Manitoba Materials Conference 2016

May 10th, 2016 Engineering & Information Technology Complex Atrium

Poster Abstracts

Hosted by

UNIVERSITY OF MANITOBA | Manitoba Institute for Materials

Sponsored by

University of Manitoba, Office of the Vice-President (Research and International)
University of Manitoba, Faculty of Science
University of Manitoba, Clayton H. Riddell Faculty of Environment, Earth, and Resources
University of Manitoba, Faculty of Engineering
Systems for Research
Innovate Manitoba
Royal Canadian Mint
EnviroTrec

The abstracts contained within the document represent a selection of work undertaken within MIM over the last year. This internal document is not intended for publication or dissemination.

Complex Natural Systems

1 **Dzananovic, Edis**
Structural characterization of interaction between dsRNA-binding protein kinase and its inhibitor Adenovirus virus-associated (VA) RNA I

34 **Fazelkhah, Azita**
Estimation of Intracellular Ion Concentrations and Cytoplasm Conductivity for CHO cells

3 **Liu, Yuqing**
A 3-D multicellular tumor spheroid on ultrathin matrix coated single cancer cells provides a tumor microenvironment model to study pithelial-to-mesenchymal transitions

4 **Ma, Daisy**
FTIR spectrochemical image of analysis hippocampal cells in control and transgenic Alzheimer's Disease mice

2 **Sharpe, Ryan**
Mass Bias Corrections for U-Pb Isotopic Analysis by Secondary Ion Mass Spectrometry: Implications for U-Pb Dating of Uraninite

Composite Material Systems

11 **Bahmer, M**
Novel Particulate Reinforced Multifunctional Composites

12 **Dunnigan, Ross**
Tribology of Polymer Matrix Composites (PMCs) fabricated by Additive Manufacturing

5 **Freitas, Pedro**
Effect of addition of doxycycline in dental adhesives on the mechanical properties of tooth-restoration interface

13 **Ghosh, Sujan**
MAX-Polymer (MAXPOL) Multifunctional Composites

58 **Giesbrecht, Patrick**
Electrocatalytic Reduction of Carbon Dioxide using N-Heterocycles

49 **Guillermic, Reine-Marie**
PDMS-based acoustic impedance-matched material in water

6 **Nickel, Rachel**
Antibacterial coated magnetic nanoparticles: a new way to treat infection

8 **SHArK**
SHArK North: Investigating Metal Oxides as Water Oxidation Catalysts

53 **Thakur, Sandeep**
Separation Of Fibre And Shives From Decorticated Flax

Composite Material Systems Continued

9 **Shateri, Mohammadhadi**
Effect of Propagation Length on The Time-Based Features of Acoustic Emission Signals Subjected in Early Failure Warning of Fiber Reinforced Polymer Rods

7 **Vykhodtsev, Anton**
Dielectric response measurements of high voltage insulating materials for outdoor applications

Crystalline Materials and Nanostructures

22 **Darabi, Mohammad Ali**
Engineering the heart: Evaluation of conductive nanomaterials for improving implant integration and cardiac function

21 **Engel, Jordan**
Four Point Probe Measurements of Silicon Microwires

10 **Khosrozadeh, Ali**
Flexible polyaniline-based composite films for electrodes of high-performance supercapacitors

23 **Leung, Craig**
The Effects of Alcohol on the Premature Rupture of PET Prosthetic Graft Materials

14 **Levin, Kirill**
NMR analysis of paramagnetic M(acac)x (M = Cr, Fe, Cu) coordination compounds: which resonances are observable?

16 **Lussier, Joey**
Stabilization of the Defect Fluortie Structure in ScMO$_3$ (M=V,Ti)

17 **Manna, Palash Kumar**
Biocompatible spherical and non-spherical iron oxide nanoparticles for magnetic field targeted delivery

18 **Manna, Palash Kumar**
Interface mixing in exchange biased systems: Does it always affect the exchange coupling?

24 **Newman, Kelly**
Optimizing the magnetism of FeCo using size and silica coating to form interfacial metal silicates

6 **Nickel, Rachel**
Antibacterial coated magnetic nanoparticles: a new way to treat infection

47 **Oncel, Nuri**
Iridium-silicide nanowires on Si(110) surface

19 **Paiva, Denis**
Dielectric properties of the Sr3WO6 at RF/microwave frequencies

20 **Sharma, Arzoo**
Exploration of Magnetic Properties of New Beryllium Substituted Langasites $A_3Ga_3Ge_2BeO_{14}$ (A=Pr, Nd, Sm, Eu)

Crystalline Materials and Nanostructures Continued

56 **Skoropata, Elizabeth**
Core-shell nanoparticle magnetism: The impact of interfacial intermixing

15 **Whattam, Jessica**
An Innovative In Situ Method for Analyzing O and H Isotopes in Tourmaline Using SIMS

High Performance Computing

27 **Kour, Gurpreet**
Computational screening of potential singlet fission molecules

26 **Perkins, Jeffery**
Can Computational Parameters Be Correlated to Experimental Efficiencies of Dye Sensitized Solar Cells?

25 **Wei, Aoran**
Interaction of Gold Nanoparticles with Protein Studied by Atomistic Simulations

High Temperature Aerospace Materials

30 **Asala, Gbenga**
Analysis of Nb Segregation Effects on Gamma Prime Precipitation Behaviour of ATI 718Plus Superalloy Weld

28 **Heggadadevanapura Thammaiah, Mallikarjuna**
Isothermal Oxidation Comparison Of Three Ni-Based Superalloys

29 **Olatunji, Oluwadamilola**
Influence of liquid-state diffusion on microstructure of TLP joint between dissimilar single crystal superalloys with different orientations.

31 **Steen, Jared**
Novel Structural Ceramics by Microstructure Design

Mechanics of Materials and Structures

33 **Sosnowski, Emil-Peter**
Characterizing Sterilization Effects on Material Strength of 3D-Printed Biocompatible Plastics

32 **Strybulevych, Anatoliy**
The Use of Synchrotron X-rays and Ultrasonics for Investigating the Bubble Size Distribution and Its Evolution in Dough

MEMS/Microfluidic Systems

41 **Afsharipour, Elnaz**
Design and fabrication of Si/SiO_2 distributed Bragg reflectors by reactive RF magnetron sputtering

40 **Glowacki, Pawel**
An infrared spectrometer based on a MEMS Fresnel zone plate for measuring incipient fault gases in high voltage equipment

39 **Li, Meiting**
Resonance Based MEMS Magnetic Field Sensor

38 **Liyanage, Sampath**
Butterfly Based MEMS DC electric field sensor with modulated sensitivity

37 **Park, Byoungyoul**
Development of a Novel MEMS Based Horseshoe shaped Lorentz Actuator Array for Adaptive Optics

35 **Woods, Bo**
Polymer Electrolyte Potentiometric Volatile Sensor

36 **Zhou, Yu**
Design and Fabrication of A Micromachined Low Voltage Electrostatic Actuated Deformable Mirror System

Photonic and Phononic Interactions

41 **Afsharipour, Elnaz**
Design and fabrication of Si/SiO_2 distributed Bragg reflectors by reactive RF magnetron sputtering

40 **Glowacki, Pawel**
An infrared spectrometer based on a MEMS Fresnel zone plate for measuring incipient fault gases in high voltage equipment

44 **Harder, Michael**
The Coherence of Strong Spin-Photon Coupling

43 **Hyde, Paul**
Indirect Coupling Between Two Cavity Photon Systems via Ferromagnetic Resonance

42 **Kaur, Sandeep**
Voltage Control of Cavity Magnon Polariton

45 **Lozada, Issiah**
New luminescent transition metal d10 complexes supported by phenanthridine-based ligands

Quantum Materials

Soft and Disordered Materials

Surfaces and Interfaces

Surfaces and Interfaces Continued

2 **Sharpe, Ryan**
Mass Bias Corrections for U-Pb Isotopic Analysis by Secondary Ion Mass Spectrometry: Implications for U-Pb Dating of Uraninite

56 **Skoropata, Elizabeth**
Core-shell nanoparticle magnetism: The impact of interfacial intermixing

59 **Vahora, Tasneem**
Surface Characterization of Canola Fibre (Brassica napus L.) Using Scanning Electron Microscopy

Poster Number: 1

Structural characterization of interaction between dsRNA-binding protein kinase and its inhibitor Adenovirus virus-associated (VA) RNA I

Presented by: Edis Dzananovic

PhD Candidate at the University of Manitoba, Department of Chemistry
Advisor(s): S McKenna

Co-Author(s): Edis Dzananovic, Trushar R. Patel, Astha, Grzegorz Chojnowski, Kevin McEleney, Janusz M. Bujnicki and Sean A. McKenna

Research Area(s): Complex Natural Systems

The mammalian innate immune system provides a first line of defence against microbial pathogens and also serves to activate an antigen-specific acquired immune program. Key components of innate immunity are the interferons (IFNs), a family of related cytokines. The IFNs exert their effects through the stimulation of numerous genes, one of which is the double-stranded RNA-dependent Ser/Thr protein kinase (PKR), a key antiviral protein found in human cells. After binding to viral dsRNA, PKR is autophosphorylated and in turn phosphorylates the alpha-subunit of eukaryotic translation initiation factor 2, causing attenuation of cellular and viral protein synthesis. Certain viruses specifically transcribe dsRNA that bind to PKR and thereby prevent its autophosphorylation. We are investigating one such inhibitor, the adenovirus virus-associated (VA) RNA I. VAI RNA contains 3 stem-loop regions; apical PKR-biding stem-loop, central inhibitory stem-loop, and terminal region that is shown to not affect binding or inhibition of PKR. We are interested in studying specific features of inhibitors that enables them to bind to PKR and inhibit its function. We have created mutant versions of VAI RNA and tested whether these mutations impact binding and/or inhibition of PKR. We have also taken advantage of in-house small angle scattering instrumentation to obtain low-resolution structural data on PKR-dsRNA complexes. SAXS envelopes and raw data were then used as constraints for computational tertiary RNA structure prediction. Taken together, we propose that a specific pseudoknot RNA fold is required for efficient inhibition of PKR.

Poster Number: 2

Mass Bias Corrections for U-Pb Isotopic Analysis by Secondary Ion Mass Spectrometry: Implications for U-Pb Dating of Uraninite

Presented by: Ryan Sharpe

Researcher at the University of Manitoba, Department of Geological Sciences

Co-Author(s): Mostafa Fayek

Research Area(s): Complex Natural Systems

Age dating using the uranium (U)-lead (Pb) system is well established and the technique has been applied, with much success, to many minerals (e.g. zircon) using secondary ion mass spectrometry (SIMS). However, the application to uranium-rich minerals (i.e. uraninite) has proved less successful, often producing erroneous results. Uranium- Pb geochronology of uraninite is critical to the study of the genesis of U deposits throughout the world. Incorrect U-Pb ages only prove to complicate the study of these already complex U systems.

Uranium and Pb isotope ratios were measured in three uraninite reference materials (RM) with varying Pb content and three samples with unknown U-Pb isotope compositions using a CAMECA 7f SIMS instrument. Measurements were made using a primary beam of O- accelerated at 12.5 kV. A mass resolving power of 1300 and a 50-volt offset were used to minimize interferences. The study demonstrates that the mass bias for U-Pb isotope ratio measurements in uraninite varies as a function of Pb content. A three-point calibration curve was developed using uraninite RM with low-, intermediate- and high-Pb contents.

Corrected ratios for both concordant and discordant uraninite were plotted on a Concordia diagram to demonstrate the effect that different correction techniques have on the resulting age. For discordant uraninite the results show that U-Pb ages can be inaccurate by as much as 130 Ma. Whereas, for concordant uraninite, correction using the varying techniques results in similar ages yet their relative position on the Concordia diagram changes drastically.

Poster Number: 3

A 3-D multicellular tumor spheroid on ultrathin matrix coated single cancer cells provides a tumor microenvironment model to study pithelial-to-mesenchymal transitions

Presented by: Yuqing Liu

Postdoctoral Fellow at the University of Manitoba, Department of Mechanical Engineering
Advisor(s): M.X. Xing

Co-Author(s): Malcolm Xing

Research Area(s): Complex Natural Systems

In tumor progression, the hypoxia-mediated epithelial-to-mesenchymal transition (EMT) works as an important survival pathway, where epithelial cells lose their polarized properties and acquire mesenchymal characteristics. Although it is known that EMT is closely related to the microenvironment of carcinoma growth, its definite mechanism under the microenvironment is still elusive. While most related research studies based on a two-dimensional (2D) monolayer culture, which was obviously deviated from the real solid tumor environment, such as the cellular morphology, proliferation, differentiation, and interactions between cell - cell and cell - extracellular matrix. Currently, various kinds of 3D models were developed, such as multicellular tumor suspension spheroids (MCTs) and 3D biopolymeric Matrices, but the poor control over tumor structure and physic-chemical properties limited their applications. In this study, a 3D multicellular tumor spheroid microenvironment was developed by using layer-by-layer (LBL) ultrathin film on single tumor cell to form niche-like matrix and sequentially assembling. The difference of 2D cultured cells and 3D cells was examined by cellular CD47, mTOR, ERK and HIF signaling, as well as their expressions of two EMT related factors: E- and N-cadherin in vitro and in vivo. This 3D spheroid model provides an alternative and flexible approach to study tumor progress.

Poster Number: 4

FTIR spectrochemical image analysis of hippocampal cells in control and transgenic Alzheimer’s Disease mice

Presented by: Daisy Ma

Undergraduate Student at the University of Manitoba, Department of Chemistry
Advisor(s): KM Gough

Co-Author(s): A.R. Capan, C. R. Findlay, B. A. Albensi, K. M. Gough

Research Area(s): Complex Natural Systems

The long term focus of this research is the development of therapeutics for enhancing memory, and for preventing and/or reversing memory impairment in Alzheimer's Disease (AD). To that end, we seek a molecular-level understanding of the changes in AD brain. We have conducted rapid *ex vivo* wide field spectrochemical imaging with ~1μm pixel resolution with a thermal IR source and Focal Plane Array, in-house, on tissue sections from control and transgenic mouse models for AD. Mouse models included a triply-transgenic mouse line: 3xTg, a common control: C57BL/6, a doubly transgenic line: TgCRND8 and their wild type litter mates: wtCRND8. Unfixed, snap-frozen, cryosections were desiccated overnight and imaged within 48 hours to avoid tissue oxidation. Given the multifactorial origins of AD, we are focused on the temporal evolution and molecular composition of senile plaques and neurofibrillary tangles (the hallmarks of diseased brain). Data were processed in MATLAB to select only those spectra associated with the cell bodies in the Cornu Ammonis (CA1) and subiculum, where early changes can be detected through standard staining methods. FTIR spectrochemical imaging analysis permits the simultaneous detection of multiple biological components; here, we are seeking features that may be overlooked or altered by histopathological and immunohistochemical methods.

Poster Number: 5

Effect of addition of doxycycline in dental adhesives on the mechanical properties of tooth-restoration interface

Presented by: Pedro Freitas

Researcher at the University of Manitoba, Department of Restorative Dentistry
Advisor(s): S Consani, M Giannini, R Franca

Research Area(s): Composite Material Systems

Matrix metalloproteinase (MMP) inhibition has been shown to reduce adhesive bond degradation. Doxycycline is tetracycline derivate that has demonstrated atsubantimicrobial dosagen has displayed a valuable therapeutic role of MMPs. This study examined the incorporation of different dosages of doxyclycline in an experimental dental adhesives. Nanoindentations was performed using a load of 1000 µN andstandard trapezoidal load function of 5-2-5s on dentin, hybrid layer and adhesive. Nanohardness and Young's modulus of each area were computed according to the Oliver and Pharr's method. Control group showed higher values for adhesive layer, the experimental groups showed no statistical difference between them. The were no difference between groups for Young's modulus values for adhesive. Control group and EXP2 showed higher values for hybrid layer nanohardness, followed by group EXP1 and EXP3. EXP4 group showed lowest values for hybrid layer nanohardness, however there no difference among it and EXP3 and EXP1 groups. Experimental groups showed increase in Young's modulus of hybrid layer, except for EXP4 that show no difference between Control group. Nanohardness and Young's modulus of dentin was not affect by incorporation of MMP inhibitor.

Poster Number: 6

Antibacterial coated magnetic nanoparticles: a new way to treat infection

Presented by: Rachel Nickel

Undergraduate Student at the University of Manitoba, Department of Physics and Astronomy
Advisor(s): J. van Lierop

Co-Author(s): H. Rahma, E. Skoropata, C. Rutley, P.K. Manna, S. Liu, J. van Lierop

Research Area(s): Composite Material Systems, Crystalline Materials and Nanostructures

Microbial resistance is quickly becoming a global healthcare problem. Topical biocides are a possible solution to many hospital born infections as they may be applied directly to the wound and have a broad spectrum of microbial targets. However, cytotoxicity is a concern. Without a mechanism to limit exposure, cells critical to wound healing will also be killed. Coating magnetic nanoparticles with the desired biocide allows removal from the infection site using a magnet, enabling control over contact time. For this application, the magnetic particle cores must be biocompatible and modifiable, with a significant magnetic response at room temperature. Spherical magnetite particles have been synthesized in a variety of sizes and coated with N-chloramine biocides. Physical properties of the uncoated particles were determined using x-ray diffraction, DLS and SEM. After coating, FTIR and TGA were used to confirm biocidal coating. Magnetic characterization, both before and after coating, was performed via MPMS and Mössbauer spectroscopy. Biological tests performed on MRSA and P. aeruginosa show the efficacy of the biocide is enhanced by the disruption of the medium during the recovery of the nanoparticles. Both 3 nm and 10 nm particles are fully recoverable from a wound simulant within 2 min, though the 10 nm particles are removed more quickly. Both 20 nm nanospheres and nanochains have been synthesized and characterized for future biocidal study.

Poster Number: 7

Dielectric response measurements of high voltage insulating materials for outdoor applications

Presented by: Anton Vykhodtsev

MSc Candidate at the University of Manitoba, Department of Electrical and Computer Engineering
Advisor(s): D. Oliver, B. Kordi

Research Area(s): Composite Material Systems

Dielectric frequency response measuring technique is one of the non-destructive diagnostic testing used for the assessment of high voltage insulation systems. This work presents dielectric measurements of the polymeric insulating materials for outdoor applications. Together with international collaborators in the CIGRE working group D1.59, round-robin tests on samples of liquid silicone rubber (LSR), high temperature vulcanized (HTV) silicone rubber (SIR) and ethylene propylene diene monomer (EPDM) rubber were carried out and analyzed.

Poster Number: 8

SHArK North: Investigating Metal Oxides as Water Oxidation Catalysts

Presented by: SHArK

Students from Daniel McIntyre Collegiate Institute (DMCI)
Advisor(s): Ms Kozoriz, Dr Herbert

Co-Author(s): L. Allison Afable, Alexis D. Lavadia, Genesis Lozada

Research Area(s): Composite Material Systems

The formation of a renewable energy source is one of the largest challenges facing society today. One approach involves the splitting of water into fuels such as hydrogen and oxygen using sunlight, in an artificial photosynthetic system. However, a large barrier exists for the water oxidation process, reducing the efficiency of the system. By using catalysts for water oxidation, this barrier can be minimized. A promising material involves metal oxide mixtures because of their light absorption properties, robustness, and cost effectiveness. But due to the millions of different combinations available for metal oxide mixtures, determining the ideal catalyst composition is challenging. This work investigates the water oxidation capabilities of a variety of ternary metal oxide mixtures under illumination and applied potential using a custom LED apparatus and potentiostat. By measuring the resulting photocurrent under basic conditions, the viability of these metal oxides as water oxidation catalysts can be determined. From these results, a more comprehensive approach towards the formation of a metal oxide catalyst for water oxidation can be taken.

Poster Number: 9

Effect of Propagation Length on The Time-Based Features of Acoustic Emission Signals Subjected in Early Failure Warning of Fiber Reinforced Polymer Rods

Presented by: Mohammadhadi Shateri

MSc Candidate at the University of Manitoba, Department of Electrical and Computer Engineering
Advisor(s): D.J. Thomson

Research Area(s): Composite Material Systems

Fiber reinforced polymer (FRP) rods have been used for reinforcing in civil structures including concrete structures and steel structures. FRP rods can be used as reinforcing as long as the allowed service load is not exceeded. There have been different studies on developing a reliable method for early failure warning of FRP rods subjected to exceeded service load, in which time-based features of acoustic emission signals are used. In this work, AE signals detected using the RMS detection method during pencil-lead break tests are studied. The attenuation of AE signals within the FRP rods and frequency dependency of AE signals with the increment of the propagation length are investigated. The results represent that the frequency is almost unchanged while the amplitude is attenuated notably with the increment of the propagation length. Therefore, it is concluded that analysis based on frequency features is more effective in study of early failure warning in fiber reinforced polymer rods.

Poster Number: 10

Flexible polyaniline-based composite films for electrodes of high-performance supercapacitors

Presented by: Ali Khosrozadeh

PhD Candidate at the University of Manitoba, Department of Mechanical Engineering
Advisor(s): M Xing

Research Area(s): Crystalline Materials and Nanostructures

Polyaniline is a promising pseudocapacitance electrode material for supercapacitors. However, its structural instability leads to low cyclic stability and limited rate capability which hinders its practical applications. Flexible polyaniline-based composite films are developed for fabrication of a high-performance supercapacitor with excellent cyclic stability and tunable energy and power densities. The electrode is a flexible film of polyaniline, tissue wiper-based cellulose, graphite-based exfoliated graphite and silver nano-particles with potential applications in wearable electronics. Our results show that an ultrahigh capacitance of 3.84 F/cm2 (240.10 F/g) at a discharge rate of 5 mA can be achieved. The obtained promising electrochemical properties are found to be mainly attributed to an effective combination of polyaniline with exfoliated graphite and silver in a cushiony cellulose scaffold, as well as the porous structure of the composite.

Poster Number: 11

Novel Particulate Reinforced Multifunctional Composites

Presented by: M Bahmer

Undergraduate Student at the University of North Dakota, Department of Mechanical Engineering
Advisor(s): S Gupta

Co-Author(s): D. Ferguson, R. Georgeson

Research Area(s): Composite Material Systems

Green design has become a integral component of research for the 21st century. Scientists and researchers are being continuously challenged on a variety of global issues, including population growth, rapid urbanization, infrastructure decline, climate change, and water scarcity. There is a potential to deliver game-changing solutions by designing sustainable materials. In this poster, as a part of undergraduate research, we will present recent developments on the research and development of novel vibration sensitive composites which can perform multifunctional functions like energy harvesting, energy storage, and solid lubrication, among others.

Poster Number: 12

Tribology of Polymer Matrix Composites (PMCs) fabricated by Additive Manufacturing

Presented by: Ross Dunnigan

MSc Candidate at the University of North Dakota, Department of Mechanical Engineering
Advisor(s): S Gupta

Co-Author(s): S. Ghosh, F. AlAnazi, J. Clemens

Research Area(s): Composite Material Systems

The integral process of depositing thin layers of material, one after another, until the designed component is created is collectively referred to as Additive Manufacturing (AM). Fused deposition process (FDP) is a type of AM where feedstock is extruded into filaments which then are deposited by 3D printing, and the solidification occurs during cooling of the melt. Currently, complex structures are being developed by FDP. For further deployment in the field, especially for turbomachinery applications, it is critical to understand the tribological behavior of these solids. In this presentation, we will report the tribological behavior of different polymer matrix composites fabricated by fused deposition process. These results will be compared with the base polymer. During this study, the tribological behavior of all the samples will be evaluated with tab-on-disc method.

Poster Number: 13

MAX-Polymer (MAXPOL) Multifunctional Composites

Presented by: Sujan Ghosh

MSc Candidate at the University of North Dakota, Department of Mechanical Engineering
Advisor(s): S Gupta

Co-Author(s): Faisal Alanazi

Research Area(s): Composite Material Systems

$M_{n+1}AX_n$ (MAX) phases (over 60+ phases) are thermodynamically stable nanolaminates displaying unusual, and sometimes unique, properties. These phases possess a $M_{n+1}AX_n$ chemistry, where n is 1, 2, or 3, M is an early transition metal element, A is an A-group element, and X is C or N. The MAX phases are highly damage tolerant, thermal shock resistant, readily machinable, and with Vickers hardness values of 2 -8 GPa, are anomalously soft for transition metal carbides and nitrides. In this paper, we report the synthesis and characterization of novel MAX-Polymer composites. It is expected that these novel composites can be used for multifunctional applications.

Poster Number: 14

NMR analysis of paramagnetic M(acac)$_x$ (M = Cr, Fe, Cu) coordination compounds: which resonances are observable?

Presented by: Kirill Levin

PhD Candidate at the University of Manitoba, Department of Chemistry
Advisor(s): S. Kroeker

Co-Author(s): Kirill Levin, Scott Kroeker

Research Area(s): Crystalline Materials and Nanostructures

Solid-state nuclear magnetic resonance (NMR) spectroscopy is a widely used technique for the characterization of materials, its versatility stemming from its sensitivity to variations in the electronic environments of atoms. However, a recognized drawback of NMR is its limited applicability to paramagnetic systems such as organic radicals and many organometallic complexes, where unpaired electrons introduce an additional layer of magnetic interactions that significantly alters the nuclear spin behaviour. We describe the effect of such interactions on the observable signal widths and intensities of ^{13}C NMR resonances in a series of metal acetylacetonate complexes M(acac)$_x$ (M = Cr, Fe, Cu) under fast magic-angle spinning. We develop a relatively robust method to predict the possibility of observing NMR signals under a given set of experimental conditions, including the effects of pulse sequence delays and electron relaxation rates. Preliminary density-functional theory calculations and experimental ^{1}H MAS NMR results are used to provide enough information to estimate the spectral visibility of other types of nuclei in the system.

Poster Number: 15

An Innovative In Situ Method for Analyzing O and H Isotopes in Tourmaline Using SIMS

Presented by: Jessica Whattam

MSc Candidate at the University of Manitoba, Department of Geological Sciences
Advisor(s): M Fayek

Co-Author(s): Mostafa Fayek, T. Kurtis Kyser, David Quirt, Frank Hawthorne

Research Area(s): Crystalline Materials and Nanostructures

The oxygen and hydrogen isotopic compositions of minerals can provide valuable information on the source of fluids and temperature of mineral precipitation. To obtain accurate measurements using secondary ion mass spectrometry (SIMS), it is important to select chemically similar standards and samples to correct for both matrix effects, and instrumental mass fractionation (IMF), collectively termed instrumental mass bias (IMB). For certain complex mineral groups (i.e. tourmalines), there are large variations in major element composition between end members. The current study utilizes three common tourmaline end members (schorl, dravite and elbaite) with the goal of constructing calibration curves to correct for IMB during SIMS analysis of oxygen and hydrogen isotopes in tourmaline.

Data obtained by SIMS from eight tourmaline grains comprising the three tourmaline end members show that mass bias for oxygen isotope measurements correlate with with Fe concentrations in tourmalines and for hydrogen isotopes, mass bias correlates with Mg concentrations. Therefore, to correct tourmalines for IMB during oxygen and hydrogen isotopic analyses, several standards that cover a wide range of Fe and Mg contents should be analyzed and calibration curves constructed. The crystallographic orientation can also lead to additional errors in the IMB of hydrogen isotopes ("orientation effects"). Depending on whether the tourmaline being analyzed has been cut as a basal section or whether analyses are taking place perpendicular to the C axis of the tourmaline, the IMB can vary by up to 15%. To resolve the errors caused by orientation effects it is recommended to mount standards in multiple crystallographic orientations.

Poster Number: 16

Stabilization of the Defect Fluorite Structure in $ScMO_3$ (M=V,Ti)

Presented by: Joey Lussier

PhD Candidate at the University of Manitoba, Department of Chemistry
Advisor(s): M Bieringer

Co-Author(s): F. Simon, K. Singh, V. Thangadurai

Research Area(s): Crystalline Materials and Nanostructures

Fuel cells are vital technologies for the future of alternative energy due to their fuel flexibility, low emissions and high conversion efficiency. Ion conductors as solid-state electrolytes play a crucial role in improving alternative energy conversion devices.Shafi, et al.[1,2] showed that the structural relationship between the bixbyite and fluorite structures permits control of oxidation states and oxygen defects (A=Sc,In; B=Ti,V). Some problems that arose in these systems include that the defect fluorite $ScVO_{3.7}$ undergoes a non-topotactic (reconstructive) oxidation and results in the formation of an ordered zircon structure. This oxidative transition occurs below the typical operating temperature of solid oxide fuel cells (SOFC) and will destroy the solid state electrolyte. Furthermore the limited oxidation state of Ti only allows the oxidation to $ABO_{3.5}$ affecting the ion conductivity. We will present our recent work to stabilize the defect fluorite structure beyond the operating temperature of common SOFCs in these systems and eliminate the problems mentioned above. We report synthesis, structural characterization, thermal analysis, ion conductivity measurements and reactivity studies using in situ x-ray diffraction.

References
1.Shafi, S. P.; Hernden, B. C.; Cranswick, L. M. D.; Hansen, T. C. Bieringer, M. *Inorg. Chem.* **2012**,*51*,1269-1277.

2.Shafi, S. P.; Lundgren R. J.; Cranswick, L. M. D.; Bieringer, M. *J. Solid State Chem.* **2007,** *180*, 3333-3340.

Poster Number: 17

Biocompatible spherical and non-spherical iron oxide nanoparticles for magnetic field targeted delivery

Presented by: Palash Kumar Manna

Postdoctoral Fellow at the University of Manitoba, Department of Physics and Astronomy
Advisor(s): Johan van Lierop

Co-Author(s): R. Nickel, Y. Wroczynskyj, Z. Sun, D. W. Miller, S. Liu, and J. van Lierop

Research Area(s): Crystalline Materials and Nanostructures

Magnetic nanoparticles coated with a suitable biocompatible material enables various biomedical applications such as targeted drug delivery, hyperthermia, topical biocide application and removal, cellular therapy, and tissue repair. The innate biocompatibility of iron oxide nanoparticles make them one of the best candidates for such purposes. Additionally, a significant magnetic field response under ambient conditions allows for the possible targeting and removal using an external magnetic field. For the above applications, nanoparticle size and shape are critical considerations for application design and implementation. For example, it has generally been found that upon injection of biocompatible iron-oxide nanoparticles, the smallest ones (<10 nm) reside in the the kidney after circulation, while medium sized nanoparticles (10-300 nm) populate the bone marrow, spleen, liver and lymph nodes. Larger particles (>1 micron, including the coating) accumulate typically in the liver and lungs. Therefore, depending upon the location of the target area, the size and shape of the nanoparticles must be tailored. Shape anisotropy and the resulting magnetic field profile and response have non-spherical nanoparticles responding differently in an external magnetic field as well as to cells and complex media. Keeping all of this in mind, we have synthesized spherical and non-spherical (e.g. rods of different lengths and aspect ratios) iron-oxide (magnetite - Fe_3O_4) nanoparticles of different sizes and coated them with bio-compatible materials such as N-(trimethoxysilylpropyl)ethylenediamine triacetate (a latching ligand for additional drug and biocide coating chemistry). The crystallite sizes and shapes have been determined by analyzing x-ray diffraction patterns and scanning electron microscopy images, respectively. The success of the coating has been verified using Fourier transform infrared spectroscopy technique. Example bio-application experiments reveal that non-spherical nanoparticles have a significantly better internalization in endothelial cells compared to spherical ones, with and without external magnetic field application.

Poster Number: 18

Interface mixing in exchange biased systems: Does it always affect the exchange coupling?

Presented by: Palash Kumar Manna

Postdoctoral Fellow at the University of Manitoba, Department of Physics and Astronomy
Advisor(s): Johan van Lierop

Co-Author(s): E. Skoropata, Y. -W. Ting, K. -W. Lin, J. W. Freeland, and J. van Lierop

Research Area(s): Crystalline Materials and Nanostructures

A ferromagnetic/antiferromagnetic/ferromagnetic type trilayered structure is a basic element of a spin-valve structure in hard drive read/write heads and future spintronics technology. This trilayer structure also provides an ideal opportunity to study the interplay between interlayer and interface exchange coupling. Both exchange bias (interface) and interlayer exchange couplings are interface driven phenomena, and since the ideal interface has typically been very challenging to achieve, a clear understanding of the chemical and magnetic natures of interfaces is pivotal to identify and understand their influence on the overall physics of the magnetism. The presence of an imperfect interface (due to oxidation, reduction and interface mixing) is widely recognized as an issue and often leads to an interpretation that the exchange coupling in a composite (core-shell and thin film) system is mediated by such 'imperfections'. We have explored the possible presence of surface oxidation and interface mixing in $\mathrm{Ni_{8}0Fe_{20}}$ (55 nm)/CoO(t = 23, 90, 185 nm)/Co (55 nm) trilayer systems and their elemental compositions and site-specific magnetism. Element-sensitive and site-specific x-ray absorption spectroscopy (XAS) and x-ray magnetic circular dichroism (XMCD) techniques show that an oxidized Ni-ferrite surface layer and a Co-ferrite interface layer are non-magnetic and therefore can not be responsible for the observed nanomagnetism. Our results also indicate that (i) the interlayer exchange coupling between $\mathrm{Ni_{8}0Fe_{20}}$ and Co is occurring despite the thickness of the spacer layer being beyond the regime where this magnetism is considered possible, and (ii) the bulk of the antiferromagnet (CoO) layer does not contribute to the exchange bias effect - exchange bias is purely an interfacial phenomenon without any contribution from the intermixed phase regions.

Poster Number: 19

Dielectric properties of the Sr_3WO_6 at RF/microwave frequencies

Presented by: Denis Paiva

PhD Candidate at the Universidade Federal do Ceara, Department of Departamento de Quimica Analitica e Fisico-Quimica
Advisor(s): PBA Fechine, MAS Silva, MB Bieringer

Co-Author(s): D. V. M. Paiva, M. A. S. Silva, A. S. B. Sombra and P. B. A. Fechine

Research Area(s): Crystalline Materials and Nanostructures

This work reports the dielectric properties of Sr_3WO_6 (SWO) double perovskite at radio frequency as a function of the temperature and a study in microwaves range to evaluate the material as a novel dielectric resonator. Thermo-activated charge transfer process for SWO ceramic was observed and two resistor - capacitor associations were fitted for the Nyquist diagram. For the microwave range, SWO shows high dielectric permittivity (13.57) and dielectric loss (0.0281). The dielectric resonator antenna (DRA) fabricated from SWO ceramic presented an operation frequency in 4.1 GHz and return loss below -40dB. From these results, the SWO based DRA shows good properties to be used as a novel microwave dielectric resonator.

Poster Number: 20

Exploration of Magnetic Properties of New Beryllium Substituted Langasites $A_3Ga_3Ge_2BeO_{14}$ (A=Pr, Nd, Sm, Eu)

Presented by: Arzoo Sharma

MSc Candidate at the University of Manitoba, Department of Chemistry
Advisor(s): C Wiebe

Co-Author(s): Silverstein, H.J.; Hallas A.M.; Wiebe, C.R.

Research Area(s): Crystalline Materials and Nanostructures

Langasites have attracted a lot of attention because of their spin-liquid like characteristics. The magnetic ions in these compounds interact in a trigonal crystal structure and occupy the corners of the triangular network forming a distorted 2-D Kagome lattice.

A greater understanding of their ground state is limited by difficulty in synthesizing new members belonging to this series due to formation of competing phases like the garnet phase. Recently we were able to synthesize four new members $A_3Ga_3Ge_2BeO_{14}$ (A=Pr, Nd, Sm, Eu) belonging to this class by substitution of Be^{2+} in the 2d tetrahedral site (D site). The substitution leads to a decrease in ratio of magnetic ion to gallium from 3:5 to 1:1 and reduces the stability of garnet structure. These compounds were characterized by x-ray diffraction, magnetization, magnetic susceptibility, heat capacity, muon spin resonance and neutron scattering measurements. Unique ground state of $Nd_3Ga_3Ge_2BeO_{14}$ was realized using the neutron scattering measurements.

Poster Number: 21

Four Point Probe Measurements of Silicon Microwires

Presented by: Jordan Engel

Undergraduate Student at the University of Manitoba, Department of Electrical and Computer Engineering
Advisor(s): D Oliver

Co-Author(s): Ashish Kumar

Research Area(s): Crystalline Materials and Nanostructures

A Proposed solar water-splitting device uses light to generate hydrogen fuel using doped silicon microwires. The electrical behavior of the microwires affect the overall efficiency of the device. Pressurized contacts using tungsten probes have already been shown to exhibit ohmic behaviour and can be used to make electrical measurements on microwires by driving current and sensing voltage with two probes.These ohmic contacts are made by slowly increasing the contact pressure until linear ohmic behaviour is observed in current-voltage measurements. Resistance must be measured for several different probe spacings to eliminate the effect of the contact resistance on the measurements. High pressure contacts often cause wires to break part way through a measurement set, making two point measurement a time consuming process that requires expertise. A four point probe technique has been developed as an alternative method for measuring the electrical properties and doping concentrations of silicon microwires. The four point technique significantly reduces the required contact pressure by using low current sensing probes to measure the voltage, while driving the current with a separate pair of probes. Four point probe electrical measurements on silicon microwires have been tested and compared with two point probe measurements and have been shown to be an effective alternative to the original two point method.

Poster Number: 22

Engineering the heart: Evaluation of conductive nanomaterials for improving implant integration and cardiac function

Presented by: Mohammad Ali Darabi

PhD Candidate at the University of Manitoba, Department of Mechanical Engineering
Advisor(s): Malcolm Xing

Co-Author(s): Jin Zhou, Changyong Wang, Malcolm Xing

Research Area(s): Crystalline Materials and Nanostructures

Engineering cardiac tissues in vitro offers new perspectives for the therapy of myocardial infarction (MI) (1). The Engineered cardiac tissues (ECTs) exert beneficial effects on heart function after implantation; however, the therapeutic efficacy in general is restricted to inhibit further pathological deterioration of infarct myocardium without expected complete reversal of myocardial dysfunction (2). The biomaterial scaffold is the main component of engineered cardiac tissues. It has been demonstrated that carbon nanotubes (CNTs) can improve the viability and proliferation of cardiomyocytes and promote their electrophysiological maturation. Given that gelatin is a kind of biocompatible materials derived from extracellular matrix, it has been reported that CNTs-incorporated gelatin methacrylate (CNTGelMA) hydrogel thin film can be used to engineer 2D cardiac patches. Nevertheless, it remains to be elucidated that whether cardiac patches based on CNT composites can exert beneficial effects on the heart function after myocardial infarction. In this study, we hypothesized that single walled carbon nanotubes (SWNT)/gelatin composite scaffolds can be used to fabricateECTs with strong contractile and electrical properties, promote the repair efficacy of ECTs to infarct myocardium, and enhance the integration between ECTs and host myocardium. Here we demonstrated a paradigm to construct ECTs for cardiac repair using conductive nanomaterials. SWNTs were incorporated into gelatin hydrogel scaffolds to construct three-dimensional ECTs. The functional measurements showed that SWNTs were essential to improve the performance of ECTs in inhibiting pathological deterioration of myocardium.

Poster Number: 23

The Effects of Alcohol on the Premature Rupture of PET Prosthetic Graft Materials

Presented by: Craig Leung

Undergraduate Student at the University Of Manitoba, Department of Biosystems Engineering
Advisor(s): M Rahman

Research Area(s): Crystalline Materials and Nanostructures

Prosthetic graft implants are vital to the medical field. These grafts can be used to prevent death and prolong human life. It is important that these grafts function properly because they transport one of the most important fluids in the human body, blood. However, about 25% and 4% prosthetic graft failures occurred due to the mechanical breakdown and bacterial infection respectively. Premature rupture of grafts can lead to internal bleeding and in some cases even death. Prosthetic grafts are not standardized, however in Canada the grafts are regulated by the Canadian Medical Device Regulations under the Food and Drug Acts. Prosthetic graft manufacturers have the burden to decide whether their grafts are in good standing. In the current research an investigation has been conducted under accelerated physiological conditions in aqueous and alcoholic alkaline media to find surface abrasion on prosthetic graft materials that may lead to premature rupture. This has been conducted by prestressing fabric samples and applying alcoholic and aqueous alkaline treatments in an in vitro setting. From this in vitro testing, surface abrasion was identified using scanning electron microscopy. Cracking, dents and deformities on the surface of the fabric fibers have been observed. However, it was observed that under identical conditions, pre-stressed samples in alcoholic alkaline solution experienced more severe surface abrasion than aqueous alkaline condition. The research speculated that the surgeons should restrict the patient’s intake of alcohol while prosthetic grafts are implanted.

Poster Number: 24

Optimizing the magnetism of FeCo using size and silica coating to form interfacial metal silicates

Presented by: Kelly Newman

MSc Candidate at the University of Manitoba, Department of Physics and Astronomy
Advisor(s): J. van Lierop

Co-Author(s): R. Desautels, M. Rowe, J. van Lierop

Research Area(s): Crystalline Materials and Nanostructures

Soft ferromagnetic materials are ideal for applications such as transformer and inductor cores due to their low hysteretic losses and high saturation magnetization. The iron cobalt (FeCo) system exhibits low coercivity and high saturation magnetization and has the added benefit that it is free of rare-earth elements, which are more expensive and subject to supply chain constraints. FeCo nanoparticles have been synthesized via a scalable metal halide reduction, producing nanoparticles that have 4 nm diameters, determined via transmission electron microscopy image analysis. The 4 nm particles were then coated in silica (SiO_2) or annealed to have diameters of 25 nm (confirmed via scanning electron microscopy image analysis and x-ray diffraction (XRD) pattern refinement). These larger particles were also coated in silica. All systems were characterized by various techniques including ^{57}Fe Mössbauer spectroscopy, XRD, AC and DC susceptibility measurements, and hysteresis loops to determine the relationships between the magnetism, and the microstructure and composition. Annealing the 4 nm particles to get the 25 nm particles provides the benefit of a bulk-like structure and order resulting in higher saturation magnetization, while still keeping the high surface to core atom ratio characteristic of nanoscale systems. The 25 nm particles have a larger saturation magnetization at all temperatures compared to the 4 nm particles in both the coated and uncoated systems. Coating the particles can inhibit particle growth and encourage beneficial interfacial effects such as spontaneous metal silicate formation leading to higher saturation magnetization. Mössbauer spectroscopy reveals more than one magnetic environment at the Fe nucleus of all $FeCo/SiO_2$ nanoparticles, indicative of Fe-silicate formation.

Poster Number: 25

Interaction of Gold Nanoparticles with Protein Studied by Atomistic Simulations

Presented by: Aoran Wei

MSc Candidate at the University of Manitoba, Department of Mechanical Engineering
Advisor(s): C Deng

Co-Author(s): Chuang Deng (supervisor)

Research Area(s): High Performance Computing

Au nanoparticles have been used for biomedical application since 1970s. However, the toxicity of them has become a rising issue, leading to an urgent need to understand the molecular mechanisms of the interaction between gold nanopartilcles and biological system, such as proteins. Self-assembled monolayers (SAMs) of organic thiols on Au surface are excellent model systems to study the interactions of Au nanoparticle and proteins. In this paper, molecular dynamics simulation of an all-atom model has been used to study the structural properties of self-assembled alkanethiol monolayers with different chain lengths chemisorbed on the Au (111), (110), and (100) surfaces . The interaction between Au-S was modeled using Morse potential, while for the Au-Au interactions, an embedded-atom (EAM) method was used. The adsorption of protein on SAMs with different chain lengths and terminals has also been investigated. We show that the arrangement of alkanethiol chains on Au largely relies on the atomic packing of Au surface. In particular, it is found that the SAM layer of alkanethiol chains forms a well-ordered $(\sqrt{3}\times\sqrt{3})$ *R*30° triangular lattice on Au (111) surface at 300K, which is consistent with the experimental results. Furthermore, the adsorption of protein varies with the composition and the length of the monolayer, e.g., the carboxyl group-terminated SAMs are more effective to absorb protein compared with the methyl-terminated SAMs.

Poster Number: 26

Can Computational Parameters Be Correlated to Experimental Efficiencies of Dye Sensitized Solar Cells?

Presented by: Jeffery Perkins

MSc Candidate at the University of Manitoba, Department of Chemistry
Advisor(s): G Schreckenbach

Co-Author(s): Jeffery Perkins, Georg Schreckenbach

Research Area(s): High Performance Computing

Interest in Dye Sensitized Solar Cells has been increasing since their introduction by Grätzel and O'Regan in the early 90's. This interest has primarily been driven by the prospect of cheap and flexible devices which should be able to reach grid parity with relative ease. However, there are still major challenges to be met before wide spread usage can be achieved. Among these is finding better and/or cheaper dye molecules, preferably using easily obtained organic molecules, and first row transition metals. In this work we have looked at various computational parameters discussed in the literature, and compare them to experimental data for a set of fifty organic dyes, looking for which parameters can be used to judge the usefulness of a proposed dye molecule. Initial results for a large set of dyes showed very weak correlations in all parameters, however splitting the dyes into sets related by molecular structures and cell construction has given much stronger correlations. Leading us to the conclusion that care is needed when comparison between different dye molecules, and cell components.

Poster Number: 27

computational screening of potential singlet fission molecules

Presented by: Gurpreet Kour

MSc Candidate at the University of Manitoba, Department of Chemistry
Advisor(s): HG Schreckenbach

Co-Author(s): Jeffery Perkins

Research Area(s): High Performance Computing

Global warming concerns and energy security have made solar energy conversion an important subject from society's point of view. More efficient solar cells would lead to wider use of this clean energy source. A quantum process called singlet fission could boost solar cell efficiency by harnessing inaccessible parts of the solar spectrum. One strategy to improve solar-cell efficiency is to generate two excited electrons from just one photon through singlet fission, which is the conversion of a singlet (S1) into two triplet (T1) excitons. One general design principle is that the energy of 2 × T1 must be equal to or less than that of S1 that is, 2E[T1] ≤E [S1]. Under this condition, the correlated triplet pair can relax to two triplets efficiently, which leads to a high singlet-fission efficiency. A large number of potentially favourable structures has been examined by the time-dependent density functional theory method to build a `library' of promising candidates for SF applications. Several likely candidates have been identified for experimental examination.

Poster Number: 28

ISOTHERMAL OXIDATION COMPARISON OF THREE Ni-BASED SUPERALLOYS

Presented by: Mallikarjuna Heggadadevanapura Thammaiah

MSc Candidate at the University of Manitoba, Department of Mechanical Engineering
Advisor(s): W. F. Caley, N. L. Richards

Co-Author(s): Dr. W. F. Caley and Dr. N. L. Richards

Research Area(s): High Temperature Aerospace Materials

Ni-based superalloys are used for high temperature components of gas turbines in both industrial and aerospace applications due to their ability to maintain dimensional stability under conditions of high stress and strain. The oxidation resistance of these alloys often dictates their service lifetime. In this study, three Ni-based superalloys, namely polycrystalline cast IN738LC, single-crystal N5 and a ternary Ni-Fe-Cr (TAS) powder metallurgy alloys were examined for relative oxidation resistance in static air at 900°C at different times up to 1000h. Based on a microstructural analysis, IN738LC exhibited a continuous dense outer scale of Cr_2O_3 and discontinuous inner scale of Al_2O_3, whereas N5 and TAS showed a dense outer scale of Al_2O_3 alone. To explain these results, the oxidation rate constant, kp was calculated for each alloy and found to be; kp = 2.79×10^{-6} $mg^2.cm^{-4}.s^{-1}$ for IN738LC, kp = 1.42×10^{-7} $mg^2.cm^{-4}.s^{-1}$ for N5 and kp = 1.62×10^{-7} $mg^2.cm^{-4}.s^{-1}$ for TAS. These results, suggest that, the N5 and TAS alloys are more oxidation resistant than the IN738LC under these conditions.

Poster Number: 29

Influence of liquid-state diffusion on microstructure of TLP joint between dissimilar single crystal superalloys with different orientations.

Presented by: Oluwadamilola Olatunji

MSc Candidate at the University of Manitoba, Department of Mechanical Engineering
Advisor(s): M.C. Chaturvedi, O.A. Ojo

Co-Author(s): O.A Ojo and M.C Chaturvedi

Research Area(s): High Temperature Aerospace Materials

Transient liquid phase (TLP) bonding technique has proved to be a preferred technique for joining extremely difficult-to-weld advanced materials, including similar and dissimilar aerospace superalloys. In the use of this technique to join dissimilar materials, liquid-state diffusion can occur, but its influence is usually ignored since it is generally assumed that the TLP bonding process is entirely controlled by solid-state diffusion. However, in this present work, the effect of liquid-state diffusion on the microstructure of a joint produced by TLP bonding of dissimilar single crystal (SX) superalloys is investigated. The results show that liquid-state diffusion can indeed have significant effect on TLP joint microstructure. In the case of bonding of dissimilar SX materials with different orientation, the occurrence of liquid-state diffusion can produce a SX joint that has a matching orientation with one of the SX substrates, instead of a bi-crystal joint. This formation of a SX joint, which cannot be produced exclusively by solid-state diffusion, has not been previously reported in the literature.

Poster Number: 30

Analysis of Nb Segregation Effects on Gamma Prime Precipitation Behaviour of ATI 718Plus Superalloy Weld

Presented by: GBENGA ASALA

PhD Candidate at the University of Manitoba, Department of Mechanical Engineering
Advisor(s): O.A Ojo, J. Andersson

Co-Author(s): Dr. O.A. Ojo and J. Andersson

Research Area(s): High Temperature Aerospace Materials

The effect of elemental micro-segregation on the precipitation behaviour of the main strengthen phase, γ’ precipitates, in the recently developed nickel-based superalloy ATI 718Plus after Tungsten Inert Gas (TIG) welding and post-weld heat treatment has been studied. Similar to its baseline superalloy, IN718, elemental micro-segregation induced Laves phase and MC type carbide particles were observed in the interdendritic regions of the fusion zone. Theoretical thermodynamic calculations were performed to study the influence of Nb segregation on both the kinetics and extent of γ’’ precipitation during post-weld heat treatment. In contrast to IN718 where Nb segregation in the fusion zone during welding affects the extent of γ’ precipitation, it is found that in the newly developed ATI 718 plus, it is the precipitation kinetics and not the extent of γ’ precipitation that is affected by the micro-segregation of Nb. The theoretical prediction is confirmed by experimental observations.

Poster Number: 31

Novel Structural Ceramics by Microstructure Design

Presented by: Jared Steen

Undergraduate Student at the University of North Dakota, Department of Mechanical Engineering
Advisor(s): S Gupta

Co-Author(s): A. Stoker, W. Steidl, Q. Tran, E. Downward, T. Gorron, J. Nelson

Research Area(s): High Temperature Aerospace Materials

$M_{n+1}AX_n$ (MAX) phases (over 60+ phases) are thermodynamically stable nanolaminates displaying unusual, and sometimes unique, properties. These phases possess a $M_{n+1}AX_n$ chemistry, where n is 1, 2, or 3, M is an early transition metal element, A is an A-group element, and X is C or N. The MAX phases are highly damage tolerant, thermal shock resistant, readily machinable, and with Vickers hardness values of 2 -8 GPa, are anomalously soft for transition metal carbides and nitrides. In this poster, we will present some of the recent research studies on the development of multilayered ceramics based systems.

Poster Number: 32

The Use of Synchrotron X-rays and Ultrasonics for Investigating the Bubble Size Distribution and Its Evolution in Dough

Presented by: Anatoliy Strybulevych

Researcher at the University of Manitoba, Department of Food Science
Advisor(s): M Scanlon, J Page

Co-Author(s): Filiz Koksel, Serdar Aritan, Valentin Leroy, John H. Page, Martin G. Scanlon

Research Area(s): Mechanics of Materials and Structures, Soft and Disordered Materials

Understanding mechanisms of aeration of dough during mixing and how the aerated structure of dough evolves during breadmaking are critical for attaining a desirable bread crumb structure. X-rays from a synchrotron source (Biomedical Imaging and Therapy beamline, Canadian Light Source) and ultrasonic transmission and reflection techniques were independently but simultaneously used to characterize the bubble size distribution and its evolution in nonyeasted dough subsamples as a function of time after mixing. The time dependent series of discrete bubble size distributions were extracted from the X-ray images using image analysis software and were fed to an ultrasonic model for predictions of ultrasonic phase velocity and attenuation coefficient. These predictions of phase velocity and attenuation coefficient derived from X-ray images exhibited frequency-dependent peaks that are characteristic of bubble resonance, as expected from the ultrasonic model. Furthermore, as the bubble size distribution changed as a function of time after mixing, the ultrasonic model qualitatively followed the changes in the experimental velocity and attenuation coefficient that accompanied changes in dough's bubbly structure. Our results point to the capability of the ultrasonic technique as a tool to noninvasively monitor the dynamic changes arising from the diffusively driven evolution of bubble sizes during breadmaking with the potential for determining the bubble size distribution in dough.

Poster Number: 33

Characterizing Sterilization Effects on Material Strength of 3D-Printed Biocompatible Plastics

Presented by: Emil-Peter Sosnowski

MSc Candidate at the University of Manitoba, Department of Biosystems Engineering
Advisor(s): J. Morrison

Co-Author(s): J. Morrison, T. Gascoyne, M. Petrak

Research Area(s): Mechanics of Materials and Structures, Soft and Disordered Materials

The use of 3D-printing of polymers to create custom biomedical implants has the potential to enable small companies to produce high-quality products. However the low-temperature nature of fusing polymer filament means that post-production sterilization must occur at a low temperature. This study characterizes the effects of hydrogen peroxide vapour sterilization by a STERIS Amsco V-PRO maX sterilizer on ASTM-compliant tensile samples of polycarbonate, polycaprolactone, and polylactic acid. Sterilization effects on the Young's modulus, yield strength, and ultimate tensile strength of the plastics were established against control samples. Statistically significant decreases in elasticity were found in all three materials. Both polylactic acid and polycaprolactone samples experienced increases in physical size as a result of sterilzation. These findings demonstrate that polylactic acid and polycarbonate 3D printed medical devices sterilized through this method must be designed in order to accommodate for any changes to the mechanical properties that may occur as a result of sterilization, and that polycaprolactone medical devices may have to be sterilized through other means.

Poster Number: 34

Estimation of Intracellular Ion Concentrations and Cytoplasm Conductivity for CHO cells

Presented by: Azita Fazelkhah

PhD Candidate at the University of Manitoba, Department of Electrical and Computer Engineering
Advisor(s): Dr. Thomson

Research Area(s): Complex Natural Systems

Cells are dynamic electronic materials that change electronic state in response to environmental pressures. There have been many demonstrations that dielectric changes occur in cells that are coincident with important physiological changes such as during programmed cell death (apoptosis).The change in cell physiological state is accompanied with the change in cell dielectric properties. In our group, we use DEP cytometer to detect apoptosis in Chinese Hamster Ovary (CHO) cells through the change in conductivity due to change in ion concentrations and followed their transition from a viable to non-viable state. There are no existing models which can link physiological state of the cells to its dielectric properties. Therefore, to have a better understanding of experimental data and its relationship with physiological state of the cell, in this work we did some theoretical calculation to estimate intracellular ion concentrations for CHO cells and used these values to estimate the conductivity of the cytoplasm.The estimated cytoplasm conductivity based on the applied theory is in agreement with the experimental values. The estimated cytoplasm conductivity changes from 0.419 S/m to 0.127 S/m as the viable cells undergo apoptosis which follows our experimental results. The measured cytoplasm conductivity for viable and non-viable CHO cells is about 0.42 S/m and 0.1 S/m, respectively.

Poster Number: 35

Polymer Electrolyte Potentiometric Volatile Sensor

Presented by: Bo Woods

MSc Candidate at the University of Manitoba, Department of Electrical and Computer Engineering
Advisor(s): G Bridges

Co-Author(s): R. Raju, S. Bhadra and G.E. Bridges

Research Area(s): MEMS/Microfluidic Systems

Ammonia gas is commonly found in environments where wastes are excreted and is important to monitor since concentration levels above 25ppm are considered unsafe for long-term exposure. We present a solid polymer electrolyte based pH sensitive passive wireless volatile sensor. The sensor is composed of a MMO working electrode, an Ag/AgCl reference electrode and amorphous hydrogel solid electrolyte [S. Bhadra, et.al., Sensors and Actuators B: Chemical, v. 209, 2015]. The electrolyte is encapsulated with a gas-permeable membrane. A volatile analyte in the sensing environment, that is permeable to the membrane, is absorbed by the hydrogel and induces an electrochemical potential at the MMO electrode. This potential, characterized by the acidity or basicity of the analyte, is applied directly to a voltage sensitive LC-tank circuit. The shift in the resonant frequency of the circuit is detected remotely through inductive coupling and is a direct indicator of the generated potential, and thus volatile concentration. We demonstrate a bio-compatible design of the sensor the size of a postage-stamp (2cm x 2cm). Potential application is in non-invasive food spoilage detection and health monitoring where acidic and basic volatiles act as indicators.

Poster Number: 36

Design and Fabrication of A Micromachined Low Voltage Electrostatic Actuated Deformable Mirror System

Presented by: Yu Zhou

PhD Candidate at the University of Manitoba, Department of Electrical and Computer Engineering
Advisor(s): C Shafai

Co-Author(s): Dr. Cyrus Shafai

Research Area(s): MEMS/Microfluidic Systems

Adaptive Optics (AO) has contributed greatly to the progress of the observational astronomy ever since its first successful application in 1989. Nowadays, most of the observatories have AO system as standard facility. Within an AO system, the deformable mirror (DM) is employed to correct and compensate the atmospheric distortion of the wavefront of light. Despite of its successfulness, most of the available DM systems require hundreds of volts of driving voltage, which not only greatly impedes its compatibility to the IC system, but leads to the need of cooling system as well. In this poster, we propose a micromachined DM system based on the bulk micromachining technique with a new design of electrostatic actuator. With this specific actuator design, the mirror is designed to achieve a decent stroke (~7 μm) with a reasonable resonant frequency (>1 kHz) and a driving voltage smaller than 30 V, which is fully compatible with existing IC.

Poster Number: 37

Development of a Novel MEMS Based Horseshoe shaped Lorentz Actuator Array for Adaptive Optics

Presented by: Byoungyoul Park

PhD Candidate at the University of Manitoba, Department of Electrical and Computer Engineering
Advisor(s): C. Shafai

Co-Author(s): Dwayne Chrusch and Cyrus Shafai

Research Area(s): MEMS/Microfluidic Systems

This paper presents the design and testing result of a horseshoe shaped Lorentz actuator array for adaptive optics; that was successfully fabricated using a bulk micromachining process. The actuated by Lorentz force that capable of lowering the operation current (1 to 10 mA) and voltage (less than 1 V) with bi-directional motion compare to an electrostatic actuator. The actuator consists of two crystalline silicon (c-Si) two loops serpentine flexures on the either end of a 25 *µm* thick and rigid *c-Si* cross-bar. These serpentine flexures provide current and heat transport pathway. Simulation results by using COMSOL Multiphysics software show ~ 0.2 *N/m* spring constant of serpentine flexure with 5 *µm* membrane mirror is needed to have 20 to 30 % inter-actuator coupling. The total required force to get ±5 *µm* deformation of the membrane is around 12 *µN*. Following this, experimental testing of the actuators was undertaken, with demonstrated actuator motion up to 50 µm agreeing with the simulated performance. This MEMS-based Lorentz actuator array promises a low power consumption and low voltage system for adaptive optics micro-mirror applications, with demonstrated potential for high fabrication yield.

Poster Number: 38

Butterfly Based MEMS DC electric field sensor with modulated sensitivity

Presented by: Sampath Liyanage

MSc Candidate at the University of Manitoba, Department of Electrical and Computer Engineering
Advisor(s): C. Shafai

Co-Author(s): Tao Chen

Research Area(s): MEMS/Microfluidic Systems

DC electric filed measurements are important in many industries. In power industry it has been used to measure voltage in the power lines and testing and identifying defective insulators. In atmospheric science electric field measurements are used to predict weather conditions like lightning. In the transportation industry eclectic filed measurement has been used to identify dangerous condition when transporting chemical goods.Traditionally, electric filed mills are used to measure DC electric filed measurements. But this device has drawbacks like bulkiness, high power consumption, frequent maintenance. Recent years different MEMS dc electric filed sensor were developed and deflection was measured by a laser position detection system. However, it faced practical issues when making measurements in the industry such as stability and size.In this work, it was simulated several MEMS sensor designs in different frequencies from 500 Hz to 2kHz with butterfly motion to increase the sensitivity with applying positive and negative voltages to the membrane at the same time. Modulation of the incident electric field with a bias voltage on the sensing membrane is used to give the sensor a wide measurement range, from sub-1 V/m to MV/m. The sensor operates by monitoring membrane displacement due to incident electric fields. Unlike field mills, this sensor does not have rotating parts, avoiding associated wear and maintenance issues. High sensitivity is achieved by using a laser position monitoring system. Compact electronic based measurement system is developed to take easy measurements.

Poster Number: 39

Resonance Based MEMS Magnetic Field Sensor

Presented by: Meiting Li

MSc Candidate at the University of Manitoba, Department of Electrical and Computer Engineering
Advisor(s): C. Shafai

Co-Author(s): Byoungyoul Park, Sampath Liyanage, Cyrus Shafai

Research Area(s): MEMS/Microfluidic Systems

A resonance based MEMS magnetic field sensor is presented. A Lorentz force actuated MEMS micromirror is used as the resonator. An AC current flows across the resonator, generating a Lorentz force at the mechanical frequency of the resonator itself. The periodic torsional motion of the micromirror is detected with a quad-cell photodetector and processed with electronics. This magnetic field sensor presents a linear response between the resonant rotational angle and the magnetic field strength. This magnetic field sensor presents a resolution of 0.4 nT at 50mArms bias current, and operation at atmospheric pressure. At different level of bias current, resonance MEMS Lorentz magnetic field sensors can work in a wide range of measurement, from nT to T.

Poster Number: 40

An infrared spectrometer based on a MEMS Fresnel zone plate for measuring incipient fault gases in high voltage equipment

Presented by: Pawel Glowacki

MSc Candidate at the University of Manitoba, Department of Electrical and Computer Engineering
Advisor(s): C Shafai

Co-Author(s):

Research Area(s): Photonic and Phononic Interactions, MEMS/Microfluidic Systems

Dissolved gas analysis (DGA) is a method for measuring incipient gases in oil impregnated high voltage equipment. Currently there exist a number of methods for performing this analysis including optical techniques such as photoacoustic spectroscopy and FTIR. In this work, a spectroscopic technique based on the application of a MEMS Fresnel zone plate for performing DGA is presented. The zone plate is designed to function as a temporal filter with a focal length of 20mm, a design wavelength of 3.045um, and a spectral bandwidth of 5nm. Simulation results in MATLAB have shown that by adjusting the focal length of the lens, the absorption profiles of most hydrocarbon incipient fault gases can be detected for a single design wavelength. Simulation results have also shown how various parameters of the lens including SNR, transmittance, and spectral bandwidth change with respect to the number of zones in plate, the design focal length and wavelength, as well as the ratio of open to opaque space in the lens. The current work being performed is building the lens using MEMS fabrication techniques.

Poster Number: 41

Design and fabrication of Si/SiO_2 distributed Bragg reflectors by reactive RF magnetron sputtering

Presented by: Elnaz Afsharipour

PhD Candidate at the University of Manitoba, Department of Electrical and Computer Engineering
Advisor(s): C.S Shafai

Co-Author(s): Cyrus Shafai

Research Area(s): Photonic and Phononic Interactions, MEMS/Microfluidic Systems

In this work, highly reflecting Distributed Bragg Reflectors (DBR) composed of high refractive index amorphous silicon (n=3.5) and low refractive index silicon dioxide (n=1.47) films are designed and fabricated. Five pairs of quarter-wavelength-thick layers are deposited on both glass and silicon substrates. Silicon and silicon dioxide layers are fabricated by radio frequency magnetron sputtering and reactive-sputtering of silicon target with oxygen gas, respectively. The presented method is reproducible and has the advantages of low-temperature and single run deposition. The maximum contrast between the refractive indices was achieved by tailoring the sputtering parameters. The effect of oxygen and argon gas flow rates, as well as deposition pressure on the refractive index and transmission of deposited SiO_2 films, is also studied. The VIS-IR spectroscopy and ellipsometry techniques are utilized to optically analyze the structure. The transmission, angle dependent reflection profiles and phase change induced by thin films, are investigated. DBRs exhibited more than 90% reflectance in a center wavelength of 640 nm which matches the simulations.

Poster Number: 42

Voltage Control of Cavity Magnon Polariton

Presented by: Sandeep Kaur

MSc Candidate at the University of Manitoba, Department of Physics and Astronomy
Advisor(s): C.-M Hu

Co-Author(s): Bimu Yao, Jinwei Rao, Yongsheng Gui

Research Area(s): Photonic and Phononic Interactions

Active voltage control of Cavity Magnon Polariton (CMP) is demonstrated in the microwave frequency regime using a varactor loaded split ring resonator cavity along with an YIG sphere. Traditionally, the CMP dispersion has been studied by using an applied magnetic field to tune the resonance response of YIG because the cavity has a fixed resonance frequency. However, the resonance response of our varactor loaded split ring resonator cavity can be continuously and accurately tuned by tuning the voltage bias applied to the varactor. Therefore, by using this cavity, the photon-magnon coupling between a cavity photon and an YIG magnon, which corresponds to the generation of CMP can be studied by tuning the applied magnetic field as well as the applied DC voltage. This planar, electrically tuneable cavity not only provides another degree of freedom to study the CMP but can also be easily adapted to an on-chip design for creating novel microwave devices that utilize light-matter interactions.

Poster Number: 43

Indirect Coupling Between Two Cavity Photon Systems via Ferromagnetic Resonance

Presented by: Paul Hyde

PhD Candidate at the University of Manitoba, Department of Physics and Astronomy
Advisor(s): C.-M. Hu

Co-Author(s): L. Bai, M. Harder, C. Match, and C.-M. Hu

Research Area(s): Photonic and Phononic Interactions

Although the field of quantum computing promises to be the next big leap in information technology, designing systems that can incorporate quantum effects while still being able to transmit and store data has proved challenging. This is mainly due to the natural instability of most quantum systems. However, within the past few years quantum behaviour has been proposed in macro-sized (a few mm) ferromagnetic (FM) systems locked in a resonating macro-state. These systems would use relatively stable FM macro-states to store quantum information, and transfer information using photons. Although many studies have been performed on energy transfer between FM systems facilitated by a single resonant photon state, we instead use an adjustable cavity to bring two cavity photon resonant modes into a coupled state with a single FM system. By coupling these three systems together, we observe a clear increase in the amplitude of the photon systems when their resonant modes are brought in-phase with each other, evidence of energy transfer between them. Since photons cannot interact with each other, this energy transfer must be being facilitated by the FM system they are coupled with. A related amplitude decrease is seen as the photon states are brought pi out-of-phase with each other. These results, the first of FM mediated photon energy transfer, are verified by comparison with a three coupled oscillator model based on the photon-FM-photon system.

Poster Number: 44

The Coherence of Strong Spin-Photon Coupling

Presented by: Michael Harder

PhD Candidate at the University of Manitoba, Department of Physics and Astronomy
Advisor(s): C.-M. Hu

Co-Author(s): Lihui Bai, Christophe Match, Jesko Sirker, Can-Ming Hu

Research Area(s): Photonic and Phononic Interactions

Understanding and controlling light-matter interactions is the kernel of materials science. In this direction, recent studies of strongly coupled spin-photon systems have revealed exceptionally long dephasing times, sparking excitement within the quantum information and spintronic communities. On one hand, such systems may represent the next generation of hybrid quantum information devices, while on the other hand, from a spintronics perspective, the coherent nature of such spin-photon coupling opens the door to coherent spin current control.

In this work we systematically study the transmission line shape of an yttrium-iron-garnet/microwave cavity system. The large spin density and low loss rates of the ferrimagnetic insulator YIG, together with the high quality of our microwave cavity, allow us to enter the strongly coupled regime. By performing two dimensional frequency and field measurements of the microwave transmission, this spin-photon system can be fully characterized. Our observations reveal new line shape symmetries which are related to the phase information of the YIG magnetization. To accurately describe these results we have built models based on harmonic coupling, electrodynamic phase correlation, and a microscopic Hamiltonian, which provide insights into the nature of the coupling, and can be easily generalized to other systems. Therefore our work represents the first step towards a deeper experimental and theoretical understanding of the coherent nature of strong spin-photon coupling, which will play a role in future quantum information and spintronic technologies.

Poster Number: 45

New luminescent transition metal d10 complexes supported by phenanthridine-based ligands

Presented by: Issiah Lozada

Undergraduate Student at the University of Manitoba, Department of Chemistry
Advisor(s): D.E. Herbert

Co-Author(s): Rajarshi Mondal, Patrick Giesbrecht, and David Herbert

Research Area(s): Photonic and Phononic Interactions

Ever since the discovery of tris(2,2-bipyridyl)ruthenium(II), chemists have been pursuing new luminescent coordination compounds with greater chemical stability, redox and luminescence, excited state lifetime and reactivity.[1] These compounds have been employed in different luminescent technologies (*e.g.* smartphones),[2] in bio-imaging,[3] optical power limiting materials,[4] and photochemical catalysis.[5] As such, chemists have exploited, largely, the platinum group metals, which have demonstrated outstanding and tunable photo- and electroluminescence.[6] These enhanced properties are consequences of the high spin-orbit coupling of these metals. However, these metals can be costly due to their scarcity in the Earth's crust, which might impede the discovery and designing of novel luminescent materials. It is therefore imperative to employ cheaper and more abundant alternatives. Our group are, therefore, pursuing *d10* transition metal complexes as alternatives, particularly, copper(I) and zinc(II) metal ions. Apart from the lower costs of these compounds, various coordination geometries can be accessed that can be advantageous in designing complex molecular structures. In addition, ligands containing phenanthridine (1) and a variety of aryl groups bound to nitrogen or phosphorous in the ligand-backbone have been synthesized, which will allow us to potentially modify the electronic structure of the complexes. Multinuclear NMR has been extensively used to characterize these novel ligands and complexes, and to determine the efficiency of the utilized synthetic methods. Moreover, single crystal X-ray diffraction of these complexes, which proved to be challenging, has been carried out to study their structures in the solid state. Lastly, UV-Vis and cyclic voltammetry of the complexes have been carried out to study their electronic structure and will be tied to their observed structure.

References:
1 Campagna, S.; Puntoriero, F.; Nastasi, F.; Bergamini, G.; Balzani, V. Photochemistry and Photophysics of Coordination Compounds: Ruthernium. In Topics in Current Chemistry. Balzani, V.; Campagna, S., Eds.; Springer-Verlag: Berlin, 2007; Vol. 280, p 119. **2** Yersin, H. and Finkenzeller, W. J. Triplet Emitters for Organic Light-Emitting Diodes: Basic Properties. In Triplet Emitters for Organic Light-Emitting Diodes: Basic Properties, in Highly Efficient OLEDs with Phosphorescent Materials. Yersin, H., Ed.; Wiley-VCH: Verlag, 2007; p 1. **3** Coogan, M. Ligand Design in d-Block Optical Imaging Agents and Sensors. In Ligand Design in Medicinal Inorganic Chemistry. Storr, T., Ed.; Wiley: Chichester, 2014; pp 81-108. **4** Spangler, C.W. J. Mater. Chem. 1999, 9, 2013-2020. **5** Ciesla, P.; Kocot, P; Mytych P.; Stasicka, Z. J. Mol. Catal. A 2004, 224, 17-33. **6** Murphy, L.; Williams, J.A.G. Luminescent Platinum Compounds: From Molecules to OLEDs. In Topics in Organometallic Chemistry. Bozec, H.L.; Guerchais, V., Eds.; Springer-Verlag: Berlin, 2010; Vol. 28, pp 75-111.

Poster Number: 46

Superdiffusive Spin Transport

Presented by: Maximilian Kiefer-Emmanouilidis

MSc Candidate at the University of Manitoba, Department of Physics and Astronomy
Advisor(s): J. Sirker, S. Eggert

Co-Author(s): H. C. Schneider

Research Area(s): Quantum Materials

We solve transport equations numerically to describe ultrafast demagnetization through spin-polarized excited electron superdiffusion in mono- and heterostructures. Thus we use a semiclassical approach that is specifically dedicated to capture the spin transport of laser-excited nonequilibrium electrons. As examples we solve the spin-dynamics for typical monostructures (Fe,Ni,Au), a ferromagnetic/nonmagnetic metallic junction (Fe/Au) and a ferromagnetic/insulator junction (Ni/MgO).

Poster Number: 47

Iridium-silicide nanowires on Si(110) surface

Presented by: Nuri Oncel

Researcher at the University of North Dakota, Department of Physics and Astrophysics
Advisor(s):

Co-Author(s): Rasika N. Mohottige

Research Area(s): Quantum Materials, Crystalline Materials and Nanostructures, Surfaces and Interfaces

As continuous miniaturization challenges lithography techniques in electronics, self-assembly based processes become more attractive. One particularly important self-assembled component is metal-silicide nanowires. These nanowires can function as low-resistance interconnects, as fins in FinFET devices and as nano-electrodes for attaching small electronic components within an integrated circuit. It has already been shown that a variety of metals form self-assembled silicide nanowires on the surface of flat and/or vicinal Si substrates. In comparison to Si(111) and Si(001) surfaces, Si(110) surface has received relatively less attention because the surface reconstruction is complicated and it is difficult to grow single large domains. However, higher hole mobility in devices fabricated on Si(110) surface and the possibility of employing self-assembled nanowires in various applications have recently increased number of studies on these systems. We studied physical and electronic properties of iridium silicide nanowires grown on the Si(110) surface with the help of scanning tunneling microscopy and spectroscopy. The nanowires grow along the [001] direction with an average length of about 100 nm. They have a band gap of ~0.5 eV and their electronic properties show similarities with the iridium silicide ring clusters formed on Ir modified Si(111) surface.

Poster Number: 48

Structure and phase separation in borosilicate glasses

Presented by: Arun Krishnamurthy

MSc Candidate at the University of Manitoba, Department of Chemistry
Advisor(s): Dr Kroeker

Co-Author(s): Scott Kroeker; Kirill Levin

Research Area(s): Soft and Disordered Materials

Glasses have unique physical and chemical properties which vary as a function of temperature and chemical composition. Understanding these properties requires an accurate structural description of the glass. The importance of both molecular-level structure and bulk morphology demand effective characterization across many length scales. We use a variety of essential methods to probe key aspects of two series of glasses. X-ray photoelectron spectroscopy (XPS) is used in an attempt to determine and quantify the boron and oxygen local environments with different co-ordination numbers in barium borosilicate glasses. More complex alkali borosilicate glasses are designed to mimic materials for nuclear waste disposal. These glasses are chemically durable and possess high waste loading capacity making them very attractive for storing radioactive nuclei which undergo long term decay. Some components that are present in a typical high level waste (HLW) stream are not easily incorporated into the glass structure. Some fraction of molybdenum tends to phase-separate as crystalline molybdates, sequestering alkali or alkaline-earth ions, making it challenging to study by a single technique. We use electron probe microanalysis (EPMA), laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS), X-ray diffraction (XRD) and solid state nuclear magnetic resonance (ssNMR, ^{23}Na and ^{133}Cs) spectroscopy to characterize different phases produced under typical processing conditions. It is found that the addition of Ca to the base glass prevents formation of water-soluble molybdate phases containing radioactive isotopes. Phase separation of these molybdates also depends on melt quench rate. Based on these results, the glass composition will be fine-tuned to increase the threshold limit of waste-loading capacity.

Poster Number: 49

PDMS-based acoustic impedance-matched material in water

Presented by: Reine-Marie Guillermic

Postdoctoral Fellow at the University of Manitoba, Department of Physics and Astronomy
Advisor(s): J.H. Page

Co-Author(s): Reine-Marie Guillermic, Anatoliy Strybulevych & John H. Page

Research Area(s): Soft and Disordered Materials, Composite Material Systems

Having a material that is matched in acoustic impedance with water can be a huge asset for many underwater acoustic applications. We have created a composite material that has the same longitudinal acoustic impedance as water using Polydimetylsiloxane (PDMS) and TiO_2 particles. The goal is to create an easy-to-handle soft material with a negligible acoustical reflection coefficient with low absorption in other words a material that would be acoustically transparent under water. To predict the concentration of particles needed in the PDMS matrix to obtain impedance matching to water, we used a Coherent Potential Approximation (CPA) model for dispersed particles in an elastic matrix. This model predicts the shear and longitudinal moduli of the final composite system. We discuss the validity and limitation of the model and show experimentally that it is possible to achieve perfect impedance matching for longitudinal waves by adding submicron particles to a soft solid, here PDMS, and also to measure its shear mechanical properties. The composite material can be cured in a mold to achieve desired sample shape in the same way as with classic PDMS, which makes it very easy to handle and to use. This material, which prevents acoustical reflections, can be used as a cell or for walls around a sample to allow the sample's acoustical properties to be probed. We plan to use this material to improve the performance of bubble metascreens for broadband superabsorption of acoustic waves in water.

Poster Number: 50

Effects of ingredients and mixing on the rheological properties of bread dough

Presented by: Xinyang Sun

PhD Candidate at the University of Manitoba, Department of Food Science
Advisor(s): M. G. Scanlon

Co-Author(s): Xinyang Sun, Filiz Koksel, Martin G. Scanlon, Michael T. Nickerson

Research Area(s): Soft and Disordered Materials

From the materials point of view, bread dough is a viscoelastic system formed by mixing ingredients (i.e., wheat flour, water and NaCl) to create a desirable structure with specific performance attributes. The effects of ingredients and mixing time, separately, on dough rheological properties have previously been studied. But how dough rheological properties are affected by the interactions of ingredients and mixing (i.e., optimal, under- and over-mixing) has not been reported yet. The objective of this research was to investigate the interactive effects of wheat cultivar, water concentration, NaCl concentration and mixing time on the rheological properties of doughs. Results showed that dough rheological properties were better discriminated according to difference in wheat flour attributes at the low-moisture and high-NaCl conditions. The effect of water on the energy input for optimal-mixed dough was more pronounced at high-NaCl conditions, whereas the effect of water on dough viscoelasticity was more significant at low-NaCl conditions. According to changes in the optimum mixing time and energy input, the doughs made from the wheat cultivars Pembina, Roblin and Harvest were more tolerant to NaCl reduction. From rheological analyses on dough elasticity, Roblin doughs prepared at optimal mixing and water addition were less responsive to NaCl changes. The interaction of mixing and NaCl on dough viscoelasticity was more significantly affected by NaCl at under-mixing conditions. In conclusion, wheat cultivar, water, NaCl and mixing time exert interactive effects on the rheological properties of bread dough. Therefore, ingredients and mixing time need to be taken into account for making bread dough with optimal viscoelasticity.

Poster Number: 51

Anomalous Diffusion of Ultrasound in close-packed Suspensions of Aluminum Beads

Presented by: Sébastien Kerhervé

PhD Candidate at the University of Manitoba, Department of Physics and Astronomy
Advisor(s): J.H. Page

Co-Author(s): S. O. Kerhervé, J.H. Page

Research Area(s): Soft and Disordered Materials

Measurements of multiply-scattered wave transport allow the characterization of heterogeneous media and may reveal anomalous wave properties. When a wave propagates through a sufficiently disordered medium, it will undergo many scattering events. This may lead to diffusive transport or even, in highly disordered media, to localized behaviour in which transport comes to a halt. These two regimes can be distinguished by measuring the evolution of the transverse intensity profile when point-like ultrasonic pulse is incident on the opposite side of a slab-shaped sample. In the case of diffusive propagation, the profile width grows without limit as the square root of time, while for localized waves, the width reaches a saturation value at long times due to the trapping of the waves in the medium.

In our experiment, the sample consists of aluminum beads randomly packed in silicone oil, creating a disordered two-component medium where diffusion was expected, based on previous work with glass bead suspensions in water. Contrary to expectations, we find that the transverse width goes through a maximum as a function of time, and varies more slowly afterwards. This novel behaviour may be due to the existence of two coupled modes of propagation: a fast diffusive mode travelling mainly through the liquid, with the propagating waves being multiply scattered off the beads, and a slower mode that involves transport via the bead network and is strongly influenced by the bead resonances.

Poster Number: 52

Vitamin A Deficiency as a Murine Model of Fetal Alcohol Spectrum Disorder (FASD): Characterization of FAS-Like Craniofacial and Neurodevelopmental Malformations.

Presented by: Berardino Petrelli

MSc Candidate at the University of Manitoba, Department of Biochemistry and Medical Genetics
Advisor(s): G Hicks

Co-Author(s):

Research Area(s): Soft and Disordered Materials

Fetal Alcohol Spectrum Disorder (FASD) is the most common cause of neurodevelopmental disorders in the western world, affecting 1-5% of North American children. Individuals with FAS have craniofacial malformations and neurodevelopmental deficits, including cognitive, memory and learning impairments. We hypothesize that acute prenatal alcohol exposure overwhelms alcohol metabolizing enzymes that normally also convert retinol (Vitamin A) to retinoic acid; moreover, this reduction of retinoic acid levels during gastrulation drives the malformations and deficits associated with FAS. To model the alcohol competitive inhibition in vivo we genetically engineered a mouse expressing Cyp26A1-eGFP from the endogenous Goosecoid (Gsc) promoter. Cyp26A1 biochemically mimics the reduced retinoic acid levels induced by acute alcohol exposure and the Gsc promoter dictates a specific spatio-temporal expression of the Cyp26A1-eGFP cassette in Spemann's Organizer (at gastrulation). Analysis of newborn F1 mice shows 88% (n=15/17) of mutant mice assessed had a discernable FAS phenotype, compared with 100% of wild-type mice assessed as normal (n=14/14). Scanning Electron Microscopy analysis further quantified the craniofacial malformations using a philtrum length measurement ratio. Gsc:Cyp26A1 x RARE-LacZ reporter mice were next used to demonstrate a reduction in Rare-LacZ expression (retinoic acid activity) in the developing forebrain region of Gsc:Cyp26A1 E8.5 embryos. Taken together, our data supports the role of alcohol-induced retinoic acid deficiency as an underlying etiology of FAS.

Poster Number: 53

SEPARATION OF FIBRE AND SHIVES FROM DECORTICATED FLAX

Presented by: Sandeep Thakur

Researcher at the University of Manitoba, Department of Biosystems Engineering
Advisor(s): Y Chen, J Morrison

Co-Author(s): Y Chen and J Morrison

Research Area(s): Soft and Disordered Materials, Composite Material Systems

Decorticated flax contains significant amount of shives, which limits applications of flax fiber. Separation of shives from the fiber is essential to improve the quality of flax fiber. The intention of this study was to use pneumatic method for separation of flax fiber and shives. For pneumatic method to be successful, differences between the terminal velocities of flax fiber and shive particles were investigated. Measurements were conducted on individual fiber and shive particles. Those particles were characterized in terms of width, length, and mass, and their terminal velocities were measured using a wind tunnel. To improve fiber quality, sorting method was also tested for separation of short and long fiber (longer fiber has higher market value). A generic fiber Sorter was used for the sorting tests with two types of decorticated flax fibers as treatments: Grade 1 and Grade 2. Their initial fiber purities were 51% and 15%, respectively. The outputs of the Sorter were analyzed to determine the machine yield and fiber purity. The results of the pneumatic tests showed that the length of fiber particles did not influence the terminal velocities of fiber. For shives, the increase in mass and width showed an increasing trend in terminal velocity. The ranges of terminal velocities for shive and fiber particles were 1.13 to 4.09 m s^{-1} and 0.51 to 1.07 m s^{-1}, respectively, which were significantly different. The results of the sorting tests showed that the sorting method resulted in the fiber purity of approximately 80% for Grade 1 and 66% for Grade 2, which were a significant improvement when compared to their initial purities. This study demonstrated the potential of the pneumatic and sorting methods for improving fiber quality.

Poster Number: 54

Attaching Mixed Monolayers of vFc/Me to Si Microwire Arrays

Presented by: Onkar Kang

Postdoctoral Fellow at the University of Manitoba, Department of Chemistry
Advisor(s): D Herbert, M Freund

Co-Author(s): Jared Bruce, Patrick Giesbrecht, David Herbert, Michael Freund

Research Area(s): Surfaces and Interfaces

A fully integrated, freestanding device for photoelectrochemical fuel generation will likely require covalent attachment of catalysts to the surface of the photoelectrodes. Ferrocene has been utilized in the past as a model system for molecular catalyst integration on planar silicon; however, the surface structure of high-aspect ratio silicon microwires envisioned for a potential device presents potential challenges with respect to stability, characterization and mass transport. Attachment of vinylferrocene to Cl-terminated surfaces of silicon microwires was performed thermally. By varying the reaction time, solutions of vinylferrocene in di-n-butyl ether were employed to control the extent of functionalization. X-ray photoelectron spectroscopy (XPS) and electrochemistry were used to estimate the density and surface coverage of the silicon microwire arrays with ferrocenyl groups, which could be controllably varied from 1.23×10^{-11} to 4.60×10^{-10} mol cm^{-2} or 1 to 30% of a monolayer. Subsequent back-fill of the remaining Si-Cl sites with methyl groups produced ferrocenyl-terminated surfaces that showed unchanged cyclic voltammograms following two months in air, under ambient conditions, and repeated electrochemical cycling.

Poster Number: 55

Comparison of Fouling Mechanisms of Four Nanofiltration Membranes: Optimal Membrane Selection for Stephenfield Regional WTP, MB, Canada

Presented by: Ian Moran

Undergraduate Student at the University of Manitoba, Department of Civil Engineering
Advisor(s): B Gorczyca

Co-Author(s): Dr. Beata Gorczyca

Research Area(s): Surfaces and Interfaces

Dual membrane filtration plants, incorporating microfiltration (MF) and nanofiltration (NF) have become widely used in potable water treatment as a method that can meet increasingly stringent THMs standards. Due to the high soluble material content in Manitoba and surrounding areas, a major concern for plant optimization is NF fouling. Over operational time, the foulant layer acts as an inhibitor of permeate flux and can significantly decrease membrane element longevity and increase plant operational cost. The extent of membrane fouling is determined by the specific interaction between the membrane and soluble material in the feed water. A detailed understanding of NF fouling mechanisms is necessary to optimize plant operation. Physical and chemical analyses were carried out on four different membranes (DOW FILMTEC NF90-400/34i, DOW FILMTEC NF270-400/34i, DOW FILMTEC BW30XFR-400/34i, DOW FILMTEC XFRLE-400/34i) to determine the optimal membrane for installation in the Stephenfield Regional WTP in southern Manitoba. Post-MF water from the Stephenfield Regional WTP was run in cross flow at 10bar (145psi) across each membrane at different operational time steps (1, 4, 12, 24, 48 hours). Virgin membrane surface roughness appears to be the governing factor for the degree and mechanism of fouling. Atomic force microscopy showed the initially rough NF90 and BW30 membranes experience a higher initial rate of fouling due to the higher surface area to attach and surface contours for soluble material to grab. The non-fouling resistant NF90 and NF270 membranes experienced a flux restoration from fouling over time. This phenomenon is predicted to be the dual result of membrane compaction and scouring. The flattening process of membrane peaks pulls down the overbearing layer of foulant causing an increase in surface roughness with greater susceptibility to the effects of cross flow scouring. The BW30 and XLE, coated with a fouling-resistant polyether block amide compound, experienced a lesser degree of fouling. The retained mass of foulant on the NF90 was three times greater than the other tested membranes due to the high virgin membrane surface roughness and lack of fouling resistant coating. This understanding of fouling mechanisms, as well as permeate quality, was used to select the NF270 as the optimal element for longevity and operational cost.

Poster Number: 56

Core-shell nanoparticle magnetism: The impact of interfacial intermixing

Presented by: Elizabeth Skoropata

PhD Candidate at the University of Manitoba, Department of Physics and Astronomy
Advisor(s): J van Lierop

Co-Author(s): R. D. Desautels, H. Ouyang, J. W. Freeland and J. van Lierop

Research Area(s): Surfaces and Interfaces, Crystalline Materials and Nanostructures

To understand the origin of the magnetic properties of core-shell nanoparticles necessitates a knowledge of core-shell intermixing effects; intermixed layers modify directly the disordered surface magnetism of the core particle, and determine the interfacial exchange interactions that mediate the magnetic coupling between core and shell. To investigate this issue, we report on the relationship between interfacial intermixing and magnetic properties of a series of γ-Fe_2O_3 based core-shell nanoparticles with Cu, CoO, MnO, and NiO shells. Using element specific techniques (Mšssbauer spectroscopy, x-ray absorption spectroscopy (XAS) and x-ray magnetic circular dichroism (XMCD)), we identify an interfacial intermixed layer consisting of transition metal ions from the shell that substituted into the octahedral (Oh) and tetrahedral (Td) sites of the γ-Fe_2O_3 core. For γ-Fe_2O_3/Cu and γ-Fe_2O_3/NiO, the intermixed layer consists of 2+ cations substituted into the Oh-sites exclusively. Interestingly, Cu and NiO shells had also similar effects on the nanoparticle magnetism, both resulting in an increased anisotropy (an enhanced HC) while also reducing substantially the surface spin disorder intrinsic to γ-Fe_2O_3 cores (revealed by changes to HEX and MS(T)). By comparison, the interfacial layer in γ-Fe_2O_3/CoO contains predominantly Co^{2+} in Oh-sites and a slight Td-site occupancy, resulting a large increase in intrinsic anisotropy and little effect on the γ-Fe_2O_3 surface spin disorder. For γ-Fe_2O_3/MnO, a mixture of Mn^{3+} Oh and Mn^{2+} Td-sites revealed a more radical site substitution, which resulted in cooperative relaxation effects among the core and interfacial Fe-spins.

Poster Number: 57

Concentration dependent diffusion modelling of electrodeposited tin on a copper substrate

Presented by: Guilherme Garrido Damaceno

MSc Candidate at the University of Manitoba, Department of Mechanical Engineering
Advisor(s): O Ojo

Co-Author(s): Dr. O. A. Ojo

Research Area(s): Surfaces and Interfaces

Bronze is a desirable material due to its good corrosion, wear and tarnish resistance, low coefficient of friction and appealing appearance. Conveying these properties to other materials by creating a bronze coating is a cost-effective approach of utilizing the beneficial properties of bronze on other materials. This can be achieved by the deposition of copper and tin on the material's surface, followed by an annealing process to produce bronze. However, during annealing of this two metals, a series of complex phase transformations take place, which result in a bronze with final surface composition that depends on a series of process parameters, such as, annealing temperature, time and coating thickness. The bronze surface composition invariably controls the surface properties. In this work, the physical process involved during the annealing process is elucidated and numerically modeled to simulate the dependence of the bronze final surface composition on the annealing parameters. Experimental verification confirms the theoretical predictions.

Poster Number: 58

Electrocatalytic Reduction of Carbon Dioxide using N-Heterocycles

Presented by: Patrick Giesbrecht

MSc Candidate at the University of Manitoba, Department of Chemistry
Advisor(s): D. E. Herbert

Co-Author(s): Patrick K. Giesbrecht, Dr. David E. Herbert

Research Area(s): Surfaces and Interfaces, Composite Material Systems

Due to the ever-rising CO_2 emission levels from fossil fuel consumption, the formation of a cheap, robust, and sustainable carbon-based fuel source from CO_2 is essential. One promising system involves the use of pyridine as an electrocatalyst for the reduction of CO_2 to formic acid and methanol through multiple proton-coupled electron transfers (PCET). Faradaic efficiencies exceeding 90% for methanol formation have been observed when this system is coupled to a light-absorbing cathode, p-GaP. Incorporation of this system into a photoelectrochemical cell has been limited, however, due to the slow kinetics and large resulting overpotentials. By extending the conjugation of the pyridine system to larger N-heterocycles, a more accessible route to CO_2 reduction is expected. In particular, phenanthridine has shown promising application in imine hydrogenation through a proton-hydride transfer to the substrate under mild conditions.

This work investigates the use of a suite of N-heterocycles as electrocatalysts for proton and CO_2 reductive processes, allowing the selectivity of CO_2 reduction over proton reduction to be determined. The resulting products from CO_2 reduction were analyzed using spectrometric and spectroscopic techniques, providing product distribution and overall Faradaic efficiencies for these systems. Interestingly, a dependence on the availability of the ortho-sites of the N-heterocycle is observed for the CO_2 reduction process. From this work, the CO_2 reductive capabilities of pyridine can be expanded to extended N-heterocycles, allowing a more generalized mechanism to be developed.

Poster Number: 58

Surface Characterization of Canola Fibre (Brassica napus L.) Using Scanning Electron Microscopy

Presented by: Tasneem Vahora

PhD Candidate at the University of Manitoba, Department of Biosystems Engineering
Advisor(s): J Morrison

Co-Author(s): Jason Morrison

Research Area(s): Surfaces and Interfaces, Soft and Disordered Materials

Natural fibres are extensively used in various industrial applications such as medical textiles, geotextiles, automobiles, aerospace and apparel. Canola was developed and is grown for its oilseed and the remainder of the plant is unused. However, the waste canola (Brassica napus L.) straw is source of natural fibre that might be usable in a variety of applications. The objective of this work is to characterize the microstructure and the elemental content of the canola fibre (Red River 1861 variety). The present experiment was carried out using scanning electron microscope (SEM) in conjunction with energy dispersive spectroscopy (EDS) for canola fibre for surface characterization and investigation of the chemical composition of the sample. The SEM images were taken at different magnifications ranging from 100x-10000x for the retted and unretted canola fibres coated using a gold:palladium (60:40) coating. Differing magnifications of the samples enabled observations of non-uniformity of surface microstructures and particulates on the fibres. Using EDS we observed that the carbon and oxygen were the major elements present in canola fibre. The weight % of carbon and oxygen (major elements in natural fibre: canola) at spot1 was 57.73 % and 42.27 %, respectively, and for spot 2 it was 54.26 and 45.74, respectively. The study suggests what could be done in future to obtain the similar results of canola fibre for comparison among existing natural fibres.