. The response of the sensor is evaluated using a commercial piezoelectric actuator as a vibration source. Such a device could be used for structural health monitoring, to identify vibrations generated from newly formed micro-cracks within a structure. A network of sensors placed around the structure could be used to triangulate the precise location of the crack based on the time response of each sensor. [1] R. Zhu, D. Wang, S. Xiang, Z. Zhou, X. Ye, “Piezoelectric characterization of a single zinc oxide nanowire using a nanoelectromechanical oscillator,” Nanotechnology, vol. 19, 2008.
35	**Analysis of Defects in Self-Assembly Monolayers (SAMs)**
	Gong, Yuanyuan; Zhang, Xin; Wang, Michael C.P.; Gates, Byron D.. SFU, Chemistry and 4D LABS
	A popular and simple technique for modifying the surface properties of a material is through the growth of self-assembled monolayers (SAMs). These single molecule thick layers are used for a variety of applications, such as resisting the non-specific adsorption of proteins for applications in biosensors or medical devices. Other applications include the use of SAMs as a low friction coating on materials. In order to pursue these and related applications, we are interested in the integrity of fluorocarbon containing silane based SAMs on silica surfaces. Silica is of particular interest for both its relatively low cost and widespread acceptance as a substrate for the construction of biosensors and medical devices. These substrates are typically modified with silane-based SAMs, which are prone to a variety of defects. The goal of our research is to minimize the defects associated with SAMs coating silica surfaces. A variety of techniques (e.g., X-ray photoelectron spectroscopy, ellipsometry, and water contact measurements) have been used in order to assess the quality of these monolayers. Through the use of these techniques a new methodology is proposed for minimizing the level of defects within these silane-based SAMs.
36	**Design and Characterization of a Compact Optical Device Based on Mach-zehnder Interferometer in Silicon on Insulator Technology**
	Conrad Rizal (UBC)

A compact optical device consisting of a Mach-zehnder interferometer and 2×3-dB couplers was designed using DW-2000® and fabricated using silicon on insulator technology. The optical characteristics of the device was analyzed using transfer matrix method whereas Mode solutions® and Matlab® were used to verify its single mode operation and optimize its geometrical parameters. The performance of the device was analyzed using finite difference time domain simulation tool and the results were compared with the experiment. The device exhibited periodically repeating transmission curves with an extinction ratio of ~ 7.5 dB. Theoretically predicted transmission spectra using transfer matrix method corresponded to the experimentally measured transmission spectra with the discrepancy of ~10% values. The measured transmission spectra showed periodicity with the peak to peak separation of ~ 0.35 nm. Also, the free spectral range of the device was constant with the change in temperature. The temperature dependent spectra showed sensitivity to effective refractive index changes, suggesting that this device can be used as an optical sensor.

37 **All-Polymer Acoustic Wave Devices for Chemical Sensing**

Robert Busch (UBC), Derek Tsan (UBC), Konrad Walus (UBC), Boris Stoeber (UBC)

Volatile organic compounds (VOCs) are known to have negative effects on human health and contribute to smog. In order to monitor the spatial variability of VOC levels in real-time to assure air quality or locate sources of pollutants, it is desirable to have a distributed network of sensors. Low-cost, yet highly sensitive chemical sensors could help reduce the expenditure of setting up such a network. The objective of this work is to investigate the capabilities of a low-cost, all-polymer acoustic wave chemical sensing platform. Polyvinylidene fluoride (PVDF) was used as the piezoelectric substrate and poly(3,4-ethylenedioxythiophene) poly(styrenesulfonate) (PEDOT:PSS) as the interdigital transducer (IDT) electrode material. The IDTs are deposited onto the PVDF films using inkjet micropatterning. A minimum track width of 55µm was achieved using a 20µm nozzle. IDTs with an interdigital spacing of 200 and 400µm were patterned. Laser Doppler vibrometry was used to characterize the out-of-plane motion exhibited by the transducer upon applying an AC voltage. These measurements revealed that films under tension have less acoustic damping than untensioned films, allowing acoustic waves to propagate far across the substrate. These results demonstrate the potential for making a chemical sensor using this platform.

38 **Investigation of the growth of GaAs and InAs/GaAs core-shell nanowires using different group III precursors**

O. Salehzadeh, S. P. Watkins (SFU)

Fabrication of core-shell semiconductor nanowires (NW) is required for the fabrication of nano scale photonic and electronic devices such as NW solar cells and NW field effect transistors. Various mechanisms have been utilized for the fabrication of these devices such as vapor-liquid-solid (VLS) mechanism where commonly employs the Au NPs to drive the NW growth. Most prior works on GaAs NWs grown using metalorganic vapor phase epitaxy (MOVPE) employs the precursor trimethylgallium (TMGa) as group III precursor in conjunction with tertiarybutylarsine (TBAs) as group V precursor. Traditionally, since the increase of growth temperature enhances the lateral growth of the NWs, the increase of growth temperature has been employed for the growth of TMGa-based shell structures. However, we show that the use of triethylgallium (TEGa) as group III precursor allows us to grow the shell structure even at low temperatures. We show that the use of TEGa for the growth of GaAs NWs enhances the lateral growth of the NWs due to its much higher decomposition efficiency at low temperatures. Finally, we demonstrate the fabrication of InAs/GaAs core-shell structure using trimethylindium (TMI) and TEGa as group III precursors for the fabrication of InAs core and GaAs shell at 400 °C.

39 **Control DTE Photochromism and Use DTE to Modulate Reactions**

Tuoqi Wu (SFU)

Diarylethenes (DTEs) are photochromic molecules bearing a hextriene back bone. The DTE molecules can be switched between colored and colorless form upon UV or visible light irradiation. By decorating DTE hextriene backbone with different functional groups or changing the cyclopentene skeleton, every DTE shows unique properties. Our research utilizes the photochromism and structure-function relationship of DTE molecules to create outstanding applications. The first application is about how to control a DTE photochromism to sense certain chemical species. The second application proves a photorelease process can be monitored based on a ‘release and report’ concept via using a DTE precursor. The third application shows a potential of using external stimulus such as light to modulate a chemical reaction by modulating Lewis acidity of a DTE molecule. All the results suggest that specially designed DTE molecules can do variety tasks that have promising applications to research and industry.

40 **Arbitrarily shaped films of aligned carbon nanotubes using inkjet printing**

Simon Beyer, Konrad Walus (UBC)

Controlling the position and orientation of carbon nanotubes (CNTs) from solution is a fundamental requirement of their successful application in electronic devices, particularly those with a polymer substrate. Here we demonstrate a method of creating arbitrary patterns of aligned CNTs without using pre-defined substrate features or external forces. Simply by controlling the evaporation rate and suspension properties, we can cause the CNTs to self-assemble into highly aligned films. We attribute this self-assembly to a combination of internal fluid flow caused by the droplets evaporation and to the nematic liquid crystalline properties of highly concentrated CNT suspensions. Using inkjet printing we can create arbitrarily shaped droplets and can thus form any pattern of aligned CNTs. We have shown that the process is insensitive to substrate composition by demonstrating its success on both silicon and polyamide. This process represents a low cost, high throughput way of controlling the orientation of anisotropic nanoparticles from solution.

41 **RHEED assisted MBE growth of GaAs1-xBix Alloys**

M. Masnadi-Shirazi (UBC), R.B. Lewis (UBC), D.A. Beaton (UBC), T. Tiedje (UVIC)

Molecular Beam epitaxy (MBE) grown GaAs1-xBix is a promising new material with many potential applications, such as emitters and detectors in the IR and THz range. Incorporation of Bi into GaAs produces a large reduction in the GaAs bandgap (88meV/% [1]), however, Bi has a strong tendency to surface segregate, thus the growth of GaAs1-xBix is challenging. Incorporation requires careful control of growth parameters, especially the As2:Ga flux ratio. Reflection high-energy electron diffraction (RHEED) is used as a crucial tool in locating the optimum growth conditions. Phase diagrams for GaAs1-xBix (001) and GaAs (001) surfaces at temperatures from 250°C to 400°C have been investigated in this study. It is observed that the (1×3), (2×3), (2×4) surface phases are common between GaAs and GaAs1-xBix but a new metallic (2×1) surface is observed only with the presence of Bi and at low As2:Ga flux ratios. Superior crystal quality, higher Bi incorporation and stronger PL emission were observed for samples grown on (2×1) surfaces, compared to samples grown on (1×3) surfaces. Activation energy of Bi desorption is estimated from the growth conditions of this new phase.
[1] S. Francoeur et al. Appl. Phys. Lett., 82, 3874 (2003)

42 **SOI Nanophotonics Fabrication Course**

Miguel A. Guillén-Torres, Han Yun, Samantha Grist, Xu Wang, Wei Shi, Robi Boeck, Charlie Li, Jiali Yu, N. A. F. Jaeger, L. Chrostowski (UBC)

Due to its high refractive index contrast, Silicon-On-Insulator (SOI) nanotechnology allows for the miniaturization of photonic devices onto a single chip for applications including optical communications, filtering, sensing, and faster on-chip communications. Consequently, in the last few years there has been an increasing interest in this technology at the industry, research, and graduate teaching level. This unique Canada-wide course, held at UBC in collaboration with CMC and IMEC, focuses on the design and characterization of nanophotonic devices based on SOI technology. We present an overview of some of the designs previously investigated and published as part of this course as well as the some of the designs of the third generation, currently being fabricated by our collaborators at IMEC Belgium.

43	**Surface Chemistry of Crystalline Selenium Nanostructures**
	Wang, Michael Chih-Pin; Gates, Byron D. (SFU)
	The surface chemistry of crystalline selenium nanostructures has been elusive. Understanding their surface chemistry is an essential component of incorporating these materials into various end applications. This understanding is important both from a materials processing perspective as well as from an application perspective. Of particular interest are selenium nanowires (Se-NWs) that can be made in gram-scale quantities, but are relatively difficult to process. One approach to controlling the surface chemistry of these nanostructures is through the use of surfactants that are suitable for many solvents. Another approach being developed is the ability to covalently couple molecules to the surfaces of Se-NWs. In order to do so, a range of surface sensitive spectroscopy techniques (X-ray photoelectron spectroscopy, energy dispersive X-ray spectroscopy, secondary ion mass spectrometry, and high resolution electron microscopy) are used to determine the success of various surface modifications. An application being pursued for the Se-NWs is absorbance of solvent molecules into porous membranes assembled from the nanostructures. The surface chemistry of these membranes can be selectively altered to absorb specific solvents.
44	**Silicon-on-insulator resonators integrated with PDMS microfluidic channels for applications in biosensing**
	Samantha M. Grist, Jonas Flueckiger, Jiali Yu, Wei Shi, Karen C. Cheung, and Lukas Chrostowski (Electrical and Computer Engineering, UBC)
	Evanescent field sensors such as surface plasmon resonance and planar waveguide sensors are amongst the most popular optical techniques for sensitive and label-free biomolecular detection. Silicon-On-Insulator (SOI) photonic microring resonators in particular have shown promising potential for real-time detection of biomolecules because of their high sensitivity towards surface binding events. It has been previously shown that SOI waveguides with dimensions smaller than the wavelength of light have a strong evanescent field at the waveguide surface. Hence the presence of surface bound molecules or molecules in close proximity to that surface alters the resonance conditions of the resonators. We use Lumerical FDTD and MODE solutions to study racetrack resonators, folded resonators, slot waveguide resonators and disk resonators in order to optimize the design (parameters such as waveguide width, gap width, coupling parameters, shape, and bend radii) for eventual applications in biosensing. The SOI substrates with the planar waveguides are integrated with a PDMS microfluidic network fabricated by soft lithography to individually expose each resonator to solutions of different optical properties. Initial measurements of racetrack resonators demonstrate Q-factors of >30 000 in air and >10 000 when exposed to water.
45	**Experimental Demonstration of the Vernier Effect Using Series-Coupled Racetrack Resonators**
	Robi Boeck (UBC), Nicolas Jaeger (UBC), Lukas Chrostowski (UBC)
	We present an explanation of the theory and experimental results of the Vernier effect using series-coupled racetrack resonators. The Vernier effect is experimentally verified with an extended free spectral range of 35.96 nm and an interstitial resonance suppression of more than 9 dB. For the purpose of comparison, we present measurements made on individual racetrack resonators having the same design parameters as the resonators within the Vernier effect device in order to show that the Vernier effect, in fact, has been achieved. Devices exhibiting similar performance to the one reported here should be useful in applications such as wavelength division multiplexers and optical sensors.
46	**Electrodeposition of Metal on GaAs Nanowires**
	Chao Liu, Omid Einabad, Simon Watkins, Karen Kavanagh (SFU)
	Copper (Cu) electrical contacts to freestanding gallium arsenide (GaAs) nanowires have been fabricated via electrodeposition. The nanowires are zincblende (111) oriented grown epitaxially on n-type Si-doped GaAs (111)B substrates by gold-catalyzed Vapor Liquid Solid (VLS) growth in a metal organic vapour phase epitaxy (MOVPE) reactor. The epitaxial electrodeposition process, based on previous work with bulk GaAs substrates, consists of a substrate oxide pre-etch in dilute ammonium-hydroxide carried out prior to galvanostatic electrodeposition in a pure Cu sulphate aqueous electrolyte at 20-60C. For GaAs nanowires, we find that Cu or Fe has a preference for growth on the gold catalyst avoiding the sidewalls. After removing gold, both metals still prefer to grow only on top of the nanowire, which has the largest potential field.
47	**Morphology controlled fluorescence polarization in PbSe quantum-rods and crosses**
	Enrico Bovero (UVIC), Jeff F. Young (UBC), Stephen Hughes (QUEEN's), Frank C. J. M. Van Veggel (UVIC)
	PbSe nano-crystals (NCs) are interesting for two reasons: their optical properties are size dependent and their emission is in the NIR, which is attractive for Telecommunication and quantum optics. Elongated NCs are particularly interesting because their emission polarization and shape may improve the coupling with optical devices that have directional properties, such as nano-cavities, amplifier, nonlinear elements, etc. We overcame the tendency of PbSe to grow with a cubic aspect by using gold nano-particles as seeds to nucleate and stimulate a directional growth of PbSe crystals. We obtained nano-rods of 2 ´ 10 nm and nano-crosses of 4 ´ 25 nm as observed in TEM. By means of time resolved fluorescence anisotropy studies, we determined the size of the NCs and we observed that the polarization of the emission bands reflects the morphology of the particles. The presence of two perpendicularly polarized emissions coming from the same object makes these particles suitable as quantum switches. Studies are underway to examine NCs with different shapes, which can be obtained by varying reaction parameters like reaction temperature, time and composition.
48	**Surface-Directed Patterning of Polymer-Nanoparticle Assemblies on Microcontact-Printed Substrates**
	Saman Harirchian-Saei (UVic), Michael Wang (SFU), Byron Gates (SFU), Matthew G. Moffitt (UVic).
	In this work, glass substrates are patterned in alternating micron-scale stripes of hydrophilic and hydrophobic regions by microcontact printing (uCP). In the first part of the work these heterogeneous surfaces are used to direct the placement and orientation of Langmuir-Blodgett films of self-assembled amphiphilic block copolymers and Quantum Dots(QDs). Successively, the patterned substrates are used to direct the polymer-polymer phase separation and nanoparticle self-assembly. We demonstrated the ability to control the phase separation of polystyrene(PS) and polymethyl methacrylate (PMMA) blends. Our future goal is to control the assembly of PS-coated CdS (PS-CdS) QDs and PMMA-coated Ag (PMMA-Ag)nanoparticles.