PCAMM 2018 Poster Program

1. Bandgap tunable Zn3-3xMg3xN2 alloy for earth-abundant solar absorber
Peng Wu, Tom Tiedje(UVic)

Abstract: Zn3-3xMg3xN2 alloy layers with x<=0.3 can be epitaxially grown at a temperature as low as 140 °C. The bandgap (Eg) of Zn3-3xMg3xN2 widens from 1.2 to 2.5eV with increasing x. The Eg value of 1.4eV is obtained at x=0.18, and the x= 0.18 film has a large absorption coefficient (10E4-10E5cm-1) in the visible region. The Zn3-3xMg3xN2 with Eg=1.4eV shows n-type conductivity with a reasonably high electron mobility of 47cm2/Vs. Therefore, Zn3-3xMg3xN2 is a candidate for an earth-abundant solar absorber that can be fabricated at low temperatures.

2. High-Frequency Transistors and Circuits Using 2D Nanomaterials Beyond Graphene
Abdelrahman Askar, Michael M. Adachi(SFU)

Abstract: Not available

3. Axial EBIC oscillations at core/shell GaAs/Fe nanowire contacts
Mingze Yang, David Dvorak, Karin Leistner, Christine Damm, Simon P. Watkins, and Karen L. Kavanagh

Abstract: Electron beam induced current (EBIC) measurements were carried out in situ in the scanning electron microscope on free-standing GaAs/Fe core-shell nanowires (NWs), isolated from the GaAs substrate via a layer of aluminum oxide. The excess current as a function of the electron beam energy, position on the NW, and scan direction were collected, together with energy dispersive x-ray spectroscopy. A model that included the effects of beam energy and Fe thickness predicted an average collection efficiency of 60%. Small spatial oscillations in the EBIC current were observed, that correlated with the average Fe grain size (30 nm). These oscillations likely originated from lateral variations in the interfacial oxide thickness, affecting the resistance, barrier potentials, and density of minority carrier recombination traps.

4. Subnanometer Gaps for Enhanced Raman Substrates
Eradzh Rakhmatov, Bruno G. daFonseca, Ali Khademi, Alexandre Brolo, Reuven Gordon

Abstract: Sub-nanometer gaps can cause extreme local field enhancements, and therefore they are used in surface enhanced raman spectroscopy (SERS). However, the fabrica-tion of this kind of substrates presents a challenge due to lack of a reliable technology that would produce consistent and uniform nanogaps. Currently, one of the ways to fabricate nanogaps is atomic layer deposition, followed by glancing angle ion miller or tape peeling method for planarization [1]. In this work, nanogaps were fabricated by using self- assembled monolayer (SAM) whose thickness is determined by the length of carbon chain. Focused ion beam was used to mill an array of squares on Au sample with a glass substrate. Then, after deposition of SAM, more Au was sputtered. Finally, the whole structure was stripped off using adhesive epoxy, exposing nanogaps whose thickness was determined by SAM. SERS mapping of these substrates showed extreme field enhancement along the gaps.

5. Self-filling microwell arrays (SFMAs) for tumor spheroid formation
Brent Godau, Amir Seyfoori, Ehsan Samiei, Neda Jalili, Mehdi Rahmanian, Leila Farahmand, Keivan Majidzadeh-A and Mohsen Akbari(UVic)

Abstract: Current methods of drug screening in cancer are limited by the high cost of in vivo testing and the inaccuracy of predicting the effects of a potential chemotherapy drug in 2D cell culture. 3D cell spheroids offer a promising solution to bridge the gap between 2D cell culture and in vivo screening by better mimicking the complex 3D cell networks, intercellular crosstalk, and nutrient supply distribution in cancer tissues. Cell spheroid generation offers a major cost benefit to high-throughput drug screening in that the amount of reagent and cell consumption is low. Current challenges in spheroid generation beg the question: how can spheroids be produced in a simple, scalable, cost-effective manner with reproducible control over the size and shape of the spheroids? Spheroid generation methods that rely on a scaffold or extracellular matrix (ECM) are at a disadvantage to matrix free methods due to their difficulty of use and expensive cost of production. Matrix free methods such as hanging drop culture, in which spheroids are formed in a droplet of media hanging from a surface, and force driven methods, in which cells are kept in suspension or flowed through microfluidic devices, are impeded by complexity and low yields, and lack of shape control and observability, respectively. Matrix free non-adhesive microwell arrays rely on a micro-molded design used to cast a non-adhesive material. The cells are then seeded in the microwells and form single spheroids in the recesses of the mold. This method offers many advantages: size and shape control, high yield, minimal labour, low shear stress, microscopic observability, and ease-of-use. We hypothesized that the use of high resolution additive manufacturing can be used to fabricate a mold in which microchannels from a central loading chamber distribute cells evenly to microwells to generate reproducible spheroids with high control over the shape and size. In this study, we employed the use of a custom dynamic light projection (DLP) 3D printer in which an ultraviolet (UV) crosslinkable resin is used in combination with DLP to produce high resolution molds layer-by-layer. The objective of this manufacturing and spheroid generation method is to: (i) simplify spheroid seeding and (ii) have control over spheroid size and shape. The self-filling microwell arrays (SFMAs) are fabricated by replica molding of the 3D printed molds in agarose. We characterize the fabrication process, demonstrate the ability to culture breast adenocarcinoma MCF-7 and glioma U87 in SFMAs and perform drug toxicity studies. We envision that the proposed innovative approach opens avenues of opportunities for high-throughput three-dimensional cell culture for drug screening and disease modeling.

6. Trapping Individual Upconverters Using Rectangle Nanoapertures

Amirhossein Alizadehkhaledi, Adarsh Lalitha Ravindranath, Adriaan L. Frencken, Ali Khademi, Mirali Seyed Shariatdoust, Frank C.J.M van Veggel and Reuven Gordon(UVic)

Abstract: Plasmonics have been used to enhance light-matter interaction at the extreme subwavelength scale. Intriguingly, it is possible to achieve multiple plasmonic resonances from a single nanostructure and these can be used in combination to multiply enhance the interactions. We report the optical trapping of a single Er^{3+} /Yb^{3+} co-doped up-converting fluorescent nanoparticle with rectangle aperture on gold sample using a continuous wave 980 nm single-beam laser. The laser also excites visible luminescence from the nanoparticles. This feature enables us to analyze the number of individual nanoparticles loading into a trap stage. We record the number of trapped nanoparticles using a CCD camera which also can be confirmed by measuring the variation in the laser intensity transmitted through the rectangle aperture. The rectangle aperture enhances the local field that serve in enabling trapping and enhancing the emission of up-converting nanoparticles. In addition, we investigate the impact of rectangle dimensions on the upconversion emission at the 550 nm and 650 nm. Results show a large enhancement of upconversion emission peaks for both 550 nm and 650 nm while sweeping through different lengths of rectangular apertures. This study could help improve the understanding of lanthanide upconversion nanoparticle interaction with plasmonic gold nanoapertures at the nanoscale level.

7. First Principles Study of n-type Dopants in Zinc Oxide

Manu Hegde and Simon Watkins(SFU)

Abstract: Zinc oxide (ZnO) is an excellent candidate for optoelectronic devices such as blue/UV light emitting diodes (LEDs), laser diodes and photodetectors. Stable n-type ZnO material can be successfully grown using approaches such as chemical vapor deposition, molecular beam epitaxy and metal organic vapor phase epitaxial techniques. In contrast, achieving p-type ZnO still remains a challenge due to large acceptor binding energies and self-compensating effects caused by native n-type point defects. There are several theoretical studies based on the density functional theory (DFT) formalism which attempt to understand the formation energy and charge transition levels of native defects and impurities in ZnO. In this work we investigate the behavior of substitutional group-III (Al, Ga and In) and group V (Sb and Bi) dopants in ZnO based on the plane-wave (PW) pseudopotential density functional theory (DFT) within the generalized gradient approximation (GGA) as well as the GGA+U level approach to overcome the under estimation of the bandgap. The calculations were performed by constructing a 72-atom ZnO supercell in which one of the Zn sites was replaced by X (X=Al, Ga, In, Sb, Bi). The total energy obtained from the DFT was used to calculate the formation energy of the impurities. The formation energy and charge transition levels obtained from our calculations further confirm the shallow n-type behavior of both group-III and group V impurities in ZnO. Group-V substitutional impurities Sb and Bi are predicted to behave as shallow donors in ZnO with modest formation energies. These results agree well with previously reported low-temperature photoluminescence studies on Ga and Sb doped ZnO nanostructures.

8. When Nano Meets Micro: Studying the Transport of Gold Nanoparticles in a Microfluidic Device

Karolina Papera Valente, Sapanbir Thind, Afzal Suleman, Alex Brolo(UVic)

Abstract: Chemotherapeutic drugs can penetrate healthy tissues by diffusion and convection. In a healthy tissue, the interstitial fluid is composed of an influx of nutrients and oxygen from blood vessels. In the case of cancerous tissue, the interstitial fluid is poorly drained due to the lack of lymphatic vasculature, resulting in an increase in interstitial pressure. Also, cancer cells invade a healthy tissue by pressing and pushing the surrounding environment, creating an increase in pressure inside the tumor and resulting in a large differential pressure between the tumor and the healthy tissue, resulting in an increase of extracellular matrix (ECM) stiffness. Therefore, due to high interstitial pressure in addition to matrix stiffening, penetration and distribution of systemic therapies are limited to diffusion, decreasing the efficacy of the cancer treatment. A strategy to mimic the ECM in vitro is to use hydrogels. Hydrogels are 3D networks composed of polymeric materials (natural and synthetic), capable of absorbing a considerable amount of water and swelling in aqueous medium, resembling in vivo tissues. In the proposed work, different types of hydrogels were injected inside of a microfluidic device in order to mimic the extracellular matrix of a cancerous tissue. Microfluidic devices allow the creation of an in vitro tumor environment that closely resembles the in vivo situation due to precise spatial and temporal control of nutrients, oxygen, and cytotoxic drug delivery and integrated biochemical and mechanical features. In addition to providing a more realistic in vitro environment for small-scale systems, microfluidic devices are cost-effective, requiring small reagent volumes, transparent, and can be used to perform high throughput assays. Therefore, the proposed work consisted of the development of a microfluidic system in order to mimic a tumor microenvironment in vitro. The microfluidic device contained a simplistic design with a central chamber and two lateral channels. The central chamber mimics the extracellular matrix of a tumor while the lateral channels simulate lymphatic/capillary vessels. A hydrogel-liquid interface was created with the aid of posts

between the central chamber and the lateral channels to allow contact between the two fluids. In addition, the proposed work systematically explored the transport of fluorescently labeled gold nanoparticles inside the microfluidic system, moving from the lateral channel towards the tumor microenvironment chamber, by tracking fluorescence. By tuning the hydrogel composition and concentration, the impact of the tumor microenvironment properties on the diffusion of gold nanoparticles was also evaluated.

9. Shape-Controlled Growth of Gold Surface Nanostructures
Sasan V. Grayli, Xin Zhang, Dmitry Star, Gary Leach(SFU)

Abstract: The size, shape and crystallinity of noble metal nanostructures play an important role in the resonant plasmonic excitation arising from free space coupling of photons with surface plasmons. The ability to control these parameters can be used as a powerful tool to tune the plasmonic characteristics of nanostructures. To exploit plasmonic effects in devices, it is not only necessary to control the nanoscale geometry of the plasmonic structures, but also to control their location on a surface, so they can be addressed with light or electricity. Here, the growth of surface nanostructures under the influence of various anionic species is demonstrated. We show that by exploiting the relative growth rates on different crystalline facets, we can create shape specific surface nanostructures. This approach can be used to form highly crystalline meta-surfaces with controlled shapes and sizes without the need for surfactants that are used in solution phase nanoparticle syntheses.

10. Molecular beam epitaxy growth of strontium bismuthate
Fengmiao Li (UBC)
Abstract: Not available

11. Low temperature photoluminescence study of CdZnTe
Mohamed Alshal, Thomas Tiedje(UVic)

Abstract: Low temperature photoluminescence of CZT has been studied. Excitation power and temperature dependence of PL has been investigated.

12. Synthesis and Characterization of New Au- and Ag-Based Plasmonic Alloy Materials
Yuan, Xiaoyun (Kelsy); Sasan V. Grayli; Gary W. Leach.(SFU)

Abstract: Confining the delocalized fields of electromagnetic waves to the nano-scale of metallic surface regions by exciting surface plasmons enables new methods of information transfer, energy conversion, red-ox chemistry and catalysis. Currently, Ag and Au are the most commonly used plasmonic materials, but neither is ideal. [1] Our goal is to synthesize and characterize new Au- and Ag-based alloy materials with improved plasmonic response, low optical losses and high chemical stability by employing an electroless reduction method to deposit the alloys through co-deposition of silver and gold ions. We have examined the deposition kinetics of the ions in solution, and characterized the resulting films. We have analyzed their optical and plasmonic properties using spectroscopic ellipsometry, their composition using X-ray photoelectron spectroscopy (XPS), and their crystalline structure and morphology using X-ray diffraction (XRD), scanning electron microscopy (SEM) and high resolution transmission electron microscopy (HRTEM). The chemical stabilities of the alloy films have also been addressed by examining their stability upon exposure to various oxidants. Nanostructured alloy films deposited through electron beam lithography (EBL) yield large area high quality crystalline nanopillar arrays. These metamaterials demonstrate plasmonic response determined by pillar

diameter, periodicity and composition. The development of new high quality, crystalline, plasmonic alloy materials will enable new and improved performance in plasmonic and metamaterial research and application.

13. 4D LABS: An Open-Access Materials Research Facility
Nathanael Sieb(SFU)

Abstract: 4D LABS is an applications- and science-driven materials research facility at Simon Fraser University. We offer access to multiple facilities housing state-of-the-art equipment for academic, industrial and government researchers. We focus on accelerating the Design, Development, Demonstration and Delivery of advanced functional materials and nanoscale devices. Our goal-oriented environment fosters intellectual freedom and creativity critical for breakthrough research. The Fabrication and Prototyping Facility offers micro- and nanofabrication equipment and associated tooling for developing new prototypes with novel materials. Much of this equipment is located in our class 100 Clean Room. The Materials and Device Testing Facility provides access to instrumentation for the high resolution characterization of novel materials and new devices. These tools enable researchers to complete in-depth investigations of material properties, including microstructure, defects, composition, and crystallinity. We provide training and support from our experienced staff of scientists and engineers who maintain the diverse set of equipment and processes to meet your needs in lithography, thin film growth and deposition, and materials and process characterization. We provide hands-on, one-on-one training in the operation of the instruments and mastery of techniques. We strive to provide our users access to the equipment and expertise necessary for success in their research and development projects. We encourage you to contact us to discuss how we can be of assistance to you.

14. Woven Gas Diffusion Layers of Polymer Electrolyte Membrane Fuel Cells: Liquid Water Transport and Conductivity Trade-off
Sadegh Hasanpour, Mohammad Ahadi, Majid Bahrami, Ned Djilali, and Mohsen Akbari (UVic)

Abstract: Gas Diffusion Layers (GDLs) are one of the main components in polymer electrolyte membrane Fuel Cells (PEMFCs) that are required to have high transports properties, electrical conductivity and thermal conductivity. One hindering factor is the accumulation of water that affects the optimum gas transport properties and leads to performance loss known as flooding. Hydrophobic treatment of GDLs with polytetrafluoroethylene (PTFE) or fluorinate ethylene propylene (FEP) is one avenue to improve water management in the fuel cell. However, the downside of the hydrophobic treatment is a reduction in thermal conductivity and electrical conductivity of GDLs. This study addresses the effect of, no coating, 30 wt% and 55 wt% FEP treatment on water transport, thermal conductivity and electrical conductivity. The ex-situ water transport analysis shows that treated samples promote propagation of water inside the GDLs and water breakthrough occurs in compressed regions. Thermal conductivity has an optimum FEP loading at 30wt%, however, the electrical conductivity decreases by increasing the FEP loadings. Hydrophobic treatments of woven GDLs is a trade-off between better water transport and thermal conductivity versus lower electrical conductivity.

15. Electrochemical polymerization of carbon tetrachloride for diamond-like carbon
Minh Hai Tran (UVic)
Abstract: Not available

16. Surface Treatment Techniques Used for Producing Novel Synthetic Fibers with the Improved Bond Strength

Mohit Garg, Boyu Wang, Rishi Gupta(UVic)

Abstract: Porous interfacial transition zone (ITZ) in fiber reinforced concrete can develop at the vicinity of the fibers, which reduce the bond strength between fiber and cement matrix. In this study, synthetic fibers (Polypropylene - PP) treated with metakaolin are produced, such that the coated metakaolin will have a pozzolanic reaction with the calcium hydroxide retained in the ITZ during concrete casting. Thus, the bond strength of the fibers with the engineered cementitious material can be improved. Five different techniques (including the control) were explored to coat PP fibers with metakaolin, and the effectiveness of surface treatment techniques was characterized using Scanning electron microscope (SEM). The first step involved the application of epoxy resin on all the fibers with dual objectives: as an adhesive and a protective layer. Metakaolin was then sprinkled on top of the epoxy layer on the fiber surface. Four different sample preparation methods were used, which include: (1) M2 - Epoxy coating (Wet) + metakaolin powder sprinkling (2) M3 - Epoxy coating (dry) + metakaolin powder sprinkling (3) Epoxy coating (dry) + Metakaolin water solution sprinkling (4) Epoxy coating + Carbon fiber coating. Among the four methods used, the first processing technique demonstrated the best effectiveness by having the maximum coating thickness, of metakaolin, as visualized with SEM as well as unaided eye vis-Ã -vis other samples. In parallel, it was found that coated metakaolin had an amorphous surface texture while epoxy-coated surface looked relatively smooth when observed under SEM, as shown in Fig. 1. The cross-sectional view of the samples under SEM revealed a gap in micron size between metakaolin and the epoxy resin. For the next step, the authors plan to use energy-dispersive X-ray spectroscopy technique to compare the chemical composition of the molecular structures observed earlier in the cross-section view. Additionally, a cement-water solution will be sprayed onto the coated fibers to test if ITZ can be reduced.

17. Sample Thickness Limitations in Defocused Electron Probe Ptychography

Arthur Blackburn (UVic)

Abstract: Ptychography determines the amplitude and phase shift imparted to an electron beam as it passes through the specimen in a transmission electron microscope (TEM). Using a defocused electron probe and a fast direct-electron detector, allows the sample to be rapidly surveyed. The time limiting step then becomes the reconstruction process. Practical reconstruction computation times are realized, however, using the assumption that the sample behaves as a simple multiplicative phase object. However, many crystalline samples, particularly above certain thicknesses and in certain orientations, exhibit strong multiple scattering and thus might not be properly represented within this algorithm and assumption. Nonetheless, useful reconstructions can still be realized in many experimental configurations, when the sample thickness is similar to the extinction distances in crystalline samples. Further aspects concerning the sample thickness, beyond the weak phase object approximation, have been treated within the X-ray and optical applications of ptychography. Here it has been found that propagation within the sample is only adequately considered when the sample thickness t = 5.2 r^2 / lambda, the electron wavelength, and r is the image resolution [2]. The validity of this useful relationship appears has not been experimentally investigated in electron microscopy prior to this work. Here experiments were performed and facilitated using a recently available, high-speed electron detector synchronized to the beam scan, the prior absence of which has hitherto hindered such explorations. Typical 80 nm square field of view regions were observed and reconstructed on a range of samples having thicknesses between ~15 nm to 100 nm, using approximately 5000 overlapping, ~5 nm diameter illumination regions. Diffraction images were

collected at 500 frames per seconds or greater, using a single Medipix chip on a Hitachi HF3300V TEM operated at 300 keV, and 200 keV allowing data from this FOV to be collected in under 10 seconds. Looking at example phase reconstructions of ~5 nm gold particles, ~20 nm NaHoF4 particles and silicon transistor devices with total sample thicknesses up to around 80 nm allowed us to see lattice fringes with period of 0.142, 0.180, and 0.192 nm respectively, without any need for an aberration corrector in the microscope. As expected the overall reconstruction quality appeared best for the thinner samples. With thicker samples care must be taken to orient the samples such to reduce the effects of dynamical diffraction appearing in the reconstructions, as shown in numerical multi-slice simulations here. From this study it appears that the relationship developed by Tsai et al [2] proves useful guide for electron microscopy too.

18. Unusual Spin Crossover Properties of Novel Fe(II) Complexes
Barbara D. Sawicka, Leah Gajecki, David J. Berg(UVic)

Abstract: Novel Fe(II) complexes have been synthesized using carbazole based di-tetrazole ligands (CzTiPr) and (CzTMes). The structure of these complexes has been determined by X-Ray crystallography and Mossbauer spectroscopy. The magnetism of these complexes has been followed using Mossbauer spectroscopy, along with solid state magnetometry and solution magnetic data. Mossbauer spectroscopy was also used to determine the high spin (HS) or low-spin (LS) state of the Fe ion depending on the nature of the ligand field. The bis-ligand Fe(II) complex (CzTiPr)2Fe shows a thermally induced spin crossover (SCO) transition from low spin (LS) at temperatures below 200K to high spin (HS) at temperatures above 300K, observed in the solid-state magnetic data as an unusual two-step transition. The Mossbauer spectra show a mix of LS and HS Fe(II), with predominant LS (83%) over HS (17%) fractions at 78 K and lower LS (38%) than HS (62%) fractions at room temperature (RT), which is consistent with a spin-admixed system where a portion of the Fe centers are low spin and a portion are high spin, rarely seen in SCO complexes. No such phenomenon was observed when the iPr substituents have been replaced by methyl-mesityl substituents, i.e., in the bis-ligand Fe(II) complex (CzTMes)2Fe. Future work will concern mono-ligand FeBr complexes that are much more reactive than the bis-ligand Fe complexes. The SCO complexes showing the inherent bi-stability (HS and LS) are interesting as they may be useful as molecular switches or information storage devices.

19. Synthesis of 2D Monolayer WS2 TMDCs using Bottom-Up CVD
M Bakhtiar Azim, Amin Abnavi (SFU), Michael M. Adachi

Abstract: Two-dimensional Transitional Metal Dichalcogenides (TMDCs) such as MX2 (M= Mo, W; X= S, Se) have been attractive for use in ultra-scaled electronic and optoelectronic devices because of their indirect-direct band gap transition, atomically-thin thickness and lack of dangling bonds. Like 2H-MoS2, it is possible to construct monolayer 2H-WS2 by sandwiching two atomic layers of S and one atomic layer of W through covalent W-S bonds. Among all the TMDCs, WS2 is getting more attention from researchers because of its exceptional photoluminescence effect that is necessary for optoelectronics devices such as LED. Moreover, solar cell, piezo-electronic devices (e.g. actuators) are some of the potential applications where WS2 can be incorporated successfully. A cost effective and reliable means is necessary to achieve large-area, high quality single crystalline materials for synthesizing monolayer WS2 into future technologies. Scotch Tape mechanical exfoliation, hydrothermal method, electrochemical exfoliation, chemical vapor deposition (CVD) etc. are most widely used methods. Among these methods, CVD is regarded as the most promising approach because of its numerous advantages including large area, high crystal quality and uniformity. The problems associated with other methods are either small flake size or low quality restricting its incorporation in electronic devices. In this study, we have successfully synthesized monolayer triangular WS2 in our lab using 3-heating zone furnace and the method associated with it is bottom-up CVD. The highest domain/lateral size we have achieved so far is ~75 µm and average crystal size is ~10-40 µm. Although, several research groups have reported about WS2 synthesis using WO3 and S precursors, specific parameters such as precursor amount, growth substrate, growth pressure and flow rate, temperature, gases, holding time etc. can vary widely from lab to lab effecting the growth morphology, mechanism, luminescence yield and Raman spectra. We have also performed Raman characterization of as-synthesized WS2 and it is evident from the Raman spectra that monolayer triangular WS2 has been synthesized successfully. Our next target is to optimize the CVD process to achieve larger crystal size with more coverage, to find out an efficient way to transfer the flake on patterned devices for optoelectronics, solar cell and piezo-electronic sensor applications. This work is supported by CMC, NSERC, CFI, 4D Labs and Department of Chemistry, SFU.

20. Strain effect and Bi incorporation in optical properties of GaAsBi
Mahsa Mahtab, Ron Synowicki, Vahid Bahrami-Yekta, Lars C. Bannow, Stephan W. Koch, Ryan B. Lewis, Thomas Tiedje (UVic)

Abstract: The effect of alloying GaAs with Bi on optical properties has been investigated through the ellipsometry measurement. Moreover, the effect of biaxial strain on Î“ point of the Brillion zone has been calculated. Considering both the composition change and strain, the optical transition from valance band to conduction band shows the red shift and blue shift with increasing Bi content and biaxial strain in GaAsBi respectively. Since the former effect is much stronger than the later one, the overall red shift of critical point energies is observed with increasing Bi content.

21. Directional IR Sensor
Siamack V. Grayli, Gary W. Leach, Behraad Bahreyni(SFU)

Abstract: Vanadium pentoxide thin films have been deposited on quartz substrate via organic sol-gel synthesis and dip coating. The process was developed to establish a reliable and inexpensive method to produce thin films with high temperature coefficient of resistance for sensing applications. The resulting thin films were placed into two groups based on the alkoxide precursor concentration used to synthesize the sol from vanadium oxy-tri-isopropoxide as the precursor alkoxide, isopropanol as the solvent and glacial acetic acid. Quartz substrates were then coated with the sol and annealed under different conditions. Effects of changes in the precursor concentration in the synthesized sol, different degrees of crystallinity of the post-annealing thin films, and stoichiometry of the deposited thin films were studied via morphological and structural analyses. The temperature coefficient of resistance values for these thin films lied in the range of -3%K-1 to -4%K-1, comparing favorably to films produced through existing techniques such as DC magnetron sputtering, chemical vapor deposition or pulsed laser deposition. We are also reporting on use of vanadium pentoxide as a thermos-resistive sensing layer on a patented vector light sensor design whereby the changes in the material's electrical resistance as result of radiative heat absorption and in conjunction with the sensor's three dimensional topology, allows for the detection of both the distance between the sensing pixels and the radiation source and the angle of incidence. The main application foreseen for the vector light sensor is room temperature proximity detection to allow real-time directional infrared sensing in manufacturing facilities co-occupied by human work force and industrial robotic arms.

22. The nucleation of ZnO nanowires on sputter deposited metal substrates.
Christopher Coutts, Simon Watkins, Erol Girt(SFU)

Abstract: ZnO is a II-VI semiconductor with a wide bandgap of 3.37 eV. This makes it a good candidate for transparent solar cells and for near-ultraviolet LEDs. In the following, the nucleation of ZnO nanowires (NWs) grown by metalorganic chemical vapour deposition (MOCVD) on sputter deposited Ta/Ru/Au layers is investigated. The aim is to achieve vapour-liquid-solid (VLS) growth of ZnO NWs. By exposing to the Au thin film to TEGa flow above the Au-Ga eutectic point, liquid Au nanodroplets can be formed on the substrate surface. Under VLS growth, these droplets act as catalysts in the nucleation of the NWs. In the following, the successful formation of liquid Au nanodroplets is demonstrated by atomic force microscopy (AFM) and the growth of (001) ZnO NWs is demonstrated by X-ray diffraction (XRD) and transmission electron microscopy (TEM) and scanning electron microscopy (SEM). However, the results indicate is not yet acheived. This may be due to the low-temperature growth conditions of the ZnO NWs. These results are further confirmed by energy dispersive X-ray spectroscopy (EDS). It is shown that there is no presence of Au in the NW tip, as would be expected in VLS growth.

23. Synthesis and Characterization Novel Lead-Free Ceramic of the (1-x)BiFeO3 xBaHfO3 Solid Solution
Wu, Hsin Yu, Pan Gao, Hua Wu and Z.-G. Ye(SFU)

Abstract: The ferroelectric materials are featured by the spontaneous polarization below the phase transition temperature and switchable polarization under external electric fields, giving rise to a typical polarization-electric field (P-E) hysteresis loop. The phase transformation in the ferroelectric materials can be displayed by the temperature dependence of the dielectric constant, which usually shows a sharp peak at Curie temperature. Many ferroelectric materials that exhibit outstanding piezoelectric and ferroelectric properties have the characteristic perovskite structure, which can be generally described by the chemical formula ABO3. Based on their promising ferroelectric and dielectric properties, ferroelectric materials have found a wide range of applications from high performance capacitors to random access memory, from microwave devices to piezoelectric transducers, sensors and actuators. The relaxor ferroelectric material exhibits a broad dielectric maximum and a significant frequency dispersion of dielectric permittivity, with the temperature of the dielectric maximum (Tmax) increasing and its magnitude decreasing with increasing frequency, which can be attributed to the presence of the polar nano-regions. Many of the high performance ferroelectric materials, e.g. lead zirconium titanate (PZT), or relaxor-based ferroelectric solid solutions, e. g. Pb(Mg1/3Nb2/3)O3 PbTiO3, are lead containing, which is toxic to environment and human health. So it is essential to develop suitable lead- free or lead-reduced ferroelectric materials with comparable properties as to replace the current usage on lead. Bismuth Ferrite BiFeO3 (BF) is one of the most studied lead-free material with both ferroelectricity and antiferromagnetism above room temperature. It has ferroelectric-paraelectric phase transition at Tc = 830 oC. It also has 6S2 lone pair, like Pd, which is essential for good ferroelectricity. There several drawbacks including large leakage current density and weak magnetic properties. Therefore, this work is focusing on improving electric property of BF by chemical modification and studied the physical property changes from relaxor to ferroelectric. The binary system of (1-x)BiFeO3 xBaHfO3 ceramic were prepared by solid solution and the structure and physical properties of the samples were systematically investigated. The structure is analysis by x-ray diffraction, electrical properties by dielectric measurement and magnetic properties by SQUID.

24. Growth of 2D Monolayer WS2 TMDCs using Bottom-Up CVD and Its Applications

M Bakhtiar Azim, Amin Abnavi, Michael M. Adachi

Abstract: Two-dimensional Transitional Metal Dichalcogenides (TMDCs) such as MX2 (M= Mo, W; X= S, Se) have been attractive for use in ultra-scaled electronic and optoelectronic devices because of their indirect-direct band gap transition, atomically-thin thickness and lack of dangling bonds. Like 2H-MoS2, it is possible to construct monolayer 2H-WS2 by sandwiching two atomic layers of S and one atomic layer of W through covalent W-S bonds. Among all the TMDCs, WS2 is getting more attention from researchers because of its exceptional photoluminescence effect that is necessary for optoelectronics devices such as LED. Moreover, solar cell, piezo-electronic devices (e.g. actuators) are some of the potential applications where WS2 can be incorporated successfully. A cost effective and reliable means is necessary to achieve large-area, high quality single crystalline materials for the growth of monolayer WS2 into future technologies. Scotch Tape mechanical exfoliation, hydrothermal method, electrochemical exfoliation, chemical vapor deposition (CVD) etc. are most widely used methods. Among these methods, CVD is regarded as the most promising approach because of its numerous advantages including large area, high crystal quality and uniformity. The problems associated with other methods are either small flake size or low quality restricting its incorporation in electronic devices. In this study, we have successfully grown monolayer triangular WS2 in our lab using 3-heating zone furnace and the method associated with it is bottom-up CVD process. The highest domain/lateral size we have achieved so far is ~75 Âµm and average crystal size is ~10-40 Âµm. Although, several research groups have reported about WS2 synthesis using WO3 and S precursors, specific parameters such as precursor amount, growth substrate, growth pressure and flow rate, temperature, gases, holding time etc. can vary widely from lab to lab effecting the growth morphology, mechanism, luminescence yield and Raman spectra. We have also performed Raman characterization of as-grown WS2 and it is evident from the Raman spectra that monolayer triangular WS2 has been grown successfully. Our next target is to optimize the CVD process to achieve larger crystal size with more coverage, to perform characterization techniques such as TEM, AFM etc. and to find out an efficient way to transfer the flake on patterned devices for optoelectronics, solar cell and piezo-electronic sensor applications.

25. Photoluminescence study of Sn-related impurity complex in ZnO

Abbas Nakhlband, Manu Hegde,Simon Watkins

Abstract: Zinc oxide is a promising substitute for GaN in the LED industry since it almost has the same direct bandgap of around 3.4 eV and is cheaper to produce. This project studies the luminescence due to the recombination of donor bound excitons (D0X) at impurity complexes, by means of photoluminescence (PL) spectroscopy. D0X are excitons bound to a donor impurity, forming a hydrogen molecule-like structure. Shallow group III donors substituting for Zn atoms, such as Al, Ga, and In are known to result in D0X emission just below the band gap energy. Less well understood are a series of shallow D0X emission lines which appear to result from complexes involving more than one impurity. The so-called I10 line is known to involve substitutional Sn, with as yet unknown constituents. There is lose evidence that suggests that I10 involves Li impurities. Our hypothesis is that I10 excitons are bound to a complex of Li (single acceptor) and Sn (double donor) that forms a single donor. So far, our research shows that the removal of the Li impurity, by annealing the tin doped samples, and diffusion of Li into the same sample has respectively shown a decrease and an increase in the intensity of the I10 peak. This approach of co-doping has been suggested as a means of achieving p-doping in the material.

26. Enhancing the photocatalytic activity of iron-doped TiO2 nanocrystals for wastewater treatment
Vahid Moradi, Faysal Ahmedi, Atieh Parisi Couri and Rodney A. Herring(UVic)

Abstract: Titanium dioxide as a photocatalyst for water purification purposes has been widely studied due to its availability, biocompatibility, among other properties. However, its catalytic activity relies on UV irradiation, which increases operation costs and reduces its viability for wastewater treatment technologies. Introducing iron atoms into the crystal structure of anatase TiO2 has been shown to reduce the lattice's band gap energy and shift the absorption spectrum into the visible band, theoretically increasing degradation efficiency under visible light. Despite this, iron-doped TiO2 nanocrystals fabricated via a traditional sol-gel method under-perform in model-pollutant (methyl orange, phenol, etc.) degradation experiments, which was theorized by our group to be caused by sub-optimal dopant concentration and by a Fe2O3 contamination layer on the surface of the crystals. Transmission electron microscopy was used to verify the presence of a contamination layer preventing charge carriers from reaching the crystal surface, and this issue was addressed using an additional acid wash step during synthesis. The optimal dopant concentration was fine-tuned, and it was theorized that excess iron in the lattice formed electron-hole recombination centers which reduced degradation efficiency. Experiments using these results have shown a drastic increase in the photocatalytic activity of iron-doped TiO2 under visible light, measured through the apparent degradation rates of model pollutants. Venues for future research, especially involving applications in surface functionalization and wastewater treatment photoreactors, are further discussed.

27. Microfluidics platform to evaluate Radiotherapy response of tumor cells
A. Palacios, S. Van Nest, A. G. Brolo(UVic)

Abstract: Raman spectroscopy (RS), an increasingly widespread laser based method for characterizing biological species, has been proven as an effective method to monitor the effects of radiation on cancer cells during Radiotherapy. The damage produced by radiation, among other factors, is proportional to cell radiosensitivity. Therefore, a RS approach was developed to identify radiation-induced biochemical responses on human cell lines (H460, MCF7, and LNCaP) after undergoing relevant doses of radiation (1-10 Gy). The spectra changes were analyzed to identify biomarkers (e. g. intracellular glycogen content) for radiosensitivity correlation. As radiosensitivity not only varies among cell origin, it also varies among patients, by determining specific radiation needs, the treatment could be tailored to each individual, reducing time and resources required for a successful treatment. In order to implement this approach the current spectra acquisition protocol needs to be optimized to be compatible to treatment time frames. To address this challenge, coupling the studies to microfluidics could lead to the automation of the process. Here, we present a microfluidic cell-based device designed to capture and observe single cancer cells (MCF7) in an optical trap, created by focusing two laser beams using a 1064nm diode laser. We experimentally evaluated the performance of the optical system with a large transverse field (~25Î¼m) and showed the effectiveness to trap cancer cells and to analyze them individually by scattered light detection. The device uses MgF2 and PDMS as platform substrates. These materials were chosen to produce a device capable of flowing, analyzing and recovering live cells, while being compatible with optical systems by allowing signal collection in the biological window of interest. A comparison of the collected in-chip spectra with previous results is fundamental to determine the efficiency of the microfluidics system.

28. Photovoltaics with Two-Dimensional Atomic Crystals
Parham Pashaei , Joshua Folk, Peyman Servati (UBC)

Abstract: Two-dimensional atomically thin crystals have recently raised significant interest for optoelectronic and photovoltaic research. In this report, we review the potentials of two-dimensional (2D) materials for solar cell applications. A background review of 2D materials and current 2D-based solar cells is given and promising structures of this new category of solar cells are summarized and investigated. Preliminary fabrication processes and results are demonstrated. The structures are simulated using experimental absorption data of individual monolayers found in literature and their external quantum efficiency (EQE) is estimated. As an example, our simulations matching with experiments within a reasonable approximation are presented. The results presented in this study show the promising potential of 2D material-based solar cells as well as providing a platform for future experiments.

29. Direct mapping of built-in potentials in tunnel diodes
Cristina Cordoba, Daniel Wolf, Axel Lubk, Magnus Borgstrom, Xulu Zeng, Taylor Teitsworth, James Cahoon, Karen Kavanagh

Abstract: We compared the built-in potential in Si and InP/GaInP tunnel diodes grown in two opposite directions n/p and p/n. Phosphorous and Boron were used as n and p-type dopants in Si. 2D electron holography sufficed to obtain the depletion region width as well as the built-in potential since the NWs are highly symmetric. As a result we found the p/n direction to have the narrower depletion width of approximately 20 nm and a built-in potential of 1V. We used Zn as p-type dopant for GaInP and S or Sn as n-type dopant for InP. InP/GaInP NWs posse a hetero-junction in which electron holographic tomography is required because of the NWs non-symmetric geometry. In this case we found the n/p direction to have the higher built-in potential, but both directions had a comparable depletion region width. Further analysis revealed that charging induced by electron beam forward biased the p/n diode, but both directions have characteristics that fulfill the basic requirements of band-to-band- tunneling. "

30. Synthesis of Lithium Niobate Nanocrystals with Size Focusing through an Ostwald Ripening Process
Rana Faryad Ali, Prof. Byron Gates (SFU)

Abstract: Lithium niobate is a unique optical material. This material has been referred to as the “silicon of photonics” due to its excellent optical properties. We developed a solution-phase approach to prepare crystalline, uniform nanoparticles of $LiNbO_3$. The growth of these nanoparticles was through an Ostwald ripening process, which controlled the growth and sizes of the nanoparticles. The nanoparticles of $LiNbO_3$ were also confirmed to be optically active for second harmonic generation (SHG).

31. Photoconductive heaters enable VLSi photonics
Hasitha Jayatilleka, Hossam Shoman, Lukas Chrostowski, and Sudip Shekhar (UBC)

Abstract: A wide range of applications, from biomedical sensing to quantum computing and machine learning rely on the precise operation of a key element, the microring resonator. Hitherto, a scalable solution to monitor and actuate these devices increase either their footprint or power consumption and cost, which limit their practical demonstration to systems with only a handful of rings. Here, we solve the aforementioned problems via doping the bent silicon microring waveguides, preserving both area and cost. These doped waveguides allow us to detect optical power and heat the microrings to manipulate light on the chip, whilst preserving fabrication simplicity. We confirm our devices' practical application through the automatic resonance alignment of 31 rings of a 16x16 switch and a 14-ring coupled resonator optical waveguide (CROW), rendering them the largest, yet most compact automatically controlled microring resonator circuits to date. These systems are more efficient and <5x smaller than prior arts.

32. Electron Holography investigation of GaN Nanowire p-n junction

Anitha Jose, Sharif Sadaf, and Karen Kavanagh

Abstract: Nanowire systems are different from their bulk structures due to their one-dimensional nature and properties such as electrical transport arising from it. GaN Nanowires (NWs) gained a lot of attention due to its applications in optoelectronic devices including light emitting diodes (LEDs), photodetectors and laser diodes. GaN NW p-n junctions are the basic elements in these devices and hence characterizing them and understanding the electrical transport is important for fabricating efficient devices. In this study the direct measurement of the electric potential and depletion width in a p-n junction was carried out using off-axis electron holography. The measured built-in voltage and depletion width in a p-n junction was found to be in good agreement with the value calculated based on the doping concentrations proving this method to be efficient in characterizing the p-n junctions based on growth conditions.

33. Relation between structure of sodium deoxycholate gel and release kinetics of the dye in the presence of cucurbit(6)uril

Sree Gayathri Talluri (presenter), Cornelia Bohne (UVic)

Abstract: Supramolecular gels are formed due to the self-assembly of small gelator molecules in a suitable solvent as a result of specific weak non-covalent interactions between the gelators. Sodium deoxycholate (NaDC) is a bile salt known for its ability to form a supramolecular gel within a certain pH range. These gels are made up of aggregates out of which 40 % of the aggregates are in water and 60 % are in the gel network1. The objective of my work is to understand how additives such as cucurbit[6]uril (CB[6]) affect the release properties of NaDC gels. The release properties will be related to morphological changes in NaDC gels in the presence of CB[6] studied by microscopy.