P1-1: Material Removal Rate for Mechanical Serial Sectioning - Preliminary Steps to 3D SEM Analysis

Presenter: Graeme Francolini (PhD, UBCV MTRL); Supervisor: Dr. Ben Britton

3D analysis can be performed using X-ray, transmission electron microscopy (TEM), and scanning electron microscopy (SEM)-based techniques. However, SEM-based techniques are destructive, and data is obtained through the repetitive removal of material slices. This process is called serial sectioning and requires material removal in highly controlled steps so that a uniform data set is obtained.

There is growing interest in performing serial sectioning using mechanical polishing within robotically automated 3D SEM analysis systems, like the 3D-MARVIN system being built at the University of British Columbia. However, there is no uniform model or equation which can predict the mechanical removal rate (h) of all materials during polishing. The removal rate must be determined for a material system through empirical measurements and systematic study to obtain an equation of high accuracy.

A preliminary study has been conducted on an additively manufactured (AM) Ti-64 sample using the semi-automated polisher included in the 3D-MARVIN system. A pattern of Vickers hardness indents was used to measure the material removal per slice and planar deviations of the polishing. Measurements were performed by placing the indents near the four corners of the rectangular sample surface and comparing the difference in depth of each indent before and after each polishing step, with SEM imaging and electron backscatter diffraction (EBSD) captured at set intervals. The RPM and the time were individually varied during the study to determine their individual and combined relationships to the subsequent material removal. This resulted in a final equation of material removal (μm/rotation) = 0.00215 (RPM*Time).

P1-2: Analytical Electron Microscopy with a Xe-plasma Focussed Ion Beam - Scanning Electron Microscope (pFIB-SEM) at UBC

Presenter: Ruth Birch (Postdoc, UBCV MTRL); Supervisors: Dr. Ben Britton, Dr. Warren Poole

The structure of materials at the nm to mm length scale is often important and can control the properties of materials and components in real engineering applications. Here we present some of the capabilities afforded by the Tescan AMBER-X Xe-plasma focussed ion beam-scanning electron microscope, which combines the ability to serial section and extract samples (pFIB) with advanced analytical electron microscopy (FEG-SEM). This instrument is equipped with a range of analytical detectors including high contrast secondary electron, in-lens, and backscatter detectors as well as fast electron backscatter diffraction (EBSD) and large area energy dispersive X-ray spectroscopy (EDX/EDS). These capabilities are demonstrated here with recent case studies where we probe the 2D and 3D nano- and micro-structure of materials, including steels used in advanced engineering applications. Highlights of this work include: large area EBSD mapping (> 4 x 4 mm2); 3D backscatter tomography (500+ slices, 200 x 200 μm, 100 nm slice thickness); and scanning transmission electron microscopy in SEM (STEM-in-SEM) imaging to reveal nanoscale precipitates and complex steel microstructures.

P1-3: 2D and 3D Characterization of Fe-rich Constituents in Al-Mg-Si Extrusions

Presenter: Yixin Wang (Postdoc, UBCV MTRL); Supervisor: Dr. Warren Poole

Iron (Fe) is a critical impurity in aluminum alloys as it promotes the formation of constituent particles that potentially act as fracture initiation sites and degrade formability. In this study, Fe-rich constituent particles in low-Fe and high-Fe AA6082 (Al-Mg-Si) extrusions were systematically characterized in terms of size, area/volume fraction, aspect ratio–orientation correlation, and pair correlation distribution. Comparative analyses using 2D SEM imaging and 3D X-ray CT revealed differences arising from sectioning effects in 2D observations and resolution limits in 3D measurements.

P1-4: 3D Characterisation of an Aluminium-Silicon Alloy

Presenter: Simon Tsianikas (Postdoc, UBCV MTRL); Supervisors: Dr. Ben Britton. Dr. Warren Poole

Reducing vehicle mass is a proven pathway to lower carbon dioxide emissions and fuel consumption, and aluminium alloys are a promising alternative to conventional steel components. Significant weight savings can also be achieved through a reduction of joints, and the associated integration of parts, via so-called 'unicastings'. In these castings, the strength of each part of the component can be tailored by the cross section as well as the precise microstructure which is created during casting. This motivates us to enhance understanding of cast microstructures and drive forward alloy design. Here, we present a 3D analysis of an A356 aluminium-silicon Al-7.14Si-0.33Mg alloy with a volume of 500 x 480 x 380 μm^3, with 250 nm^3 voxel size, resulting in 6 billion voxels collected using plasma focussed ion beam-scanning electron microscopy (pFIB-SEM) tomograph with a TESCAN AMBER-X instrument. Low-Energy Backscatter Electron (LE-BSE) micrographs were used to enable segmentation via U-Net deep learning semantic segmentation in DragonFly to provide 3D characterization including the size and shape of primary aluminium, eutectic, and the iron- and magnesium-rich intermetallic phases. Large volume and many slice segmentation is essential for this work, both as the cast microstructure has features that extend > 100 µm in size such as the Al-dendrites together with finer sub- µm features such as the intermetallic particles and Al-Si eutectic, as well as the statistical implications of these measurements on real engineering casting applications.

P2-1: Characterizing the Microstructures in Nitrogen-Containing Titanium and Its Interaction with Molten Titanium

Presenter: Joey Chan (MASc, UBCV MTRL); Supervisor: Dr. Daan Maijer

Titanium and its alloys have become a critical material in the aerospace industry since its commercialization in the early 20th century. However, the chemically active nature of titanium makes producing this metal challenging. Nitrogen contamination in titanium during the manufacturing process can lead to localized regions of increased hardness and low ductility. This type of defect, known as a high interstitial or hard-alpha defect, could act as a fatigue crack initiation site and lead to a premature failure of a component.

This research has focused on the binary titanium - nitrogen system and the interaction between molten titanium and porosity in hard-alpha inclusions during early stages of their removal process. A comprehensive suite of characterization methods has been employed to characterize changes in these materials following experiments. These methods include optical imaging, electron probe microanalysis (EPMA), wavelength dispersive X-ray analysis (WDX), energy dispersive X-ray analysis (EDX), electron backscatter diffraction (EBSD), and X-ray microtomography (XMT). These complementary characterization techniques have provided unprecedented insight into the titanium-nitrogen system and molten titanium's infiltration kinetics.

P2-2: Seeing Crystallographic Defects in a Scanning Electron Microscope

Presenter: Muhammad Haroon Qaiser (PhD, UBCV MTRL); Supervisor: Dr. Ben Britton

Electron channelling contrast imaging (ECCI) is a scanning electron microscopy (SEM) based technique for imaging crystallographic defects that includes dislocations, stacking faults, and low-angle grain boundaries. Unlike transmission electron microscopy (TEM), which requires thin, difficult-to-prepare lamellae, SEM-based ECCI can map defects across large areas directly in bulk samples with spatial resolution down to < 4 nm. ECCI produces contrast by exploiting electron channelling in the crystal lattice: with careful alignment of beam and sample, imperfections appear as contrast features against the crystal background. This poster introduces the principles of ECCI and highlights its application to defect analysis with case studies on natural olivine material and GaAs thin films, demonstrating how ECCI aid our characterization of defects and microstructure in materials.

P2-3: Critical Metal Enrichment by Post-Emplacement Deformation of Sulphides in Northern BC

Presenter: Victoria Scoging (PhD, UBCO); Supervisor: Dr. Renelle Dubosq

The enrichment of critical metals in sulphide minerals has been linked to deformation-induced remobilization within crystal defects. This process occurs in pyrite (FeS_2), one of the most economically significant sulphides, yet the specific mechanisms by which metals segregate to these defects remain poorly understood. Herein, we investigate pyrite from the NW Zone, a Au-Ag deposit, located in the Golden Triangle, northern British Columbia. The NW Zone juxtaposes the McLymont fault, which may have driven post-emplacement deformation and subsequent remobilization of critical metals. To test this, we combined a suite of material characterization techniques on sampled pyrite. Optical microscopy and micro-X-ray fluorescence (μXRF) helped identify the types and relative timing of sulphides within mineralized veins suggesting six distinct fluid events, three of which produced sulphide minerals, particularly pyrite. Backscattered electron (BSE) revealed orientation contrast within pyrite grains that were further characterized via electron backscatter diffraction (EBSD). EBSD maps indicate that deformation was dominated by brittle microfracturing, locally accommodated by minor crystal plasticity, as evidenced by misorientation gradients and low-angle grain boundaries. These defects may have acted as traps for trace metals. Future work will involve higher-resolution characterization of high strain regions in pyrite using electron channelling contrast imaging (ECCI) and geochemical mapping of critical metals via laser ablation inductively coupled plasma mass spectrometry (LA-IC-PMS). Atom probe tomography (APT) to quantify trace element distributions in 3D at the atomic scale and determine diffusion mechanisms.This study will refine sulphide remobilization models, with implications for less invasive exploration strategies and improved metallurgical recovery.

P2-4: Positive Feedback: Cataclasis and Interface-Coupled Reactions in Ultracataclastic Veins Hosted in the Naxos Granodiorite, Greece

Presenter: Olivia Rolfe (PhD, UBCO); Supervisor: Dr. Renelle Dubosq

Ultracataclastic and pseudotachylytic veins are interpreted as direct evidence of coseismic slip, reflecting the conditions and mechanisms associated with fault rupture. Although the Naxos granodiorite, Greece, is known for its pristine exposure of seismic structures, these features remain largely understudied in terms of their microstructural evolution and implications for mid-crustal seismicity. Herein, we examine a suite of well-preserved ultracataclastic veins sampled from the immediate footwall of the fluid-rich Naxos-Paros Detachment System (NPDS). The NDPS is a tectonic scale extensional fault active between c. 12-9 Ma, that accommodated > 80 km of displacement. The veins possess a similar composition as the surrounding host rock of primarily albite ($NaAlSi_3O_8$), quartz (SiO_2), orthoclase ($KAlSi_3O_8$), and biotite ($K(Mg, Fe)_3AlSi_3O_{10}(F, OH)_2$). Electron backscatter diffraction mapping of host rock porphyroclasts of albite, orthoclase, and quartz crosscut by ultracataclastic veins demonstrates that cataclasis is the dominant deformation mechanism. Variations in microstructural maturity of vein fragments suggest episodic emplacement, with rupture exploiting pre-existing slip planes. Cuspate phase boundaries between orthoclase and albite, initially observed in optical and scanning electron microscopy, are confirmed by electron microprobe analyses as a result from dissolution-precipitation reactions. These features indicate deformation by dissolution-precipitation creep. The results suggest that fluid-mediated reactions localized at vein tips contributed to weakening, generating a mechanical-chemical feedback loop that promoted ultracataclastic vein propagation along the detachment. Transmission electron microscopy will be employed to clarify the presence of melt-origin structures in the fault rocks and refine the emplacement model.

P3-1: Characterizing Imbibition in the Fibre Walls of Paper

Presenter: Sam Brown (PhD, UBCV CHBE); Supervisor: Dr. Mark Martinez

Wicking in hierarchical porous materials like paper is governed by microscale mechanisms that are not yet fully understood. While classical models, such as the Bell-Cameron-Lucas-Washburn equation, predict imbibition speed based on capillary radius, unexpectedly rapid flow has been observed through the relatively small pores of cellulose fibre walls, despite their relatively high resistance. However, the specific dynamics of this flow remain unclear, and the additional driving force required to overcome the resistance remains unidentified. We investigate axial flow through these fibre wall pores in a multiscale study. We used a variety of characterization tools, including X-ray imaging and fluorescence microscopy, to analyze this process. To identify the cause of the enhanced flow rate, we conducted experiments on chemically-modified samples and developed mechanistic mathematical models to illustrate our findings.

P3-2: Revealing the Internal Distribution of Cellulosic Fibers in Bioproducts via Labeling for X-Ray Tomography

Presenter: Anderson Thiago Vasconcelos Veiga (PhD, UBCV CHBE); Supervisor: Dr. Emily Cranston

Advanced imaging characterization methods are essential for expanding the use of cellulosic fibers and optimizing their performance in composites, packaging, bioproducts and paper-based applications. X-ray tomography enables three-dimensional visualization of cellulosic fiber networks at the micro- and nanoscale, allowing for an advanced understanding of structure-property relationships in cellulosic-based products. However, distinguishing specific types of cellulosic material in carbon-based matrices, such as pulp blends and the role of microfibrillated cellulose in paper, requires labeling with materials possessing higher X-ray attenuation. Recently, we developed a method for labeling pulp fibers and examined their efficiency for a variety of types of fibers and morphology. This method involves the in situ deposition of iron oxide nanoparticles from iron salts and immersing the material in oil. In the current study, we have investigated a "universal" labeling and imaging protocol that enhances contrasts across diverse cellulosic materials. This method facilitates the visualization of cellulosic fibers in various bioproducts, such as reinforced polymeric matrices and paper, and expands the use of X-ray tomography in the development of cellulose-based materials.

P3-3: Plastic-Binding Peptides for Microplastic Detection in Water Using a UV-LED Activated Sensor

Presenter: AnnaMaria Zubieta (MASc, UBCV CHBE); Supervisor: Dr. Fariborz Taghipour

Microplastics (MP) are emerging environmental contaminants that have been widely observed in many natural water systems. The toxicity of MP is a concern, as those approaching the nanoscale can enter cells and disrupt cellular functions. MP identification can improve our understanding of where microplastic pollution is most abundant, which can inform regulatory and policy decisions. In particular, remote areas without access to advanced sensing and characterization methods are often at risk of higher MP levels and therefore require frequent monitoring techniques. However, the small size and polymeric nature of MP hinder their differentiation from natural organic matter in complex water matrices, making identification challenging. Currently, most analyses rely on spectroscopy and spectrometry methods, with no robust portable method available. These methods are time consuming, expensive, and depend on spectrum matching to databases that are often unreliable for such complex water samples. Therefore, there is a need for a portable, rapid sensor for the on-site detection of MP.

Our work develops a sensing technique using plastic-binding peptides and UV-LED activation for MP identification in natural waters. The sensor uses quantum dots (QD), whose rapid fluorescence quench in the presence of MP can be used to determine MP concentration. The use of plastic-binding peptides boosts sensor selectivity by ensuring only MP contribute to QD quenching. To verify peptide-MP interactions, fluorometry, fluorescence microscopy, and Scanning Electron Microscopy (SEM) are used. Results of MP sensing in pure, tap, and synthetic samples are presented, and advantages and limitations of this technique are discussed.

P3-4: Fluorescence-Based Monitoring of Organic Matter in Solid and Liquid Phases for Gravity-driven Membrane Applications

Presenter: Nurul Shishir (PhD, UBCV CVL); Supervisor: Dr. Pierre Berube

The performance of gravity-driven membrane (GDM) systems is strongly influenced by the composition of organic matter in the biofilm layer, with proteinaceous material (PN) exerting the greatest impact on permeability. Seasonal variability in temperature-corrected permeability has been hypothesized to arise from fluctuations in PN content, underscoring the need for reliable in situ characterization tools. Solid-phase excitation–emission matrix (SP-EEM) spectroscopy offers a promising approach for monitoring biofilm components directly on membrane surfaces. However, the absence of standardized protocols and the complexity of interpreting spectra in mixed organic matrices remain key challenges. This study investigated the fluorescence characteristics of PN and polysaccharides (PS) in different states and combinations, using bovine serum albumin (BSA) and gluconic acid (GLA) as representative model compounds. A factorial experimental design considered powders at varying hydration levels, aqueous solutions, and foulant layers formed on polyvinylidene fluoride (PVDF) membranes during filtration. Results showed that hydration significantly altered PN spectra: dry powders displayed dual peaks, while slurries and liquid samples exhibited a single peak. On the membrane surface, BSA alone generated weak signals, but BSA–GLA mixtures produced strong dual-peak spectra, resembling dry powders. These findings suggest that EEM spectroscopy can differentiate hydration states of proteins and detect PN–PS interactions within foulant layers. The work highlights the potential of SP-EEM as a qualitative diagnostic tool for monitoring biofilm composition in GDM systems, while also identifying the need for future studies on fluorescence quenching effects of natural organic matter such as humic acids.

P4-1: Volume Electron Microscopy at the UBC BioImaging Facility: Focused Ion Beam Scanning Electron Microscopy (FIB-SEM) Applications in Materials and Biological Sciences

Presenter: Reilly Perovich (MSc, BIF Technical Staff; UBCV Botany, BIF); Supervisors: Dr. Lacey Samuels (thesis), Dr. Miki Fujita (BIF)

Focused Ion Beam (FIB) - Scanning Electron Microscopy (SEM) is a powerful destructive volume electron microscopy (vEM) technique that enables users to visualize both material and biological samples to an isotropic resolution of ~4 nm in volumes ~ < 100,000 μm^3, while maintaining adequate signal-to-noise ratios for downstream 3D modelling from current sample preparation methods. Thus, it provides TEM-like resolution at volumes only matched by serial block face SEM or colossal serial section TEM efforts. At the UBC BioImaging Facility, we reliably visualize samples at 4-4.5 nm resolutions with volumes up to ~ 50,000 μm^3 over weekends with ~ < 8 hours of in-person microscope use. BIF is currently operating FIB-SEM for room temperature resin-embedded samples, along with a gas injection system to constructively add to samples, an Energy Dispersive X-ray (EDX) for elemental analysis, and a micromanipulator for lamella lift out. Datasets can be analyzed within the Atlas5 software as vEM industry standard formats (.MRC) or processed downstream by Dragonfly 3D. Standard workflows for deep learning AI segmentation of materials and high contrast biological samples have been established in the BIF, allowing for guidance of user-segmented data, full pipeline training, or exploratory modelling as a service. The Samuels Lab has established efficient workflows for high-pressure frozen and freeze-substituted biological samples, pressing the envelope of both resolution and some of the largest volumes of FIB-SEM conducted within Archaeplastida to date. Such datasets have elucidated the cellular biology facilitating secondary cell wall thickening in Arabidopsis and secondary metabolite trafficking in Cannabis glandular trichomes.