6th Alberta Nano Research Symposium

Edmonton Convention Centre

May 2-3, 2019

Salon 3

NaNoTeCH: Celebrating the Periodic Table

Contents

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Organizing Chairs' Welcome

On behalf of the organizing committee, welcome to the 6th Annual Alberta Nano Research Symposium. The Alberta Nano Research Symposium is co-hosted by the University of Alberta and University of Calgary Nanotechnology Groups; professional student groups that plan and execute entrepreneurial, academic, and outreach events to promote nanotechnology.

Our theme this year is "NaNoTeCH: Celebrating The Periodic Table" which highlight the International Year of the Periodic Table and the 150th anniversary of the discovery of the Periodic System by Dmitry Mendeleev. We hope you can recognize how each oral and poster presentation celebrates various elements on the Periodic Table, from carbon to gold and many more! Each presentation will showcase valuable insight into innovative synthesis and characterization techniques, as well as fabrication and devices towards applications in biomedicine, energy conversion and storage.

Since 2014, the Alberta Nano Research Symposium has continued to attract an array of stakeholders in the fields of nanoscience and nanotechnology, from academics and government representatives to industry professionals. Specifically, individuals with backgrounds in Physics, Chemistry, Biology, Engineering, and Computer Science are in attendance. Registrants are encouraged to share knowledge, develop collaborations, and celebrate their accomplishments with fellow experts in the nanotechnology field.

On behalf of the committee, we would like to thank all of our partners and supporters of the symposium, without which this event would not be possible. We would also like to express our sincere gratitude for the outstanding contribution from the organizing committee who worked diligently over the past year.

Thank you for participating in the 6th Annual Alberta Nano Research Symposium!

Kind Regards,

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Agenda

Thursday, May 2nd, 2019

11:00 – 12:00		**Registration/Lunch**	**Salon 4**
		Opening Remarks	**Salon 3**
12:00 – 12:15	**Organizing committee chair**	Introduction	
12:15 – 13:15	**Dr. Robert Carpick**	Nanoscale Factors Controlling Friction, Adhesion, and Lubrication: From 2D Materials to Engine Oil – **Keynote**	
13:15 – 13:30		**Coffee and Snack Break**	**Salon 4**
		Session A – Nanosynthesis, Characterization and Simulation 1	**Salon 3**
13:30 – 13:45	**David Purschke**	Terahertz Photoconductivity of SnIP Inorganic Double Helices	
13:45 – 14:00	**Peng Gong**	Examining the Wetting Transparency through Friction Behaviour on Graphene	
14:00 – 14:30	**Dr. Jonathan Veinot**	Who would have though Group 14 nanomaterials could be so complicated (and useful)? – **Invited**	
14:30 – 14:45	**Parisa Bazazi**	Cellulose Nano Crystals Stabilized Liquid-Liquid Interfaces: Effect of Interfacial Rheology and Structures	
14:45 – 15:00	**Yecan Wang**	Dendrimer Functionalized Nanocrystalline Cellulose as Advanced Environmental Materials	
15:00 – 15:30	**Dr. Md Kibria**	Artificial Photosynthesis for Sustainable Fuels and Feedstocks – **Invited**	
15:30 – 16:00		**Coffee and Snack Break**	**Salon 4**
		Session B – Nanosynthesis, Characterization and Simulation 2	**Salon 3**
16:00 – 16:15	**Alison Fulton**	Au Nanoparticle Assemblies on Porous Silicon by Pulsed Laser-induced Dewetting	
16:15 – 16:30	**Anna Farquhar**	Preparation of High Performance Supercapacitor Electrodes via Electrochemical Deposition of Aminonapthalene Precursors on Carbon	
16:30 – 17:00	**Dr. Yujun Shi**	Fabrication of Au, Pt, and AuPt Nanoparticles by Pulsed Laser-induced Dewetting and Their Characterization – **Invited**	

17:00 – 17:15	**Katelynn Daly**	Synchrotron-Based Investigation of Nanoscale Water Splitting Catalysts for Clean Energy Storage
17:15 – 17:30	**Alyxandra Thiessen**	Understanding the Anatomy of a Silicon Nanoparticle
17:30 – 17:45	**Nicholas Chan**	Adhesion Characterization for a Silicon-Diamond System using Frequency-Modulated Atomic Force Microscopy
17:45 – 19:45	**Poster session**	**Salon 4**
1	**Wenjihao Hu**	An amphiphobic graphene-based hydrogel as oil-water separator and oil fence material
2	**Muhammad Zubair**	Banana Peel/Graphene Oxide Derived Adsorbent for Water Treatment
3	**Kerry Rose**	Using the Portable Scanning Electron Microscope to Promote Inquiry-Based Laboratory Activities in Alberta Secondary Schools
4	**Dinara Zhalmuratova**	Mimicking 'J-shaped' and anisotropic stress-strain behavior of human aorta by fabric-reinforced elastomer composites
5	**Mohamad Ebrahimi**	Fabrication of hybrid Atomic Force Microscopy probes for enhancing sensitivity of AFM IR-spectroscopy
~~6~~	**Dr. Wei-Zheng Shen**	Synthesis of Carbon Quantum Dots for Bioimaging Using Lignin from West Fraser Co. Ltd.
7	**Yangkyu Park**	Nanoporous Microcantilevers with Plasmonic Absorbers for Photothermal Infrared Spectroscopy
8	**Bomin Kim**	Low Energy Partial Upgrading of Heavy Crude Oil Using Cavitation and Nanofluid
9	**Sina Rezvani**	Development of Piezoelectric Force Sensor Using PZT/CNT/PVA Nanocomposites
10	**Lei Liu**	Enhancements of Hybrid Copper Inks with Cellulose Nanocrystals
11	**Nidhika Bhoria**	Nanostructured MOF Catalysts for Electrochemical Reduction of Carbon dioxide.
12	**Zahra Abooalizadeh**	Friction and Mechanical Stiffness Variation Resulting from Water Intercalation between Graphene Hydrophilic Substrates

13	**Milad Ahmadi Khoshooei**	In-situ Upgrading Technology: Nanocatalyst for Improved Product Quality
14	**Shaghayegh Shajari**	High Yield Synthesis and Characterization of Very long Silver Nanowires via Multistep Polyol Method for Flexible Electronics
15	**Taylor Lynk**	The Hunger Games: In-Process Quality Control of Cannabis-Based Consumables
16	**Owen Baiwen Wang**	Novel Synthesis for Water-Soluble InP/ZnS Quantum Dots with Fluorescence Capability
17	**Casey Rusin**	A Water Dispersible Surface-Enhanced Raman Scattering Substrate using Plasmonic Cellulose Nanofibers
18	**I Teng Cheong**	Tunable Silicon Nanocrystal-Polystyrene Microresonators for Display Pixels
19	**Christopher Jay T. Robidillo**	Bioconjugation of Silicon Quantum Dots with Active Enzymes

Friday, May 3rd, 2019

		Opening Remarks	**Salon 3**
08:45 – 09:00	**Organizing committee chair**	Introduction	
09:00 – 10:00	**Dr. Xiaowu (Shirley) Tang**	Nanocarbon-Bio Hybrid Materials: Chemistry and Applications – **Keynote**	
10:00 – 10:30		**Coffee and Snack Break**	**Salon 4**
		Session C – Nanomaterials for Sensing Applications	**Salon 3**
10:30 – 11:00	**Dr. Mark McDermott**	Nobel metal nanoparticle enhanced measurements on surfaces and in solution – **Invited**	
11:00 – 11:15	**Lelin Zheng**	Voltage Colorimetric Sensing Device using Fe3O4@SiO2 Nanoparticles for Zin-air Battery	
11:15 – 11:30	**Osama Abuzalat**	High Performance, Room Temperature Hydrogen Sensing with a	

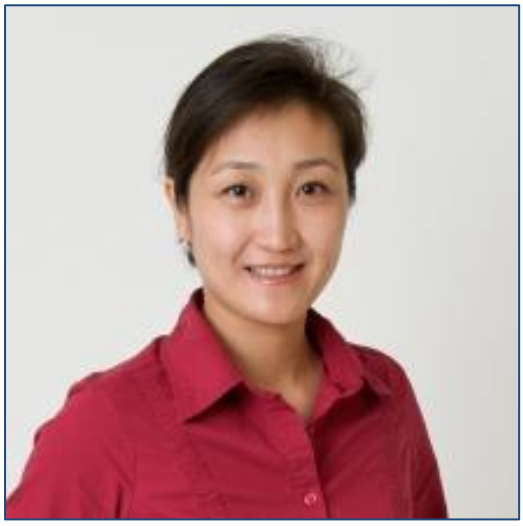
		Cu-BTC/Polyaniline Composite Film on a Quartz Crystal Microbalance
11:30 – 11:45	**Danny Wong**	Multi-modal Hydrogen Sensing with a Near Field Electrospun Nanofiber on Quartz Tuning Fork
11:45 – 12:00	**Dr . Dhanjai**	Sensing Devices for Rapid Screening
12:00 – 13:15		**Lunch Break** **Salon 4**
		Session D – Nanotools in Biology **Salon 3**
13:15 – 13:45	**Dr. Justin MacCallum**	Towards the Design of a Cannabis Biosensor – **Invited**
13:45 – 14:00	**Anuja Tripathi**	Enzyme-like Activity of Glancing Angle Deposited (GLAD) Nanofilm for Uric Acid Sensing
14:00 – 14:15	**Matthew Halma**	Insight into gene regulation in West Nile Virus from the nanomechanics of viral RNA
14:15 – 14:30	**Remko van den Hurk**	AlMo Nanocomposite Membrane Fabrication, Characterization, and Biosensors
14:30 – 14:45	**Dinara Zhalmuratova**	Mimicking 'J-shaped' and anisotropic stress-strain behavior of human aorta by fabric-reinforced elastomer composites
14:45 – 15:15		**Coffee and Snack Break** **Salon 4**
		Session E – Device and Fabriction **Salon 3**
15:15 – 15:45	**Dr. Hyun-Joong Chung**	Quenched Polyampholyte Hydrogels: Low-Temperature Properties and Energy Device Applications – **Invited**
15:45 – 16:00	**Bradley Hauer**	Dueling Dynamical Backaction in a Cryogenic Optomechanical Cavity
16:00 – 16:15	**Syed A Bukhari**	Electrical and photo-caloric actuation using vanadium dioxide (VO2) MEMS resonator
16:15 – 16:30	**Chungyeon Cho**	Conductivity loss of reduced graphene oxide coated meta-aramid under abrasion and its application as end-of-life indicator for textiles
16:30 – 16:45	**Ebenezer Owusu-Ansah**	Fabrication of Complex Multi-depth Channels in Borosilicate Glass Substrate using Femtosecond Laser Material Processing
16:45 – 17:15		**Closing Remarks**

Keynote Speakers

Dr. Robert W. Carpick

John Henry Towne Professor and Chair
Mechanical Engineering and Applied Mechanics (MEAM)
Materials Science and Engineering (MSE)
University of Pennsylvania

Robert Carpick studies nanotribology, nanomechanics, and scanning probes. His numerous awards include the ASME Newkirk Award and a NSF CAREER Award, and he is a Fellow of several societies including the American Physical Society, the Materials Research Society, the AVS, and the Society of Tribologists and Lubrication Engineers. He holds 6 patents and has authored over 170 peer-reviewed publications. Previously, he was a faculty member at the University of Wisconsin-Madison. He received his B.Sc. (University of Toronto) and his Ph.D. (University of California at Berkeley) in Physics, and was a postdoc at Sandia National Laboratory.



Dr. Xiaowu (Shirley) Tang

Associate Professor and Associate Dean of Science, Research
University of Waterloo

Shirley Tang joined the Department of Chemistry & Waterloo Institute for Nanotechnology (WIN) at the University of Waterloo (UW) in 2006. Currently, she is the Associate Dean of Science, Research, and a member of the Board of Directors for WIN. During 2014-2017, she served as the Director of Nanotechnology Engineering (NE) program, Canada's only undergraduate NE program. Prior to joining UW, she received her Ph.D. from Massachusetts Institute of Technology (MIT) and pursued postdoctoral work at Stanford University. She also had 3 years of industrial experience in Silicon Valley, California, and is a co-founder of LeNano Diagnostics, Inc, a company incorporated in 2016

Invited Speakers

Dr. Mark McDermott

University of Alberta

Dr. McDermott received his B.Sc. (Cum Laude) in Chemistry from the University of Pittsburgh at Johnstown and Ph. D. in Analytical Chemistry from The Ohio State University under Professor R. McCreery. He was a postdoctoral fellow at Iowa State University under Professor M. Porter. He is now an Associate Professor of Chemistry at the University of Alberta and a Group Leader at the National Institute for Nanotechnology. He is currently Associate Chair of Graduate Studies in the Department of Chemistry and is the Chair of the Analytical Chemistry Division of the Canadian Society for Chemistry.

Dr. Md Golam Kibria

University of Calgary

Dr. Kibria is an Assistant Professor in the Department of Chemical and Petroleum Engineering at University of Calgary, Canada. He received MASc and PhD degrees from McMaster and McGill University, respectively. He is interested in nanomaterials, heterogeneous catalysis, system design and techno-economic analysis for sustainable synthesis of renewable fuels and feedstocks, including electro-/photo-catalysis for CO2 reduction and water splitting for sustainable energy and environment. He has published over 45 peer-reviewed articles in refereed Journals, including Science, Nature Communications, Advanced Materials, Energy and Environmental Science, Journal of American Chemical Society etc. Dr. Kibria is a recipient of Banting Fellowship, Academic Gold Medal, Tomlinson Doctoral fellowship from McGill University, Green Talents Award from German Federal Ministry etc.

Dr. Jonathan Veinot

University of Alberta

Dr. Jonathan (Jon) Veinot joined the Department of Chemistry at the University of Alberta being promoted to Associate Professor in 2008 and Professor in 2012. While his research team has explored such topics as super-hydrophobic/self-cleaning surfaces, metal oxide nanomaterials and polymers for organic electronic devices, their primary focus lies in the development of Group 14 (i.e., Si and Ge) nanomaterials (e.g., quantum dots, nanosheets, etc.) and their applications (e.g., bio/medical imaging, batteries, display technologies, solar cells, etc.). For his efforts he was awarded the 2017 Award for Excellence in Materials Chemistry from the Chemical Society of Canada (Materials Chemistry Division) and the 2016 DIACHEM Award from the Burghausen Chemical Industry and City of Burghausen, Bavaria. Jon has also built strong professional and personal ties with colleagues in Germany, particularly at the Technical University of Munich where he was a visiting research professor in 2012 with Prof. Dr. Bernhard Rieger and is now a TUM Research Ambassador. He established and is the Canadian Director of the "Alberta-Technical University of Munich International Graduate for Hybrid Functional Materials (ATUMS)" that is supported by the NSERC CREATE and DFG IRTG programs as well as Alberta Innovates. He is also President/co-Founder/CTO of Applied Quantum Materials Inc.; a new start-up venture that aims to commercialize intellectual property developed in his academic labs and provides employment opportunities for highly qualified personnel from the University of Alberta and surrounding academic institutions.

Dr. Justin MacCallum

University of Calgary

Justin L. MacCallum is the Canada Research Chair in Biomolecular Structure and Design at the University of Calgary. He dis his Ph.D. at the University of Calgary and his post-doctoral work at the University of California - San Francisco. His research interests lie in the fields of integrative structural biology, protein-protein interactions and the development of biosensors and biological therapeutics.

Dr. Hyun-Joong Chung

University of Alberta

Hyun-Joong Chung is an Assistant Professor of Chemical and Materials Engineering at the University of Alberta since 2013. He received B.S. from KAIST and Ph.D. from the University of Pennsylvania. His thesis was on the phase behavior of polymer blends and nanocomposite films. Following graduation, he worked 3 years as a senior engineer at Samsung Display in Korea, where he contributed in developing prototype large-area OLED TVs. Then, he developed a wearable epidermal and epicardial biosensor arrays during his postdoctoral training at the University of Illinois at Urbana-Champaign. His current research interests are on tough hydrogels and elastomers and their applications in energy storage devices and wearable bioelectronics. He is the recipient of Hanwha Non-Tenured Faculty Award in 2015.

Dr. Yujun Shi

University of Calgary

Dr. Yujun Shi is Professor and Associate Head in the Department of Chemistry at the University of Calgary. She received her PhD in Chemistry in 2001 from the University of Western Ontario (now Western University) in Canada. She did her postdoctoral work in the Steacie Institute for Molecular Sciences at the National Research Council of Canada with an NSERC Visiting Fellowship. Dr. Shi's research focuses on application of laser dewetting methods for metal nanoparticle formation, development of laser analytical techniques, and understanding the chemical vapor deposition at a molecular level. Her research has been published in peer-reviewed journals, including Acc Chem Res, Adv Mater, and Adv Funct Mater.

Oral Presentations

Keynote Speakers

Nanoscale Factors Controlling Friction, Adhesion, and Lubrication: From 2D Materials to Engine Oil

Dr. Robert W. Carpick

Thursday, May 2rd, 12:15 – 13:15

New insights into friction and wear from atomic force microscopy (AFM) and in situ transmission electron microscopy (TEM) are presented. First, nanocontacts with 2-dimensional materials like graphene are discussed, where friction depends on the number of layers. An initial model attributing this to puckering [1] is now enhanced by molecular dynamics (MD) simulations showing a strong role of energy barriers due to interfacial pinning and commensurability [2]. Second, nanoscale asperity-on-asperity sliding experiments were conducted using a nanoindentation apparatus inside a transmission electron microscope [3], allowing for atomic-scale resolution of contact formation, sliding, and adhesive separation of two silicon nanoasperities. Forming and separating the contacts without sliding revealed small adhesion forces; sliding during retraction resulted in a nearly 20 times increase in adhesion. These effects were repeatable multiple times. We attribute this surprising sliding-dependent adhesion to the removal of passivating terminal species from the surfaces, followed by re-adsorption of these species after separating the surfaces. Finally, I will discuss results where AFM is used to develop new insights into practical lubrication mechanisms. We study zinc dialkyldithiophosphates (ZDDPs), which are highly effective anti-wear additive molecules used nearly universally in engine oils. We developed a novel AFM-based approach for visualizing and quantifying the formation of ZDDP anti-wear films in situ at the nanoscale. Film growth depends exponentially on temperature and stress, which can explain the known graded-structure of the films. Our findings provide new insights into the mechanisms of formation of ZDDP derived anti-wear films and the control of lubrication in automotive applications [4,5].

[1] C. Lee *et al. Frictional Characteristics of Atomically-Thin Sheets*. **Science**, 328, 76 (2010).

[2] S. Li *et al. The Evolving Quality of Frictional Contact with Graphene*. **Nature** 539, 541 (2016).

[3] T.D.B. Jacobs *et al. Nanoscale Wear as a Stress-Assisted Chemical Reaction*. **Nature Nanotech**. 8, 108 (2013).

[4] N.N. Gosvami *et al. Mechanisms of Antiwear Tribofilm Growth Revealed in situ by Single Asperity Sliding Contacts*, **Science**, 348, 102 (2015).

[5] N.N. Gosvami *et al. An In Situ Method for Simultaneous Friction Measurements and Imaging of Interfacial Tribochemical Film Growth in Lubricated Contacts*, **Tribology Letters** 66, 154 (2018).

Nanocarbon-Bio Hybrid Materials: Chemistry and Applications

Xiaowu (Shirley) Tang

Friday, May 3rd, 9:00 – 10:00

Controlled assembly of biopolymers, minerals, and carbon nanostructures, specifically graphene, carbon nanotube (CNT), and their chemical derivatives, can lead to nanocarbon- bio hybrids that not only impart specific bio-functionalities but also possess extraordinary physical and chemical properties. CNT and graphene are among the most frequently investigated nanomaterials in the past decade, and yet both continue to offer exciting opportunities for the discovery of new science and applications. In this talk, I will present our recent progress in the creation of advanced materials and devices through hierarchical organization of nanocarbon-bio hybrids. Examples include CNT and graphene oxide nano-porous membranes, sp_2-C incorporated 3D tissue scaffolds, and various C/inorganic hybrid architectures. Our main interests are to develop new material and surface chemistries for material synthesis, to pursue fundamental studies on interface dictated phenomena, and to explore potential applications, especially in biosensing and tissue engineering. I will also offer perspectives on nanoscience and nanotechnology in general.

Nanosynthesis, Characterization and Simulation 1

Terahertz Photoconductivity of SnIP Inorganic Double Helices

David N. Purschke*, Ebru Üzer, Claudia Ott, Markus Pielmeier, Naaman Amer, Tom Nilges,
Frank A. Hegmann

Thursday, May 2rd, 13:30 – 13:45

Recently synthesized, tin iodide phosphorus (SnIP) is the first of a new class of materials with carbon-less double-helix structure, consisting of an outer SnI helix wrapping around an inner P helix. SnIP forms long, semiconducting needles with a bandgap of 1.85 eV, measured by photoluminescence and diffuse reflectance spectroscopy. Recent results indicate that SnIP and SnIP hybrids are promising new materials for photocatalytic energy conversion, however, the underlying carrier dynamics and recombination processes remain entirely unexplored. Here we study SnIP with time-domain and time-resolved terahertz (THz) spectroscopy (TDS & TRTS). TRTS measurements using both sub-gap and above-gap excitation reveal recombination dynamics that follow a stretched exponential and power law decay, respectively, with a lifetime on the order of 10 ps. Measurement of the frequency-dependent THz conductivity is complicated by a strong vibrational mode of the outer SnI helix at 1.4 THz, as shown by TDS measurements. Using a modified thin-film formula that accounts for the vibrational mode, we show that the AC conductivity displays suppressed low frequency conductivity, characteristic of Drude-Smith behaviour. From this model, we find a scattering time in SnIP of 30 fs and report the first measurement of the carrier mobility, found to be 20 cm2/Vs, which we suggest is limited by strong carrier localization.

Examining the Wetting Transparency through Friction Behaviour on Graphene

Peng Gong* and Philip Egberts

Thursday, May 2rd, 13:45 – 14:00

Wetting transparency of graphene is an effect where graphene partially changes or screens the surface energy of the underlying substrate material, rather than completely replacing it as a result of graphene's own intrinsic surface energy. However, as contradictory results regarding the wetting transparency phenomena have been reported, the applicability of wetting transparency to interpret experimental measurements influenced by surface energy on two-dimensional materials is still unclear. In this work, the friction behavior of graphene will be measured using ultra-high vacuum atomic force microscopy (UHV-AFM) to investigate the influence wetting transparency of graphene. To realize this goal, graphene produced through mechanical exfoliation with varying coverages (0-4 layers of graphene) on silicon substrates will be examined. Additionally, samples are prepared through two different processes: one sample that is baked at 120°C for 4 hours (pristine graphene) and a second that undergoes an additional heat treatment at ~800°C for 4 hours (heated graphene). The magnitude, hysteresis, and layer-dependence of friction will be compared between the pristine and heated samples, exemplifying the influences of environmental contamination and surface adsorption on the measured friction behaviour. Furthermore, lattice-resolution load-dependent friction measurements were acquired, allowing extraction of surface physical parameters through a modified analytical Prandtl-Tomlinson (PT) model analysis. The dependence of graphene's energy corrugation with load was obtained and the friction strengthening effect was observed. This work will contribute to gaining further insight on the surface energy and wetting properties for two-dimensional materials, especially when they are applied as a coating on various surfaces.

Who would have though Group 14 nanomaterials could be so complicated (and useful)?

Dr. Jonathan Veinot*

Thursday, May 2rd, 14:00 – 14:30

The study of "small semiconductor crystallites" known as "Quantum Dots (QDs)" has grown from Brus' first reports thirty years ago into an important cross-disciplinary research area. Much of the foundational QD work has focused on the development of toxic CdSe-based; this is primarily because of the ease of preparing these materials. To date, many prototype applications have appeared and Cd-free compound semiconductor QDs are even being used as emitters in commercially available state-of-the-art displays. Somewhat surprisingly, the development and application of QDs based upon the quintessential semiconductor on which much of our world is reliant upon (i.e., silicon) remain in a comparative state of infancy. The reasons for this are complex and often attributed to the strong directional bonding that complicates syntheses, their indirect band gap and surface states that can lead to poor and/or irreproducible optical response, among others. Despite these limitations, the community has seen impressive advances related to these challenges and many prototype SiQD applications (e.g., solar materials, light-emitting diodes, rechargeable batteries, drug delivery, sensors, among others) have emerged. This has led to predictions that "nanosilicon" applications could produce up to $2.1 billion US annually. This presentation will highlight ongoing studies of the Veinot team that focus on the development of Group 14 nanomaterials. Our discussion will begin with a brief overview of the development of a convenient preparative method that afforded SiQDs of tailored size and move to an overview of methods used to tailor SiQD surface chemistry and end with a discussion of optical response. We will then shift direction and delve into our investigations of more complex GeQDs. Finally, the presentation will conclude with a brief look at potential applications of Si and Ge QDs as well as the preparation and potential of other Group 14 nanomaterials.

Cellulose Nano Crystals Stabilized Liquid-Liquid Interfaces: Effect of Interfacial Rheology and Structures

Parisa Bazazi*, S. Hossein Hejazi

Thursday, May 2rd , 14:30 – 14:45

Introduction: Cellulose nanocrystals (CNCs) have been attracted lots of attention as a green source of nanofluid in the past few years. CNCs are crystalline rod shaped nanoparticles that have highly negative surface charges. In this work, we investigate the effect of CNC particles in combination with cationic CTAB surfactant on the interfacial properties of oil-water systems. We examine the emulsification and emulsion stability of CNC-CTAB mixtures.

Method: The surfactant concentrations are fixed at 0.1 and 0.5 CMC (, and). Five CNC concentrations (0 to 1 wt.%) are used in combination with surfactants. Drop shape analysis is utilized to measure the dynamic interfacial tension (IFT) and drop oscillation method is employed to study the interfacial rheology of the CNC-CTAB interfacial layers. Emulsion formation and stability of the CNC-CTAB mixtures are quantified using confocal laser scanning microcopy.

Results: The results show that CNC particles by themselves are not surface active and they do not change the IFT of oil-water. The addition of CTAB at very low concentrations can surface activate the the CNC particles. CNC-CTAB laden stabilized interfaces show high values of elastic modulus signaling the presence of a particle-surfactant network at the interface. CNC-CTAB stabilized emulsions generated with rigorous shaking remain stable for over two months. The results reveal the link between the high stability of CNC-CTAB stabilized emulsions and their high interfacial elasticity.

Discussion: Considering IFT and interface elasticity as the two major factors in emulsification, this study provides a method for formulating emulsions with desired structure and stability. Low values of IFT are required for emulsion formation and high values of interface elasticity are required for emulsion stability.

Dendrimer Functionalized Nanocystalline Cellulose as Advanced Environmental Materials

Yecan Wang* and Qingye Lu

Thursday, May 2rd, 14:45 – 15:00

As a biodegradable polymer obtained from the nature, nanocystalline cellulose (NCC) has been regarded as an excellent building matrix to develop advanced functional materials for environmental applications due to its unique surface chemistry, mechanical and physical properties. In this work, we report the new method to prepare the dendrimer (i.e., different generations of polyamidoamine PAMAM, G1 to G4) functionalized NCC. Carboxylated NCC (NCC-COOH) was obtained by TEMPO (2,2,6,6-tetramethyl-1-piperidinyloxy) oxidation of NCC, which was reacted with ethylenediamine to give aminated NCC (NCC-NH2). Then PAMAM dendrimer functionalization to the surface of NCC-NH2 was accomplished by first Michael addition (alkylated with methyl acrylate) and then ester amidation with ethylenediamine. The materials were characterized by FTIR, XPS, TGA and TEM. The resulting products were evaluated as advanced environmental materials, by testing their CO2 capture capacity at different temperatures and selenium removal efficiency from simulated wastewater. The study shows NCC-G2 has a better adsorption performance, compared with other modified or unmodified NCC materials, of 12.21±1.93, 8.59±2.08 and 8.06±2.84 mg/g at 25°C, 35°C and 45°C respectively. This result proved the possibility of substituting conventional solid absorbents with NCC materials because of low cost and sustainability when similar effects shown.

Artificial Photosynthesis for Sustainable Fuels and Feedstocks

Dr. Md Golam Kibria*

Thursday, May 2rd, 15:00 – 15:30

Artificial photosynthesis, i.e. the chemical transformation of sunlight, water and carbon dioxide into energy-rich fuels or feedstocks is one of the key sustainable energy technologies that has gained tremendous momentum in recent years. Although significant progress has been made over the last decade, the development of efficient, stable, scalable, and cost-competitive electro-/photocatalyst materials and systems has remained one of the key challenges for the large-scale practical application of this frontier technology. Here, I will present our recent success on selective and sustained electroreduction of CO_2 into high-value and economically viable feedstock i.e., ethylene. Our approach leverages progress in mechanistic understanding of CO_2 reduction pathways; nano-interface design; and system engineering. Furthermore, I will present on our efforts in the development of metal-nitride nanowire based photocatalyst for solar-powered artificial photosynthesis for sustainable hydrogen production.

Nanosynthesis, Characterization and Simulation 2

Au Nanoparticle Assemblies on Porous Silicon by Pulsed Laser-induced Dewetting

Alison Fulton*, Dr. Yujun Shi

Thursday, May 2nd, 16:00 – 16:15

Metallic nanoparticles (NPs) can be fabricated on patterned substrates through pulsed laser-induced dewetting (PLiD) of metallic thin films. The morphology and spatial distribution of the resulting NPs are dependent on the topographical features of the underlying substrate, differing greatly from the use of polished substrates. In this work, electrochemically anodized porous n-type silicon (PS) is used as a substrate for NP formation. The PS features are tunable through control over the anodization conditions and are dependent on the intrinsic properties of the silicon itself. It has been found through FESEM imaging and AFM analysis that it is only under specific conditions that the PS substrates influence NP formation, being linked to the magnitude of the topographical features. This novel method avoids the need for expensive lithographic techniques and produces large areas of consistent NP distribution and size. This approach is theoretically applicable towards a wide range of metals given the appropriate PLiD conditions are met. These NP arrays have a multitude of applications including sensing (1), surface enhanced Raman spectroscopy (SERS) (2), and as catalytic arrays (3).

1. *Jiao, Y. et. al., Appl. Phys. Lett. 2010, 97 (15), 153125.*
2. *Novara, C. et. al., J Phys Chem C 2016, 120 (30), 16946-16953.*
3. *Oh, Y. J. et. al., Small 2009, 5 (7), 860-865.*

Preparation of High Performance Supercapacitor Electrodes via Electrochemical Deposition of Aminonapthalene Precursors on Carbon

Anna K. Farquhar*, Mustafa Supur, Scott R. Smith, Richard L. McCreery

Thursday, May 2nd, 16:15 – 16:30

Climate change and fossil fuel depletion have stimulated a massive research effort in renewable energy. A major challenge is the ability to store energy from renewable sources such as solar and wind. Supercapacitors are a viable candidate for use in renewable energy storage. Supercapacitors rely on surface processes for energy storage, and have high power densities, charge/discharge rates and stability. However, their energy density is much lower than batteries, limiting usability.

In this work, electrochemical grafting of a 1,8-diaminonapthalene precursor on both flat and commercially available carbon materials was investigated. On flat substrates, the modification resulted in a 100-200× increase in the electrode capacitance. This substantial capacitance enhancement was a result of an increase in the electrical double layer capacitance caused by the high surface area of the electrode after grafting this nanoribbon like film, and a significant psuedocapacitve component resulting from redox active nitrogen groups scattered throughout the nanoribbon structure. The electrodes also showed impressive stability, with no loss of capacitance after 10,000 charge/discharge cycles. When the grafting protocol was applied to commercial carbon black powders, the resulting electrodes gave capacitances of 950-1890 F/g. A capacitance of 1890 F/g projects to an energy density of 590 Wh/kg over a 1.5 V range, which greatly exceeds the 10 Wh/kg of today's commercially available supercapacitors,

and rivals that of lithium ion batteries.

This presentation will discuss the grafting procedure used for preparation of these high capacity electrodes, and subsequent electrochemical studies will demonstrate the remarkable performance of these modified carbon materials.

Fabrication of Au, Pt, and AuPt Nanoparticles by Pulsed Laser-induced Dewetting and Their Characterization

S. Bonvicini, A. J. Fulton, E. Owusu-Ansah, Y. J. Shi*

Thursday, May 2nd, 16:30 – 17:00

Gold (Au) and platinum (Pt) nanoparticles (NPs) have found many applications in catalysis, sensors, magnetic storage devices and nanoelectronics. The fabrication of Au and Pt NPs is most commonly accomplished by wet chemical methods. However, it is challenging to obtain metallic nanoparticles of long-range order using this approach. Pulsed laser-induced dewetting (PLiD), on the other hand, provides an alternative, simple and high-throughput method for the production of metallic NPs with controlled spacing and order. In this talk, I will present our recent work on the fabrication of Au and Pt NPs via PLiD of single-layer metallic films. Our work has shown that PLiD can be used to produced NPs of both low-melting-point and high-melting-point metals, providing a powerful alternative to thermal dewetting. In addition, quantitative evidence has been provided to show that PLiD of Au and Pt follows spinodal dewetting mechanism. Pt-Au bimetallic NPs can be produced via PLiD of bilayer thin films. The effect of laser parameters, substrate and sputtering sequence on the NP size, long-range order and composition will be discussed.

Synchrotron-Based Investigation of Nanoscale Water Splitting Catalysts for Clean Energy Storage Daly, Katelynn Daly*, Trudel, Simon

Thursday, May 2nd , 17:00 – 17:15

Approximately 35% of total anthropogenic greenhouse gas emissions are attributed to the energy supply sector; currently primarily derived from fossil-fuels. The global energy consumption is projected to double by 2050, illustrating the pressing need for sustainable and GHG emission-free energy cycles. Renewable energies are rapidly gaining ground, but suffer from intermittency issues. Using chemical fuels (e.g., hydrogen gas, H2) is regarded as an effective way to store renewable energy when it is largely available in periods of low demand, for use in periods of low supply and high demand. Water electrolysis, splitting water is a promising way to store renewable energy wherein H2 functions as a storable chemical fuel. While H2 is the desired fuel, the sluggish oxygen-evolution reaction hinders H2 production as it is thermodynamically and kinetically challenging and requires potent and expensive catalysts to be driven at an appreciable rate. The large-scale deployment of energy storage requires fundamental improvements in the catalysts employed. There is a broad effort to develop new oxygen-evolution reaction catalysts (OERCs) that are both high-performance and low-cost. Metal (oxy)hydroxides meet both criteria, especially when employing Earth-abundant metals (e.g., Fe, Co, Ni). Improvements in OERC capabilities are reported from mixed Fe-Co-Ni oxides, however the synergistic roles of Fe, Ni and Co are still unclear. This analysis utilized X-ray absorption spectroscopy to study 16 compositions of Fe-Co-Ni amorphous mixed-metal (oxy)hydroxide thin films. This work will allow for a comprehensive view of catalyst activity and stability, delivering

an understanding of how to better design next-generation OERCs.

Understanding the Anatomy of a Silicon Nanoparticle

Alyxandra Thiessen*, Michelle Ha, Riley Hooper, Vladimir Michaelis, Jonathan Veinot

Thursday, May 2nd, 17:15 – 17:30

Silicon nanocrystals (SiNCs) display optoelectronic properties and biocompatibility that make them desirable for biological imaging and LED applications. These materials however have been plagued by low quantum yields and broad FWHM that limit their application in these areas. It is known that the structure of these nanomaterials influences their optical, chemical and material properties, therefore, it is important to understand the structure of these materials to optimize them for various applications. To study the structure of these materials, we employed a combination of 29Si solid state NMR, FTIR, XPS, XRD and TEM to analyse the structure of the materials ranging from 3 to 64 nm in diameter. We found that the H-SiNCs consist of a size dependent layered structure made up of surface, subsurface and core silicon species. This understanding can be applied beyond the optical properties of these materials to give insight into their effectiveness for other applications (i.e. lithium-ion battery anodes).

Adhesion Characterization for a Silicon-Diamond System using Frequency-Modulated Atomic Force Microscopy

Nicholas Chan*, Carrie Lin,Tevis Jacobs, Robert Carpick, Philip Egberts

Thursday, May 2nd , 17:30 – 17:45

The work and range of adhesion are material parameters that are commonly used to describe the atomic interactions for a given material system. While there are some existing techniques that allow for the determination of these parameters, there are several limitations associated with these techniques and significant discrepancies in the measured values between the numerous studies. Here In this work, the work and range of adhesion between a silicon probe and a diamond surface were experimentally determined in ultra-high vacuum (UHV) using frequency modulated atomic force microscopy (FM-AFM). Firstly, interaction forces between the probe and surface were experimentally determined and calculated via (frequency-shift)-distance spectroscopies. Secondly, theoretical calculations of these interaction force curves were generated using an integrated 12-6 Lennard-Jones potential over the experimental shape of the tip apex, as imaged by post-mortem transmission electron microscopy (TEM) images. Best fit work and range of adhesion parameters were then determined by performing a least squares regression fitting between the experimental and theoretical data. In general, the theoretical interaction forces, generated by the 12-6 Lennard-Jones potential, underestimatedthe the repulsive forces , generated from the 12-6 Lennard Jones potential, were underestimated at larger separation ranges and overestimated the repulsive forces at shorter separation distance when comparing to the experimental data. This suggestings an oversimplification in the interaction potential for the silicon-diamond system. Furthermore, significant variance in the work of adhesion was observed spatially over the diamond surface. This observation may suggest that localized roughness or contamination of the surface may play a significant role in the adhesion interaction in this material system.

Nobel metal nanoparticle enhanced measurements on surfaces and in solution

Mark T. McDermott*, Sunil Rajput, Casey Rusin, Ahmed Mahmoud

Friday, May 3rd, 10:30 – 11:00

Surface enhanced Raman spectroscopy (SERS) has experienced significant recent growth as a platform for analytical and bioanalytical measurements. This growth has tracked the development of the synthesis and modification methods of metallic nanostructures. This presentation will describe our groups efforts into developing biologically produced (biogenic) silver nanoparticles into SERS labels for a diagnostic clinical immunoassay and also in synthesizing hybrid nanomaterials for SERS measurements in solution. Assays that predict a cancer patient's response (sensitivity or resistance) to a specific treatment improve diagnosis and treatment and ultimately, quality of life. Prostate cancer (PCa) accounts for 11% of all cancer types among North American men. Enzalutamide and Abiraterone are the two major hormonal therapies for PCa. Both of these hormones prevent the binding of a steroid (androgen) to its protein receptor (androgen receptor, AR). Resistance to these hormonal therapies and been recently linked to an androgen receptor variant named AR-V7. We have developed a nanomaterial enhanced sandwich immunoassay for AR-V7 in the blood sera of prostate cancer patients. Highly sensitive detection will be driven by the optical properties of noble metal nanoparticles. The biomarker is captured onto a chip containing specific antibodies and subsequently labeled for detection by antibody coated biogenic silver nanoparticles. Measurement of the number of nanoparticles that bind to the chip will be accomplished using SERS which provides a unique chemical fingerprint of the label. The method allows the biomarker to be measured in blood or urine and will not require an invasive tissue biopsy.

A number of biosensing strategies like that above have been developed on planar SERS substrates. While these SERS measurement on solid substrates have shown widespread utility, the sample must be deposited on the solid surface. The exploration of SERS substrates that are dispersible in aqueous solutions has been less widespread. We have been investigating in-solution SERS substrates in two formats. One format are hybrid nanomaterials consisting of spherical metal nanoparticles attached to a second nanomaterial that is itself water dispersible. In this case, silver and gold nanoparticles are deposited onto cellulose nanomaterials, specifically, cellulose nanofibers (CNF). Reduction of silver or gold ions in the presence of CNF and CNC under specific conditions deposits a high density of nanoparticles on the nanomaterial surface. In the figure below, the scanning electron image on the left shows an example of the CNF/Ag hybrid material. The decorated materials remain water dispersible and the high density of closely spaced particles provide SERS enhancement in solution. The second platform includes highly structured individual nanoparticles that provide high intrinsic enhancement. In our case, we have optimized the synthesis of gold nano-stars for in-solution SERS. We have examined the effect of nano-star morphology on the SERS signal. Both in-solution SERS formats can be paired with hand-held Raman instrumentation creating a mobile platform for a variety of applications.

Voltage Colorimetric Sensing Device using Fe3O4@SiO2 Nanoparticles for Zin-air Battery

Lelin Zheng*, Thuy Nguyen Thanh Tran, Dinara Zhalmuratova, Hyun-Joong Chung

Friday, May 3rd, 11:00 – 11:15

Induced by electrical field of different intensities, Fe3O4@SiO2 nanoparticles can be self-assembled into photonic

crystal structure that diffracts lights of different wavelength. It can exhibit colors of increasing hue from red to dark blue with voltages from 0 to 4V added. While detecting battery in-situ behaviours in operations without electrical measurements remains a challenge, the voltage responding device using this self-assembled Fe3O4@SiO2 nanoparticles provides a reliable, efficient and simple solution. With nanoparticles synthesized and characterized, we further developed a voltage colorimetric sensing device and used it as a battery behaviour indicator for zin-air battery. From the different colors exhibited by the nanoparticle device, we can easily detect behaviours including discharging, charging, overcharging and aging of the battery by naked eyes.

High Performance, Room Temperature Hydrogen Sensing with a Cu-BTC/Polyaniline Composite Film on a Quartz Crystal Microbalance

Osama Abuzalat*, Danny Wong, Simon S. Park, Seonghwan Kim

Friday, May 3rd, 11:15 – 11:30

In this work, we demonstrate a high-performance hydrogen sensor by growing a Cu-BTC/polyaniline (PANI) nanocomposite film on a quartz crystal microbalance (QCM) using intense pulsed light. The QCM was first sputter coated with a 200 nm thin layer of copper. The copper layer was then oxidized by sodium hydroxide and ammonium persulfate. A solution containing the organic ligand (BTC) and PANI was then dropped and dried on the copper hydroxide surface of a QCM with intense pulsed light which resulted in Cu-BTC/PANI nanocomposite film on a QCM. The gas sensing performance of the Cu-BTC film and Cu-BTC/PANI composite film was compared at room temperature. It was found that both selectivity and sensitivity of the Cu-BTC/PANI nanocomposite film to hydrogen were significantly improved. In addition, a fast response time (from 2 to 5 seconds), operation at room temperature even in the presence of high relative humidity (up to 60%), good repeatability were achieved with the Cu-BTC/PANI nanocomposite film-grown QCM sensor.

Amphiphilic Lipid-Substituted Cationic Polymers for Delivery of Gene Medicines

Danny Wong*, Simon S. Park

Friday, May 3rd, 11:30 – 11:45

Hydrogen gas is frequently used for transportation applications such as fuel cell vehicles. In addition, hydrogen is a common byproduct in industrial and chemical processes. It has no smell and no taste, but it poses immediate safety risks because it is combustible in air. Multi-modal hydrogen sensors are developed by depositing nanofibers on quartz tuning forks (QTF). Near field electrospinning (NFES) was used to produce flexible, semi-conductive ~500 nm diameter nanofibers that can be integrated into many electronic systems as environmental gas sensors. The electrospinning parameters were optimized to increase sensor performance. Treated multi-walled carbon nanotubes, polyaniline and platinum nanoparticles were used as the sensing materials with polyethylene oxide being used as an electrospinning guide. Camphorsulfonic acid (HCSA) and cetyltrimethylammonium bromide were tested as doping agents with HCSA providing better sensing performance. Intense pulsed light and sputter coating were used to maximize adhesion of the fibers onto the devices. The QTF sensor combines sensitive mechanical and selective electrochemical sensing methodologies. Changes in the resonance frequency were used to determine gas adsorption. Changes in the electrical impedance were used to determine the electrochemical gas properties. As a result, the sensors were selective to hydrogen versus other gases and vapors including methane, hexane, toluene, ammonia, ethanol and carbon dioxide. Furthermore, the sensors can also detect ppm levels of hydrogen even in the

presence of high humidity that typically mitigates sensor response. The sensors exhibited responses as fast as 3 s to concentrations as low as 4 ppm.

Sensing Devices for Rapid Screening
Dhanjai*, Samuel M. Mugo, Weihao Lu, Nancy Yu
Friday, May 3rd, 11:45 – 12:00

Biomolecules are integral constituents of living beings which regulate numerous biochemical functions of the body. Detection of various biomolecules such as metabolites, vitamins, neurotransmitters, nucleic acids, proteins is of prime importance in modern time due to increasing disbalance in natural metabolism of human body. Irregularities and alteration in concentration of biomolecules lead to different kinds of genetic, metabolic and cancerous diseases which have created a great requirement of highly sensitive, accurate and stable detection systems for their quick and specific screening. Our research focuses on the development of advanced sensing devices based on different nanostructure and biomolecules for rapid screening of disease biomarkers and contaminants for point-of-care diagnostics, food safety and environmental protection. Advanced approaches for fabrication of portable integrated electrochemical devices have been emphasized.

Nanotools in Biology

Towards the Design of a Cannabis Biosensor
Justin MacCallum*
Friday, May 3rd, 13:15 – 13:45

I will present our work towards the design of a biosensor sensitive towards the psychoactive compounds found in cannabis. I will focus on both computational and experimental work on characterizing the binding of fatty acids and cannabinoids to fatty acid binding proteins. The experimental results include microscale thermophoresis and fluorescence displacement experiments. We observe that in addition to binding to individual fatty acid molecules, these proteins also bind to fatty acid micelles, which complicates analysis. Our computational work predicts that several phytocannabinoids bind with similar poses and that binding is coupled to the dynamics of the protein.

Enzyme-like Activity of Glancing Angle Deposited (GLAD) Nanofilm for Uric Acid Sensing
Anuja Tripathi*, Kenneth D. Harris, Anastasia L. Elias
Friday, May 3rd, 13:45 – 14:00

While natural enzymes or peroxidase have been used for decades to catalyze the formation of free radicals from hydrogen peroxide, they are known to exhibit limitations such as denaturation, high manufacturing cost, and limited shelf-life. On the other hand, nanomaterials (generally nanoparticles) have high catalytic activity while requiring very low volume in a reaction. However, nanomaterials are costly and they are difficult to recover from solution after use. Therefore, we present glancing angle deposition (GLAD) as a method to form helical structured

nickel nanofilms, which act as simple and reusable "enzyme-like" nanostructures. Here, GLAD film acts as a peroxidase to oxidize colorless 3,3′,5,5′-tetramethylbenzidine (TMB) to the blue-green oxidized form of TMB (oxTMB). This reaction is inhibited by the presence of uric acid (UA), allowing the concentration of UA to be determined based on the color change of the solution. The high absorbance of oxTMB at 652 nm recorded using UV-Vis spectroscopy was crucial in the detection of low concentrations of UA. We measured a low Michaelis-Menten constant for GLAD films, which indicates high peroxidase-like activity in comparison to monometallic nanoparticles and enzymes. We also achieved a low limit of detection (5ppm) for UA from this approach, which is suitable for monitoring the concentration of UA in human sweat. Furthermore, limited activity was observed for glucose and urea as potentially interfering species with merits of simple operation and good reliability. This work shows potential for the development of simple and inexpensive uric acid sensors with reusable nickel GLAD films.

Insight into gene regulation in West Nile Virus from the nanomechanics of viral RNA

M.T.J. Halma*, D.B. Ritchie, M.T. Woodside

Friday, May 3rd, 14:00 – 14:15

Numerous viruses like SARS, HIV, and West Nile virus, make use of "programmed ribosomal frameshifting" (PRF) to express multiple proteins in defined ratios from a single RNA message, as an efficient way to compress genetic information. PRF provides an attractive target for developing new anti-viral drugs, as virus replication can be inhibited by modulating the levels of PRF. However, the mechanisms underlying PRF, and in particular the factors that influence PRF efficiency, are still incompletely understood, hindering drug development. We studied the structural elements in viral mRNA that stimulate PRF to understand better what determines the efficiency of PRF stimulation, focusing on the stimulatory structure from West Nile virus, which has one of the highest known levels of PRF. Using optical tweezers to apply tension to the RNA molecule, mimicking the tension applied in the cell by the ribosome when it tries to read through the viral mRNA, we studied the nanomechanics of the RNA unfolding. We found that the West Nile virus RNA exhibited extreme structural heterogeneity, forming a wide array of different hairpins and pseudoknots. This work supports the hypothesis that conformational heterogeneity under tension is a leading predictor of PRF efficiency, suggesting that searching for RNA-binding ligands that reduce conformational heterogeneity should be a promising strategy for developing new anti-viral drugs.

AlMo Nanocomposite Membrane Fabrication, Characterization, and Biosensors

Remko van den Hurk*, Masoud Baghelani, Jie Chen, Mojgan Daneshmand, Stephane Evoy

Friday, May 3rd, 14:15 – 14:30

Nanomembranes with thicknesses less than 100 nm and high width-to-thickness ratios are of interest in sensing, energy storage, actuator, and optical applications. Fabrication of conductive nanocomposite aluminum-molybdenum (AlMo) membranes as thin as 10 nm with high fracture strength is presented. The density, Poisson's ratio, Young's modulus and intrinsic stress of the membranes were determined. Furthermore, the resonance frequencies of the membranes were assessed using FEA and measured by optical interferometry. The average fracture strength and resistivity of the membranes were 1.89±0.45 GPa and 5.81±0.44 μΩ-m respectively. This high fracture strength and low resistivity makes AlMo membranes attractive for the design of devices requiring ultrathin yet electrically conductive membranes.

One application of these ultrathin AlMo membranes is as resonance-based biosensors. The functionalization of a nanocomposite AlMo surface with a bifunctional diazonium linker is presented. Binding of diazonium molecules to the AlMo surface was validated through XPS measurements of 4-bromobenzenediazonium tetrafluoroborate and the linking molecule 4-formylbenzene diazonium hexafluorophosphate. The linker was then used to bind monoclonal antibodies specific for bovine herpesvirus-1 (BHV-1) to the AlMo surface coated chips. BHV-1 was successfully captured on the chip surface. The functionalization process was then implemented on 10 nm thick AlMo membranes and resonance measurements were performed to successfully detect BHV-1. Finally, a method for calculating the mass of BHV-1 on the surface of the membranes is presented and validated via FEA.

Mimicking 'J-shaped' and anisotropic stress-strain behavior of human aorta by fabric-reinforced elastomer composites

Dinara Zhalmuratova* , Thanh-Giang La, David Nobes, Chun-il Kim, Darren Freed, Hyun-Joong Chung

Friday, May 3rd, 14:30 – 14:45

Lipid nanoparticles are one way to package and deliver drugs and control release of drugs at targeted locations, both in treatment of patients and in biotechnological applications. The classical example is liposomal preparations of certain cancer drugs. In principle, lipid nanoparticles can be used to deliver RNA and DNA, and play a key role in personalized medicine. We are using computer simulations to study the components of lipid nanoparticles to better understand the role of they play in assembly, structure, stability, uptake and eventual destruction, leading to the release of the nanoparticle cargo. I will give a brief overview of the capabilities of molecular simulation to study lipid assemblies and focus on our work on one particular type of lipid nanoparticle that is capable of delivering siRNA.

Devices and Fabrication

Quenched Polyampholyte Hydrogels: Low-Temperature Properties and Energy Device Applications

Hyun-Joong Chung*, Xinda Li, Thanh-Giang La, Hemant Charaya

Friday, May 3rd, 15:15 – 15:45

With recent emergence of flexible electronics, gel polymer electrolytes (GPEs) are gaining increased attention due to their unique properties that combine the merits of solid and liquid state electrolytes. Charge-balanced polyampholyte hydrogels (PAHs), where their cross-linking originates from inter- and intra-chain ionic crosslinking between counter charged functional groups, have unique advantages such as anti-polyelectrolyte effect, self-healing ability, and good adhesion onto contacting surfaces. We have recently performed a series of studies using a polyampholyte random copolymer that consists of two oppositely charged ionic monomers, sodium 4-vinylbenzenesulfonate (NaSS) and [3- (methacryloylamino)propyl]trimethylammonium chloride (MPTC). Firstly, we studied the nano- to meso-scopic structure of the PAH in as-prepared state by using small-angle x-ray scattering (SAXS) and various electron microscopic techniques. SAXS results at room temperature indicate a networked globule structure in the charge-balanced PAHs, whereas the globular size and its clustering structure are dependent on synthesis parameters. Secondly, temperature-dependent structure evolution of the PAHs were also studied. At

low temperatures (measured down to −54 °C), an interconnected globular network structure of polymer-rich phase at low temperature appears to preserve ion-conducting channels of nonfrozen water molecules at low temperatures, whereas the mobility of such water molecules were confirmed by solid-state NMR. Thirdly, specific ion effects on mechanical and ion conductive properties were studied by dialyzing the PAH in various salt ions. For anions, the trend of ionic interaction follows Hofmeister series in exact manner, whereas some anomaly is observed among cations. Finally, the fundamental understandings were utilized in fabricating (i) thermosensitive smart windows, (ii) flexible and self-healing supercapacitors that works greatly at low temperatures (measured down to −30 °C), and (iii) pressure & temperature sensing arrays by utilizing PAH as transparent electrode.

Dueling Dynamical Backaction in a Cryogenic Optomechanical Cavity

B. D. Hauer*, T. J. Clark, P. H. Kim, C. Doolin, and J. P. Davis

Friday, May 3rd, 15:45 – 16:00

Dynamical backaction has proven to be a versatile tool in cavity optomechanics, allowing for precise manipulation of a mechanical resonator's motion using confined optical photons. In my talk, I will present measurements of a silicon whispering-gallery-mode optomechanical cavity where backaction originates from opposing radiation-pressure and photothermal forces, with the former dictating the optomechanical spring effect and the latter governing the optomechanical damping. At high enough optical input powers, we show that the photothermal force drives the mechanical resonator into self-oscillations for a pump beam detuned to the lower-frequency side of the optical resonance, contrary to what one would expect for a conventional radiation-pressure-dominated optomechanical device. Using a fully nonlinear model, we fit the hysteretic response of the optomechanical cavity to extract its properties, demonstrating that this non-sideband-resolved device exists in a regime where photothermal damping could be used to cool its motion to the quantum ground state.

Electrical and photo-caloric actuation using vanadium dioxide (VO2) MEMS resonator

Syed A Bukhari*, Ankur Goswami, Ryan McGee, Liang Zhou, Faheem Khan, Hyun-Joong Chung, and Thomas Thundat

Friday, May 3rd, 16:00 – 16:15

Microelectromechanical systems (MEMS) resonators have demonstrated many attributes in terms signal processing, communication, frequency mixing, modulation and filtering purposes which have potential applications in sensing, detection (temperature, mass and humidity) and energy harvesting. Among all the applications tuning or modulating frequency is the fundamental requirement of a resonator on which device performance depends by and large. Among many materials studied in the past vanadium dioxide (VO2) is one of the key material which can satisfy these demands to a larger extent because of its phase changing nature. VO2 possesses a reversible metal insulator transition (MIT) ideally at 68 oC where monoclinic (M1 phase-insulator) phase transforms to tetragonal or rutile (R phase-metal). This phase transition results in a change to the electrical resistance by more than three orders of magnitude and significant change in the visible light transmittance. Although this transformation depends predominately on externally applied conductive heat, but recently radiative heat, electric field, pressure and optical excitation have been used . Recently it has been observed that VO2 also changes its structure from M1 to R phase due to an externally applied DC electric field (> 1 kV/m) at room temperature, known as the electric field induced

MIT (EMIT)3. Here we will show that these transition can be also activated by a broad spectrum of optical wavelength operating at low power (<100 μW) as well as very low AC electric field. By fabricating suspended VO2 microstring MEMS resonator we demonstrated the tuning of resonance frequency (both positive and negative direction) of the device can be achieved 3 to 4% by applying different wavelength of the light of very low power. Further, we will also show by changing the frequency of the applied AC electric field, the resonant frequency of the resonator can be tuned. These experiments may provide a new platform for MEMS based frequency modulation applications.

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4. Ruzmetov, D., Gopalakrishnan, G., Deng, J., Narayanamurti, V. & Ramanathan, S. Electrical triggering of metal-insulator transition in nanoscale vanadium oxide junctions. J. Appl. Phys. 106, (2009).

Conductivity loss of reduced graphene oxide coated meta-aramid under abrasion and its application as end-of-life indicator for textiles

Chungyeon Cho*, Anastasia L. Elias, Jane Batcheller, Patricia Dolez, Hyun-Joong Chung

Friday, May 3rd, 16:15 – 16:30

High-performance textiles – especially those used in protective clothing – age slowly, undergoing a gradual decrease in their protective properties, and becoming unserviceable in the end. We propose that an electrically conducting layer that loses its conductivity steadily under aging conditions can be used as an end-of-life-sensor for protective clothing. In this work, we present a simple method to deposit reduced graphene oxide (rGO) as conductive layers on a woven meta-aramid fabric. After 15 times GO “dip, dry and reduction” cycles were performed, rGO layers were wrapped around individual m-aramid fiber with rGO sheets completely, and 10 cycles were sufficient to achieve the electrical conductivity that remained stable for up to 10 simulated-laboratory wash cycles, which are equivalent to 50 domestic laundry cycles. In addition, these rGO layers on fabrics maintained their conductivity upon immersion in water for 5 days. Finally, we developed a fabrication protocol for patterning rGO tracks both single- and double-sided on the m-aramid fabric. The single-sided rGO tracks are designed to lose their conductivity upon abrasion, while double-sided rGO tracks are designed to represent a gradual transition in properties during aging. Assessment with a Martindale abrasion tester showed that the resistance of all rGO tracks gradually increased with the number of abrasion cycles. The resistance of single-sided rGO track increased 150 times after 150 abrasion cycles, whereas that of double-sided rGO-tracks only increased 10 times up to 3000 abrasion cycles. These results demonstrate that a simple rGO coating technique can be introduced to fabricate end-of-life sensors for protective clothing textiles.

Fabrication of Complex Multi-depth Channels in Borosilicate Glass Substrate using Femtosecond Laser Material Processing

Ebenezer Owusu-Ansah* and Colin Dalton

Friday, May 3rd, 16:30 – 16:45

Femtosecond laser material processing (FLMP) technique has been used to develop, control, and machine micro/nanotechnology (MNT) features that are not easily accomplished using traditional MNT fabrication methods, such as photolithography. FLMP does not require expensive photomasks, chemical etching procedures or high vacuum systems. It involves a computer numerically controlled (CNC) motion that can machine complex patterns through cycles of laser beam passes over a substrate with high precision and fast processing speeds. Our custom built FLMP setup can produce 2.8 W output power at 1 kHz repetition rate and 100 fs pulse duration with precise motion control over a 150 mm x 150 mm area. The technique is ideally suited to micro-structuring, as the ultra-short femtosecond pulse width is shorter than the thermal diffusion times of most materials, such as glass and metals. This causes less damage to the material and leads to very fine control of feature sizes not possible with conventional CO2 lasers. Applications of FLMP include the fabrication of microelectrode features on substrates, and creation of multi-depth etch profiles for microfluidic systems.

We report here the fabrication of complex multi-depth microfluidic channels in a borosilicate glass substrate. The effect of FLMP parameters, such as processing speed, laser power and beam diameter, on the microfluidic channel depth was studied and optimized. Within the range of laser power investigated (0 – 2.8 W), we determined a threshold processing speed of 20 mm/s beyond which the roughness of the etched surface increases significantly. This work has demonstrated that FLMP is an efficient technique for making microfluidic devices with complex geometries and aspect ratios not possible through other methods.

Poster Presentations

An amphiphobic graphene-based hydrogel as oil-water separator and oil fence material

Wenjihao Hu*, Dr. Hongbo Zeng

Graphene-based hydrogel materials have attracted increasing attention in engineering applications such as oil-water separation. In this work, we report a novel, facile, environmental-friendly and cost-effective synthesis method for fluorographene nanosheets through Michael's Addition reaction and the fabrication of amphiphobic LA/F/rGO hydrogel, based on a low-temperature hydrothermal process of partially reduced graphene oxide (rGO) and 1H,1H,2H,2H-perfluorodecanethiol (PF) in the presence of a reducing agent l-ascorbic acid (LA). The LA/F/rGO hydrogel has a low density of ~19 mg/ml, with excellent thermal stability and regenerable adsorption capacity (up to 20 times its original weight) for various organic solvents. The as-prepared LA/F/rGO hydrogel shows intriguing oil repellant and oil bouncing behaviors underwater. Pre-soaking with water or oil allows selective and efficient separation of water or oil from their mixtures. The new LA/F/rGO hydrogel developed in this work has been demonstrated as a promising candidate for efficient adsorbent of oil pollutants in waste water treatment, oil/water separator and oil fence material. This work provides new insights into the development of novel graphene-based

nanocomposite materials for oil-water separation and oil leaking, with a wide range of engineering and environmental applications.

Banana Peel/Graphene Oxide Derived Adsorbent for Water Treatment

Muhammad Zubair*, Aman Ullah

One of the most serious global challenges is inadequate access to fresh water, that is predicted to grow worse in the future as demand continues to rise due to ever increasing world population, rapid industrialization and greater energy needs. Clean water is essential to protect human and any other life on the planet earth. However, one tenth of the global population do not have access to safe drinking water. Conventional approaches such as reverse osmosis, decontamination and disinfection can address many water problems. However, these methods are often chemically, energetically and operationally intensive and, thus require considerable infusion of capital. Herein, we are proposing the development of an integrated low cost, robust and efficient water treatment technology based on banana peel/ graphene oxide with a potential to remove metals, organics and pathogens in a single treatment without further stressing environment. In this study, graphene oxide was prepared and characterized using XRD, TGA, FTIR techniques. For the synthesis of banana peel/GO derived adsorbent, banana peel has been dried followed by grinding. Then, powdered banana peel and graphene oxide were mixed using suitable solvent. Furthermore, the adsorbent properties will be evaluated with XRD, AFM, Raman spectroscopy, XPS, solid state NMR and TEM. This study can open up new horizons to exploit unique properties of both banana peel and graphene oxide for water purification.

Using the Portable Scanning Electron Microscope to Promote Inquiry-Based Laboratory Activities in Alberta Secondary Schools

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The Hitachi TM 3000 tabletop scanning electron microscope is a durable and portable tool that requires little technical expertise to operate. During the 2018/2019 school year, this instrument, equipped with an EDX (Energy Dispersive X-ray Spectrometer) travelled to secondary schools in Alberta, Canada and was used for student-designed inquiry projects in nanoscience. This project was supported by CMASTE (the Centre for Mathematics, Science and Technology Education), NRC-Nano (National Research Council of Canada – Nanotechnology) and Alberta Innovates. With the aid of a trained teacher-facilitator, junior high and senior high school students (grades 7 – 12) were able to plan nanoscience-related experiments and investigations, carry them out, and use the images, and in some cases EDX data, to answer their research questions. The microscope travelled to 10 schools in northern and central Alberta upon teacher request. The teachers were encouraged to have the students use the SEM for hands-on project work. Although research data is still being gathered and analysed, early results show that both teachers and students are engaged by the experience, and teachers are more likely to engage in this type of student-designed scientific inquiry when encouraged by the SEM visit parameters. This project will continue for at least one more school year, and the data gathered from students and teachers over the next 18 months will be used to further refine and revise how the SEM may be used to help students understand the potentials and challenges in using the primary tool for nanoscience, the electron microscope.

Mimicking 'J-shaped' and anisotropic stress-strain behavior of human aorta by fabric-reinforced elastomer composites

Dinara Zhalmuratova*, Thanh-Giang La, David Nobes, Chun-il Kim, Darren Freed, Hyun-Joong Chung

The ex vivo heart perfusion device allows the donor heart to maintain full functionality during transfer between extraction and implantation surgeries. One of the current challenges include the mismatches in mechanical properties of synthetic tube materials compared to human aorta. This leads to frequent injuries to the soft and moving heart at the junction, which may result in the rejection of the donor heart for transplantation. In this study, we mimic the 'J-shaped' (rapidly strain-stiffening) and anisotropic stress-strain behaviour of human aorta by utilizing fabric-reinforced elastomers. Firstly, we measured the mechanical properties of human and porcine aorta to quantify anisotropic behaviour and a non-linear response. Fabric-reinforced elastomer composites (neo-aorta materials) were prepared from four different textiles to mimic aorta's non-linear response to strain in three-layer sandwich design. The resulting composites exhibited the J-shaped strain-stiffening behaviour with anisotropicity that matches the properties of natural human and porcine aorta. Most notably, we developed analytical constitutive models based on Gent's and Mooney-Rivlin's constitutive law (to describe elastic matrix) combined with Holzapfel–Gasser–Ogden's law (to represent the stiff fibers) to represent strain-stiffening behavior of natural aorta and confirm aorta-like behavior of fabric-reinforced composite. We anticipate the novel neo-aorta materials to be used in the ex vivo heart perfusion device to increase the number of successful heart transplants.

Fabrication of hybrid Atomic Force Microscopy probes for enhancing sensitivity of AFM IR-spectroscopy

Mohamad Ebrahimi*, Seoghwan (Sam) Kim

Atomic force microscopy infrared-spectroscopy (AFM-IR) has emerged as a novel method that combines nanoscale resolution of AFM with IR-spectroscopy. In this technique heat generated by IR absorption within the sample will induce dynamic thermal expansion which is detected by AFM probe, in contact with the sample, to discover the chemical composition of the sample based on IR absorption spectrum. One of the issues in applying this technique is that the heat generated in sample will also diffuse to the probe, due to thermal conduction, which results in reducing the sensitivity of the probe. One of the alternative solutions to overcome this problem is to replace the AFM probe, which is commonly made by silicon, with a photo-polymeric AFM probe. Since thermal conductivity of photopolymers are orders of magnitude lower than silicon, this alternative seems to be promising. To address this issue, we are developing a MEMS fabrication method enabling us to make a hybrid AFM probe (silicon cantilever with photo-polymeric tip). In the first step of fabrication process we fix an ordinary AFM probe over a Petri dish with some photopo lymeric resin which covers underneath of the cantilever. Secondly, we silanize the surface of the cantilever and then we replicate the tip of the cantilever using soft lithography with PDMS (Polydimethylsiloxane) to make a mold for tip fabrication. Finally, we cure a photopolymer inside the PDMS tip mold in contact with a silicon cantilever. The firm contact between silicon cantilever and ease of detaching tip from the PDSM are two crucial factors for choosing a proper photo-polymer for this application. Poly (ethylene glycol) diacrylate (PEG-DA has been proved to both make a good attachment to silicon and a fair mold release from PDMS. After fabrication of a hybrid AFM probe, with silicon cantilever and a PEG-DA tip, we need to investigate how much a photo-polymeric tip will add to the sensitivity of the probe by conducting AFM-IR spectroscopy over different samples at different wavelengths.

Synthesis of Carbon Quantum Dots for Bioimaging Using Lignin from West Fraser Co. Ltd.

Dr. Wei-Zheng Shen*, Jonathan Espiritu, Dr. Paolo Mussone

Carbon quantum dots (C-dots) are new class of functional, water-soluble, biocompatible, chemically and photostable nanomaterials that have the potential to replace conventional quantum-dots in bioimaging applications.
Industrial scale quantities of C-dots are currently not available because their synthesis requires a complex uneconomical iterative process that involves multiple separation steps.

In this project we resolved this bottleneck by synthesizing C-dots from lignin through a one-step chemical reaction known as hydrothermal carbonization. In this autogenous and mild exothermic process, lignin is transformed into carbon-dense materials in presence of water in a closed pressurized vessel. This approach enables high product yields while minimizing the production of carbon dioxide and carbon monoxide. The C-dots are easily purified by commercially available membrane separation units.

We studied the lignin-based C-dots using spectroscopic, thermogravimetric and microscopy techniques establishing the first known correlation between synthesis parameters such as reaction temperature and residence time, and their chemical and physical properties. Finally, we identified biocompatible lignin-based C-dots and, using fluorescence microscopy, we demonstrated that they are able to penetrate Hela cells' membranes and enter into the cytoplasmic area.

The results generated during this project show that it is possible to synthesize biocompatible C-dot for with direct application as bioimaging materials using lignin through an efficient one-step reaction protocol.

Nanoporous Microcantilevers with Plasmonic Absorbers for Photothermal Infrared Spectroscopy

Nicholas Simin, Yangkyu Park*, Seonghwan (Sam) Kim

A nanoporous anodic aluminum oxide (AAO) bimetallic cantilever enhanced by a gold coating on the nanopores creates a plasmonic crystal structure. The fabricated sensor is used for photothermal cantilever deflection spectroscopy (PCDS). Explosive compounds tested, show both highly selective and sensitive spectra. Through a two-step anodization process, photolithography, and a bimetallic and plasmonic coating, a sensitive photothermal microcantilever is fabricated. The bimetallic layer thickness is optimized through analytical calculations. The plasmonic layer thickness is optimized through experimentation. Molecules adsorbed onto the cantilever surface have their mass quantified through a measured change in 2^{nd} mode resonant frequency of the cantilever. Simultaneously, the molecules are identified by high power infrared (IR) spectroscopy. For standoff IR spectroscopy, thermomechanical sensitivity of a plasmonic enhanced AAO cantilever is shown to be improved 10-fold and 7-fold from a silicon cantilever and a plain bimetallic AAO cantilever, respectively. The limit of detection for standoff TNT sensing is determined to be 63.42 ng/cm^2.

Low Energy Partial Upgrading of Heavy Crude Oil Using Cavitation and Nanofluid

Bomin Kim*, Jongho Won, Simon S. Park

Extracted heavy crude oil/bitumen from oil sands need to be diluted using diluents or partially upgraded to enable them to flow through pipelines by reducing viscosity. However, the conventional partial upgrading methods for unconventional hydrocarbon resources have shown drawbacks including high-energy consumption, high greenhouse gases (GHG) emission, high operating costs, and high initial capital expenditure (CAPEX) requirement, which demands innovations in partial upgrading technology. The combination of cavitation and novel nano stimulators can overcome the drawbacks of the conventional approaches. Cavitation can create regional hotspots with extremely high temperature (~10,000 K) and high pressure (~1,000 atm) that are capable of breaking chemical bonds of long chained heavy hydrocarbons. This study uses cavitation that is based on ultrasonic irradiation where the acoustic waves induce pressure fluctuation causing local pressure drop. For different time intervals, the changes in physical properties of crude oil samples exposed to ultrasonic irradiation were observed. Viscosity measurement confirms that there is an optimum duration for ultrasonic irradiation, at which the viscosity of crude oil reduced to the minimum value. Subsequently, the nanofluid establishes the stability of treated crude oil. The present technology will provide benefits including environmentally friendly partial upgrading, heavy oil viscosity reduction with less use of diluents for efficient pipeline transportations, and high valued crude oil production. We envision that the present partial upgrading technology will reduce considerable amount of energy consumption and diluent addition, thereby reducing GHG emissions remarkably compared to the conventional partial upgrading technologies.

Development of Piezoelectric Force Sensor Using PZT/CNT/PVA Nanocomposites

Sina Rezvani*, Lei Liu, Jihyun Lee, Simon Park

Piezoelectric sensors are the most common devices used to measure dynamic force and acceleration. However, the performance of the recent piezoelectric sensors can be affected by temperature and have high fabrication costs. In this study, a novel cost-effective lead zirconate titanate (PZT)/ carbon nanotube (CNT)/ Polyvinyl alcohol (PVA) nanocomposite force sensor is developed. It has been shown that the inclusion of a conductive phase can enhance dielectric and piezoelectric properties of the composite. CNTs have attracted great interest for this purpose, because they will improve the mechanical properties of the composite in addition to electrical and piezoelectric properties. Furthermore, carbon black can be also introduced to the composite through carbonization of the binder. The impacts of PVA carbonization on the properties of the composite material is also investigated in this research. Moreover, a finite element model is used to predict the piezoelectric properties of the nanocomposite and finally, based on the optimized composition, a force sensor is fabricated and its force sensing performance is examined through testing.

Enhancements of Hybrid Copper Inks with Cellulose Nanocrystals

Lei Liu*, Danny Wong, Simon Park

Copper has been chosen with increasing frequency as the main material in conductive inks rather than silver or gold due to its cost efficiency and good electrical conductivity. A hybrid copper-based ink has developed by adding

silver nitrate to overcome challenges associated with copper oxidation. However, copper-based inks still have durability concerns. When these ink films are repeatedly bent and stretched, they are liable to cause structural cracks and lose electrical conductivity. To overcome this challenge, we proposed to integrate cellulose nanocrystals (CNC) with copper-based ink and use a sintering process based on intense pulsed light (IPL) in an argon atmosphere. Sintering in argon provided an improvement in electrical resistance. It has been experimentally determined that CNC improved adhesion of the copper ink film from 0B to 4B by the ASTM standard test method. CNC also reduced the damage caused by bending and stretching. The ink film containing 10% CNC increased the resistance by only 3.82 times after 600 bending cycles versus the resistance increased by 34.4 times without CNC. Under the 30% strain of stretching, the change in resistance of the ink film containing 10% CNC was 1.75 times lower than in the case of no CNC. It was observed by an optical profiler that this is because the presence of CNC reduced the formation of cracks.

Nanostructured MOF Catalysts for Electrochemical Reduction of Carbon dioxide.

Nidhika Bhoria*, Md Golam Kibria

Efficient electrocatalysts need to be developed for carbon dioxide (CO_2) reduction reaction. Metal organic framework (MOF) based nano-catalyst has benefits of both the molecular and heterogeneous systems with enhanced activity and selectivity for CO_2 reduction. Nanostructured MOF based catalyst has been synthesised for targeted formation of C^{2+} products. The synthesised catalyst was characterised using SEM, FTIR, XRD, and BET. Electrochemical CO_2 reduction was performed in a flow cell configuration. The liquid and gas products were analysed using NMR and GC, respectively. High C^{2+} product selectivity with improved current density and stability were observed by nanostructured MOF-based catalysts, thereby providing a pathway for high-throughput CO_2 conversion for industrial-scale applications.

Friction and Mechanical Stiffness Variation Resulting from Water Intercalation between Graphene Hydrophilic Substrates

Zahra Abooalizadeh*, Peng Gong, Leszek Josef Sudak, Philip Egberts

The interplay between water and solid lubricants is of great interest in the field of tribology, as water is typically present in most mechanical systems, be it biological or artificial systems. While this fact is true, access to the influence of water on these lubricants at the molecular and nanometer length scale has only just begun to be accessible. Graphene presents as an ideal material system to study this effect: it is a dry lubricant and has been shown to be strongly influenced by the presence of water, in particular on hydrophilic substrates (e.g., mica and silicon oxide). Here, we report the effects of water intercalated between graphene layers and between graphene and a mica substrate, specifically examining its impact on the mechanical and friction properties measured with a Si tip in both contact mode atomic force microscopy (AFM)
and dynamic mode AFM. In these measurements, we found that when a monolayer of water was intercalated between the graphene and the mica, the friction decreased while the out-of-plane elastic modulus slightly decreased. We also observed that the impact of water on the out-of-plane modulus decreased as the number of graphene layers increases, suggesting the possibility of determining the location of the water (eg. under the first layer of graphene, or between graphene and the substrate) and how its location impacts the lubricating properties of graphene. The impact on the out-of-plane modulus on graphene in the presence of water may explain some of the

unique observations made of graphene, such as strengthening or sliding history, that are difficult to reproduce in atomistic simulations.

In-situ Upgrading Technology: Nanocatalyst for Improved Product Quality

Milad Ahmadi Khoshooei*, Carlos E. Scott, Lante Carbognani, Pedro Pereira-Almao

A new nanocatalyst preparation pathway, using ultrasound, for an in-situ upgrading technology (ISUT) is investigated in this study. An ultrasonic probe is employed for preparing the microemulsions of the molybdenum solution with vacuum residue (VR), while high-shear mixing is used for preparation of microemulsion of nickel solution in VR. The results of catalyst preparation showed that the synthesized NiMo nanoparticles are half the size of the particles prepared conventionally using a high shear mixer. The two prepared batches of suspended nanocatalysts in VR were then tested for evaluating their activity for upgrading reactions. In the upgrading tests, VR+cat and hydrogen were injected in the reactor, packed with silica sand, where residence time was 48 hr for all experiments. Appreciable quality enhancement was observed for the ultrasound-assisted nanoparticles test. Using the new preparation method, the density and viscosity, as well as tendency to coking decreases, while the demetallization and desulphurization extent were both enhanced. Moreover, smaller size nanoparticles are more favourable for the ISUT process, as it ensures that the permeability of the porous medium remains intact after catalyst deposition.

High Yield Synthesis and Characterization of Very long Silver Nanowires via Multistep Polyol Method for Flexible Electronics

Shaghayegh Shajari*, Farbod Sharif, Mahmoud Rajabian, Uttandaraman Sundararaj, Les Jozef Sudak

Silver nanowires (AgNWs) have recently opened up new prospect for fabricating soft electronic devices and nanoelectronics such as capacitors, batteries, flexible transparent electrodes, organic light emitting diods (OLEDs), and antistatic Electromagnetics shielding (EMI) material. AgNWs have been synthesized using a polyol method, but producing high-aspect-ratio AgNWs via a simple and optimised process still remains an obstacle. In this work, a modified polyol method is developed in which the multistep growth of silver nanowires from the initial silver seeds facilitated the high yield production of very long Ag NWs with 100-200μm in length and 30nm-100nm in diameter. We report a comprehensive study of transparent and conductive silver nanowire, including a scalable fabrication process, morphologies, flexibility properties, and various routes to improve the performance. The overall properties of transparent AgNW electrodes meet the requirement for many applications in the flexible electronics.

The Hunger Games: In-Process Quality Control of Cannabis-Based Consumables

Taylor P. Lynk*, Sunil Rajput, Casey J. Rusin, Arsh S. Hazarh, Wolfgang Jäger, Mark T. McDermott

The recent legalization of cannabis in Canada, as well as the upcoming legalization of cannabis edibles, presents an opportunity to fill an unmet need for an analytical tool to ensure quality control of consumable cannabis products. This is especially important with the expected rise in popularity of cannabis beverages such as cannabis-based beer, wine, and soft-drinks. This new branch of the cannabis industry will require efficient, real-time detection and quantification of cannabinoids and terpenes in complex food matrices to ensure product regulation during production. It will be vital to monitor both cannabinoids and terpenes due to their synergetic effects on the potency

of the cannabis product. In this study, surface-enhanced Raman spectroscopy (SERS) is evaluated as a candidate for cannabinoid and terpene detection due to its ability to rapidly provide a chemical fingerprint for target molecules with a high degree of sensitivity and selectivity. A gold nanostar substrate will be evaluated for the detection of target cannabis compounds in a solution dispersible form. A cannabis beverage sample can be directly dispersed into a small amount of the SERS substrate to allow for facile and sensitive beverage monitoring. Theoretical Raman spectra calculated using density functional theorem (DFT) for the target compounds were used to assess peaks of interest in the measured spectra. With no current standardized quantification method for cannabis consumables in Canada, a rapid, sensitive, and cost-effective detection platform for such purposes is crucial for the expanding Canadian cannabis market.

Novel Synthesis for Water-Soluble InP/ZnS Quantum Dots with Fluorescence Capability

Owen Baiwen Wang*, Nikhil Pradhan, Julia Bodnariuc, Dr. Max Anikovskiy

Indium phosphide quantum dots (InP QD) are small, monodispersed and fluorescent nanostructures. InP QD's as a biolabeling tool is shown to be better compared to the conventional cadmium selenide quantum dots (CdSe QD) used in clinical diagnosis due to its lower toxicity. Current syntheses have proven to be either expensive or inconsistent, and result in a water insoluble product that is unsuitable for biological applications. Here, we synthesized InP QD shelled with zinc sulfide (ZnS) and capped with oleylamine using previously described methods. The capping agent was swapped with 1-mercaptopropionic acid (MPA) or cysteine (cys) during a phase transfer reaction to produce water soluble QD's. The phase transfer procedure was adjusted with varying capping agent concentrations and the addition of a reducing agent. Comparing with the standard InP/ZnS with oleylamine capping, the synthesized QD with MPA capping displayed similar absorbance and fluorescence, with cys capped QD showing a red shift in both spectra. The phase transfer efficiency was greater for MPA capped QD with increased fluorescence in comparison to cys capped QD's. The differences observed between the capping agents can be attributed to the colloidal stability of the QD's, as FCS data show aggregation for cys capped QD's. The addition of the reducing agent improved the phase transfer efficiency for both capping agents. Here, we demonstrate the successful phase transfer of InP/ZnS QD into an aqueous solvent with potential for further functionalization.

A Water Dispersible Surface-Enhanced Raman Scattering Substrate using Plasmonic Cellulose Nanofibers

Casey J. Rusin*, Yaman Boluk, Mark T. McDermott

Surface-enhanced Raman scattering (SERS) is an ultrasensitive detection technique based on Raman spectroscopy and the surface plasmon resonance of metal nanoparticles. A lot of interest and time has been invested in the development of SERS substrates for simple and rapid analyses. The development of SERS substrates is generally focused on solid-based substrates, where the analyte of interest is delivered via a drop of solution. However, this method suffers from poor precision and long analysis times. Our research aims at developing water-dispersible SERS substrates for reproducible and rapid analyses. A solution-based SERS platform offers good signal reproducibility and shorter analysis times via solution homogeneity and quick analyte adsorption facilitated with solution mixing. The development of plasmonic cellulose nanofibers involves a simple in-situ synthesis of gold and silver nanoparticles on the cellulose nanofibers. In this work, the cellulose nanofibers are acting as a biotemplate for nanoparticle growth and a dispersing agent for the substrate. We have characterized and optimized our substrate using Raman and UV-Vis spectroscopy and imaging techniques. We have focused on the detection and

quantitation of common pesticides and fungicides using plasmonic cellulose nanofibers.

Tunable Silicon Nanocrystal-Polystyrene Microresonators for Display Pixels

I Teng Cheong*, William Shread, William Morrish, Al Meldrum, Jonathan G.C. Veinot

Quantum dot (QD) displays have attracted attentions for the next generation flexible electronics due to their high colour-saturated photoluminescence, processability, and stability in comparison to conventional organic light-emitting diodes (OLED). However, current commercialized QD displays employ heavy metals (e.g. Te, Zn, Se, Cd, etc.) that are both toxic and unabundant. Silicon nanocrystals (SiNC)-based displays alternatively have been investigated due to their biocompatibility and abundance, yet their broad PL remain a challenge to be solved for a desirable colour quality. In this work, a SiNC-polymeric based microresonator is fabricated and demonstrated to be used as display with tunable and narrow photoluminescence.

Bioconjugation of Silicon Quantum Dots with Active Enzymes

Christopher Jay T. Robidillo*, Jon Veinot

In many cases, diseases result from the accumulation of substances that disrupt normal cell operation. The introduction of enzymes, catalytic protein molecules essential for normal biological function, that act on these disruptive substances provides an attractive alternative for curing such diseases. Silicon quantum dots, owing to their limited toxicity, unique photodynamics, and magnetic response, offer a new, potentially safer, and more efficient bioimaging platform compared to status quo organic dyes.1 – 3 In this context, a hybrid material consisting of enzymes interfaced with silicon quantum dots could offer simultaneous imaging and therapy. This study reports methods for the preparation of enzyme-conjugated silicon quantum dots from native enzymes and acid or alkene-terminated silicon quantum dots through the amide coupling and thiol- ene reactions, respectively. Model enzymes, glucose oxidase and lactase were successfully immobilized on silicon quantum dots as confirmed by Fourier transform infrared spectroscopy and X-ray photoelectron spectroscopy. Moreover, single reaction and cascade kinetic assays confirm that the conjugated enzymes retain their selective catalytic activity. The hybrids manifested excellent solubility or good dispersibility in buffer, and were photostable, exhibiting bright orange photoluminescence after more than a month of dispersion in an aqueous medium.4,5 The methods reported herein are general and can be used for the preparation of bioinorganic silicon-based hybrids that can be employed in personalized medicine for targeting and potentially treating diseases like cancer and other metabolic disorders.References

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