Clean Technologies Research Institute

Room 226
Chemistry Building
Dalhousie University, Halifax, Nova Scotia, Canada
Wednesday, 28 June 2017

9:00 – 9:30 am	Dr. Josef Zwanziger, Interim Director Clean Technologies Research Institute *Welcome and Opening Remarks*
9:30 – 10:30 am	Dr. Thomas Zawodzinski, University of Tennessee-Knoxville and Oak Ridge National Lab *Redox Flow Batteries and Efficient Electrochemical Conversions for Use with Renewable Electrons*
10:30 – 10:50 am	Break
10:50 – 11:20 am	Dr. Mark Obrovac, Department of Chemistry, Dalhousie University *Alloy Negative Electrodes for Metal-Ion Batteries*
11:20 – 11:50 am	Dr. Mita Dasog, Department of Chemistry, Dalhousie University *Materials for Solar Fuels, Optoelectronics and Beyond*
12:00 – 1:15 pm	Lunch
1:15 – 1:45 pm	Dr. Paul Bishop, Department of Mechanical Engineering, Dalhousie University *Net shape processing of engineered components from metal powders*
1:45 – 2:15 pm	Prof. Brian Lilley, School of Architecture *Clean + Green Architecture - an approach based on Materials Research*
2:15 – 2:45 pm	Dr. Ghada Koleilat, Dept. of Electrical and Computer Engineering *Solution-processed nanomaterials for energy applications*
2:45 – 3:00 pm	Closing Remarks

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Redox Flow Batteries and Efficient Electrochemical Conversions for Use with Renewable Electrons

Dr. Tom Zawodzinski
University of Tennessee-Knoxville and Oak Ridge National Lab

New energy imperatives, especially the widespread production of renewable electricity, are providing impetus toward using electrons in various sectors (replacing thermal energy in synthesis for example). This opens up an area of emphasis of executing chemical conversions using electrochemistry at the highest possible efficiency. To do this at scale, recent advances in energy conversion (fuel cells, for example) and storage (batteries, capacitors) devices can be leveraged. In this talk, I will familiarize the audience with the basics and some of the advances in 'open batteries' that combine characteristics of fuel cells and batteries. We have recently made significant advances in one such open system, redox flow batteries, by implementing and adapting components from fuel cells. These advances will be described in some detail along with a discussion of new areas of inquiry related to the special chemical environment in the open battery/reactor system. Finally, we will project this forward and consider other applications in light of how electrochemical systems can generally improve the energy efficiency of these conversions.

Thomas Zawodzinski is presently the Governor’s Chair in Electrical Energy Conversion and Storage, with appointments in the Chemical and Biomolecular Engineering Dept. at the University of Tennessee-Knoxville and at ORNL. He also is a Visiting Professor at the University of Padua and was a Royal Academy of Engineering Distinguished Visiting Research Fellow at Imperial College. He previously was the Ohio Eminent Scholar in Fuel Cells, Director of the Case Advanced Power Institute, and the founding Director of the Wright Fuel Cell Group. Dr. Zawodzinski is a Fellow of the Electrochemical Society and of the American Chemical Society Polymer Division. Recently he was awarded the Electrochemical Society Energy Technology Division Research Award. Dr. Zawodzinski was the PI for the Wright Center for Fuel Cells in Ohio, a $60M joint university/academic center. He directed a 10-investigator ARO-MURI project on ‘An Integrated Experimental and Computational Approach Toward Catalyst Design for Fuel Cell Systems.’ As Team Leader for Fuel Cells at LANL until 2002, Dr. Zawodzinski led a comprehensive program with R&D components related to automotive, stationary and portable power applications of PEM and Direct Methanol Fuel Cells. In addition to his continuous involvement in the fuel cell program, he initiated and led programs including preparation of new electrolytes and new methods for studies of transport and electrode materials in Li batteries; self-assembled monolayers for device preparation; biosensors and chemical sensors for chemical warfare agents and simulants; artificial muscles and electrochemical reactors. Recent work focuses on extending the lessons learned from fuel cell research to areas such as redox flow and metal-air batteries as well as developing next-generation components for electrochemical systems.

He has published more than two hundred refereed papers and a number of book chapters, holds five patents with several more pending, has co-edited several books on fuel cells and related topics, and has been an active public speaker with hundreds of presentations and short courses given around the globe on fuel cell, electrochemical device and sensor-related topics and research. He has served on Technical Advisory Boards of several companies and the International Editorial Advisory Board for J. Power Sources.

Dr. Zawodzinski received his Bachelor’s and Ph.D. degrees from the State University of New York at Buffalo. His Bachelor’s studies were in Chemistry and Cell/Molecular Biology and his Ph.D. work, under the supervision of Robert Osteryoung, focused on Room Temperature Chloroaluminate Molten Salts.

Alloy Negative Electrodes for Metal-Ion Batteries

Dr. M.N. Obrovac
Department of Chemistry, Dalhousie University

Li-ion battery operation is based on the reversible electrochemical insertion of Li+ ions into host structures. Current Li-ion battery materials are based on intercalation hosts, where typically the positive electrode is a layered transition metal oxide and the negative electrode is graphitic carbon. It has been discovered that much more lithium can be stored per unit volume in metal and semi-metal hosts, such as Si, Sn, Bi, Pb, Au, etc., compared to graphite. During the charge of a Li-ion cell with a metallic negative electrode, Li+ ions are inserted into the metallic hosts to form new lithium metal alloys. This is a reversible non-intercalation process that involves bond breaking and results in colossal volume expansions of the host materials, of up to 300%. The process is very different than traditional metal alloying methods that involve heating alloys above their liquidus temperature followed by quenching. Because electrochemical alloying reactions occur at room temperature, new metastable binary intermetallic phases can be formed that have not been observed before. Surprisingly, electrochemical alloying has been found not only to occur for Li insertion, but also for the room temperature alloying of Na and Mg into host metals.

In this presentation, the electrochemical alloying process will be reviewed and the characteristics of metal alloy negative electrodes in Li batteries will be discussed in relation to their composition and microstructure. Based on these properties, a method for the rational design of alloy materials for use in practical Li-ion batteries will be presented. Advances in enabling technologies including, electrode design and binder chemistry will also be discussed.

Mark Obrovac received his B.Sc. in Chemical Physics from Simon Fraser University in 1995, a Ph.D. in Physics in 2001 and was a Postdoctoral Fellow in Chemistry at Cornell University. In 2002 he joined 3M Company where he worked for 8 years as Research Specialist and project leader for the research, development and manufacturing of Si alloy anode materials for Li-ion batteries. In 2010 Mark joined Dalhousie University, and is currently Professor of Chemistry and Physics, and 3M Canada/NSERC Industrial Research Chair in Metal-Ion Batteries.

Materials for Solar Fuels, Optoelectronics and Beyond

Dr. Mita Dasog
Department of Chemistry, Dalhousie University

We live in a technologically advanced world that is made possible by our ability to harness energy. However, our increasing use of fossil fuel based energy sources poses a great threat to the global climate, economy, and geopolitical stability. Technologies such as fuel cells, solar cells, batteries, photo-electrochemical cells etc. have the ability to satisfy our energy demands in a sustainable manner. The real application of such devices will depend critically on fabrication of new functional materials with the merits of low cost, scalability, high efficiency, and abundance. This presentation will highlight recent research from Dasog lab on development of materials for solar-to-fuel devices and reactive nanomaterials using earth-abundant elements.

Mita Dasog obtained her BSc in 2009 from the University of Saskatchewan. She then moved to the University of Alberta to begin her PhD studies with Jonathan Veinot where she focused on the syntheses, properties, and applications of silicon based nano/micromaterials and thin films. After a short stay at Technical University of Munich as a Green Talents visiting scholar, Dasog went on to hold an NSERC post-doctoral position with Nathan Lewis at the California Institute of Technology, where she is studied the interaction of light with semiconductors. She joined the Dalhousie University Chemistry Department in July 2016 as an Assistant Professor where she is currently researching functional nanomaterials for solar fuel generation and other optoelectronic applications. Dasog has published over 25 papers in the field of nanomaterials, and has received numerous awards including the Canadian Council of University Chemistry Chairs (CCUCC) Chemistry Doctoral Award, CSC Award for Graduate Work in Inorganic Chemistry, and a "*Top 25*" Global Young Scientists in Sustainable Research award sponsored by the German Federal Ministry.

Net shape processing of engineered components from metal powders

Dr. Paul Bishop
Department of Mechanical Engineering, Dalhousie University

The release of greenhouse gas (GHG) emissions is a major concern in Canada. While there are many contributory sources, those related to the transportation sector (automotive, trucking, and aerospace) are particularly impactful. Here, GHG release is obviously encountered in the actual operation of the ground/air system itself. As such, system light-weighting (and the concomitant improvement in fuel economy) is viewed as a core component of the overall solution that strives for drastic reductions in GHG emissions. Such gains can be further amplified when the lightweight structures are manufactured using technologies that are in and of themselves efficient in both energy and material usage. Two of the more advanced technologies that are playing an increasingly important role in this context are powder metallurgy and additive manufacturing. In this presentation a technical overview of each fabrication approach will be given in the context of industrial exploitation. Pertinent work presently underway at Dalhousie will also be discussed as will the University's position as a leading player on the national stage of advanced manufacturing.

Paul Bishop conducts research in the area of metallic and composite powders with a focus on lightweight aluminum alloys. His research includes the design of unique powders with a view to optimize their industrial consolidation characteristics and the in-service mechanical performance of products derived from them. He is very active in the translation of his research outcomes into industrial applications within the automotive, aerospace, energy, and powder production sectors. Several aspects of his work are now patented and commercially exploited in the high volume manufacture of heat sinks, camshaft bearing caps, planetary carriers, and transmission retainer rings for the automotive sector. He has published 68 journal and 25 conference articles, a book chapter, and has 6 patents. He has also given 59 presentations on his work and received the H.I. Sanderow award from the Metal Powder Industries Federation in 2010 and again in 2016 for his pioneering work on aluminum powder metallurgy.

Clean + Green Architecture - an approach based on Materials Research

Prof. Brian Lilley
School of Architecture, Dalhousie University

This paper considers the value of materials research toward creating healthy and sustainable environments, by examining a number of Architectural projects that have been able to utilize new materials or novel methods toward that goal. Collaboration is essential for this form of endeavour to proceed successfully, as there are numerous checkpoints and hurdles to overcome. From material invention to assembly prototyping, measured improvements in performance are achieved. A high-rise in Berlin, a Health Centre in Nova Scotia, and a Greenhouse in Halifax will be discussed regarding environmental performance and new material strategies. Further research into ceramics, wool, and wood examine the potential for passive climate balancing and new forms of construction.

Brian Lilley currently teaches Architecture at Dalhousie University, and practices on Canada’s Atlantic Coast. Formerly a partner in the Berlin-based architectural firm sauerbruch hutton architekten, he has primary experience with ecological-based design and assemblies- most notably the sensored double-façade design for the GSW Headquarters project, winner of the Deutscher Architekt prize. In Canada, he has completed a Health Center for the Pictou Landing First Nation; served as the chair of the Canadian Design Research Network’s Sustainability Group; and was the chair of the 2007 Acadia Conference in Halifax. Over the past few years he has been involved in many material workshop activities: most notably with Smart Geometry and cross-disciplinary material research into ceramic materials. Other research activities include Dalhousie Architecture Summer Freelabs, and the 2012 Canadian entry into the Venice Biennale. Recently he has been awarded a Lieutenant Governor’s award for the design of the Hope Blooms greenhouse in Halifax. He has also been an active member of the former Dalhousie IRM, now re-christened CTRI, for the past 10 years.

Solution-Processed Nanomaterials for Energy Conversion

Dr. Ghada Koleilat
Department of Electrical and Computer Engineering, Dalhousie University

Emerging optoelectronic technologies seek to push the boundaries of both efficiency and cost-effectiveness through the use of flexible platforms and novel material systems. My talk will primarily center on the potential of solution-processed colloidal quantum dots and semiconducting single-walled carbon nanotubes in energy conversion and sensing applications. Colloidal quantum dots (CQDs) are nanometer scaled semiconductor crystals that are synthesized in, processed with, and deposited from solution. These materials offer a new paradigm for optoelectronics; one in which materials properties are not strictly material dependent, but are also influenced by physical dimension. With CQDs, the optical absorption ranges can be tuned by adjusting the size of the nanoparticles on the angstrom length scale. In particular, for photovoltaics, this enables facile access to much broader range of the sun's spectrum than is accessible through conventional photovoltaic materials such as silicon and gallium arsenide. The second part of my talk will focus on the emerging field of single-walled carbon nanotubes (SWNTs) photovoltaics. SWNTs are typically synthesized as a mixture of chiralities, with one-third of the mixture being metallic and the remaining two-third being semiconducting. I will talk about a facile polymer-sorting strategy that allowed us to selectively disperse and separate the semiconducting small-diameter - and thus larger bandgaps - carbon nanotubes that are optimal for the active layer of a single junction solar cell from the metallic SWNTs that are ideal for transparent conductive electrodes. Finally, I will give a quick overview about what my research group is investigating.

Ghada Koleilat is an assistant professor in the department of Electrical and Computer Engineering, cross-appointed to the departments of Process Engineering and Applied Science and Physics and Atmospheric Sciences. She was a Banting postdoctoral fellow in the Chemical Engineering department at Stanford University before joining Dalhousie University in 2016. Her group at Dal is interested in investigating the morphological, electrical, optical and mechanical properties of solution-processed nanomaterial systems that harvest specific bands of light. Ghada received her PhD in 2012 in Electrical Engineering at the University of Toronto. Throughout her career, she received many prestigious awards: most recently, she was the recipient of the highly competitive Banting postdoctoral fellowship awarded by the Natural Sciences and Engineering Research Council. She was ranked 3rd overall among all the natural science and engineering applicants.