PCAMM 2023 Posters Titles and Abstracts

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1	Spins	**Kevin Winther**	Antiferromagnetic Coupling in Co/RuY/Co (Y = Co and Fe)	Nunn, Zachary R.; Besler, Juliana; Arapan, Sergiu; Legut, Dominik; Schulz, Frank; Goering, Eberhard; Mckinnon, Tommy; Myrtle, Spencer; Girt, Erol
2	Spins	**Manuel M Rojas**	Structural and Magnetic Properties of RuFe	Myrtle, Spencer; Besler, Juliana; Ryan, Dominic H.; Hubner, Ren; Omelchenko, Pavlo; Nunn, Zachary R.; Girt, Erol
3	Spins	**Symphony Huang**	Competition between stripy and 120^{o} spin correlations in the spin glass ground state of the triangular quantum antiferromagnet $ErMgGaO_4$	S. Petit, Z. W. Cronkwright, E. M. Smith, S. Bhattacharya, J.-M. Zanotti, Q. Berrod, E. Kermarrec, and B. D. Gaulin
4	Spins	**Juliana Lisik**	Controlling Alignment Between Magnetic Moments of Adjacent Ferromagnetic Layers	Erol Girt, Juliana Lisik, Pavlo Omelchenko, Zachary Nunn, Spencer Myrtle, Bretislav Heinrich Claas Abert, Sabri Koraltan, and Dieter Suess
5	Spins	**Vidhi Chauhan**	Structure, Antiferroelectricity and Energy-Storage Performance of Lead Hafnate in a Wide Temperature Range	Bi-Xia Wang and Zuo-Guang Ye
6	Photons	**Ali Dehghanian**	Demonstration of an Integrated Planar Guided-wave Terahertz Low-Pass Synthesized Filter	Mohsen Haghighat, Thomas Darcie, Levi Smith
7	Photons	**Alireza Noori**	Terahertz Spectroscopy of the Superconducting State of TiN	Laleh Mohtashemi, J. Steven Dodge
8	Photons	**Michael Watson**	Trivalent Lanthanide Nanoparticles used for Multiple-Photon excitation Spectroscopy	Frank van Veggel

9	Photons	**Mohsen Haghighat**	Demonstration of THz SSPP Filter Excited by CPS feedlines	Thomas Darcie, Levi Smith
10	Photons	**Shirin George**	Nanoaperture optical fibre tweezers fabricated with a low-cost colloidal pattern transfer method.	Michael Dobinson, Reuven Gordon
11	Photons	**Anne Yang**	Label-free tracking of proteins through plasmon enhanced interference	Matthew Peters, Declan McIntosh, Dr. Alexandra Branzan Albu, Dr. Cuifeng Ying Dr. Reuven GordonPresenter: Annie Yang
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13	Photons	**Sahar Gholami Milani**	Effect of laser power on SERS Stokes and anti-Stokes intensities	Sahar Gholami Milani, Filomeno Soares De Aguiar Junior, Michele L. de Souza, Sanker Timsina, R. de Sousa, Alexandre G. Brolo
14	Microfab	**Nicholas Lin**	Biofabrication and 3D Bioprinting with Pleurotus ostreatus	Lorena Polovina, Isobel McLean, Alireza Taghizadehmakoei, Juan Santana, Christopher Moraes, Steven Hallam, Joseph Dahmen
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16	Microfab	**Peyman Firoozy**	A highly sensitive and stable buckling-based MEMS relative gravimeter for lunar exploration	Milad S. Haghighi, Mikhail Kanygin, Emad Esmaeili, Glyn Williams-Jones, Behraad Bahreyn
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PCAMM 2023 Posters Titles and Abstracts

1. **Antiferromagnetic Coupling in Co/RuY/Co (Y = Co and Fe)**, Nunn, Zachary R.; Winther, Kevin D.; Besler, Juliana; Arapan, Sergiu; Legut, Dominik; Schulz, Frank; Goering, Eberhard; Mckinnon, Tommy; Myrtle, Spencer; Girt, Erol *SFU*

   Since its discovery in 1986, interlayer exchange coupling in metallic multilayer structures between two ferromagnetic layers across a nonmagnetic spacer layer (FM/NM/FM) has been widely researched for its usage in spintronic devices. Modern device deposition techniques, such as magnetron sputtering, can cause interlayer mixing between the ferromagnetic layers and the spacer layers, which affects the exchange coupling strength. This has not been researched in depth until now. In this work, the strength of antiferromagnetic coupling in Co/RuY/Co (Y = Co and Fe) was studied as a function of RuY composition and thickness. It was found that antiferromagnetic coupling can be achieved across RuY spacer layers with maximum concentrations of 60 at.% for Co and 79 at.% for Fe. Additionally, it was found that the bilinear coupling constant, J1, in Co/Ru(d)/Co structures oscillates as the spacer layer thickness, d, increases. These oscillations persist with the addition of Fe to the spacer layer but are damped following a 1/d^2 dependence with the addition of Co as seen in Fig. 1 (a) and (b). In Fig. 1 (c) for Co(2)|Ru_(100?x)Y_(x)(d)|Co(2) structures where d is fixed to a thickness of two atomic layers (d = 0.4 nm), J1 strongly increases with the addition of Fe to a maximum of 6.9 ? 0.3 mJ/m2. This is the largest antiferromagnetic interlayer exchange coupling ever observed in sputtered multilayers. It was also found that the addition of Co to the Ru spacer layer causes J1 to decrease monotonically. Electronic structure calculations of Co(2)|Ru_(100?x)Y_(x)(d)|Co(2) structures performed with the Vienna Ab initio Simulation Package (VASP) depicted in Fig 1. (c), show direct agreement with experimental results. To further investigate the reasoning for the high values of J1 when Fe is introduced to the spacer layer, X-ray Magnetic Circular Dichroism measurements were performed and found that the Fe in the spacer has a large magnetic moment directly impacting the coupling strength.

2. **Structural and Magnetic Properties of RuFe ,** Rojas, Manual**,** Myrtle, Spencer; Besler, Juliana; Ryan, Dominic H.; Hubner, Ren; Omelchenko, Pavlo; Nunn, Zachary R.; Girt, Erol *SFU*

   Iron is a highly abundant material with the largest magnetic moment of all elements above room temperature. For this reason, it is widely used for the fabrication of magnetic devices. This study investigates how the structural and magnetic properties of iron are affected by the addition of ruthenium in Ru100-xFex(d) films (x = 50 and d = 20 nm). X-ray diffraction and transmission electron microscopy demonstrate that for x < 80, the alloy has hexagonal close-packed (hcp) structure, while for x > 93 the alloy has body-centered cubic (bcc) crystal structure. For 80 < x < 93, both hcp and bcc structures are present in the alloy. The vibrating sample magnetometry and Mossbauer spectroscopy measurements show that the hcp RuFe phase is paramagnetic while bcc RuFe phase is magnetic. The dependence of the remanence, Mr, saturation magnetization, Ms, and their ratio Mr/Ms of Ru100-xFex alloy as a function of x is shown in Fig. 1. From Fig. 1 it is evident that the Mr/Ms ratio for pure Fe films is 0.93, while for Ru100-xFex and x ? 93, the Mr/Ms ratio is below 0.5. Furthermore, the external magnetic fields required to saturate the magnetization in Ru100-xFex (x ? 96) are over 5 T, as shown in Fig. 2. Since magnetic domains are removed in much smaller external magnetic fields, the large saturation fields indicate a noncollinear magnetic alignment in bcc RuFe alloys. The noncollinear magnetic structure of bcc RuFe alloys is modelled with micromagnetic calculations. This finding is important since for most applications it is desired that Fe have a noncollinear magnetic alignment.

3. **Competition between stripy and 120° spin correlations in the spin glass ground state of the triangular quantum antiferromagnet $ErMgGaO_4$**, S. H.-Y. Huang, S. Petit, Z. W. Cronkwright, E. M. Smith, S. Bhattacharya, J.-M. Zanotti, Q. Berrod, E. Kermarrec, and B. D. Gaulin *McMaster*

$ErMgGaO_4$ is a quantum antiferromagnet wherein pseudospin 1/2, Er^{3+} degrees of freedom decorate two-dimensional triangular planes separated by disordered non-magnetic bilayers of Mg2+ and Ga3+. Its sister compound, $YbMgGaO_4$, has attracted much interest as a quantum spin liquid ground state candidate, although the presence of the disordered Mg-Ga bilayers add complexity to this description. In contrast ErMgGaO4 shows a clear spin glass transition near Tg = 2 K, about 1/3 of its Curie-Weiss temperature. We have carried out new inelastic neutron scattering measurements on powder $ErMgGaO_4$ samples, which show the frozen elastic component of the scattering to develop below Tg. It is separated by a = 0.25 meV gap from a continuum of dynamic spectral weight with a = 0.75 meV bandwidth. The frozen (elastic) and fluctuating (inelastic) spin correlations are analysed separately, using a combination of reverse Monte Carlo and Warren line shape analysis. These are consistent with fluctuating 120° spin correlations at all temperatures, and the development of competing stripy static correlations below T_g.

4. **Controlling Alignment Between Magnetic Moments of Adjacent Ferromagnetic Layers**, Erol Girt, Juliana Lisik, Pavlo Omelchenko, Zachary Nunn, Spencer Myrtle, Bretislav Heinrich, Claas Abert, Sabri Koraltan, and Dieter Suess *SFU*

Interlayer exchange coupling in transition metal multilayers has been intensively studied for more than three decades and is incorporated into almost all spintronic devices. Though the optimal design of these devices almost always requires noncollinear magnetic alignment between adjacent ferromagnetic layers, only collinear alignment can be reliably achieved across the current spacer layers. Recently, a class of spacer layers was discovered that can precisely control the angle between the magnetic moments of two ferromagnetic layers between 0 and 180° by changing the composition and thickness of the spacer layer. These spacer layers consist of a nonmagnetic material (Ru or Ir), used to achieve a large antiferromagnetic interlayer exchange coupling, alloyed with a ferromagnetic material (Fe or Co). The composition and thickness ranges of the spacer layers that give rise to noncollinearity between ferromagnetic Co layers have been studied, as well as the coupling strengths and angle between the ferromagnetic layers and the magnetization of the spacer layer.

For coupling in Co|(Ru,Ir)Fe|Co, the bilinear coupling strength, J1, can be much larger than J1 for Co|(Ru,Ir)|Co. In fact, the largest J1 ever observed across a spacer layer with a thickness of 0.6 nm or larger was achieved across IrFe. Additionally, the largest measured biquadratic coupling strengths J2 of Co|RuFe|Co and Co|IrFe|Co structures (3.8 and 2.46 mJ/m2, respectively), are larger than any J2 value previously reported. For the RuFe thickness range from 0.5 to 0.8 nm and the IrFe thickness range from 0.6 to 0.8 nm, the coupling angle remains constant with thickness for most of the (Ru,Ir)Fe compositions measured. On the other hand, varying the concentration of Fe in Ru or Ir allows for precise control of the coupling angle.

The saturation magnetization of RuFe, RuCo, and IrFe spacer layers was found to increase with Fe/Co concentration in the spacer layer composition ranges for which noncollinear coupling is observed. A simple atomistic model reveals that noncollinear coupling across RuX spacer layers, where X is a ferromagnetic element, originates from the competition between the ferromagnetic coupling between neighbouring X atoms and the antiferromagnetic coupling between X atoms separated by at least one Ru atom. The atomistic model successfully reproduces the experimental trends in the magnetization of the spacer layer and the coupling strengths and angle between the ferromagnetic layers. Additionally, the atomistic model and experimental measurements agree that the noncollinear coupling is independent of the exchange stiffness in the ferromagnetic layer.

5. **Structure, Antiferroelectricity and Energy-Storage Per-formance of Lead Hafnate in a Wide Temperature Range**, Vidhi Chauhan, Bi-Xia Wang and Zuo-Guang Ye *SFU*

Lead hafnate ($PbHfO_3$) has attracted a lot of renewed interest due to its potential as an antiferroelectric (AFE) material for energy storage. However, its room temperature (RT) energy-storage performance has not been well established and no reports on the energy-storage feature of its high-temperature intermediate phase (IM) are available. In this work, high-quality $PbHfO_3$ ceramics were prepared via the solid-state synthesis route. Based on high-temperature X-ray diffraction data the IM of $PbHfO_3$ was found to be an orthorhombic, Imma space group, with antiparallel alignment of Pb^{2+} ions along the [001] cubic directions. The polarization electric field relation of $PbHfO_3$ is displayed at RT as well as in the temperature range of the IM. A typical AFE loop revealed an optimal recoverable energy-storage density (W_{rec}) of 2.7 J/cm^3, which is 286% higher than the reported data with an efficiency of 65% at 235 kV/cm at RT. A relatively high W_{rec} value of 0.7 J/cm^3 was found at 190 ^oC with an efficiency of 89% at 65 kV/cm. These results demonstrate that $PbHfO_3$ is a prototypical AFE from RT up to 200 ^oC, making it a suitable material for energy-storage applications in a wide temperature range.

6. **Demonstration of an Integrated Planar Guided-wave Terahertz Low-Pass Synthesized Filter**, Ali Dehghanian, Mohsen Haghighat, Thomas Darcie, and Levi Smith *UVic*

At terahertz (THz) frequencies there are few experimental works which demonstrate filter synthesis to obtain a desired filter response (i.e., Chebyshev, Butterworth, Bessel, etc.). Currently, the majority of literature perform THz filter analysis that is characterizing the filter response after design procedure. In this work, we apply filter synthesis methods from microwave engineering to design several integrated planar low-pass filters (0.8 THz). We find that the transmission characteristics align with theory and simulation.

Filters play a crucial role across the electromagnetic spectrum, employed for applications such as noise reduction, (de)multiplexing, and signal processing. While filter design is well-established in the electrical and optical frequency ranges, the terahertz (THz) gap (0.1-10 THz) presents unique challenges and opportunities. Existing THz filters are often bulky and lack integration with miniaturized planar guided wave transmission lines (TLs). This work addresses the gap in literature by exploring microwave filter synthesis at THz frequencies, focusing on the integration of synthesized Bessel stepped-impedance low-pass filters (LPF) into coplanar striplines (CPS).

The novelty lies in the first demonstration of an integrated planar guided-wave synthesized filter (Bessel) at THz frequencies, specifically targeting a high cut-off frequency (>500 GHz). The study involves the systematic design and experimental validation of these filters, emphasizing the use of coplanar stripline TLs on a thin Silicon Nitride substrate. The selected design parameters and fabrication process enable the investigation of 3rd, 4th, and 5th order Bessel filters.

The design process involves specifying the desired cut-off frequency and filter order, selecting feedline and impedance parameters, and calculating section lengths. Experimental characterization is conducted using a modified THz-time domain spectroscopy system, integrating electrical and optical components. The results demonstrate minimal pulse distortion in the temporal response, aligning with the linear phase response of the designed filters. The spectral response exhibits a roll-off near the designed cut-off frequency, showcasing the effectiveness of the synthesized Bessel filters at THz frequencies.

7. **Terahertz Spectroscopy of the Superconducting State of TiN**, Alireza Noori**,** Laleh Mohtashemi, and J. Steven Dodge *SFU*

We present terahertz time-domain spectroscopy measurements of titanium nitride as a function of temperature in the superconducting state. By employing a maximum-likelihood analysis method developed previously by our group, we demonstrate that the Mattis-Bardeen theory of disordered superconductivity can describe the complex frequency-dependent conductivity at each temperature with only one free parameter, the temperature-dependent energy gap $\Delta(T)$. A conventional analysis of the same data yields comparable values of $\Delta(T)$ at each temperature, but without reliable estimates of the uncertainty bounds or goodness of fit. Our results provide a quantitative test of the Mattis-Bardeen theory and demonstrate the advantages of the maximum-likelihood framework to analyze time-domain terahertz spectroscopic data. This contributes towards understanding the superconducting behavior of TiN and establishes a foundation for future explorations.

8. **Trivalent Lanthanide Nanoparticles used for Multiple-Photon excitation Spectroscopy**, Michael Watson, and Frank van Veggel *UVic*

LaF3:Ln3+ nanoparticles were synthesized with the purpose Showing that multiple photon excitation correlation spectroscopy which could have future application in detection and labeling for biological systems. These particles were characterized by transmission electron microscopy (TEM) and X-ray diffraction (XRD). Characterization of single photon excitation emission were performed on four trivalent lanthanides, Eu3+, Tb3+, Dy3+, and Sm3+ with excitation with optimal wavelength for emission on an OPOTEK radiant tunable laser system. Excitation leads to nearly identical emission spectra for Eu3+ and Tb3+, with reduced intensity. Dy3+ and Sm3+ did not emit strong signals but gave guidance for future work in this field. Showing that multiple photon excitation correlation spectroscopy could have future application in detection and labeling for biological systems.

9. **Demonstration of THz SSPP Filter Excited by CPS feedlines**, Mohsen Haghighat, Thomas Darcie, and Levi Smith *UVic*

There is a surging interest in Spoof Surface Plasmon Polariton (SSPP) structures within the Terahertz (THz) frequency range, particularly for filtering, sensing, and communication applications. Despite widespread interest, the scarcity of experimental validations for SSPP characteristics at THz frequencies remains notable, with existing literature predominantly centered on simulations or validations

conducted at the more accessible Gigahertz (GHz) frequencies using standard vector network analyzers. Addressing this gap, our work pioneers the experimental verification of SSPP characteristics in the THz spectrum, employing a guided wave system with coplanar strip (CPS) feedlines. Three distinct SSPP structures, featuring varying band-edge frequencies (1.04 THz, 0.63 THz, and 0.53 THz), were designed, fabricated, and their low-pass transmission characteristics verified using a modified THz-time-domain spectrometer (THz-TDS) system. The results reveal a compelling alignment between simulation, theoretical expectations, and experimental outcomes, marking a significant stride in the understanding and practical application of SSPP structures at THz frequencies.

10. **Nanoaperture optical fibre tweezers fabricated with a low-cost colloidal pattern transfer method**, Shirin George, Michael Dobson, Reuven Gordon *UVic*

    Optical trapping using nanoapertures such as double nanoholes (DNHs) is a useful technique for analysing proteins and other small particles which unfortunately is inaccessible for many due to the complicated optical setup and nanofabrication requirements. Integrating a DNH aperture on the tip of an optical fiber greatly simplifies the technique as it allows for fully fiber-based trapping systems which require only minimal optics experience. Previous works have demonstrated nanoaperture optical fiber tweezers, but fabrication has been based on expensive top-down approaches. This work presents a method to fabricate nanoaperture optical fiber tweezers by colloidal pattern transfer with a low-cost pattern fabricated using colloidal lithography. Results of optical trapping using a fabricated nanoaperture fiber tweezer with a polystyrene nanoparticle size standard are also presented.

11. **Label-free tracking of proteins through plasmon enhanced interference**, Annie Yang, Matthew Peters, Declan McIntosh, Dr. Alexandra Branzan Albu, Dr. Cuifeng Ying, Dr. Reuven Gordon *UVic*

    Fluorescent labels and tethers modify the biophysical properties of proteins. Observing proteins in their natural state is difficult due to their extremely small scattering cross section. Three approaches have emerged to image single proteins but tracking has proven to be difficult for even relatively large proteins. Here we show enhanced scattering from single proteins using laser-protein scattering combined with surface plasmon-protein scattering from a nanoaperture.

12. **A Novel Approach to Evaluate SERS Substrates: Introducing Key Parameters and Metric**, Arash Azarakhshi, Li-Lin Tay, Alexandre G. Brolo *UVic*

    Ultra-high sensitivity, the ability to work labelled and label-free, and real-time feedback made Surface-Enhanced Raman-scattering (SERS) a powerful tool in both qualification and quantification streams. Along with expanding the borders of SERS applications, many groups and companies are exploiting different chemical and physical techniques to provide reliable SERS substrates for the community. From a commercial standpoint, it?s a $20 million market with immense potential for exponential growth in the coming years. The lack of standard

techniques and well-defined protocols to achieve higher reproducibility is a drawback that should be addressed as well. The significant enhancement of the signal in SERS is a result of surface-plasmon excitation on the surface of the nano-structured metals. The non-uniform distribution of electric field enhancement imposes experimental challenges to establishing appropriate parameters for the substrates' metrology goals. In this work, we aim to introduce evaluation parameters based on temporal and spatial signal acquisition in both high-fluctuation-SERS (HF-SERS) and average-SERS (Av-SERS) regimes. The temporal and spatial resolutions cover signal fluctuations at a single point and throughout the surface, respectively. A simple SERS signal simulation has been used to make a bridge between pure statistical signal analysis and the hotspot distribution.

13. **Effect of laser power on SERS Stokes and anti-Stokes intensities,** Sahar Gholami Milani, Filomeno Soares De Aguiar Junior, Michele L. de Souza, Sanker Timsina, R. de Sousa, Alexandre G. Brolo *UVic*

    The anti-Stokes and Stokes signals' nonlinearity can be linked to several occurrences. Photon pair formation is one of the factors that may contribute to this behavior. In this paper, we conduct an experiment on power dependence and investigate potential causes of the behavior we see. Furthermore, we model the SERS substrate in order to comprehend the impact of various resources.

14. **Biofabrication and 3D Bioprinting with Pleurotus ostreatus**, Nicholas Lin, Lorena Polovina, Isobel McLean, Alireza Taghizadehmakoei, Juan Santana, Christopher Moraes, Steven Hallam, Joseph Dahmen *UBC*

    Biofabrication using mycelium, the root-like network of fungi, has gained considerable attention within the past ~15 years. Mycelium biocomposites have enormous potential as environmentally-friendly alternatives to replace conventional materials that are energy- and carbon-intensive to produce. Recently, several studies have shown that mycelium biofabrication techniques can be enhanced with 3D bioprinting technologies to achieve high value functional mycelium products with complex shapes. In this study, we demonstrate workflows combining living Pleurotus ostreatus mycelium with sawdust and other additives to achieve large-scale functional mycelium biocomposites as well as intricate 3D bioprinted mycelium structures.

15. **Precision Temperature Control of Microsystems using On-Package Heaters and Sensors**, Mohammadreza Hajipour, Fatemeh Eshaghi, Mikhail Kanygin, and Behraad Bahreyni *SFU*

    High-precision applications require stable operating environments for the components, with temperature stability often being the most critical requirement. Existing methods for temperature control rely on a combination of device level (i.e., on-die) and system level (i.e., board and enclosure) temperature control and shielding to achieve the necessary temperature stability. However, device-level solutions offer little post-fabrication flexibility, and board/enclosure-level solutions add to system bulk and power consumption. Herein, we demonstrate a simple, widely applicable method of using on-package heaters and sensors for temperature control. Various configurations of surface-mount heaters

and sensors were arranged around a standard ceramic package. A simple proportional-integral temperature controller was developed and used for the integrated temperature control. We demonstrate that the method achieves similar accuracies to having an on-die sensor, and hence, is easily applicable to many high-performance sensing applications. We further show that a temperature stability of ~1 mK is possible with a power consumption of ~500 mW.

16. **A highly sensitive and stable buckling-based MEMS relative grvaimeter for lunar exploration,** Pehman Firoozy, Milad S. Haghighi, Mikhail Kanygin, Emad Esmaeili, Glyn Williams-Jones, Behraad Bahreyni *SFU*

Historically, gravimetry instruments have been significantly expensive (>$100k) and heavy (>8 kg), which prevents them from unmanned space exploration. But we offer using Micro-Electro-Mechanical-Systems (MEMS) which are low-cost (<$2k) and lightweight (on the order of grams) for the Moon subsurface exploration.

17. **Tracking of Cathode Degradation in LiNi0.5Mn1.5O4 Lithium-Ion Batteries Through Intermittent Post-mortem Material Characterizations**, Duncan, Kelsey L.(1); Chu, Vivian(1); Daher, Maya(1); Nesvaderani?, Farhang (2); Reid, O?Rian (2); Hadidi, Lida (2); ?Gates, Byron* (1) 1) Simon Fraser University 2) NanoOne Materials Corp.

Degradation of lithium-ion battery (LIB) cathode materials is a common issue plaguing LIB development. To deconvolute the failure mechanisms of batteries post-mortem (PM) autopsy is performed by disassembling a “dead” battery to analyze each component separately. Typically, only whole-cathodes are studied in this way, where cathode microparticles are encased in polymeric binders and adhered to a current collector support. Analysis of whole-cathodes limits our understanding of degradation to what can be observed on the surface layer of microparticles, and ignores the deterioration that may occur on inner and base layers of cathode particles. Structural characterization is also limited by the presence of organics in the binder matrix. Using previously developed methods to further dissect the whole-cathode for non-destructive isolation of single cathode particles, detailed study can be performed. In this work, isolated single particles of $LiNi_{0.5}Mn_{1.5}O_4$ are harvested from LIBs at different time points in their life-cycle to identify and track their degradation throughout electrochemical cycling. Many high-resolution scanning electron microscopy images are analyzed systematically for physical cues of degradation, supporting PM x-ray diffraction data and standard electrochemical analyses.

18. **Stabilization of Nanostructured Platinum Catalysts by Encapsulation**, Annabelle M. K Hadley, Sakshi Gautam, and Byron D. Gates

The development of hydrogen fuel cell technology is necessary to reduce our reliance on fossil fuels and to meet Canada’s Sustainable Development Goals. There remains room for improvement in fuel cell durability, especially since fuel cells are of interest for long-distance transportation. Fuel cell durability relies in large part on the stability of the carbon supported platinum (Pt) catalysts that facilitate the generation of electricity from the combination of hydrogen and oxygen. Nanoscale catalysts are desirable because of their high activity and economical use of costly Pt. However, they are prone to degradation mechanisms that lead to losses of active Pt surfaces either by nanoparticles coalescing or dissolving altogether. For this study, nanostructured Pt was encapsulated by niobium oxide to see whether the addition of the highly corrosion resistant material could preserve the initial morphology of the Pt. Additionally, electrochemical techniques were used to understand how the porous niobium oxide

layer impacted reactant access to the Pt surface. It was found that while ~3 nm of niobium oxide reduced the activity of the catalyst, it successfully preserved the initial active Pt surface area during extended durability testing compared to the ~36% decrease in the un-encapsulated Pt.

19. **Enhancing Coating Performance: Investigating the Impact of Nanofillers in Anti-Corrosion Coating**, Prakriti Raizada and Rishi Gupta *UVic*

Corrosion poses a significant challenge in various industries, leading to material degradation, structural failure, and increased maintenance costs. Organic coatings have shown promise as effective corrosion barriers, offering outstanding mechanical properties and chemical resistance. The incorporation of nanofillers into coatings is an emerging approach to further enhance their corrosion protection capabilities. This study aims to elucidate the effect of nanofillers on the corrosion resistance of polyurea-based coatings through a comprehensive analysis of surface properties and Electrochemical Impedance Spectroscopy (EIS). In this research, we will systematically investigate the influence of different types and concentrations of nanofillers on the surface properties of organic coating, such as surface roughness, hydrophobicity, and adhesion strength. The findings of this study will provide valuable insights into the potential of nanofillers in enhancing the corrosion protection properties of anti-corrosion coatings. Ultimately, this research will contribute to the development of advanced coatings for various industries, including oil and gas, automotive, and infrastructure, with the aim of mitigating corrosion-related challenges and extending the lifespan of critical assets.

Key Words: Adhesion, Contact angle, corrosion, electrochemical impedance, surface energy.

20. **Conducting Polymer Films with High Maximum Salt Adsorption Capacity for Capacitive Deionization Applications**, Saghafifar, Sepideh; Kaake, Loren G. *SFU*

The increasing demand for freshwater, coupled with the retreat of mountain glaciers, has elevated water scarcity to a global concern. To address this issue, numerous desalination technologies have been developed. Capacitive Deionization (CDI) stands out as a promising and relatively underutilized water treatment method with the potential for low energy consumption and cost-effectiveness. Over the past two decades, materials with improved durability, high salt absorption capacity, hydrophilicity, and sufficient conductivity for efficient operation have been developed. Building on previous work in our group, this study investigates the effectiveness of poly(3,4-ethylene dioxythiophene):poly(styrene sulfonate) (PEDOT:PSS) as a CDI electrode material. PEDOT:PSS, a pi-conjugated polymer, transports cations effectively. We employ a custom-made six-electrode CDI cell to facilitate in-situ measurements of salt concentration and electrochemical currents during the deionization process. The maximum salt adsorption capacity of PEDOT:PSS is found to be comparable to the state-of-the-art materials, exceeding activated carbon at the highest feed stream concentrations. The results demonstrate important differences in the mechanism of ion coupling between the PEDOT:PSS and activated carbon electrodes.

21. **Synthesis and Characterization of Zwitterionic Dielectric Materials**, Simranjeet Kaur, Renita D'Souza, Timothy Kelly, Vance Williams, and Loren Kaake *SFU*

The high dielectric constant of organic materials is a highly desirable property for energy related applications, such as low input voltage operations in printed electronics, additives in batteries and biomedical devices. The ionic liquids (ILs) have a high dielectric constant; however, the migration of the

constituent ions limits their applications, which makes the tethered structure of the zwitterion attractive. Although zwitterions have a large dipole moment, the electrostatic intermolecular interactions between the molecules in solid state can disrupt their application as high dielectric constant materials. We report the synthesis of a novel zwitterionic molecule which melts below 100 oC. The compound was blended with poly(methyl methacrylate) and its dielectric properties were studied. The frequency-dependent capacitance depends strongly on the amount of zwitterion in the film and on the temperature of the device. At low concentrations of zwitterion and low temperatures, the film shows small capacitance (~3 nF/cm2). Above a specific concentration and temperature, capacitance is greater than 10 ?F/cm2, consistent with electrostatic double layer formation. In order to achieve this high of a capacitance value, the bulk of the film must be field-free. As such, we suggest that zwitterions exhibit strong electrostatic correlations behaviour. This interpretation is supported by grazing incidence wide angle x-ray experiments which show evidence of zwitterion crystallization only at high concentrations. This demonstrates a non-electrolyte dielectric with a very high capacitance and illustrates the importance of the nanoscale electrostatic environment on the properties of this class of materials.

22. **Ordered deficient perovskite La2/3TiO3 films grown via molecular beam epitaxy**, Joan Weng, Joan Weng ; Hyungki Shin ; Simon Godin ; Mohamed Oudah; Ronny Sutarto ; Rebecca Pons ; Bruce A. Davidson ; Ke Zou *UBC*

    Molecular beam epitaxy growth of the ordered deficient perovskite $\ce{ La_{\frac{2}{3}}TiO_{3} }$ has been achieved. A-site vacancy ordering can occur along a pseudocubic perovskite axis, such that planes of the crystal normal to the axis have stoichiometries of $\ce{ LaO,TiO_{2}}$, and $\ce{ La_{\frac{1}{3}}O }$. Here, we achieve ordering by a cooling-and-annealing growth method, monitored *in situ* by reflection high-energy electron diffraction. Ordering normal to the film surface is revealed by X-ray diffraction; ordering in the plane of the film surface is also suggested by reflection high-energy electron diffraction. Grown as an epitaxial film, $\ce{ La_{\frac{2}{3}}TiO_{3} }$ has well-defined domains over chip-sized area: it appeals as a "parent compound" into which ions can be electrochemically inserted. The $\ce{ La_{\frac{1}{3}}O }$ layers in the ordered $\ce{ La_{\frac{2}{3}}TiO_{3} }$ film may act as highways that conduct inserted ions, as suggested by high ionic conductivity of the promising solid state electrolyte $\ce{ Li_{3x}La_{\frac{2}{3}-x}TiO_{3} }$; with controlled lithium insertion, probing the phase diagram of the mixed valence system $\ce{ Li_{x}La_{\frac{2}{3}}Ti^{4+}_{1-x}Ti^{3+}_{x}O_{3} }$ can give rise to new iontronics.

23. **Positive to Negative He Ion Production in a He Ion Microscope**, Philip Jackle, A. Bunevich, K. L. Kavanagh, and M. Dehnel (D-Pace Inc) *SFU*

24. **4D LABS - An Open-Access Materials Research Facility**, Nathaniel Sieb

25. **Fabrication Capabilities at the SBQMI Nanofab, UBC node of the Quantum Colaboratory**, Khush Hydri, Mario Beaudoin, Matthias Kroug & Pinder Dosanjh

    This poster highlights some of the fabrication capabilities at the UBC SBQMI Nanofab, such as our 100KV EBL system and Vanguard photonic wirebonder amongst other more conventional micro- and nano-fabrication equipment.

26. **Analyzing InGaN/GaN axial Nanowire p-i-n junction LEDs using electron holography**, Anitha Jose, Maria Tchernycheva, Noelle Gogneau, Cristina Cordoba, Arthur Blackburn, Martha McCartney, and Karen L. Kavanagh

    Axial n-GaN/InGaN/p-GaN Nanowires (NW) p-i-n light emitting diodes (LED) were grown by Molecular Beam Epitaxy using Si and Mg as the n-type and p-type dopants respectively. Two kinds of NW growth were observed from the SEM image on the same substrate. Off-axis electron holography (EH) was used to quantify the potential distribution in both kinds of NWs correlated with the composition, structure and growth conditions.

27. **Radiation damage to 2D crystals at beam energies in the range 10-30 keV**, Cristina Cordoba, Matthew Fitzpatrick, Arthur M. Blackburn, Robert McLeod

    Electron diffraction mapping and studies of crystalline polymers can be readily performed in a scanning electron microscope (SEM) type instrument at room temperature [1]. This capability has been aided by recent developments in hybrid direct electron detectors with sensitivity optimized for < 30 keV [2]. While radiation damage is expected to increase with lower electron beam energies, compared to the more usual > 80 keV used in transmission electron microscopy (TEM), it is also recognized that elastic scattering cross-sections can increase at a greater rate. Thus, a greater information arises at lower beam energies [3]. However, hitherto there has been little experimental confirmation of this in the range 10 - 30 keV, owing to the absence of efficient pixelated detectors operating in this energy range, and the potential complications of configuring a conventional TEM to operate in this energy range.

    To help address this experimental absence, we study radiation damage on samples of paraffin (C36H74) 2D crystals supported on an amorphous carbon film as function of electron fluence in an immersion lens SEM / scanning TEM (STEM) instrument (Hitachi SU9000) operating at 30 keV. This instrument was fitted with an uncoated pixelated hybrid direct electron detector [2] (embedded within a Quadro camera from Dectris AG, Switzerland). Diffraction pattern acquisitions were performed blind using an electrostatic beam blanker between stage moves, to ensure accurate low dose iterative exposures, as controlled from Azorus 4D-STEM software (Hitachi High-Tech Canada, Inc). The diffraction patterns were then analyzed to determine a measure of the radiation damage, taken as the ratio Is/Io where Is is the average detector counts in 5 to 6 first order diffraction peaks, and Io is the forward scattered beam intensity, where both are determined after removing local background counts [3].

    Figure 1(a) shows the variation of this radiation damage measure with electron fluence. At the beam energies studied, there is a rapid decay of Is/Io at low fluence, followed by a steadier decay at higher fluences. Initial analysis of our data indicates that the data appears to fit well to a double exponential model of the form IS/I0 = A exp{exp(H-f/k)}, where f is the fluence, k is a decay parameter, and A and H are constants. While there is more work to be done to understand these characteristics, it is interesting to observe the near linear fit between acceleration voltage and decay parameter presented in Figure 1(b). Combining this data with information on total inelastic and elastic cross-sections, will allow a more

complete picture of information coefficient to be obtained for low energy electron microscopy.

[1] C. Cordoba, Y. Zhang, et al., Microsc. Microanal. 27 (Suppl 1), pp 2488-2489, (2021).
[2] G. Tinti, H. Marchetto et al., Journal of Synchrotron Radiation 24, 963-974 (2017).
[3] M. J. Peet, R. Henderson, et al., Ultramicroscopy, 203, 125-131, (2019).

28. **Sub-pixel object segmentation of convergent beam electron diffraction disks using neural networks,** Matthew Fitzpatrick, Arthur M. Blackburn, Robert McLeod

Recent technological developments in hybrid-type pixelated direct electron detectors have sparked growing interests in 4-dimensional scanning transmission electron microscopy (4D-STEM) techniques. These techniques can be used to determine for instance orientation and structural information in crystals, as well as phase information when combined with ptychography. However, the accuracy of 4D-STEM techniques are often limited by the presence of distortion in the collected convergent beam electron diffraction (CBED) patterns, caused by aberrations of the electromagnetic lenses. Existing distortion characterization techniques typically involve estimating the centers of the CBED disks in a given pattern, using e.g. the radial gradient maximization (RGM) technique [C. Mahr, et al., Ultramicroscopy, 196, 74-82 (2019)], and then performing some kind of least-squares optimization procedure according to an expected or assumed reciprocal lattice system. In cases where the CBED patterns are subject to appreciable degrees of elliptical and pincushion distortion, methods like RGM can potentially breakdown as they rely on the CBED disks being more or less circular or elliptic. Recently, in the field of medical imaging a deep learning framework was proposed for performing sub-pixel object segmentation on magnetic resonance images of organs [R. Sheombarsing, et al., arXiv:2110.15233v1, (2021)]. We adopt their framework in our current work to perform object segmentation on CBED disks in CBED patterns. The advantage of estimating the distorted disk contours rather than the disk centers is that we can use the former in a least-squares optimization scheme that does not require knowledge of the reciprocal lattice system. The only constraint applied in this optimization scheme is that the points on a given CBED disk contour need to lie on a circle upon correcting for distortion. We train our object segmentation models using artificially generated CBED disks that are subject to a variety of different distortion transformations and dosage levels to maximize the diversity of images to which our models can be applied. In this contribution, we present our results from the object segmentation models that we have trained, and discuss how these models can be used to perform distortion correction.

29. **Obtaining wider-angle on-axis TKD patterns in SEM using a multi-exposure fusion method and a direct electron detector**, Tianbi Zhang, and T. Ben Britton

Diffraction pattern analysis can be used to reveal the crystalline structure of materials, and this information is used to nano- and micro-structure of advanced engineering materials that enable modern life. For nano-structured materials typically diffraction pattern analysis is performed in the transmission electron microscope (TEM) and TEM diffraction patterns typically have a limited angular range (less than a few degrees) due to the long camera length, and this requires analysis of multiple patterns to probe a unit cell. As a different approach, wide angle Kikuchi patterns can be captured using an on-axis detector in the scanning electron microscope (SEM) with a shorter camera length. These transmission Kikuchi diffraction (TKD) patterns present a direct projection of the unit cell and can be routinely analysed using EBSD-based methods and dynamical diffraction theory. In the present work, we enhance this analysis significantly and present a multi-exposure diffraction pattern fusion method that increases the dynamic range of the detected patterns captured with a Timepix3-based direct electron detector (DED). This method uses an easy-to-apply exposure fusion routine to collect data and extend the dynamic range, as

well as normalise the intensity distribution within these very wide (>95?) angle patterns. The potential of this method is demonstrated with full diffraction sphere reprojection and highlight potential of the approach to rapidly probe the structure of nano-structured materials in the scanning electron microscope.

30. **Towards Critical Dose Reduction in Electron Microscopy using Combined High-Speed Beam Scanning and Shuttered Detection**, Zekun Fang and Arthur Blackburn

Many technologically important materials, such as perovskites and polymers, are very electron dose sensitive (have a low critical dose) and existing electron microscopy techniques give weak and noisy structural information on these materials. Improving the information obtainable from such materials by increasing the critical dose will enable more robust microstructural characterization. Some recent work has increased the critical dose using pulsed-laser stimulated electron emission microscopy [1], but this technique has very low accessibility. Using existing electron microscope beam deflectors and relatively low-cost high-speed cameras instead of a pulsed laser to alter electron delivery, would improve access to the increased critical-dose benefit of pulsed electron beams. Furthermore, this new technique would provide an accessible tool to allow the detailed investigation of the role of electron impact spatial and temporal separation statistics on sample damage. Here we present the work taken towards these goals.

[1] E. J. VandenBussche and D. J. Flannigan, Nano Letters 2019 Vol. 19 (9) 6687-6694

31. **Donor Concentration Estimation in Doped ZnO NWs**, Shirin Riahi, David Lister, and Simon Watkins

Zinc oxide has been investigated for several decades due to its direct bandgap, and relative ease of n-type doping. Control of donor dopant concentration in ZnO nanowires (NWs) while simultaneously controlling the morphology is a challenging task. Photoluminescence spectroscopy (PL) indicates doping ZnO NWs result is an asymmetric broadening at the lower energy side of the donor-bound exciton peak. Characterizing donors in NWs is inherently challenging, with existing methods such as atom probe tomography, Hall effect measurements, and nanoprobe resistivity measurements each presenting distinct drawbacks. The first one is expensive and destructive, the Hall effect measurement is challenging as NWs are tiny and it is hard to put the side contacts, and the last one is an in-direct measurement that does not give carrier concentration or mobility directly. In response to these challenges, our study focuses on the change in PL peak associated with dopant flow, utilizing the optical linewidth of doped NWs as a quantitative measure for donor concentration. Employing a model based on the interaction of donor-bound exciton pairs, we estimated donor concentration through pair model simulations. This simulation considers the localization of a single exciton at pairs of donors with varying separations modelled by a random impurity distribution. Notably, nearby pairs exhibit a larger binding energy than distant pairs, resulting in a pronounced redshift of PL for higher doping levels. Our model demonstrates promising results for quantitatively estimating donor concentration, enabling us to establish a systematic correlation between donor concentration and dopant flow.

32. **Asymmetric Geometry MoS_2 Diodes for Sensing Applications**, Mirette Fawzy, Thushani de Silva, et al. Miriam Rosin, Karen L. Kavanagh and Michael Adachi.