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Poster Abstracts

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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.

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Poster Number: 1

Temporal Analysis Of Carbon Black-Organic Polymer Composite Sensors For Machine Olfaction

Presented by: Shaun Ryman
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Advisor(s): M Freund

Co-Author(s): Dr. M. S. Freund, Dr. N. D. B. Bruce

Research Area(s): Complex Natural Systems

The human olfactory system can classify new odors, while simultaneously reducing the influence of background odors. Replication of this capability is an active area of research over the past 3 decades and would provide benefits to medical diagnostics, environmental monitoring, industrial monitoring and others. Currently new methods for rapid dynamic temporal evaluation of analytes are being explored. High and low frequency filtering of changing sensor responses are such methods; applied to reduce the affects of background signals as well as sensor drift over time. Temporal analysis using principal component analysis (PCA) shows the ability to classify odors in the presence of changing sensor response associated with evolving odor concentrations. This approach, and others being explored, facilitates classification independent of quantitation. The suitability of this approach using Artificial Neural Networks (ANN) for classification is also discussed.

Briglin, S. M., & Lewis, N. S. (2003). Characterization of the Temporal Response Profile of Carbon Black-Polymer Composite Detectors to Volatile Organic Vapors. J. Phys Chem. B (107), 11031-11042.
Lewis, N. S. (2004). Comparisons bewteen Mammalian and Artificial Olfaction Based on Arrays of Carbon Black-Polymer Composite Vpor Detectors. Acc. Chem. Res. (37), 663-672.

Poster Number: 2

Calibration Of Dielectric Based Moisture Sensing In Stones, Mortars And Stone-Mortar Sandwiches

Presented by: Junhui Zhao
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Advisor(s): D. Thomson

Co-Author(s): Douglas Thomson, Evangeline Murison

Research Area(s): Complex Natural Systems

Accumulation of moisture causes decay, corrosion and microbial growth of structural materials, leading to structural damage. The quantitative assessment of moisture content is required for monitoring and predicting its impact on structural health. The sensors and instruments for measuring moisture content need to be calibrated with regards to the materials applied for the structure. This work involves the moisture sensor construction and calibration for the masonry materials. The calibration equations are established for calculating the moisture content in masonry stones and mortar from the electrical signals acquired by the sensing electronics with a wireless data logger system.

Poster Number: 3

Quantifying The Surface Charge Of Functionalized Nanoparticles In Complex Media Using Electroacoustics: Working Towards Targeted Drug Delivery.

Presented by: Yaroslav Wroczynskyj
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Advisor(s): J van Lierop

Co-Author(s): John Page, Don Miller, Zhizhi Sun, Johan van Lierop

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

Fundamental to the successful use of magnetic nanoparticles for biomedical application is a thorough understanding of not only their magnetic and surface properties, but also the effects that complex media (e.g. biological tissue) have on these quantities. Limitations with current methods used to assess nanoparticle surface properties (e.g. light scattering requiring dilute suspensions in optically transparent media) have precluded a complete qualitative understanding in conditions suitable for application and at pharmacologically relevant concentrations. Using an AC electric field, pressure oscillations can be induced in colloidal nanoparticle suspensions that provide information about their size and surface charge. This technique allows for the concurrent determination of the surface properties of colloidal suspensions in conditions analogous to application, allowing for the first time a rigorous examination of the behaviour of nanoparticles suspended in complex media.

Here, I present results which demonstrate the feasibility of this method for the measurement of nanoparticle behaviour in complex media, particularly in assessing their zeta-potential. Differences in the pressure oscillations produced from various nanoparticle formulations will be highlighted, along with a preliminary mapping to relevant theory.

Poster Number: 4

Experimental Investigation Of Anderson Localization In A 3D 'Mesoglass'

Presented by: Laura Cobus
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Advisor(s): J.H. Page

Co-Author(s): Aubry Alex, Skipetrov Sergey, van Tiggelen Bart, Derode Arnaud, Page John H.

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

Wave localization is characterized by the absence of diffusion; waves (electromagnetic, acoustic, matter, etc.) in a disordered, strongly scattering material can be 'trapped' in space by interference effects. While localization occurs for any amount of disorder in one and two dimensional systems, a material with a very large amount of disorder is required to observe the phenomenon in three dimensions. Localization of classical waves has proven very difficult to observe due to the challenge of creating materials with enough disorder. We present an experimental study of the localization of ultrasonic waves in a sample of disordered sintered aluminum beads - a mesoscale analogue of an atomic glass. The response of the material to an input wave pulse was probed with both transmission and reflection measurements. We measure how localization cuts off the transport of energy from the source position, and compare our results with theory. In both transmission and reflection geometries, the transition between diffuse and localized regimes is observed, and some aspects of localized wave behaviour are measured. In addition, the wave phenomenon of 'recurrent scattering' was observed, which is related to the probability of a wave returning to its starting spot. The time dependence of the recurrent scattering intensity was found to change dramatically near the transition from diffusive to localized behaviour.

Poster Number: 5

FTIR Spectrochemical Imaging For Determination Of The Nutritional Content Of The Arctic Sea-Ice Diatom Fragilaria Cylindrus After Growth In Various Light Levels

Presented by: Alexandra Ciapala
Undergraduate Candidate at the University of Manitoba, Department of Chemistry

Advisor(s): K. M. Gough

Co-Author(s): Catherine Findlay, Aurelie Delaforge, CJ Mundy, Kathleen Gough

Research Area(s): Complex Natural Systems

Diatoms, an incredibly diverse type of algae best known for their intricately detailed silicate frustules, are among the major primary producers on Earth (estimated 20% of carbon fixation). Diatoms live in virtually all bodies of water including the Arctic and Antarctic seas where they live in sea-ice pores and the water column beneath. Vast blooms of Arctic sea-ice diatoms in spring constitute an important aquatic food source. Global climate change is raising Arctic temperatures; sea ice is melting faster and earlier, leading to an increase in light penetrating the water column. We are determining the impact of changing light exposure on the nutritional composition of Arctic sea-ice diatoms (Fragilaria cylindrus) using Fourier Transform Infrared (FTIR) spectroscopy, a fast, non-destructive, non-invasive technique ideally suited to probing the chemical composition of biological samples. Cultures were first acclimated to growth at normal light levels of 30 μmol photons m-2s-1, then switched to light levels of 0, 10, 30, 120, and 330 μmol photons m-2s-1. Samples from each light condition were collected over 2 weeks to monitor initial stress reaction and any subsequent adaptive response. The integrated FTIR absorbance intensities of the bands for fatty acid (CH2 stretch) and protein (amide 1 band) were chosen as biomarkers that reflect nutritional value. The (CH2):(Amide1) intensity ratio was used to ensure analysis was independent of the number of diatoms present. Preliminary results show an initial increase in (CH2):(Amide1) in the 330 μmol photons m-2s-1 condition relative to the control, followed by a steady decline.

Poster Number: 6

Nonlinear System Identification based on Extended Modal Space Formulation

Presented by: Sushil Doranga
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Advisor(s): C Wu

Co-Author(s): Christine Wu

Research Area(s): Composite Material Systems, Mechanics of Materials and Structures

Most of the nonlinear system identification techniques described in the existing literature required force and response information at all degrees of freedom (DOFs). For cases, where the excitation comes from base motion, those methods cannot be applied as it is impossible to obtained the measurements of motion at all DOFs from an experiment. The objective of this research is to develop the methodology for the nonlinear system identification of continuous, multi-mode and lightly damped systems, where the excitation comes from the moving base. For this purpose, the closed-form expression for the equivalent force also known as the pseudo force from the measured data for the base excited structure is developed. A hybrid model space is developed to find out the nonlinear restoring force at the nonlinear DOFs. Once the nonlinear restoring force is obtained the nonlinear parameters are extracted using 'multilinear least square regression' in a modal space. A modal space is chosen to express the direct and cross coupling nonlinearities. Using a cantilever beam as an example, the proposed methodology is demonstrated, where the experimental setup, testing procedure, data acquisition and data processing are presented. The example shows that the method proposed here is systematic and constructive for nonlinear parameter identification for based-excited structure.

Poster Number: 7

Synthesis And Characterization Of Conducting, Collagen-Based Biomaterials For Electrical Stimulation Of Cells

Presented by: Ramesh Kumar Mani
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Advisor(s): MS Freund

Co-Author(s):

Research Area(s): Composite Material SystemsComposite Material Systems

Bifunctional films with higher electrochemical and bioactive properties have many promising applications including tissue engineering, drug delivery, nerve regeneration and bone healing. Studies have revealed that electric stimulation (in the order of μV) has positive effects on the cell growth, and enhances the mineral formation in Osteoblast-like bone cells. However the mechanisms behind these effects are not well understood. Electric stimulation is generally performed through the implantation of metal electrodes, which need to be removed after the treatment. This sometimes requires surgery that can lead to complications including infection and damage of newly formed tissue. Therefore, in the search of new implant material that is bioactive (allow different cells to grow over it) and electrically conductive (to perform electrical stimulation), we aim to synthesize a hybrid composite material by integrating the electro-active properties of the conducting polymers (e.g., polypyrrole) with the biological properties of collagen (protein, which is majorly present in cornea) and collagen-calcium phosphate membranes (which mimics the composition of bone) in order to perform electrical stimulation in Corneal Fibroblast (for artificial cornea) and Osteoblast (for bone cement) cells. To synthesize the hybrid composite material, collagen membrane is aggregated electrochemically, followed by the electrochemical incorporation of Poly 3,4-ethylenedioxythiophene (PEDOT). FTIR studies revealed that increasing the weight percentage of PEDOT in the electrolyte increases the quantity of PEDOT that is incorporated onto the collagen membrane. Four-point probe and DSC thermograms reveal that the conductivity and denaturation temperature of the collagen-PEDOT membranes increase with the weight percentage of PEDOT in the electrolyte.

Poster Number: 8

Conducting Polymer-WO3 Bulk Heterojunction For Resistive Memory

Presented by: Patrick Giesbrecht
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Advisor(s): M S Freund

Co-Author(s): Michael Freund

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

Due to the physical limit observed in modern.day Si.based transistor memory systems, alternative approaches to memory storage are of great interest. One approach that has garnered much enthusiasm is resistive memory, where the high and low states (1,0) depend on the high and low conductive states of the system. This system offers the potential for a larger bit density, with a facile fabrication process. Previous work in the group has developed such a system using a reduced conducting polymer, poly(pyrrole) dodecylbenzylsulphonate (PPyLi+DBS-), and oxidized WO3 films, with this configuration defining the low state. The high state is achieved through Li+ motion into the WO3 film, oxidizing the polymer while simultaneously reducing WO3, increasing the conductivity of each film. Unfortunately, this memory system exhibits slow ion motion, setting a limit on its switching dynamics between high and low states. One possible solution is to increase the interfacial surface area between the films, forming a bulk heterojunction-like system, where faster switching dynamics due to a reduced ion diffusion length between the films is predicted. In this work, a junction has been developed, where a porous WO3 film was formed, allowing polymer deposition into these features. The structure of this composite was analyzed under SEM and TEM, showing the porous nature of the WO3 film, as well as the polymer incorporation into the film. The solution.based and solid.state electronic properties of the composite were also tested, with faster ion motion observed in the solid state.

Poster Number: 9

The Effect Of Freeze-Thaw And Wet-Dry Cycling On Early Age Cracking Of GFRP-RC Bridge Deck Slabs

Presented by: Amir Ghatefar
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Co-Author(s): Dr. El-Salakawy, Ehab and Dr. Bassuoni, Mohamed

Research Area(s): Composite Material Systems, Mechanics of Materials and Structures

If the volumetric change of concrete due to shrinkage and thermal stresses is restrained, tensile stresses will develop in concrete. If the induced tensile stresses are higher than the tensile strength capacity of the concrete, the concrete will crack. In the last decade the use of the non-corrodible fiber-reinforced polymer (FRP) bars in concrete bridges has significantly increased especially in Canada. Due to the corrosion resistance of FRP reinforcement, Canadian Highway Bridge Design Code (CHBDC) permits a crack width up to 0.5 mm in RC members for exterior exposures. However, compared to steel reinforcement, the low modulus of elasticity of FRP may result in larger crack widths and higher intensity of cracking in concrete members reinforced with FRP. This serviceability issue can be aggravated by harsh environmental conditions. Hence, the main objective of this research is to investigate the effect of cyclic environments on early-age cracking of GFRP-RC bridge deck slabs. In comparison to a control specimen tested in adiabatic laboratory conditions, two full-scale cast-in-place RC deck slabs measuring 2500 mm long × 765 mm wide × 180 mm thick were constructed and tested under freezing/thawing and wetting/drying conditions, respectively. All specimens were effectively anchored at their ends to two 1473×1000×1200 mm fixed concrete blocks. The test results are presented in terms of cracking pattern, width and spacing, strains in the GFRP bars, penetration rate of chloride ions in concrete, and internal micro-cracks of concrete. In-progress results indicate that the minimum reinforcement ratio (0.7%) recommended by CHBDC for bridge deck slabs reinforced with GFRP bars is conservative under laboratory conditions. Also, this ratio satisfied the serviceability requirements after being subjected to the simulated exposures of freezing-thawing and drying-wetting cycles.

Poster Number: 10

Nano-Modified Mortar: A New Approach For Cold Weather Masonry Construction

Presented by: Hooman Kazempour
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Advisor(s): M Bassuoni, F Hashemian

Co-Author(s): Mohamed Bassuoni, Fariborz Hashemian

Research Area(s): Composite Material Systems, Mechanics of Materials and Structures

In North America, cold weather masonry construction is a major concern for contractors as they either have to implement thorough heating practices for laying and curing masonry systems or postpone the construction to warmer seasons. This can lead to loss of productivity, delays in construction schedules, and inevitably extra cost. To minimize the adverse effects of cold weather on masonry construction, a new approach based on the use of nano-silica (NS) in the mixture design of mortar joints is proposed. This study presents an assessment on the incorporation of NS with dosages ranging from 2 to 6% by mass of the cementitious binder in Type S mortars mixed and cured at a low temperature (5°C). Flowability, air content and setting time of fresh mortar mixtures and compressive strength of mortar cubes at different (early and later) ages were determined. Backscattered scanning electron microscopy (BSEM), Isothermal calorimetry (IC), energy dispersive X-ray (EDX) and thermogravimetric analyses (TG) were also carried out on thin sections to capture the microstructural development of mortar. In addition, the nano-modified mortar was used as joints for masonry prisms built and cured at 5°C. The prisms were tested for compressive strength and modulus of elasticity. Results from the various tests show that NS can be successfully used to minimize the adverse effects of cold temperature on mortar joints by shortening the setting time and increasing the strength at early ages, which offers a promising approach for controlling the effects of cold weather on masonry construction.

Poster Number: 11

Biological & Composite Samples With High Mag. FTIR Spectroscopy: No Synchrotron

Presented by: Richard Wiens
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Advisor(s): K Gough, J Paliwal

Co-Author(s): Catherine Liao, Jason Morrison, Kathleen Gough and Jitendra Paliwal

Research Area(s): Composite Material Systems, Complex Natural Systems

The study of microscopically heterogeneous samples, whether biological tissues or manufactured material composites, requires both high spectral resolution and high spatial resolution. Towards this end, Fourier Transform Infrared (FTIR) spectrometers have been coupled to microscopes in a variety of instruments from bench-top thermal source to synchrotron source, across the globe. In biological tissues, the molecular composition varies across distances smaller than commercially available spectrometers, where each detector is ~5 microns on a side. To date the best spatial resolution was 0.55 microns per side, achieved at the now-decommissioned IRENI instrument, Synchrotron Radiation Center, University of Wisconsin-Madison. Our in-house capability has now been upgraded with the beta-release of high magnification optics from Agilent-Cary (one of three units in the world), enabling us to measure spectra at a grid with ~1.25 micron spacing. At this spatial resolution, sub-cellular tissue details can be resolved. We present the first bench top thermal source, spectrochemically-resolved images of Alzheimer disease plaque in human brain. With this spatial resolution, dense core plaque protein signatures are clearly resolved, along with other tissue features. Also presented are analyses of neuronal bodies from mouse brain tissues, wherein we spatially resolve cell nuclei (DNA). With the addition of an Attenuated Total Reflection accessory, that spatial resolution will improve to about 300 nm. Standard imaging of the Air Force Target and grid targets illustrate this spatial resolution that was previously available only at a single synchrotron.

Poster Number: 12

Development Of X-Ray Photoelectron Spectroscopy Techniques For Characterization Of Rod Functionalization Of Silicon Micro-Rod Arrays

Presented by: Kevin McEleney
Researcher at the Manitoba Institute for Materials (University of Manitoba), Department of Chemistry

Advisor(s): M.S. Freund

Co-Author(s): J.P. Bruce

Research Area(s): Crystalline Materials and Nanostructures

The properties of modern materials are strongly influenced by their underlying morphology. For instance, crystalline planar silicon for photovoltaics suffer from the need for high purity silicon to enable the minority-carrier diffusion length to approach the depth of optical absorption. High aspect ratio, patterned silicon rod arrays, where the minority carriers can travel radially over a much shorted distance, while the length of the rod provides the optical absorption depth, are a lower cost alternative to planar silicon[1]. Optimal electric properties of the silicon rods relies on a surface free of oxide which can be achieved by functionalizing the surface with organic groups[2]. Furthermore, grafting of electrocatalysts to the surface converts the rods into photocathodes for hydrogen generation from water and sunlight[3]. Morphology and surface functionalization of these rods are clearly important for the function of these devices. Additionally, understanding how the light harvesting and catalytic properties interact will allow us to create more efficient photosynthetic devices. X-ray photoelectron spectroscopy (XPS) is a highly surface sensitive technique making it ideal for studying the effects of surface functionalization on these rods. However, the high aspect ratio of the structure presents a challenge for characterization by XPS which will be addressed in this work.

[1]Boettcher, S.W. et al., Science, 2010, 327, 185.
[2]Yahyaie, I. et al., Energy Environ. Sci., 2012, 5, 9789.
[3]McKone, J.R. et al., Energy Environ. Sci., 2011, 4, 3573.

Poster Number: 13

Sol-Gel Synthesis And Structural Investigation Of The $YPrO_{3+Y}$ ($0 \leq Y \leq 0.5$) Series

Presented by: Kevin Szkop
Undergraduate Candidate at the University of Manitoba, Department of Chemistry

Advisor(s): M Bieringer

Co-Author(s): Joey Lussier and Mario Bieringer

Research Area(s): Crystalline Materials and Nanostructures

Fuel cells can convert diverse fuels directly into electrical energy and are attracting tremendous interest from many materials researchers working on alternative energies. Fuels range from hydrocarbons, through biofules to pure hydrogen. Solid oxide fuel cells (SOFCs) only use solids for cathodes, anodes and electrolytes and thus require almost no maintenance. In order to sustain the oxidation of the fuel solid state electrolytes have to be highly conducting for oxide anions. Typically an yttrium stabilized zirconia, YSZ, which requires high temperatures for O^{2-} anion mobility, is used. SOFCs are attractive for energy conversion since the fuel in case of hydrogen is the product of water-splitting reactions. As such, SOFC-solar cell coupling is a potential candidate for sustainable energy production. Oxide deficient materials with good ionic conductivities increase the mobility of the oxide anions and therefore increase reaction rates and efficiency of SOFCs at lower temperatures.
Single phase $YPrO_{3+y}$ samples were prepared by a citric acid sol-gel method. Controlling the redox chemistry of $YPrO_{3+y}$ allows fine-tuning the oxygen stoichiometry in the mixed-oxide structures. The oxidation and reduction of praseodymium (Pr^{3+} and Pr^{4+}) permits controlling the oxide and defect concentrations in the target material. Oxygen stoichiometries were analyzed by thermogravimetric analysis (TGA). Powder X-ray diffraction and powder neutron diffraction experiments provide insights into the structural details of the oxide defect structures as a function of oxygen content and processing conditions. The topotactic redox reactions for the $YPrOP_{3+y}$ ($0 \leq y \leq 0.5$) phases were studied by high temperature in-situ diffraction experiments.

Poster Number: 14

Influences Of Solute Segregation On Grain Boundary Motion

Presented by: Hao Sun
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Advisor(s): C Deng

Co-Author(s): Chuang Deng

Research Area(s): Crystalline Materials and Nanostructures

Nanocrystalline materials are polycrystalline solids with grain size in the nanometer range (< 100nm), which have been found to exhibit superior properties such as high magnetic permeability and corrosion resistance, as well as a considerably increase of strength when compared with their coarse grain counterparts. All those improved properties are attributed to the high volume fraction of grain boundaries (GBs). However, the high density of GBs brings a large amount of excess enthalpy to the whole system, making the nanostructures unstable and suffer from severe thermal or mechanical grain growth. In order to maintain the advantageous properties of nanocrystalline materials, it is necessary to stabilize GB and inhibit grain growth. Alloying is an effective way of achieving stabilized nanostructure, but the direct quantification of solute effects on GB motion still poses great challenge for investigating thermal stability of general nanocrystalline materials.

In this research, impurity segregation and solute drag effects on GB motion were investigated by extending the interface random-walk method in direct molecular dynamics simulations. It was found that the GB motion was controlled by the solute diffusion perpendicular to the boundary plane. Based on the simulation results at different temperatures and impurity concentrations, we found that the solute drag effects can be well modeled by the theory proposed by Cahn, Lücke and Stüwe (CLS model) more than fifty years ago. However, we propose that a correction to the original CLS model needs to be made in order to quantitatively predict the solute drag effects on a moving GB.

Poster Number: 15

Sub-Kelvin Magnetic Order In Sm3+-Containing Hyperkagomé Lattice: Sm3Ga5O12

Presented by: Arzoo Sharma
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Advisor(s): C Wiebe

Co-Author(s): Harlyn Silverstein, Chris Wiebe

Research Area(s): Crystalline Materials and Nanostructures

The garnets remain one of the most studied classes of materials due to their technological applications. Despite this, there are relatively few studies of the nature of their low-temperature magnetic ground states. This is especially surprising given the current surge in the literature in studies relating to hyperkagomé lattices. Sm3Ga5O12 was synthesized and grown into a single crystal using the floating zone technique. X-ray diffraction was used to map out the exchange pathways and make clear distinctions between different hyperkagomé sublattices. Magnetic susceptibility and low temperature heat capacity show that like other rare-earth containing garnets, Sm3Ga5O12 orders below 1 K.

Poster Number: 16

Design Of An Accelerated Ageing Test Facility For Cross-Linked Polyethylene (XLPE)-Based Electrical Insulators

Presented by: Mohammad Nadimi
PhD Candidate at the University of Manitoba, Department of Electrical and Computer Engineering

Advisor(s): D Oliver

Co-Author(s): Dr. Derek Oliver

Research Area(s): Crystalline Materials and Nanostructures

Polymers with intercalated nano-scale fillers (1-20 nm nanoparticles) have attracted great interest in the field of high voltage electrical insulation. Nelson et al. have reported that these materials provide significant improvements in breakdown strength, voltage endurance and water-treeing performance when compared to standard insulator materials [1-3]. While it is understood that insulation materials undergo changes as a consequence of their operating environment, in particular the long-term effect of applied electrical and thermal stress, less detail of the underlying mechanisms of ageing and lifetime characteristics of these materials is fully understood [4]. In order to develop better understanding of their performance, an accelerated ageing test facility has been designed. At the core of the test chamber, the sample is held between a pair of solid brass electrodes: one connected to the high voltage source and the other one to ground. To prevent surface flashover between the electrodes while the experiment is in progress, the sample and electrodes will be immersed in transformer oil. This will enable a constant electrical stress of up to 110 kV/mm to be applied to the sample. To control the temperature of the oil-filled chamber, a heating coil that can maintain at a preset levels between 25 °C and 120 °C will be used. This facility will enable studies of the time to breakdown (failure) as well as controlled ageing to be undertaken on test samples of XLPE-based insulators that contain nanoparticles as well as control samples without nanoparticles.

[1] J. K Nelson, "Dielectric polymer nanocomposites", Springer, 2010.
[2] R.C. Smith, C. Liang, M. Landry, J.K. Nelson, L.S. Schadler, ÒThe mechanisms leading to the useful electrical properties of polymer nanodielectricsÓ, IEEE Transactions on Dielectrics and Electrical Insulation, vo. 15, 2008, pp. 187- 196.
[3] L. Hui, R.C. Smith, J.K. Nelson and L.S. Schadler, ÒElectrochemical treeing in XLPE/silica nanocompositesÓ, IEEE Conference of Electrical insulation and dielectric phenomenon, 2009, pp. 511- 514.
[4] J. C. Fothergill "Ageing, space charge and nanodielectrics: ten things we don't know about dielectrics", IEEE International Conference on Solid Dielectrics, 2007 , pp. 1-10.

Poster Number: 17

Seebeck Rectification Enabled By Intrinsic Thermoelectrical Coupling In Magnetic Tunneling Junctions

Presented by: Zhaohui Zhang
PhD Candidate at the University of Manitoba, Department of Physics & Astronomy

Advisor(s): C Hu

Co-Author(s): Yongsheng Gui, Simon Hermour, Ke Wu, Desheng Xue, Can-ming Hu

Research Area(s): Crystalline Materials and Nanostructures

Increasing energy consumption is a big issue we have to face seriously. Thinking about the amount of heat generated by your laptop, it is not hard to understand the fact that more than 80% of energy is wasted as heat, hence harvesting this wasted heat energy is definitely a way to conserve both energy and money. The Seebeck effect, an effect which converts heat to electrical energy, give us possibilities to recycle the heat energy by converting it to other forms of working energy. In modern devices, high data storage is key to improving device performance, but electrical current heating consumes much of the energy used to store and retrieve this data. In those products, utilizing this heat energy will not only conserve battery life, but also improve device performance.

Poster Number: 18

Controlling Vacancy Driven Magnetism In Nonmagnetic Oxides : The Case Of Fe Doped CeO2 Nanoparticles.

Presented by: Vinod Kumar Paidi
MSc Candidate at the University of Manitoba, Department of Physics and Astronomy

Advisor(s): J van Lierop

Co-Author(s): Nilson Ferreira, Charles Roberts (Toyota)

Research Area(s): Crystalline Materials and Nanostructures

Vacancy modulated magnetism at the nanoscale provides charge and spin as controls pointing to new directions to improve the efficiency of magneto-electronic devices, and offers a unique window into catalytic processes through the resulting relationships between composition and induced magnetism. We use undoped and transition-metal-ion (iron) doped ceria nanoparticles to provide new insights into the structure/composition/magnetism relationships from the (initially) induced magnetism from finite size effects at the nanoscale. $Ce_{1-x}Fe_xO_2$ ($0 \le x \le 0.20$) nanoparticles were prepared with a co-precipitation technique using $Ce(NO_3)_3 \cdot 6H_2O$ and $FeCl_2 \cdot 4H_2O$ as precursors. X-ray diffraction, magnetometry and Mössbauer spectroscopy were used to characterize these nanoparticles. The crystallographic phases and effects of doping on the phases were observed in these nanocrystalline materials, and magnetic measurements identified paramagnetic behavior between 5 to 300 K, with the onset of an apparent coupling between the ceria's vacancy-driven magnetism and an enhanced magnetism from Fe-O-Ce clusters in the nanoparticles. The 10 K ^{57}Fe Mössbauer spectra presented hyperfine parameters (e.g. isomer shift, quadrupole moment and hyperfine field) that tracked with increasing cluster size induced by greater Fe doping, and at a critical concentration of $x>0.12$, a minor phase of iron-oxide began to form, altering the magnetism considerably.

Poster Number: 19

Mechanism Of Si Intercalation In Defective Graphene On SiC

Presented by: Thaneshwor Kaloni
Postdoctoral Candidate at the University of Manitoba, Department of Chemistry

Advisor(s): G Schreckenbach , M Freund

Co-Author(s): Udo Schwingenschlogl

Research Area(s): Crystalline Materials and Nanostructures

Previously reported experimental findings on Si-intercalated graphene on SiC(0001) seem to indicate the possibility of an intercalation process based on the migration of the intercalant through atomic defects in the graphene sheet. We employ density functional theory to show that such a process is in fact feasible and obtain insight into its details. By means of total energy and nudged elastic band calculations we are able to establish the mechanism on an atomic level and to determine the driving forces involved in the different steps of the intercalation process through atomic defects.

Poster Number: 20

Microwave Imaging Using A Solid State Microwave Sensor

Presented by: Lei Fu
PhD Candidate at the University of Manitoba, Department of Physics and Astronomy

Advisor(s): CM Hu

Co-Author(s): Y. S. Gui, D. Flores-Tapia, S. Pistorius and C. -M. Hu

Research Area(s): Crystalline Materials and Nanostructures

Motived by the rapid progress in microwave imaging in biomedical applications, we explore the feasibility of solid sensors in microwave imaging applications by adapting microwave radar technique, which is traditionally used to determine the position and speed of distance targets. In this work, we demonstrate that solid state microwave sensor has the capability to perform microwave imaging. The solid state sensor can be spintronic devices or semiconductor devices. To image the unknown target, the solid sensor is used to detect both the amplitude and phase of scattered microwave covered a wide band frequency. This broadband technique allows the determination of the time delay of the microwave scattered by the target. Combining microwave radar technique and wavefront reconstruction algorithm, the proposed sensor approach has demonstrated the feasibility to image the multiply scattered target in complex circumstances involved liquid.

Poster Number: 21

Developing Microwave Detector Based On A Magnetic Tunnel Junction

Presented by: Yongsheng Gui
Researcher at the University of Manitoba, Department of Physics and Astronomy

Advisor(s): CM Hu

Co-Author(s): L.H. Bai, M. Jaidann, H. Abou-Rachid, H. Guo, and C.-M. Hu

Research Area(s): Crystalline Materials and Nanostructures

Recent dynamics studies of magnetic tunnel junctions (MTJs) have revealed new principles for devices such as nano-oscillators and spin diodes and thus opened many possibilities to incorporate MTJ devices in microwave applications. The voltage responsivity of spintronic detectors has been improved about by four orders of magnitude to a level of 12,000 mV/mW, that can compete with the commercial semiconductor Schottky diode detectors. However, the external applied magnetic field required for such operation hinders its practical application. In this work, the microwave rectification in MTJs is estimated based on the nonlinear I-V curve in the absence of an external applied magnetic field. It has been found that the sensitivity of MTJ microwave detectors can be either enhanced or suppressed by applying a dc current because of the coupling between the dc current and the microwave induced resistance change. A sensitivity of about 350 mV/mW, about one order of magnitude greater than that at zero bias, is achieved under a dc current bias of about -10 uA in the absence of external applied magnetic field.

Poster Number: 22

Ba2CePtO6 Synthesis And Characterization

Presented by: Joey Lussier
MSc Candidate at the University of Manitoba, Department of Chemistry

Advisor(s): M Bieringer

Co-Author(s): Shahid Shafi, Mario Bieringer

Research Area(s): Crystalline Materials and Nanostructures

The perovskite structure (ABX3) provides exceptionally diverse applications for magnetic, ferroelectric, dielectric, multiferroic, thermoelectric, catalytic and ion conducting materials etc. The diversity of the perovskite systems is largely due to compositional tolerance which is enabled through a variety of cooperative distortion modes and superstructure formations capable of accommodating almost any cation, and the ability to mix ions in either A, B, or X. The Bieringer group has developed a particular expertise in the synthesis of these doped perovskite phases and determining order vs. disorder in the materials.

We are focusing on the BaCeO3 system which, when heated in the presence of platinum, incorporates Pt into the B-Site. Platinum is a particularly inert material, and is used in a variety of applications as such (i.e. heating elements, crucibles, etc). It is therefore important to understand the reactivity of platinum as a dopant. We will be reporting the formation of Ba2Ce(2-x)PtxO6 double perovskites and the challenges in its synthesis and characterization. This phase was first reported by Ouchetto et al. (Ouchetto, K., et al. J. Mater. Sci. Lett. 1991, 10, 1277-1279) and will be expanded upon here. The discussion will be supported by ambient temperature X-ray diffraction, TGA/DTA, XPS, and in-situ powder X-ray and powder neutron diffraction data.

Poster Number: 23

Dielectric Spectroscopy Of Polymeric Thin Films

Presented by: Mina Shenoudm
MSc Candidate at the University of Manitoba, Department of Electrical and Computer Engineering

Advisor(s): D Oliver

Co-Author(s):

Research Area(s): Crystalline Materials and Nanostructures

Dielectric Spectroscopy used to measure the dielectric properties of materials as a function of frequency. My goal is to develop a technique for estimating variations in the relative permittivity of polymeric thin films (100-200 nm thick) over the range of frequency range 40 Hz _ 100 MHz . Polymeric thin films are not free-standing. These require a supporting substrate, where the permittivity measurement is derived from the fringing fields in the thin film.

The measurement electrodes were designed with an interdigitated structure (IDC). An analytical model was used to predict the total capacitance and resistance of the IDC [1]. This was validated by finite element techniques (COMSOL).

A negative mask was used for the fabrication processes. Trenches of 120 nm in the SiO_2/Si wafer were created using plasma etching followed by deposition of a 20 nm layer of Cr as a diffusion barrier. Then, 100 nm of Cu layer was thermally evaporated to form the electrodes.

The electrical measurements used HP4294A impedance analyzer and a probe station. The IDC devices fabricated had electrode widths of 50 μm and a separation of 50 μm between the individual fingers. The interdigitated portion of the devices was 500 μm from the contact pads. IDC devices ranging from 20 to 100 fingers per device were investigated. The total capacitance for a 20-finger IDC was 8 pF. Close matching between FEM and measurements was observed. The polymer contribution was estimated to be ~2% of the fabricated IDCs' total capacitance.

[1]Giovanni et al, IEEE T-MTT, 47(12),1999,p.2287

Poster Number: 24

Self-Assembly And Manipulation Of Liquid Crystal Functionalized Gold Nanorods

Presented by: Xiang Feng
PhD Candidate at the University of Manitoba, Department of Chemistry

Advisor(s): TH Hegmann

Co-Author(s): Torsten Hegmann

Research Area(s): Crystalline Materials and Nanostructures

The significant interest in anisometric nanomaterials arises from their unique optical and electronic properties that can easily be tuned through small changes in size, structure and shape. However, the fabrication of orientational ordered arrays of anisotropic nanoparticles from the bottom up remains a challenging quest.

To address this problem, we fabricated hydrophobic gold nanorods coated with liquid crystals (LCs) organosilanes to trigger the self-assembly of these LCs functionalized gold nanorods (LC-GNRs). Fascinatingly, we found that these LC-GNRs can be manipulated by thermal annealing and with magnetic fields, with the LC-GNR orientation following the magnetic field lines. Moreover, we dispersed LC-GNRs in LCs host and utilized alignment technique to obtain planar alignment of LCs and the dispersed GNRs. The quality of the alignment of the inserted nanorods were characterized by polarized visible spectro- photometry. The insertion affection of the LC and GNRs composites were investigated by conductivity measurement (time of flight) and X-ray scattering as well.

Poster Number: 25

The Role Of ZnO Morphology On Gas Sensing Properties

Presented by: Onkar Singh Kang
Postdoctoral Candidate at the University of Manitoba, Department of Chemistry

Advisor(s): M Freund

Co-Author(s): R.C.Singh, Department of Physics, Guru Nanak Dev University, Amritsar, India

Research Area(s): Crystalline Materials and Nanostructures

The need for simple and inexpensive gas sensors to control the quality of environment and to improve the economics of industrial processes has given rise to a wide variety of solid state sensing devices. Over the past few years, a great deal of research efforts have been directed towards the development of miniature gas sensing devices for domestic applications, toxic gas detection and manufacturing process monitoring etc. In this paper, synthesis and gas sensing properties of zinc oxide nanostructures for liquefied petroleum gas (LPG) has been reported. Zinc oxide powder has been synthesized as nanoparticles and nanorods by following a chemical route. Synthesized zinc oxide powder was then characterized by using XRD and FESEM techniques. The investigations revealed that the reaction temperature played a great role in controlling the morphology of zinc oxide nanostructures. Morphologically different zinc oxide was deposited as thick film to act as gas sensors and their comparative response to liquefied petroleum gas was investigated at different temperatures and concentration. The investigations also revealed that LPG sensor fabricated using ZnO nanoparticles exhibited better sensing response than that from ZnO nanorods.

Poster Number: 26

Experimental And Theoretical NMR Analysis Of Paramagnetic M(acac)3 (M = Cr, Mn) Coordination Compounds

Presented by: Kirill Levin
MSc Candidate at the University of Manitoba, Department of Chemistry

Advisor(s): S. Kroeker

Co-Author(s): Kirill Levin and 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. The versatility of NMR spectroscopy stems from its sensitivity to variations in local structural environments. However, a recognized drawback of NMR is its limited applicability to paramagnetic systems such as organic radicals, metals, conductors and some organometallic complexes, where the presence of unpaired electrons introduces an additional layer of difficulty to spectral acquisition and interpretation. Recent advances in instrumentation have reopened the investigation of paramagnetic solids. We are studying a series of isostructural metal acetylacetonate complexes to better understand the experimental and analytical particularities of such systems. 13C magic-angle spinning NMR of M(acac)3 (M = Cr, Mn, Co, Al) reveals interesting spectral differences which are related to the electronic structure and bonding, thereby providing valuable clues about optimizing acquisition and inferring electronic distributions. For example, Cr(acac)3 and Mn(acac)3 produce dramatically different NMR spectra due to the presence of t2g3 and t2g3eg1 configurations, respectively. Density functional theory provides detailed electron distribution maps of the complexes which are used to assign crystallographic sites and delineate spin-transfer mechanisms. Molecular orbital theory renders the analysis more intuitive and facilitates extensions to other materials. The use of simple model coordination compounds is intended to provide the foundation for a more general approach to utilizing unpaired spin density as a new tool for structural analysis of paramagnetic materials.

Poster Number: 27

A Microstructural Study Of HAZ Cracking In Conventionally And Directionally Cast Poly Crystalline, And Single Crystal IN 738LC

Presented by: Jinal Sanghvi
MSc Candidate at the University of Manitoba, Department of Mechanical and Manufacturing Engineering

Advisor(s): M.C. Chaturvedi, O.A. Ojo

Co-Author(s):

Research Area(s): High Temperature Aerospace Materials

Precipitation hardened nickel-based superalloys are widely used in aero and industrial gas turbine engines due to their excellent high temperature strength and remarkable hot corrosion resistance. A drawback of IN 738 alloys is that they are very difficult to weld due to their high susceptibility to heat affected zone (HAZ) cracking, both during welding and post weld heat treatments (PWHT). HAZ cracking in IN738 is attributed to constitutional liquation of secondary solidification constituents (MC Carbides, M3B2 borides, M2SC sulpho-carbides, (γ-γ′) eutectics and also γ′ precipitates that are present at the grain boundaries. This is the main cause of grain boundary liquation and the resultant intergranular microfissuring in welds. In this work, a study of weld cracking in the autogenous laser welds of a conventionally and directionally solidified polycrystalline (PC and DS), directionally solidified single crystal (SC) IN 738LC during welding and post weld heat treatment (PWHT) was performed. The alloys were subjected to different heat treatments before welding. The results show that it is possible to minimize HAZ cracking by reducing the number of grain boundaries in the alloy through directional solidification casting coupled with the use of a suitable pre-weld heat treatment.

Poster Number: 28

Physically Metallurgical Modeling Cracking Mechanisms Of Laser-Processed Aerospace Superalloys

Presented by: Zhiguo Gao
Researcher

Advisor(s):

Co-Author(s):

Research Area(s): High Temperature Aerospace Materials

Physical metallurgy models are established to theorize the essential mechanisms of solidification-induced and liquation-induced cracking along the solid-liquid interface during laser processing aerospace superalloys. The influence of the key matrix compositions, crystallographic orientations, precipitate thermodynamical instability and grain boundary mobility on cracking behavior is discussed with regards to single crystal and polycrystalline superalloys, respectively. Results show that approximate processing configuration minimizes the effect of both the dimension of dendrite trunk spacing and the positions of boundaries of anisotropy dendritic selection on the interdendritic solidification cracking during processing single crystal nickel-based superalloys, while the two guidelines of using high-carbon and high-niobium additions in the matrix composition and utilizing less heat input both ameliorate effectively intergranular liquation cracking in the subsolidus portion of heat-affected zone (HAZ). The theoretical predictions of important features of cracking behavior agree reasonably well with the experimental results. Additionally, the developed models are also available to the general case of other alloy systems.

Poster Number: 29

Thermomechanical Fatigue Behavior Of Welded IN738 Nickel- Base Superalloy In A New Pre-Weld Heat Treatment Condition

Presented by: Johnson Aina
MSc Candidate at the University of Manitoba, Department of Mechanical & Manufacturing Engineering

Advisor(s): O.A. Ojo, M.C. Chaturvedi

Co-Author(s): Olanrewaju Ojo, Mahesh Chaturvedi

Research Area(s): High Temperature Aerospace Materials

A new pre-weld heat treatment was recently developed for IN738 nickel-based superalloy that has been reported to have about 70% reduction in weld cracking when compared to the common solution pre-weld heat treated material. In-phase thermomechanical fatigue (TMF) tests using temperature range of 4500C and 8500C of welded materials, in the new pre-weld heat treatment condition, and materials without weld in the solution treated and aged conditions were investigated. Contrary to the general observation, at lower strain ranges, TMF lives of welded samples treated with the new pre-weld heat treatment were higher than the samples without weld. Also, at higher strain ranges, TMF lives for samples in welded and without weld conditions were comparable. This remarkable performance by the welded samples could be due to the minimal effect of low cracking extent on the mechanical properties of welded materials. Further, metallographic and fractographic analyses showed that oxidation, carbides and gamma prime depletion contributed to the TMF failure of the alloy in the two investigated conditions. The results in the present work show that welding in the new pre-weld heat treatment condition does not degrade the TMF property of the alloy.

Poster Number: 30

Gamma Prime Intermetallic Growth Modeling In A Powder Metallurgy Nickel-Based Superalloy

Presented by: Gabriel Tellier
MSc Candidate at the University of Manitoba, Department of Mechanical Engineering

Advisor(s): N. Richards, W. Caley

Co-Author(s): Norman Richards, William Caley

Research Area(s): High Temperature Aerospace Materials, Crystalline Materials and Nanostructures, Mechanics of Materials and Structures

Gamma Prime (Ni_3Al) precipitates greatly influence the characteristics and behaviour of many nickel-based superalloys. Depending on the heat history of the alloy, the precipitates can vary substantially in size. To better predict the size of these precipitates, a growth model for variable-rate cooling was developed using the Lifshitz-Slyozof Encounter Modified (LSEM) theory of precipitate growth. To assess the model, the temperatures of several samples of a powder-metallurgy nickel-based superalloy were recorded at 10ms intervals while cooling. The samples were then imaged using an Atomic Force Microscope (AFM) to allow characterization of sub-100nm precipitates. The model was then iterated for each 10ms time interval to simulate the growth of Gamma Prime precipitates. The model was compared with the experimental precipitate size obtained from the AFM images; a linear trend line between the two data sets showed an R^2 value of 0.86.

Poster Number: 31

But Where Do We Look? Methods For Efficiency In FTIR Microscopy Research

Presented by: Emil-Peter Sosnowski
Undergraduate Candidate at the University of Manitoba, Department of Biosystems Engineering

Advisor(s): J Morrison

Co-Author(s): Japandeep Sethi, Jason Morrison, Richard Wiens, and Kathleen Gough

Research Area(s): High Performance Computing, Complex Natural Systems

The use of Fourier Transform Infrared (FTIR) microscopes allows chemical (i.e., spectral) analysis at a grid of microscopic locations. This chemically sensitive equipment has been at coarse spatial resolutions for bench instruments (~5.5 microns per detector side) with high magnification only at specific synchrotron locations (~0.54 microns). Analysis of a sample has been done in two stages first at the normal level on the bench and later at a high magnification at the synchrotron. With development of a handful of prototypes, Agilent is bringing higher magnification to the bench instruments. While the high magnification of this prototype allows for the collection of twenty-five times more data per square millimeter from each sample (~1.25 microns), more care must be allocated in data acquisition and analysis to ensure efficient use of the equipment and personnel. If a researcher decided to collect high magnification data of an entire sample then a typical 5-hour process becomes more than five days. This research focuses on developing a methodology and supporting tools to quickly identify which of the regions require high magnification. We present an effective method to isolate regions of interest by segmenting the visual image and the spectra separately and identifying variation within identifiable regions of the sample. Thus the sample may be analyzed at a lower resolution, processed to identify the locations of regions of interest. These regions can then be analyzed at high magnification, providing data at select points in the sample. The combination of these techniques limits wasted time collecting data in regions that lack important chemical signatures, ultimately speeding the process of data collection, processing and analysis.

Poster Number: 32

Finding Infected Grain Kernels: Methodology For Correlated Visual & NIR Spectroscopy

Presented by: Shawn Wiebe
MSc Candidate at the University of Manitoba, Department of Biosystems Engineering

Advisor(s): J Morrison, J Paliwal

Co-Author(s): Jason Morrison, Jennifer Brown, and Jitendra Paliwal

Research Area(s): High Temperature Aerospace Materials, Complex Natural Systems

Fusarium Head Blight is a fungal infection that affects cereal crops and leads to entire lots of grain having low value if not toxic content. The identification of infected kernels is a key process in the assurance that Canada's multi-billion dollar grain industry continues to have the highest quality product. Classification of samples in real world conditions using Near Infrared (NIR) imaging has shown some promise but is not yet accurate enough for field use. Current classification methodologies to identify grain quality require qualitative visual assessment of samples, or a more labour and time intensive approach of gravity table sorting, or even longer chemical testing and fungal cultures. The presented research focuses on providing a data analysis methodology that enables a researcher to locate NIR spectra from visually identified infected wheat kernels. The developed methodology requires registration (i.e., alignment) of a visual image of a grain pile with the NIR image. The method is then a semi-automated process using segmentation of both visual regions and NIR spectra to identify regions that are both visually and spectrally similar. A researcher can then use the interactive tool to classify regional sets of spectra as, visually infected and visually sound. The developed tools and methodology allows the researcher to work with tens of thousands of spectra and translating data into knowledge that will be used in better grain classification.

Poster Number: 33

Computational Investigation Into GFRP Reinforced Glue-Laminated Spruce Pine Curved Beams

Presented by: Hanan Alhayek
Researcher at Prince Sultan University, Department of Architecture

Advisor(s):

Co-Author(s): Sami Alshurafa

Research Area(s): Mechanics of Materials and Structures

This paper presented results obtained from the computational investigations into fiber-reinforced plastic (FRP) reinforced glue-laminated curved spruce pine beam. The main goal of the paper was to study the structural response of curved beam as a result of changing the thickness, location and the applied length of the FRP reinforcement for increasing the strength capacity and the stiffness of the beam. The Tesi-wu and the maximum stress theories criteria were used for modelling the failure of wood, the FRP and the interface between FRP and the spruce pine wood. ANSYS finite element modelling was carried out to investigate the influence of several parameters affecting the strength and the stiffness of the curved beam. It was affirmed that the FRP can be used as valid solution for strengthening and stiffening curved beams.

Poster Number: 34

Study Of The Effect Of Casting And Hot Deformation Parameters On The Formation Of Delta Ferrite In 304L Stainless Steels

Presented by: Soheyl Soleymani
Researcher at the University of Manitoba, Department of Mechanical and Manufacturing Engineering

Advisor(s): O.A. Ojo, N. Richards

Co-Author(s): O.A. Ojo, N. Richards

Research Area(s): Mechanics of Materials and Structures, Crystalline Materials and Nanostructures

Three different 304L austenitic stainless steels with chromium equivalent to nickel equivalent (Cr_{eq}/Ni_{eq}) ratios of 1.57, 1.62, and 1.81 were chosen for this study. The influence of chemical composition on liquid state as well as solid-state formation of delta ferrite phase during casting and hot deformation was investigated. Solidification tests under controlled cooling were conducted at 0.3 to 25°C/sec cooling rates. Compression tests were also performed at temperature, strain and strain-rate ranges of 1200 to 1300°C, 10 to 70% and 0.1 to $10s^{-1}$ respectively. It was found that increasing the colling rate enhanced the delta ferrite formation. Increasing the temperature, strain and strain rate of hot deformation also led to increased formation of delta ferrite. The results showed that the formation of delta ferrite during casting and hot deformation is also strongly dependent on chemical composition. The higher the Cr_{eq}/Ni_{eq} ratio, the higher the tendency for the formation of delta ferrite in both production processes.

Poster Number: 35

Corrosion And Fretting Corrosion Studies Of Medical Grade CoCrMo In A More Clinically Relevant Novel Simulated Body Fluid Environment

Presented by: Emmanuel Ocran
MSc Candidate at the University of Manitoba, Department of Mechanical and Manufacturing Engineering

Advisor(s): O. A. Ojo, U Wyss

Co-Author(s): Urs P. Wyss, Olanrewaju A. Ojo

Research Area(s): Mechanics of Materials and Structures, Surfaces and Interfaces

In artificial joint replacements, the good success enjoyed by CoCrMo implants is due to its low wear rate and spontaneous formation of a protective passive film. However, in modular implants, particularly those with heads larger than 32mm, fretting corrosion (micro-motion) at the modular head/neck and neck/stem interface leads to the frequent depassivation and repassivation of the protective passive film, causing increase in metallic ion release and adverse tissue reactions. Since passivation is a surface mechanism, the type of fluid used to simulate the fretting corrosion of biomedical materials is crucial for the reliability of laboratory tests. Therefore, to properly understand and effectively design against fretting corrosion damage in modular hips, there is the need to replicate the human body environment as closely as possible during in-vitro testing and validation. In this work, corrosion behavior of CoCrMo in a clinically relevant novel simulated body fluid (sbf) is compared with pre-existing fluids (0.14 M NaCl and phosphate buffered saline (PBS)). Also, fretting corrosion studies of CoCrMo alloy in the clinically relevant novel sbf environment is studied. The presence of phosphate ions in PBS accounted for the significantly higher corrosion rate when compared with 0.14 M NaCl and sbf environment. Despite the low and comparable corrosion rates in 0.14 M NaCl and sbf, the nature of the protective passive film formed in sbf shows the suitability of the novel sbf for future corrosion and fretting corrosion analysis. Finally, the influence of micro-motion on the concentration of metallic ions released into the synovial fluid and surrounding tissues will also be presented.

Poster Number: 36

Prediction Of Orbital Debris Impact Damage In Composite Overwrapped Pressure Vessels

Presented by: Aleksandr Cherniaev
PhD Candidate at the University of Manitoba, Department of Mechanical Engineering

Advisor(s): I. Telichev

Co-Author(s):

Research Area(s): Mechanics of Materials and Structures, Composite Material Systems

This work presents results of numerical simulations aiming to develop a methodology for modeling of orbital debris impact damage in composite overwrapped pressure vessels (COPVs). The simulations investigate effects of filament winding patterns on composite damage under orbital debris impact, and justify necessity of detailed meso-scale representation of composite laminate. Approach for accurate predictions of hypervelocity impact damage in composites is presented and verified against experimental data available in the open literature for standard laminated fiber-reinforced plastics. Future work is advanced to conduct a series of physical experiments on filament-wound composites and to develop approach to modeling of gas-vessel and gas-debris cloud interactions.

Poster Number: 37

Analysis Of Microstructural Changes In Fiber Laser Welded DP980 And HSLA Steels

Presented by: Jianqi Zhang
MSc Candidate at the University of Manitoba, Department of Mechanical Engineering

Advisor(s): J. Q. Zhang, A. K. Khan, O. Ojo

Co-Author(s): Jianqi Zhang, Abdul K. Khan, Olanrewaju Ojo

Research Area(s): Mechanics of Materials and Structures

Dual phase (DP) steels, which are designed to obtain soft ferrite and hard martensite, have gained increasing popularity in structural applications. Fiber laser welding (FLW) is becoming increasingly widely used method for welding. However, the rapid thermal cycle involved in FLW generates significant microstructural changes in the heat affected zones (HAZs) and Fusion Zone (FZ). The large microstructural gradient in the HAZ and the ultra-fine structure in the FZ make it very difficult to properly elucidate microstructural changes involved during welding. Evaluation of the microstructural changes is, nonetheless, vital in order to understand and predict how FLW affects the mechanical properties of welded materials. In this research, the microstructural changes that occur in narrow HAZ and FZ are systematically studied by using a Gleeble thermo-mechanical simulation system and transmission electron microscopy (TEM). It is found that significant microstructural changes occurred in the FZ and HAZ, which could result in dramatic changes in the mechanical properties of welded materials. An indication of this is the observation that the microhardness values in the FZ and adjacent HAZ are notably disparate from that in the base metal (BM).

Poster Number: 38

An Accelerated Test For Physical Salt Attack On Concrete

Presented by: Md. Mahbubur Rahman
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Advisor(s): M. Bassuoni

Co-Author(s): M. M. Rahman, M. T. Bassuoni

Research Area(s): Mechanics of Materials and Structures

Physical salt attack (PSA) on concrete is distress caused by the crystallization of salts in pores near drying faces or evaporative zones, which leads to progressive scaling and flaking of concrete surface. While many concrete structures/elements are vulnerable to PSA during service, there is currently no standard test method in North America for PSA of cement-based materials. Therefore, this study aimed at developing an accelerated laboratory test to assess the resistance of concrete to PSA. Based on the phase diagram of sodium sulfate, an exposure was designed to stimulate PSA by cyclic temperature (20 to 35°C) and relative humidity (90 to 40%). The bottom portions of concrete specimens were partially immersed in 10% sodium sulfate solution, while the drying portions of specimens were exposed to cyclic environments. The concrete mixture design variables were w/cm ratio (0.4 and 0.5), type of binder (GU cement or GU cement blended with fly ash) and incorporation of ultra-fine particles (3 and 6% nano-alumina by mass of binder). The assessment criteria were based on physico-mechanical properties (visual appearance, mass loss and change of dynamic modulus of elasticity and strength). In addition, alteration of microstructure was examined by microscopy and mineralogical analysis. The results show that the proposed procedures can successfully assess the performance of concrete under PSA and capture performance risks related to mixture design parameters within a relatively short time interval. Hence, it can be used in the prequalification stage to facilitate decision making on optimum concrete mixtures proposed for exposures conductive to PSA.

Poster Number: 39

Electrical Detection Of Direct And Alternating Spin Current Injected From A Ferromagnetic Insulator Into A Ferromagnetic Metal

Presented by: Lihui Bai
Researcher at the University of Manitoba, Department of Physics

Advisor(s): CM Hu

Co-Author(s): P. Hyde, D.M.J. Kumar, B.W. Southern, S. Y. Huang, B. F. Miao, C. L. Chien and C.-M. Hu

Research Area(s): Mechanics of Materials and Structures

Charge current carries information in your computes and smart phones, which generates a huge amount of Joule heating and inceases energy consumption. Both Joule heating and energy consumption are important factors in electric devices. Electron spin is used as information carrier too, for example, in hard disk, Magnetoresistive random-access memory (MRAM), etc. Spin can be transferred into ferromagnetic material to rewrite the magnetizations on basis of quantum exchange interaction, thus drastically reducing energy consumption by suppressing Joule heating.

Spin current has been studied beginning with spin polarized charge current driven by a dc voltage through a ferromagnetic metal such as Permalloy (Py). A pure spin current was discovered flowing inside of ferromagnetic insulator yttrium iron garnet (YIG) which completely blocked the charge current. Very recently, an ac spin current was proposed theoretically. In this work, both dc and ac spin current pumping by magnetization precession in ferromagnetic insulator is presented. Our results demonstrate that Py enables electrical detection of both dc and ac spin current in the spin pumping from YIG, which reveals a new path for developing insulator spintronics.

Poster Number: 40

An Analysis Of The Piezoresistive Response Of Doped, Functionalized Silicon Microwires Under Applied Strain

Presented by: Megan McClarty
MSc Candidate at the University of Manitoba, Department of Electrical and Computer Engineering

Advisor(s): D. Oliver, M. Freund

Co-Author(s): Jared Bruce, Iman Yahyaie, Sommayeh Asgari, Derek Oliver, Michael Freund

Research Area(s): Mechanics of Materials and Structures, Crystalline Materials and Nanostructures

As the world's population grows and worldwide energy demands increase, the development of sustainable energy production becomes an ever more active area of research. A solar water-splitting cell which produces hydrogen from sunlight and water has been proposed as a potential response to the growing movement away from fossil fuel-derived energy [1, 2]. The device design incorporates arrays of doped silicon microwires which absorb incident sunlight to drive a chemical water-splitting reaction. Reducing the resistivity of the microwire arrays may help to reduce the overall system resistance and improve the device's efficiency, and therefore its commercial feasibility. When stressed, silicon has been shown to exhibit a piezoresistive response dependent on its doping type and concentration, as well as its crystalline orientation [3, 4]. This work investigates the current response of a selection of n-type silicon microwires as they undergo applied strain. Electrical testing is performed using conductive tungsten probes to make direct ohmic contact to individual silicon microwires. These microwires are bent under pressure from the same tungsten probes, and the corresponding change in current response is noted. Results show a decrease in n-type silicon microwire resistivity as applied strain is increased. Further work will seek to investigate incorporation of strained silicon into the design of the water-splitting cell.

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[2] M. Walter, E. L. Warren et al, Chem. Rev., vol. 110, 2010.
[3] C. S. Smith, Phys. Rev. Lett., vol. 94, pp. 42 _ 29, 1954.
[4] P. Alpuim, J. Gaspar et al, J. App. Phys., vol. 109, p. 123717, 2011.

Poster Number: 41

Quantitative Cell Migration Analysis Of Lymphocytes Using A Microfluidic Device

Presented by: Xun Wu
MSc Candidate at the University of Manitoba, Department of Immunology

Advisor(s): FL Lin, AJM Marshall,

Co-Author(s): Xun Wu, Hongzhao Li, Jiandong Wu, Daniel F. Legler, Aaron J. Marshall, Francis Lin

Research Area(s): MicroElectricalMechanical Systems (MEMS)/Microfluidic Systems

Lymphocytes migration is crucial for adaptive immunity. Manipulation of signaling molecules for cell migration combined with in-vitro cell migration analysis provides a powerful research approach. Compared to conventional migration assays, such as Transwell assay, microfluidic devices can precisely configure chemoattractant fields and allow quantitative single cell analysis. Here we apply microfluidic device technology in two different studies of lymphocyte migration mechanisms. First we developed a microfluidics-based method to study the migration of Jurkat cells mediated by transfected chemokine receptor CCR7. CCR7 and its ligands play critical role in T cell trafficking within Secondary Lymphoid Tissue (SLT). Here we generated transiently CCR7 transfected Jurkat cells to investigate the distribution of CCR7 as well as function of cytoplasmic tail of CCR7 in chemotaxis.To our best knowledge, this is the first successful demonstration of functional migration and chemotaxis of T cell lines expressing transiently transfected chemokine receptors using microfluidic devices. We also have applied this methods to study the role of membrane D3 phosphoinositides and their binding proteins in B cell migration. Here we focus on the function of a phosphoinositide lipid PI(3,4)P2 and its binding protein Lamellipodin(Lpd) in B cell migration and chemotaxis. We envision this established method would provide a useful platform to functionally test various signaling mechanisms at the cell migration level in simple or complex cellular guiding microenvironments.

Poster Number: 42

A Microfluidic Method For Selecting Chemotactic Stem Cells

Presented by: Kanmani Natarajan
MSc Candidate at the University of Manitoba, Department of Physics and Astronomy

Advisor(s): F Lin

Co-Author(s): Chantal Tian, Rundi Zhang, Bo Xiang, Jixian Deng, Ganghong Tian, Francis Lin

Research Area(s): MicroElectricalMechanical Systems (MEMS)/Microfluidic Systems

Stem cells hold great promise for treating various degenerative diseases. However, the outcomes of preclinical and clinical cell therapy studies are still not close to our expectation due to: 1) insufficient homing of implanted stem cells into target organs; 2) use of heterogeneous cell populations for cell therapy. Therefore, there is a need to develop effective guiding technique for stem cells to migrate to the target organs and to isolate effective stem cell populations. Toward this direction, we have previously demonstrated chemotaxis of rat adipose-derived stem cells (ASC) to a well-defined gradient of epidermal growth factor (EGF) using a microfluidic device. In the current study, we further developed a microfluidics-based method for selecting chemotactic ASC to EGF. This method consists of three steps including cell patterning, chemotaxis and cell extraction. All the three steps are conducted sequentially on a single microfluidic chip. ASC were first patterned on one side of the microfluidic channel by applying a controlled stream of dissociation solution. Then, the patterned ASC were exposed to an EGF gradient to induce chemotaxis. By the end of the chemotaxis, the ASC migrated to the region with a high level of EGF (i.e. high chemotactic cells) were then extracted from the device by applying a controlled stream of dissociation solution. The remaining cells (i.e. low chemotactic cells) were extracted afterward. Afterwards, we monitored chemotactic movement of the two extracted sub-populations of ASC and confirmed that the high chemotactic cells migrated more effectively toward the EGF gradient than the low chemotactic cells. In summary, we have developed a microfluidics-based method for isolating a sub-population of high chemotactic stem cells. This developed method can be broadly applied to select different chemotactic stem cells in response to different chemotactic factors with the potential to improve stem cell delivery for transplantation therapies.

Poster Number: 43

Monitoring Apoptosis In Chinese Hamster Ovary Cells Using A Dielectrophoretic (DEP) Micro-Fluidic Cytometer

Presented by: Bahareh Saboktakin Rizi
MSc Candidate at the University of Manitoba, Department of Electrical and Computer Engineering

Advisor(s): D. Thomson

Co-Author(s): Katrin Braasch, Elham Salimi, Kaveh Mohammad, Ashlesha Bhide, Samaneh Afshar Delkhah, Teslin Sandstorm, Micheal Butler, Gregory Bridges and Douglas Thomson

Research Area(s): MicroElectricalMechanical Systems (MEMS)/Microfluidic Systems

Apoptosis or programmed cell death is a process in which a cell undergoes complicated biochemical events leading to cell death. Changes in ion concentrations are thought to trigger apoptosis. In the apoptotic cell, an influx of Na ions and efflux of K ions has been observed. The changes in ion concentrations can be inferred as changes in cytoplasm conductivity and dielectric response of the cell at a particular frequency. Monitoring the onset of apoptosis has a significant role in controlling growth rate of a culture and physiological state of a population. Employing a reliable, marker-free and fast cytometer to track physiological status of a population has a substantial benefit in pharmaceutical productions and cancer research.

In this work, a dielectrophoretic (DEP) cytometer was employed to track cytoplasm conductivity and apoptosis. The detection is based on differential pairs of coplanar electrodes. For each cell two peaks are detected as the signal amplitudes before and after DEP actuation at 6MHz. The normalized difference between the peaks (force index) is related to the magnitude of the DEP force and therefore the Clausius Mossotti factor (KCM). Changes in dielectric properties of cells at a particular frequency can be quantified by force index.

At 6 MHz, the dielectric response of the cell is dominated by cytoplasm conductivity. Consequently, force index modulations quantifies changes in cytoplasm conductivity and monitors apoptosis of a population.

Poster Number: 44

The Cu/Cr/Cu Multilayered Horseshoe Shape MEMS Actuator With Low Current And Large Deformable Mirror 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): Cyrus Shafai, T. Chen, M. Li & Y. Zhou

Research Area(s): MicroElectricalMechanical Systems (MEMS)/Microfluidic Systems

Micro-electro-mechanical (MEMS) actuators are required in many applications that displace out-of-plane from the substrate such as adaptive optics and steering mirrors. Four main transducing mechanisms, electrostatic, piezoelectric, thermal and magnetic, have been proposed and developed to produce a motion from electrical signal in microsystems. Within the enormous variety of actuators, electromagnetic actuators have the advantage of requiring low voltage drive with high stroke and frequency (over 1 kHz).

The actuator consists of two Cu/Cr/Cu multi-layered thin film cantilevers on the each end of a 7 um thick copper cross-bar. This multi-layered structure provides an initial deflection of the actuator by utilizing stress which gives enough space to pull down a deformable mirror (DM). Calculation results shows 90 um initial deflection with 200 um length cantilever with 0.02 ~ 0.2 N/m spring constant (K). To determine the spring constant of the overall system, square shape c-Si and SU-8 membranes were studied, with resulting spring constants of around 10 N/m for each 1 um (thickness) c-Si membrane and 5 um (thickness) SU-8 membrane with 2,500 um (width). By combining both spring constants of each cantilever, the total required force to get ±5 um deformation of the membrane is around 2.3×10^{-5} N and 5.6×10^{-5} N for c-Si and SU-8 membrane, respectively. This force will be coupled to the membrane through a small bonding area on the long cross-bar which presses against the membrane. Therefore, the cross-bar will be reinforced with thick copper by electroplating technique to prevent its bending.

Poster Number: 45

Assessing Neutrophil Chemotaxis In COPD Using A Compact Microfluidic System

Presented by: Jiandong Wu
PhD Candidate at the University of Manitoba, Department of Biosystems Engineering

Advisor(s): F. Lin, D. Levin

Co-Author(s): Jiandong Wu, Lipang Ouyang, Michael Zhang, Simon Liao, Craig Hillier, Paul Komenda, Ricardo Lobato de Faria, David Levin and Francis Lin

Research Area(s): MicroElectricalMechanical Systems (MEMS)/Microfluidic Systems

Chronic Obstructive Pulmonary Disease (COPD) is a common lung disease resulting from narrowed airway that causes breath difficulty. It ranked as the fifth leading cause of death worldwide in 2002 and will climb to the third in 2030 predicted by WHO. Spirometry is the current standard method for COPD diagnosis but requires patient cooperation. Previous studies showed that COPD is correlated to neutrophil infiltration to the airway through chemotactic migration. However, whether and how well neutrophil chemotaxis can characterize COPD is not well understood. Microfluidic devices provide a powerful quantitative test bed for cell migration studies owing to its unique ability for controlling cellular microenvironments and miniaturization. However, existing microfluidic cell migration systems heavily rely on specialized research facilities and personnel. In the present study, we in the first time applied a recently developed USB microscope-based Microfluidic Chemotaxis Analysis System (UMCAS) to assessing neutrophil chemotaxis in COPD. UMCAS is a low-cost and compact system that integrates microfluidic device, imaging module, environmental control, real-time data acquisition and analysis, which allows on-site clinical chemotaxis testing. We tested neutrophil chemotaxis to the sputum samples from COPD patients or healthy control subjects using the UMCAS. Our results demonstrated strong neutrophil chemotaxis to sputum samples with interesting different characteristics in cellsÕ migratory responses to COPD and control sputum samples. These current results suggest the potential of neutrophil chemotaxis as a clinical biomarker at the cellular function level for COPD and demonstrate the practical use of UMCAS for clinically-oriented research.

Poster Number: 46

Dielectrophoresis Study Of Electroporation Induced Changes In The Dielectric Response Of Biological Cells

Presented by: Elham Salimi
PhD Candidate at the University of Manitoba, Department of Electrical & Computer Engineering

Advisor(s): G Bridges

Co-Author(s): Katrin Braasch, Michael Butler, Douglas Thomson, Greg Bridges

Research Area(s): MicroElectricalMechanical Systems (MEMS)/Microfluidic Systems

Electroporation affects the dielectric properties of cells by creating pores in their membrane which allows transport of ions and other complex molecules. Dielectric characterization techniques are powerful tools to study electroporation induced changes with the advantage of being label free and non-invasive. In this study we use a dielectrophoresis (DEP) cytometry technique to study the dielectric properties of single biological cells before and immediately after electroporation. We fabricated a microfluidic device with integrated sensing and actuating electrodes and performed experiments on single Chinese hamster ovary (CHO) cells. Our experiments demonstrated significant changes in the DEP response of cells after exposure to microsecond duration pulses and a correlation between the intensity of applied pulses and the extent of changes in the cell dielectric properties. This is significant as it allows us to infer changes in the ionic concentration of cells due to electroporation.

Poster Number: 47

Micromachined Electric Field Mill Employing A Vertical Moving Shutter

Presented by: Tao Chen
PhD Candidate at the University of Manitoba, Department of Electrical and Computer Engineering

Advisor(s): C Shafai, A Rajapakse

Co-Author(s): Byoungyoul Park

Research Area(s): MicroElectricalMechanical Systems (MEMS)/Microfluidic Systems

This paper presents a new type of micromachined electric field mill (MEFM) for measuring dc electric fields. This MEFM employs vertical movement of an electrically grounded shutter to mill the amplitude of the electric field incident on underlying sense electrodes. Vertical shutter movement addresses a principle drawback of existing MEFMs employing lateral moving shutters, which is loss of measurement sensitivity when their shutter is displaced in the presence of large electric fields.

Of importance are the dimensions of the comb fingers, in comparison to the underlying sense electrodes. Simulation results shows that narrower finger spacing results in superior electrode shielding. We also explored ΔQ as a function of shutter finger length, showing that beyond electrodes length minimal improvement occurs. Thermal cooling transient simulation finds the time constant of the thermal actuator to be ~ 130.s (7kHz). When the sensor operates at 7kHz in a 1kV/m dc electric field, the output is ~1pA. This is similar in performance to other MEFM devices.

Poster Number: 48

Lorentz Force Actuated Micromirror For A MEMS Spectrometer

Presented by: Meiting Li
MSc Candidate at the University of Manitoba, Department of Electrical and Computer Engineering

Advisor(s): C. Shafai

Co-Author(s): P. Glowacki

Research Area(s): MicroElectricalMechanical Systems (MEMS)/Microfluidic Systems

Micromirrors have been widely used in many applications, such as optical communications, spatial light modulators, and spectrometers. We present the design of two Lorentz force actuated micromirrors for spectrometer. Reflective blazed gratings are etched on the rotating mirror to separate different wavelength. The other design, a pop-up mirror, acts as an optical switch. Both mirrors are driven by electromagnetic force, which is useful for high accuracy control. COMSOL results show that the micromirror achieves a tilting angle of 45° at 35mA current and a dynamic response less than 5ms. These unique micromirrors enable accurate angle control, low temperature and fast response for spectrometer application.

Poster Number: 49

Creating An Acoustic Double-Negative Metamaterial With Bubbly Drops

Presented by: Reine-Marie Guillermic
Postdoctoral Candidate at the University of Manitoba, Department of Physics and Astronomy

Advisor(s): J.H. Page

Co-Author(s): Reine-Marie Guillermic, Fabrice Lemoult, Valentin Leroy and John H. Page

Research Area(s): Photonic and Phononic Interactions, Soft and Disordered Materials

A metamaterial is an artificial material with subwavelength internal structures, which can affect deeply the propagation of waves, creating unusual behaviours. The interest in such unconventional materials has been steadily increasing since the pioneering work of Veselago and Pendry in electromagnetism. Finding acoustic analogs to electromagnetic metamaterials is also a very vibrant subject. Ten years ago, Jensen Li and C.T. Chan predicted theoretically the existence of an acoustic double negative metamaterial, exhibiting both effective negative bulk modulus and negative density, but the experimental observation of such a system has still not been made. Double-negativity means that the material displays an anomalous response at some frequencies, such that it expands upon compression (negative bulk modulus) and when pushed moves in the opposite direction (negative density) at the same time. The double-negativity induces an acoustic negative refractive index, i.e., a wavevector opposite to the propagation direction, and a high transmission.

We show in this work that it is possible to create such a metamaterial using different constituents to those proposed by Li and Chan, namely drops of bubbly liquid in a liquid or soft solid matrix. In addition to their particular properties corresponding exactly to the conditions needed (inclusions with low sound velocity, wavelength close to their size…), bubbly drops are also easy to produce, which made this system a good candidate. Here, we first present the theoretical predictions using an effective medium model. Then, some simulation results (Finite Element Method with COMSOL) for acoustic propagation through layers of bubbly drops are shown. The model explains very well the simulation results, and those tools allow us now to predict real experimental observations, which are currently in progress.

Poster Number: 50

Application Of Optical Imaging To Detect Aging Of Kraft-Paper In Power Transformers

Presented by: Hamid Hassanzadeh
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Advisor(s): Dr. Kordi, Dr. Sherif

Co-Author(s): Nathan Jacob

Research Area(s): Photonic and Phononic Interactions

Lifetime of a power transformer is basically determined by durability of its insulating material. Kraft paper impregnated with mineral oil is traditionally the main insulating material among windings of a power transformer. Chemical reactions in presence of electromagnetic fields and thermal stress will gradually age micro-scale cellulose fibers of the kraft paper. Aging of the kraft paper eventually will cause failure of the power transformer and unreliable electric power delivery.

Detection of kraft paper deterioration with non-invasive methods is mostly desired. To prevent transformer failures on time, chemometric methods such as dissolved gas analysis is performed. Conventional condition assessment methods for power transformers need transformer de-tanking (extracting the coil from the container) and providing paper/oil samples to the lab. These methods are usually invasive, time-consuming and expensive.

Using optical methods as a condition assessment tool has the potential to perform non-destructive contactless diagnosing routines with further benefit of immunity to the high-voltage environment. Regarding this fact, various optical methods based on imaging and interferometry with different illumination sources can be used. In this research we have focused on optical imaging and interference to find a correlation between aging of the kraft paper and optically obtained data.

Poster Number: 51

Super Absorbance Of Acoustic Waves With Bubble Meta-Screens

Presented by: Anatoliy Strybulevych
Researcher at the University of Manitoba, Department of Physics and Astronomy

Advisor(s): J.H. Page

Co-Author(s): V.Leroy, M.Lanoy,F.Lemoult, A.Tourin,J.H. Page

Research Area(s): Photonic and Phononic Interactions

A bubble meta-screen is a single layer of bubbles entrapped in a soft elastic medium. It has been shown that such structures were very efficient for blocking low frequency acoustic waves, due to the Minnaert resonance of the bubbles. However, the low transmission of ultrasound through the bubble meta-screen is, in general, not associated with a strong absorption (most of the energy is reflected). In this presentation, we show that a simple model predicts that 50% of the incident energy can be dissipated by the screen if its structure and viscosity are optimized. The strong absorption extends over a broad range of frequencies, including low frequencies, for which the wavelength is one order of magnitude larger than the thickness of the screen. Absorption can even be close to 100% in the case of a bubble meta-screen close to a perfect reflector. Numerical calculations with MST (Multiple Scattering Theory) and finite element simulations using COMSOL confirm the predictions of the simple model. We present experimental observations.

Poster Number: 52

Electrical Characterization Of Methyl-Terminated n-Type Silicon Microwire/PEDOT:PSS Junctions For Solar Water Splitting Applications

Presented by: Sommayeh Asgari
MSc Candidate at the University of Manitoba, Department of ECE

Advisor(s): M.S Freund, D.R Oliver,

Co-Author(s): Sommayeh Asgari, Jared P. Bruce, Derek R. Oliver and Michael S. Freund

Research Area(s): Photonic and Phononic Interactions, Crystalline Materials and Nanostructures

The role of high doping levels and the interfacial structure on the junction behavior between n-type silicon microwires and the conducting polymer, PEDOT:PSS, was investigated using tungsten probes, an established technique for Ohmic contact to individual microwires. The resistance and doping concentration of carriers as a function of length along each microwire as well as the junction resistance between individual microwires and the conducting polymer were characterized by making Ohmic contact to microwires. The junction between highly-doped n-Si microwires and the conducting polymer had relatively symmetric current-voltage characteristics and a significantly lower junction resistance as compared to low-doped microwires. The current.voltage response of junctions formed between the polymer and low-doped microwires which still incorporated the metal catalyst used in the growth process was also studied. Junctions incorporating copper at the interface had similar current.voltage characteristics to those observed for the highly-doped microwires, while junctions incorporating gold exhibited significantly lower resistances.

Poster Number: 53

Synthesis Of Liquid Crystal Silane-Functionalized Gold Nanoparticles And Their Composites With A Structurally Related Nematic Liquid Crystal

Presented by: Javad Mirzaei
PhD Candidate at the University of Manitoba, Department of Chemistry

Advisor(s): T. Hegmann, M. Freund

Co-Author(s): Martin Urbanski, Heinz-S. Kitzerow, Torsten Hegmann

Research Area(s): Soft and Disordered Materials, Crystalline Materials and Nanostructures,

Incorporation of metallic nanoparticles or semiconductor quantum dots into nematic liquid crystals (N-LCs) can have unique effects on optical and electro-optical properties of the host liquid crystal material. [1-2] Despite the great interests in the field, instability and inhomogeneity of liquid crystalline nanocomposites have remained as major challenges. These challenges are arising due to desorption of surface ligands of nanoparticles or their incompatibility with host liquid crystal molecules. To address these challenges, chemically and thermally robust liquid crystal silane-functionalized gold nanoparticles were synthesized via silane conjugation. Colloidal dispersions of these particles with mesogenic ligands structurally identical or compatible with molecules of the N-LC showed superior colloidal stability and dispersibility. The observed results explain thermal, optical and electro-optic behavior of the N-LC composites at different concentrations of each gold nanoparticle considering both the structure and the density of surface ligands.

[1] U. Shivakumar, J. Mirzaei, et al. T. Hegmann Liquid Crystals, 2011, 38, 1495-1514.
[2] J. Mirzaei, M. Reznikov, T. Hegmann J. Mater. Chem., 2012, 22, 22350-22365.

Poster Number: 54

The Role Of Yarn Imperfection In Polyester Vascular Graft Failures

Presented by: Mohammad Islam
MSc Candidate at the University of Manitoba, Department of Textile Sciences

Advisor(s): M Rahman

Co-Author(s): Mashiur Rahman

Research Area(s): Soft and Disordered Materials

An investigation has been carried out in order to examine the role of yarn imperfections in the premature rupture of polyester vascular grafts that resulted in numerous human deaths. It was found that the breaking load of a 2-plied weft yarn (35 inch), when tested at various places with the sample length of 3 inch along the length, was 8.1 N with the standard deviation of 1.9. However, when tested different weft yarns from the same fabric, the average breaking load was found to be 7.8 N with the standard deviation of 1.3.

Microscopic analysis of a single yarn diameter showed that the largest and smallest diameter was 572.14µm (thick place) and 319.3µm (thin place) respectively and the variation of yarn diameter was 56.7%. In a textile spun yarn, thin places contain fewer numbers of fibres in the yarn cross- section which affect the yarn breaking strength and breaking extension. Therefore, the present study concluded that the variations in the spun yarns that are used to make vascular grafts are the one of the major contributors for the premature rupture (work of rupture) of polyester grafts.

Poster Number: 55

Investigating Noodle Dough Using Ultrasound In Air

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. Kerherve, D. Daugelaite, A. Strybulevych, D.W. Hatcher, M.G. Scanlon & J.H. Page

Research Area(s): Soft and Disordered Materials

In this work, we develop a new non-contact on-line quality control technique for use in food processing of sheeting products. Non-contact control is important in food processing to avoid any risks of contamination or damage to the food. It is very common to use ultrasound for non-destructive testing, as it provides a convenient and powerful method for assessing the mechanical properties of materials. This new technique uses air-coupled ultrasound transducers, and is being applied for the characterization of of Asian noodle dough, which is a viscoelastic material.

Experiments conducted during this project have shown the feasibility of using a non-contact ultrasound technique to assess the mechanical properties of the dough. Moreover, we are able to detect changes in the macroscopic properties of the dough samples associated with changes in the composition (water quantity or types of salt) or in the processing (different work inputs). The next step of the project is to develop an on line tester to apply this non contact transducer technique in a real production environment, and to establish its feasibility and adaptability for processing control outside the laboratory context. In the near future, this tool will be a powerful way for non invasive quality control measurements in an industrial context.

Poster Number: 56

Effect of autoclaving on hand and surface properties of brassica fibres.

Presented by: Md. Rabiul Islam Khan
MSc Candidate at the University of Manitoba, Department of Textile Sciences

Advisor(s): Dr. Rahman

Co-Author(s): Rahman, Mashiur

Research Area(s): Soft and Disordered Materials

The changes in hand and surface properties for the autoclaved samples for the two different brassica fibres were investigated. It was found that both brassica fibres, aged (18 months old) and fresh green house samples, survived four autoclaving cycles, each autoclaving cycle lasted for 30 minutes at 121°C.

The hand properties indicated that the scoured-bleached brassica fibres maintained higher flexibility than the scoured fibres. However, the changes in colour, using AATCC Grey scale for colour change, indicated that the largest colour change occurred for the scoured-bleached greenhouse samples than the aged and green-house scoured samples.

Scanning electron microscopy (SEM) micrographs showed that the surface of the aged samples (scoured) was much rougher and produced craters during autoclaving, however, no surface craters were observed for both scoured and scoured-bleached green-house autoclaved samples. No difference in surface properties was observed for virgin and autoclaved green-house samples.

From this result, it is concluded that brassica fibres can be used for medical applications where autoclaving is necessary.

Poster Number: 57

Triple Junction Mobility Extracted By Thermal Fluctuation

Presented by: Qingzhe Song
MSc Candidate at the University of Manitoba, Department of Mechanical Engineering

Advisor(s): Dr. Deng

Co-Author(s):

Research Area(s): Surfaces and Interfaces

Triple junctions and grain boundaries, owning to the disordered atom distribution and high potential energy, are thermodynamically instable which potentially contribute to grain growth in crystalline materials under heat treatment or applied stress especially when the grain size is reduced to nanoscale. Previous work on grain growth and microstructural evolution in nanocrystalline materials mainly concentrated on the mobility of individual grain boundaries. The mobility of triple junctions, on the other hand, was rarely studied, although triple junctions add strong constrains to the motion of grain boundaries and play an important role during the overall microstructural evolution in materials. In this study, we extended the interface random walk method originally developed to extract grain boundary mobility from molecular dynamics simulations to study triple junctions. For this purpose, four different methods were used to accurately keep track of the thermal fluctuation of triple junctions. The triple junctions showed similar random walk behavior to that found for grain boundaries due to purely thermal effects, which can be used to extract the triple junction mobility.

Poster Number: 58

Graphene-Based Bipolar Membrane Interfacial Layer With Enhanced Water Dissociation Capability For Transparent, Electrically Conductive PEC Membranes Capable Of Performing OER And HER Under Different pH Conditions

Presented by: Michael McDonald
PhD Candidate at the University of Manitoba, Department of Chemistry

Advisor(s): M Freund

Co-Author(s): Michael B. McDonald and Michael S. Freund

Research Area(s): Surfaces and Interfaces

Emerging technology capable of efficient photoelectrochemical (PEC) water-splitting for production of clean fuels involve integrated membrane systems. Membranes being developed must be capable of dissipating both ionic and electronic charge while remaining as passive to the PEC process as possible. As PEC materials being considered perform in different pH, a bipolar membrane (BPM), consisting of an anion- and cation-exchange membrane, has been proposed to attenuate electrolyte cross-over and maintain pH via water dissociation (WD) in its interfacial layer. Graphene materials have been introduced into the BPM interfacial layer and measured in terms of the resulting permselectivity and WD overpotential. It was found that graphene oxide (GO) is an exceptional WD catalyst, with an overpotential of 75% less than a control, and outperforming a commercial BPM. The O-functional groups were found to be the catalytic sites, but their presence disrupts electrical conductivity. It was demonstrated that this property can be reintroduced by controllably reducing GO in order to potentially fulfill the figures of merit for PEC-BPMs.

Poster Number: 59

Mussel-Inspired Ultrathin Film On Thermally Oxidized Ti-6Al-4V Surface For Enhanced Osseointegration

Presented by: Ziyuan Wang
MSc Candidate at the University of Manitoba, Department of Mechanical Engineering

Advisor(s): O.A. Ojo, M. Xing

Co-Author(s): Malcolm Xing, Olanrewaju Ojo

Research Area(s): Surfaces and Interfaces

Thermal oxidation is advantageous in improving the biocompatibility of titanium and its alloys. However, the clinical application of thermally oxidized titanium and its alloys has been limited by their inadequate osseointegration capability. In the present work, a mussel-inspired alginate/chitosan film is constructed onto the thermally oxidized Ti-6Al-4V surface to enhance its osseointegration capability. Contact angle goniometry (CAG), X-ray photoelectron spectrometry (XPS) and atomic force microscopy (AFM) analyses demonstrate that the construction of alginate/chitosan film is successful. More importantly, the excellent in vitro performance of the Ti-6Al-4V-based structure, as indicated by mesenchymal stem cell (MSC) viability, morphology and proliferation tests, will also be presented.

Poster Number: 60

Developing Chemically Diverse Sensor Arrays Using Electrochemically Copolymerized Pyrrole And Vinyl Substituted Derivatives

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Co-Author(s):

Research Area(s): Surfaces and Interfaces

Mammalian olfaction possesses a high capacity for odor discrimination and detection. The existence of over 1000 different receptors with broad sensitivity (i.e., the ability to respond to many odorants) represents a significant degree of 'chemical diversity'. To functionally mimic these characteristics in an electronic device has been the subject of many research investigations. The use of electronically conducting polymers (ECP's) as vapor sensing material offers one such transduction mechanism and chemical variations of these materials has been demonstrated as a means for creating chemical diversity. However, the degree of diversity and the ease of deposition remain significant challenges.

Novel chemically diverse sensor arrays were developed in this work involving copolymers of conducting polymer monomers (e.g., pyrrole) and substituted vinyl derivatives (e.g., styrene, 4-m-styrene and 4-t-butoxystyrene) through electrodeposition. By selecting a range of substituted styrenes and controlling deposition conditions it was possible to create a wide range of chemical variations resulting in differential partitioning and in turn differential sensor responses. This represents a useful development in the effort to mimic human olfaction.

Poster Number: 61

Controlled In-Situ Grafting Of Polyacrylamide Hydrogel From PET Surface Via SI-ARGET-ATRP

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Research Area(s): Surfaces and Interfaces

Well-defined polyacrylamide (PAM) hydrogels were produced on the surface of poly(ethylene terephthalate) (PET) film via surface-initiated activators regenerated by electron transfer atom transfer radical polymerization (SI-ARGET-ATRP). Following the deposition of an ATRP initiator (2-bromoisobutyrylbromide) on PET film, PAM hydrogel was grafted from the functionalized PET surface via SI-ARGET-ATRP. XPS and ATR-FTIR confirmed that PAM hydrogel was successfully grafted on the PET surface. Results from AFM, SEM and FTIR-ATR-FPA images showed that PAM hydrogel uniformly covers the surface of PET film. The degree of grafting increased linearly with the increase of reaction time, indicating that the growth of PAM hydrogel on the surface of PET is well-controlled. In a fibroblast cell adhesion assay, the PAM hydrogel grafted PET film (PAM hydrogel-g-PET) showed significantly lower adhesion to human cells than the untreated PET film. To impart PAM hydrogel-g-PET with antibacterial function, AgNPs were self-assembled along the amide side chains of PAM hydrogel. AgNPs loaded-PAM hydrogel-g-PET resulted in >99% reduction of multi-drug-resistant P. aeruginosa within 2 hours of contact.

Poster Number: 62

Synthesis Conditions, Interfacial Intermixing, And The Magnetism Of Core-Shell Nanoparticles

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

The structure, composition, and magnetism of core-shell nanoparticles prepared using different synthesis conditions to alter the core-shell intermixing amounts is examined. Using a detailed characterization with x-ray diffraction, Mössbauer spectroscopy, x-ray absorption and magnetic circular dichroism spectroscopy, high-resolution transmission electron microscopy, and electron diffraction over angstrom scales, we find that the relative amount of pure core and interfacial core-shell intermixing varied systematically with the reaction temperature used during the shell addition step of the synthesis. We demonstrate that a deliberate alteration of the core-shell intermixing amounts provides an original way to tune the magnetism of a nanoparticle.

Poster Number: 63

Layer-By-Layer Assembly Of Epidermal Growth Factors On Polyurethane Films For Wound Closure

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Research Area(s): Surfaces and Interfaces

To facilitate the healing of chronic wounds, growth factors such as epidermal growth factor (EGF) need to be safely encapsulated for their sustained and effective delivery to the wound bed. Using a Layer-by-Layer (LbL) assembly technique, EGF is successfully encapsulated on the surface of polyacrylic acid - modified polyurethane (PU) film. The amount of encapsulated EGF is controlled by adjusting the number of chitosan (CH)/EGF bilayers. A controlled release of EGF from the surface of PU film for a period of 5 days is achieved while well retaining over 90% bioactivity as evidenced by a cell proliferation assay. The cell migration rate in our wound healing model is over twice as fast when fibroblasts are exposed to EGF -loaded PU films compared to control PU films. Fluorescent staining of F-actin also reveals that released EGF induces differences in cytoskeletal organization consistent with promoting cell migration and proliferation. It is concluded that the LbL assembly technique promotes higher bioactivity at significantly lower concentrations of EGF than hitherto reported, and that this is a promising approach for the development of more cost-effective, efficacious wound dressings.

Poster Number: 64

Understanding The Surface Functionalization Of Silicon Microwires

Presented by: Jared Bruce
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Research Area(s): Surfaces and Interfaces, Crystalline Materials and Nanostructures

An integrated photoelectrochemical device has been proposed to absorb incoming solar radiation and couple photogenerated charge carriers to catalysts to carry out the oxygen evolution reaction (OER) and hydrogen evolution reaction (HER). High-aspect ratio silicon microwires retain the optical density of silicon and do not suffer from recombination losses of lower quality silicon[1]. However, the formation of a silicon oxide layer on the surface of a silicon microwire limits charge transfer out of the material, reducing the efficiency of a device. Passivation and protection of the surface while allowing rapid charge transfer can be achieved by the introduction of a Si-C bond to the surface. This bond is kinetically stable and slows the silicon oxide formation.

Throughout the literature Si-C bond formation was focused on Si (111) however, the surfaces of silicon microwires are dominated by Si (110) and Si (211) phases which have different surface density and bond angles to Si (111)[2]. In this work we have focused our efforts on understanding if these inherent differences between phases affect the termination of the surface. X-ray photoelectron spectroscopy was used to investigate the surface coverage of single-crystal phases representative of microwire surfaces and subsequent oxide formation was followed over the course of a month utilizing the same technique.

1. Gray, H., Powering the planet with solar fuel Nat Chem 2009, 1 (2), 112-112.
2. Wagner, R. S.; Treuting, R. G., Morphology and Growth Mechanism of Silicon Ribbons. J Appl Phys 1961, 32 (11), 2490.

Poster Number: 65

Verification That Large Femoral Heads Of Artificial Hip Joints Leads To More Corrosion Damage

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Research Area(s): Surfaces and Interfaces

Orthopaedic researchers have recently tried to identify which design factors contribute towards corrosion damage of artificial hip joints. Corroded implants can result in the patient experiencing pain, becoming sensitive to metal particles, developing a pseudotumour, and requiring revision surgery. The purpose of this project is to demonstrate that an increased femoral head size can lead to more corrosion damage of artificial hip joints. Finite element models of the head-neck taper interface of artificial hip joints were created with different head sizes. By increasing the head size, this resulted in more micromotion from a greater toggling torque that deteriorates the passive oxide film along the alloy surface; thus, making the head-neck taper interface more susceptible to corrosion. To verify this, in vitro corrosion fatigue testing was performed where different head sizes were subjected to ten million cycles of loading with a force ranging from 300 N to 3300 N in PBS. When comparing two different head sizes, the most corrosion damage was found in the largest head size.

Poster Number: 66

Physical and Electronic properties of Ir modified Si(111) surface

Presented by: Dylan Nicholls
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Advisor(s): N. Oncel

Co-Author(s): Deniz Cakir, Ben Ware, Nuri Oncel

Research Area(s): Surfaces and Interfaces

The physical and electronic properties of Ir-modified Si(111) surface have been investigated with the help of STM (scanning tunneling microscopy), LEED (low energy electron diffraction) and ab-initio DFT (Density Functional Theory). The LEED pattern of the surface exhibits sqrt(7) x sqrt(7)-R19.1° reconstruction. STM images show that sqrt(7) x sqrt(7)-R19.1° reconstruction originates from Ir-ring clusters. Ring clusters consist of one Ir atom that is surrounded by six Si adatoms. STS (scanning tunneling spectroscopy) measurements revealed that there are two peaks located on either side of the Fermi level that dominate the electronic properties of the surface. DFT calculations have been performed to investigate the origins of these states and the details of the structure of the ring clusters.

Poster Number: 67

An STM Study Of Zn(II)-Phthalocyanine Physisorption Effects On Graphene

Presented by: Ben Ware
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Advisor(s): N Oncel

Co-Author(s): Ben Ware, Dylan Nicholls, Nuri Oncel

Research Area(s): Surfaces and Interfaces

Semiconductors are used in nearly all modern electronic and solar technology. However, semiconductors are currently limited in their ability to transport electrons, an inability which generates unnecessary heat and limits applications in spintronics. Graphene could prove as a viable successor because its massless Dirac fermionic nature virtually erases heat generation, its long distance spin correlation is ideal for spintronics, and its chemically inert structure prevents degradation and the need for a protective coating that could adversely affect these properties. But, it's a metallic surface so it must be modified to have a band gap. In our study, we chose to modify graphene with the physisorption of Zn(II)-Phthalocyanine (Zn-pc) because it is capable of physisorbing on the chemically inert surface of graphene and it contributes both donor and acceptor atoms from within its structure. Scanning tunneling microscopy and spectroscopy showed partial surface coverage and localized doping effects from Zn-pc on graphene.

Poster Number: 68

Fatigue Analysis Of Welded HAYNES 282 Alloy Using FEM

Presented by: Md Nuruzzaman
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Advisor(s): C. Wu

Co-Author(s): Yunhua Luo, Christine Wu

Research Area(s): Mechanics of Materials and Structures

The effect of loading frequency and loading level on the fatigue behavior of welded and unwelded Haynes 282 Alloy has been investigated using the finite element method (FEM). The location of the weakest point in the welded structure due to the loading has been predicted. A simple model was used to illustrate the technique of fatigue analysis of welded Haynes 282 alloy, which is a new nickel-based superalloy and possesses excellent temperature strength, is intended for use in high temperature applications related to both air and land-based gas turbines particularly in sheet and plate forms for welded structures. These components are primarily used in situations where low cycle fatigue, creep and their combination are dominant damage mechanisms. Finite element analysis was carried out to predict the stresses and the fatigue life of the component. It was found that the fatigue life of this material increases as the loading frequency increases for the same loading condition and the fatigue life decreases as the loading level increases for both welded and unwelded structure. The finite element analysis has been done using ANSYS.

Poster Number: 69

Crack Monitoring Sensor For Bridge Girders

Presented by: Farnaz Raeisi
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Advisor(s): Dr. Mufti, Dr. Thomson

Co-Author(s): Aftab Mufti, Douglas Thomson, Bahareh Saboktakin

Research Area(s): Composite Material Systems

Introduction: Many steel bridges subjected to cyclic loading from traffic can be susceptible to fatigue cracking. Although visual inspections are typically used to assess the condition of bridges, small fatigue cracks are harder to detect and can be missed. Several sensors have been developed for monitoring cracks, such as fiber optics, but they are very costly and the installation of them is expensive. Due to numerous bridges that would benefit from this type of monitoring, there is a need for an accurate and cost-effective sensor.

Objective: Design a sensor that can be easily deployed on large structures at low cost.

Methodology: The sensor will be composed of a thin metal wire which is attached to the structure with a carefully designed adhesive system. The sensor will be designed so that when a crack of less than 0.2 mm forms, the local increase in strain will cause the wire to break. The break can be easily detected using standard electronics. The design of the adhesive and wire system is very challenging. To develop this sensor, different materials will be tested. Preliminary testing on copper wire and some adhesives was promising. The adhesives will be tested using ASTM standard techniques to extract basic properties so that FEM simulations of the system can be used to guide the design and testing. The sensor will be tested on different test structures in the laboratory such as steel and concrete and will be simulated with FEM software -Abaqus- to reconcile laboratory results with theory.

Sensitivity of the sensor to temperature will be investigated.