



THE UNIVERSITY OF BRITISH COLUMBIA

Characterization @ UBC
Research Excellence Cluster

October 20-22, 2026

UBC Vancouver

PROGRAM BOOKLET

Characterization @ UBC Fall School

characterization.ubc.ca



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Day 1 - Tuesday, October 20

Theme: Introduction to Characterization

8:00 - 8:30 am	<i>Registration + Breakfast</i>
8:30 - 9:30 am	Lecture I - Introduction to Scanning Electron Microscopy Dr. Ben Britton (UBCV)
9:30 - 10:30 am	Lecture II - From X-rays to Chemistry: An Introduction to Quantitative Microanalysis Dr. Anette von der Handt (UBCV)
10:30 - 11:00 am	<i>Break</i>
11:00 - 12:00 pm	Lecture III - Transmitted Light, Fluorescence, Confocal and Advanced Fluorescence Microscopy Techniques Dr. Miki Fujita (UBCV)
12:00 - 1:00 pm	<i>Lunch</i>
1:00 - 2:00 pm	Lecture IV - Introduction to Micro-CT James Drummond (UBCV)
2:00 - 3:00 pm	Lecture V - Powder X-ray Diffraction Dr. Cole Mauws (UBCV)
3:00 - 3:30 pm	<i>Break</i>
3:30 - 5:00 pm	Lecture VI - Scanning Transmission Electron Microscopy: Methods and Applications Dr. Ismail El Baggari (UBCV)

Day 2 - Wednesday, October 21

Theme: Analysis & Applications

8:00 - 8:30 am	<i>Registration + Breakfast</i>
8:30 - 9:30 am	Plenary I - Solar System Exploration Through Coordinated Micro & Nanoanalysis Dr. Rhonda Stroud (ASU)
9:30 - 10:00 am	Welcome Remarks Dr. Mark MacLachlan (UBCV)
10:00 - 10:30 am	<i>Break</i>
10:30 - 12:00 pm	Trainee's Oral Talks
12:00 - 1:00 pm	<i>Lunch</i>
1:00 - 2:30 pm	Introduction to Electron Backscatter Diffraction (EBSD) Dr. Ben Britton (UBCV); Introduction to Focused Ion Beams Dr. Ruth Birch (UBCV); Characterizing Biological Samples In Situ Using Cryo-FIB and Electron Tomography Dr. Claire Atkinson (UBCV)
2:30 - 3:30 pm	<i>Poster session</i>
3:30 - 5:00 pm	Elemental Analysis by Laser-induced Breakdown Spectroscopy (LIBS) Dr. Cassady Harraden (UBCV); Atom Probe Tomography: Visualizing Materials at the Atomic Scale Dr. Renelle Dubosq (UBCO); ICP Spectrometry: Trace Element Characterization by Light, Mass and Time Dr. Mark Button (UBCO)

Day 3 - Thursday, October 22

Theme: New & Emerging Techniques

8:00 - 9:00 am

Registration + Breakfast

9:00 - 10:00 am

**Plenary II - Atomic Scale Understanding of
Material Synthesis and Degradation
Mechanisms: Two Sides of the Same Coin |**
Dr. Arun Devaraj (PNNL)

10:00 - 10:30 am

Break

10:30 - 12:00 pm

**Advances In STEM: From Imaging Atoms to
Multidimensional Information |**
Dr. Natalie Hamada (CCEM);
High Resolution Imaging Mass Spectrometry |
Dr. Jeremy Bougoure (PNNL);
NMR: From Basic Principles to Applications |
Dr. Suzana Straus (UBCV)

12:00 - 1:30 pm

Lunch + Poster Session

1:30 - 3:00 pm

**Seeing Is Believing: Cathodoluminescence (CL)
Imaging of Non-Metals |**
Dr. Brendan Dyck (UBCO);
Advances in Atom Probe Tomography |
Dr. Aparna Saksena (MPIE);
Multiscale Investigations of Battery Materials |
Dr. Yug Joshi (MPIE)

3:00 - 3:30 pm

Break

3:30 - 4:30 pm

Closing + Awards

Lab Tours

As part of this Fall School, we offer three lab tours sessions for trainees to participate in. Registration is required for these lab tours.

**Mon, Oct 19,
10-11.30 am**

Biolmaging facility (BIF), Center for High-Throughput Phenogenomics (CHTP)

**Mon, Oct 19,
5-6 pm**

Electron Microbeam & X-ray Diffraction Facility (EMXDF), Pacific Centre for Isotopic and Geochemical Research (PCIGR)

**Tues, Oct 20,
5-7 pm**

Materials Eng & Brimacombe Electron Microscopy Lab (EM Lab), Quantum Materials Electron Microscopy Centre (QMEMC)

Talk Abstracts - Day 1

*Session Chair: Dr. Renelle Dubosq
(UBCO Earth & Environmental Sciences)*

Lecture I - Introduction to Scanning Electron Microscopy | Dr. Ben Britton (UBCV)

Scanning electron microscopy (SEM) is a versatile materials-characterization technique that enables imaging and localized analysis across a broad range of length scales, from macroscopic features to nanoscale microstructural detail. It provides complementary information to optical microscopy, X-ray diffraction (XRD), transmission electron microscopy (TEM), and other analytical electron-microscopy methods by linking microstructural morphology, composition, crystallography, and functional response at specific locations within a specimen.

This lecture introduces the role of SEM within the wider materials-characterization toolbox and develops the conceptual foundation needed to select, acquire, and interpret SEM data effectively. Topics include SEM instrument architecture and operating principles; the electron source, column, specimen chamber, and detector systems; image formation and contrast mechanisms; resolution and its practical limitations; and the principal interactions between an incident electron beam and matter.

These electron-matter interactions underpin a range of SEM-based imaging and analytical methods. The lecture will cover secondary-electron and backscattered-electron imaging; electron-channeling contrast and diffraction, including electron-channeling contrast imaging (ECCI) and electron backscatter diffraction (EBSD); characteristic X-ray generation and elemental analysis; scanning transmission electron microscopy in the SEM (STEM-in-SEM); cathodoluminescence; and electron-beam-induced current (EBIC). Illustrative examples will demonstrate how detector selection, accelerating voltage, probe current, working distance, specimen geometry, and material properties influence the information obtained.

To aid users, the lecture will also introduce specimen requirements and practical preparation considerations, including surface finish, cleanliness, conductivity, charging, coating, and beam sensitivity and ultimately help users design effective SEM experiments and recognize common imaging and analytical artefacts. By the end of the lecture, participants will be able to connect SEM operating conditions and signal-generation mechanisms to the microstructural, compositional, crystallographic, and functional information required to address a given materials problem.

Talk Abstracts - Day 1

*Session Chair: Dr. Renelle Dubosq
(UBCO Earth & Environmental Sciences)*

Lecture II - From X-rays to Chemistry: An Introduction to Quantitative Microanalysis | Dr. Anette von der Handt (UBCV)

Electron microscopy and microanalysis are fundamental tools for characterizing minerals, metals, ceramics, and many other materials. While electron microscopy can reveal microstructures and show where different elements occur within a material, accurately determining how much of each element is present requires a quantitative approach to X-ray microanalysis. This presentation introduces the fundamental principles of quantitative chemical analysis using energy-dispersive (EDS) and wavelength-dispersive X-ray spectrometry (WDS) in the scanning electron microscope (SEM) and electron probe microanalyzer (EPMA).

The talk will introduce the roles of standards, matrix corrections, analytical conditions, counting statistics, detection limits, and quality control. Examples will illustrate the complementary strengths of SEM-EDS and EPMA-WDS, common analytical challenges, and how sample preparation and experimental choices affect accuracy, precision, and spatial resolution.

Session Chair: Dr. Anette von der Handt (UBCV EOAS)

Lecture III - Transmitted Light, Fluorescence, Confocal and Advanced Fluorescence Microscopy Techniques | Dr. Miki Fujita (UBCV)

EThis lecture covers the principles and applications of optical microscopy, including transmitted light, fluorescence, confocal and advanced fluorescence microscopy techniques. By the end of the lecture, attendees will be able to evaluate principles and applications of various optical microscopy techniques, and select appropriate microscopy techniques and equipment based on the nature of the research inquiry.

Talk Abstracts - Day 1

Session Chair: Dr. Mark Martinez (UBCV CHBE)

Lecture IV - Introduction to Micro-CT | James Drummond (UBCV)

Micro-CT, or Micro-Computed Tomography, is an X-ray-based imaging technology that can provide non-destructive 2D and 3D interior views of a range of materials at micrometer, or sub-micrometer-level resolution. The principles of Micro-CT will be discussed, along with applications and challenges, and general sample considerations, as well as data processing. UBC's Micro-CT capabilities will be discussed, and examples of materials scanned will be shown.

Lecture V - Powder X-ray Diffraction | Dr. Cole Mauws (UBCV)

Powder x-ray diffraction is a method for elucidating the crystal structures of materials. The various applications of pXRD can give a wide variety of information on the chemical, physical and morphological properties of materials, and some variations of pXRD are used in any discipline of materials science. We will give a brief overview of the fundamentals of powder x-ray diffraction and its various applications. Then we will take a focused look at the methods for quantitative phase analysis. There are a variety of quantitative methods using calibrant and calibration-free methods. It is worth discussing the advantages and pitfalls of the various methods, but we will focus on the application of the most robust method – Rietveld full pattern decomposition with examples from geological samples.

Session Chair: Dr. Ben Britton (UBCV MTRL)

Lecture VI - Scanning Transmission Electron Microscopy: Methods and Applications | Dr. Ismail El Baggari (UBCV)

Scanning transmission electron microscopy (STEM) enables measurements of structure and chemistry at the atomic scale. This talk introduction will cover the basic principles of STEM imaging and spectroscopy, with an emphasis on understanding image contrast, interpreting experimental data, and data analysis for mapping local strain and order in materials. Examples from materials science will illustrate how these methods reveal defects, interfaces, and nanoscale ordering.

Talk Abstracts - Day 2

Session Chair: Dr. Ben Britton (UBCV MTRL)

Plenary I - Solar System Exploration Through Coordinated Micro & Nanoanalysis | Dr. Rhonda Stroud (ASU)

The Earth, the Moon, comets and asteroids were built from recycled microscopic bits of dust and ice from stars older than our Solar System. The cosmic recycling process of making new solar systems out of old stardust mostly erases the signatures of pre-solar origins, but a few bona fide stardust grains survive and can be recognized through micro-to-nanoscale analysis of astromaterials. Coordinated microanalysis, with electron, x-ray and ion beams of returned samples from the Moon, comets and asteroids allows us to better understand the cosmic recycling process and explore the history of materials across our solar system.

Session Chair: Dr. Mark Martinez (UBCV CHBE)

Session I - Introduction to Electron Backscatter Diffraction (EBSD) | Dr. Ben Britton (UBCV)

Electron backscatter diffraction (EBSD) is a scanning electron microscopy (SEM)-based technique that provides spatially resolved crystallographic information from crystalline materials. It is widely used to characterize microstructure by mapping crystal orientation, phase distribution, grain morphology, grain-boundary character, crystallographic texture, and local orientation variations associated with deformation or strain.

EBSD acquires and indexes electron backscatter patterns (EBSPs, or Kikuchi patterns) as the electron beam is scanned across a suitably prepared specimen. It can be combined with energy-dispersive X-ray spectroscopy (EDS) to improve phase identification and with focused ion beam (FIB) serial sectioning for three-dimensional EBSD tomography. This lecture introduces the principles and practical use of EBSD through case studies in natural and engineered materials. Topics include Kikuchi-pattern formation, automated indexing, SEM-EBSD geometry, specimen preparation, and common EBSD datasets, including phase, orientation, pattern-quality, grain, and grain-boundary maps. These data will be used to illustrate quantitative measurements of grain size, phase fraction, boundary character, local misorientation, and crystallographic texture.

By the end of the lecture, participants will be able to acquire, interpret, and critically assess EBSD data within a broader materials-characterization workflow.

Talk Abstracts - Day 2

Session I - Introduction to Focused Ion Beams | Dr. Ruth Birch (UBCV)

Similar to a scanning electron microscope (SEM), it is possible to form a focussed ion beam (FIB) and scan it across surface. Repeat scanning of this beam across the surface can be used to remove localized regions, for example to perform sample preparation (e.g. for TEM-lamella), cross-section analysis, or repeat layer removal combined with scanning electron microscopy-based imaging of the newly revealed layer to perform (destructive) 3D tomography. In this talk, I will introduce the FIB, how it works, and common uses, including the use of Ga⁺ and Xe⁺ ions, and accessories such as gas injection systems and nanomanipulators. This will then be followed by more in-depth discussion on two applications: tomography and (S)TEM lamella preparation. Finally, I will briefly introduce the FIB instruments available across the cluster.

Session I - Characterizing Biological Samples In Situ Using Cryo-FIB and Electron Tomography | Dr. Claire Atkinson (UBCV)

Cryo-electron microscopy can be used as a powerful technique to characterize biological samples in their biological context, without need for chemical fixation. Cryo-electron tomography (cryo-ET) is used to generate 3D volumes from biological samples, from which the structures of biological molecules can be determined. Cryo FIB milling can be used to thin biological samples to make them amenable to cryo-ET. The cryo-FIB/cryo-ET workflow will be discussed, along with considerations for selecting, milling and imaging appropriate targets. Bacterial secretion systems will be used as an example, including the structure of the Type III secretion system from E.coli determined by cryo-ET.

Session Chair: Dr. Anette von der Handt (UBCV EOAS)

Session II - Elemental Analysis by Laser-induced Breakdown Spectroscopy (LIBS) | Dr. Cassady Harraden (UBCV)

Laser-induced breakdown spectroscopy (LIBS) is an atomic emission method which can be used to rapidly assess chemistry. This method is capable of detecting most elements in the periodic table, including elements with low atomic numbers (e.g., Li, Na, and Mg) which are difficult to discriminate using other methods. The rastering capabilities of some systems can produce chemical maps which reflect chemical variability as well as textural and spatial relationships of materials in the analysis area. The theory behind the method, how data is interpreted into chemical information, and some common applications of the technique across science will be discussed. The presentation will include a live demonstration using a portable LIBS instrument to show the chemical mapping capabilities.

Talk Abstracts - Day 2

Session II - Atom Probe Tomography: Visualizing Materials at the Atomic Scale | Dr. Renelle Dubosq (UBCO)

Materials have complex structures spanning from the macroscopic scale down to the sub-nanometer scale. The distribution of elements within a material directly affects its physical and chemical properties. This concept applies to all solid materials, from engineering alloys to natural minerals. Thus, investigating structure-property relationships requires material characterization techniques capable of resolving sub-ppm composition at the near atomic scale. Atom probe tomography is one of the few techniques that can achieve this, providing three-dimensional compositional mapping with sub nanometer resolution. This presentation introduces the method, including sample preparation, the mechanisms of field evaporation, and the reconstruction and visualization of data, along with brief examples of applications across a range of materials.

Session II - ICP Spectrometry: Trace Element Characterization by Light, Mass and Time | Dr. Mark Button (UBCO)

Inductively coupled plasma (ICP) spectrometry provides several complementary approaches to determining the elemental and isotopic composition of materials. This presentation provides an overview of three ICP techniques available at the Fipke Laboratory for Trace Element Research at the University of British Columbia Okanagan: Inductively Coupled Plasma-Optical Emission Spectrometry (ICP-OES), ICP-Triple Quadrupole Mass Spectrometry (ICP-QQQ-MS) and ICP-Time of Flight-Mass Spectrometry (ICP-TOF-MS). The operating principles, strengths and limitations of each technique will be illustrated using examples covering routine elemental analysis, isotope-ratio measurements, geochronology and laser-ablation elemental mapping. Some novel applications for each technique will be highlighted, including reaction-cell mass-shift methods, in situ isotope-ratio analysis and rapid multi-element imaging.

Talk Abstracts - Day 3

Session Chair: Dr. Ismail El Baggari (UBCV PHAS; QMI)

Plenary II - Atomic Scale Understanding of Material Synthesis and Degradation Mechanisms: Two Sides of the Same Coin | Dr. Arun Devaraj (PNNL)

Materials scientists dream of pinpointing each atom's location to unlock how processing affects material properties. At the atomic scale, these insights can guide the development of processing strategies, including solid phase processing and additive manufacturing, and help reveal how materials change under corrosive environments, neutron irradiation, and hydrogen exposure. Such knowledge is vital to designing durable, high-performance materials for demanding applications, from fusion energy systems to space exploration. Because materials synthesis and degradation involve complex processes across many length scales, no single technique can provide a complete picture. A comprehensive understanding instead requires complementary in situ and ex situ characterization, computational modeling, and mechanical testing. Dr. Devaraj's team at Pacific Northwest National Laboratory combines advanced electron microscopy, in situ atom probe tomography, and synchrotron-based high-energy X-ray diffraction with predictive modeling to investigate these processes. This talk will present examples of how multimodal characterization can reveal the mechanisms governing both materials synthesis and degradation and show how those insights can inform the design of materials for extreme environments.

Session Chair: Dr. Anette von der Handt (UBCV EOAS)

Session I - Advances In STEM: From Imaging Atoms to Multidimensional Information | Dr. Natalie Hamada (CCEM)

A new era of scanning transmission electron microscopy (STEM) has moved beyond the direct imaging of atoms at sub-ångström resolution. New-generation hardware, including pixelated electron detectors and in situ holders, together with advances in computational methods for 4D-STEM, are enabling researchers to probe challenging materials under diverse experimental conditions. These developments are expanding the range of information that can be obtained with both aberration-corrected and uncorrected instruments.

This talk will highlight recent advances and their applications for investigating the structure, chemistry, and properties of materials, with the aim of inspiring new ways to apply STEM techniques to your research.

Talk Abstracts - Day 3

Session I - NanoSIMS - High Resolution Imaging Mass Spectrometry | Dr. Jeremy Bougoure (PNNL)

In this presentation, I intend to describe the NanoSIMS technique and discuss examples of its application in biological, environmental and materials applications. Briefly, nanoscale secondary ion mass spectrometry (NanoSIMS), extends secondary ion mass spectrometry analyzes to spatial resolutions below 100 nm while maintaining high sensitivity at high mass resolution (e.g., ppm sensitivity for isotopic imaging while resolving isobaric interferences). NanoSIMS can measure up to seven secondary ions in parallel, offering high-quality isotopic ratio imaging from the same small volume while maintaining perfect image superimposition. NanoSIMS can be used for enhanced, simultaneous, nanoscale imaging of elements/isotopes of inorganic and organic surfaces in environmental samples, sub-cellular structures, minerals, and a host of other solid samples.

Session I - NMR: From Basic Principles to Applications | Dr. Suzana Straus (UBCV)

This presentation will provide some introductory concepts on how NMR works and demonstrate some of the state-of-the-art applications in the areas of interest to the audience.

*Session Chair: Dr. Renelle Dubosq
(UBCO Earth & Environmental Sciences)*

Session II - Seeing Is Believing: Cathodoluminescence (CL) Imaging of Non-Metals | Dr. Brendan Dyck (UBCO)

Cathodoluminescence (CL) is the emission of light from a material under electron-beam excitation. It is widely used to reveal microstructure in geological materials, dielectrics and ceramics, which covers essentially any non-metal with an energy gap between its valence and conduction bands. CL is highly sensitive to two things: chemistry, especially trace-element activators and quenchers at ppm levels, and intrinsic lattice defects such as vacancies, broken bonds and radiation damage. As a result, CL routinely shows growth zoning, overgrowths, healed fractures and alteration microstructures that are invisible in optical or backscattered-electron images. In this talk I will introduce the physics of CL emission and the practicalities of CL imaging and spectroscopy, then look at what CL tells us about mineral microstructure, focusing on quartz and feldspars.

Talk Abstracts - Day 3

Session II - Advances in Atom Probe Tomography | Dr. Aparna Saksena (MPIE)

Understanding how light elements interact with materials remains a major challenge because their distribution can change rapidly during specimen preparation or exposure to ambient conditions. This is particularly critical at solid-liquid and gas-metal interfaces, where transient chemical states often control material performance but are difficult to preserve and characterize at the nanoscale.

My research develops and applies advanced atom probe tomography (APT), cryogenic specimen preparation, controlled gas charging, to access these otherwise elusive states. Cryogenic workflows provide a route to arrest reactions, preserve volatile or mobile species, and investigate their three-dimensional distribution with near-atomic scale. In this presentation, I will introduce how these approaches can be used to investigate hydrogen at defects and gas-metal interfaces, lithium redistribution in electrochemical materials, and frozen solid-liquid interfaces. Examples will illustrate both the opportunities and experimental challenges associated with detecting light elements by APT. Ultimately, these methods aim to connect local chemistry and microstructure with processes occurring under realistic reaction conditions, providing mechanistic insight for the design of materials for hydrogen and electrochemical technologies.

Session II - Multiscale Investigations of Battery Materials | Dr. Yug Joshi (MPIE)

Phase transformations and their propagation play a vital role in determining the performance of lithium-ion batteries. In this talk, we will examine different battery components from multiple perspectives.

First, at the macro scale, I will discuss diffusion phenomena in a cubic spinel LiMn_2O_4 using operando optical microscopy. This method enables the determination of concentration-dependent transport coefficients as well as activation energies.

Furthermore, the study highlights the interface-controlled growth of phases and its influence on other methods used to investigate transport coefficients.

Next, moving to the micrometer scale, with the aid of scanning electron microscopy, we investigate the spatial degradation of layered cathode materials using electron backscatter diffraction (EBSD) in a nickel-rich layered hexagonal system. By varying the grain size, we identify the underlying failure mechanisms and establish their correlation with the microstructure of the cathode active material.

Finally, at near-atomic-scale resolution, we introduce a protocol for investigating solid-state electrolytes using atom probe tomography and discuss the key effects of measurement conditions. This protocol will enable future studies of lithium cycling and its segregation at localized point defects, which can create hotspots for lithium dendrite growth.

Contributed Oral Abstracts

Session Chair: Dr. Ismail El Baggari (UBCV PHAS; QMI)

1. Clara Kramer (UBCV CHBE) - Understanding the Role of Cellulose Nanocrystals on Crystallization, Structure, and Performance in Biodegradable Polyester Composites

The use of biodegradable plastics has become increasingly important in consumer applications, with the most widely used commercial bioplastics being polybutylene adipate terephthalate (PBAT) and polylactic acid (PLA). However, the crystallization behavior of these polymers is complex to monitor and control, and their resulting crystal structures remain not fully understood, which limits both processing and end-use performance. Additives can be used to make the properties more comparable to those of conventional alternatives, while still achieving a biodegradable material. Cellulose nanocrystals (CNCs) offer a promising strategy to tailor the properties of these systems, as their high crystallinity and surface functionality can influence nucleation, crystal growth, and overall morphology, thereby affecting the thermal and mechanical properties of the composites. In this work, the effect of varying CNC concentrations on the crystallization behavior and performance of PBAT was investigated. Crystallization kinetics and thermal evolution were examined using detailed thermal characterization combined with advanced techniques such as small-angle X-ray scattering (SAXS), allowing comparison of crystallization behavior across various polymer systems and CNC loadings. In addition, tensile testing of PBAT-CNC composites was conducted to evaluate the relationship between crystallization behavior and resulting mechanical properties, enabling comparison of structure-property relationships within the system.

Contributed Oral Abstracts

2. Dwiti Mistry (UBCV CHEM) - Comparison of Plant Wax Secondary Alcohols

Cuticular waxes cover land plant surfaces and consist of various compounds. The secondary alcohol nonacosan-10-ol has been reported to form nanotube crystals lining surfaces of mosses, ferns, gymnosperms, and angiosperms and it has been implicated in the self-cleaning 'Lotus effect', though biosynthesis of cuticular secondary alcohols remains unknown. This study compared distantly related angiosperms with cuticular secondary alcohols. Analytical, thermal, and microscopy methods were used to investigate leaf wax compositions of Liliaceae, Cercidiphyllaceae, Caprifoliaceae, Rosaceae, Tropaeolaceae, and Anacardiaceae species, and nonacosan-10-ol tubules. Wax profiles from gas chromatography analysis with mass spectrometer and flame ionization detection showed secondary alcohols to be the dominating compound class for all species studied, with nonacosan-10-ol as the major compound and isomer. These secondary alcohols were found to be associated with alkanediols, and together, formed the tubules in scanning electron micrographs of the abaxial and adaxial leaf surfaces of all species. Isomer profiles of secondary alcohols revealed two distinct hydroxylation patterns supporting different biosynthesis pathways of production. Differential scanning calorimetry results demonstrated that plant secondary alcohols are biosynthesized with high enantiomeric purity. These results suggest that there is convergent evolution of formation of the same type of wax crystal through multiple biosynthesis pathways.

Contributed Oral Abstracts

3. Reilly Perovich (UBCV Botany) - vEM elucidates the cell biology underpinning the multi-billion-dollar Cannabis sativa medical and recreational markets by quantifying and visualizing glandular trichome plastid-endoplasmic reticulum membrane contact sites and the “ER-Highway” of cannabinoid trafficking

Cannabis sativa is legal in Canada, and Canadians spent over five and a half billion dollars on medicinal and recreational cannabis products¹, specifically the flowers that are covered with glandular trichomes². In the trichomes, the parent cannabinoid, cannabigerolic acid (CBGA), is trafficked from the plastid to the cell wall, where tetrahydrocannabinolic acid (THCA) is synthesized and stored in an extracellular storage cavity^{3–5}. THCA breaks down upon heating to form THC, the most notorious cannabinoid. The mechanism by which cannabinoid precursors are produced within the cellular structure of glandular trichome secretory disks is unknown. Previous TEM studies of high-pressure-frozen/freeze-substituted cannabis trichomes revealed non-photosynthetic plastids (leucoplasts) with unusual internal membrane cores and abundant interactions with the endoplasmic reticulum (ER)⁶. We hypothesize that CBGA is synthesized at plastid-ER contact sites and moves through ER membranes to the plasma membrane for export⁷. To test this “ER highway” hypothesis of cannabinoid trafficking, we used a combination of cryo-fixation⁸ and focused-ion-beam scanning-electron-microscopy (FIB-SEM) to image the 3D cellular structure of secretory disk cells of glandular trichomes. These 3D datasets allow quantification of organelle volume and interactions, demonstrating abundant ER contact sites with both plastids and the cell membrane. The FIB-SEM data also produce three-dimensional reconstructions of the cellular details, further supported by customized deep-learning AI models. Here for the first time, we detail the interconnectivity of ER-plastid, ER-mitochondria, and ER-plasma membrane, along with the highly branched and stromulated interconnected network of leucoplasts, and the total volume of the enigmatic yet poorly understood leucoplast paracrystalline cores, all within the glandular trichome, both qualitatively and quantitatively. Together, our vEM and 3D modelling work represent the largest-volume investigations into trichome cell biology in Cannabis and across Viridiplantae using cryo-fixed volume electron microscopy (vEM). Further, our novel deep learning models, based on a modified U-NET++ architecture, have enabled efficient, semi-automated segmentation of thousands of single-digit nanometre slices, paving the way for higher-throughput vEM explorations of Cannabis and vascular plant cell biology in the future.

Contributed Oral Abstracts

4. Olivia Rolfe (UBCO Earth & Environmental Sciences) - Applications of electron microscopy to investigate the mechanics of ancient earthquakes in the Okanagan Valley

Seismic activity can generate enough frictional heat to instantaneously melt rocks along a fault, producing veins made of dark glass. These structures act as a rare geological record of ancient earthquakes and the weakening mechanisms associated with fault rupture. Such a record is particularly valuable along the Okanagan Valley Shear Zone (OVSZ) of southern British Columbia, where ~90 km of extension was accommodated despite its mechanically unfavourable low-angle geometry. We combine scanning electron microscopy (SEM), energy-dispersive spectroscopy (EDS), and electron backscatter diffraction (EBSD) mapping of a glassy vein from the OVSZ to investigate the deformation mechanisms associated with strain localization and vein formation. SEM and EDS reveal a strongly foliated ultra-fine-grained vein matrix (between 0.5 μm –5 μm) rather than the amorphous composition expected of frictional melt material, indicating that these veins experienced extensive solid-state deformation. EBSD mapping of recrystallized quartz bands (grain diameters of between 10–120 μm) within the vein enables the differential stress associated with this solid-state deformation to be estimated from grain size and internal lattice distortion of the grains. Together, the microstructural observations and estimated stress magnitudes will resolve the emplacement and subsequent evolution of these glassy veins, providing insight into the conditions that facilitated slip along the OVSZ.

5. M. Haroon Qaiser (UBCV MTRL) - Dislocation analysis in a Scanning Electron Microscope using Electron Channeling Contrast Imaging (ECCI)

Electron Channeling Contrast Imaging (ECCI) is a scanning electron microscopy based technique that enables direct imaging of crystallographic defects in bulk crystalline materials. Unlike conventional transmission electron microscopy (TEM) approaches, ECCI allows defects to be investigated in relatively large bulk samples with minimal preparation, making it particularly attractive for studying natural and engineered materials. This short talk aims to introduce the principles of electron channeling, explain how Electron Channeling Patterns (ECPs) are used to achieve channeling conditions, and demonstrate how ECCI can be used to image crystallographic defects such as dislocations and stacking faults in research applications related with Earth Sciences and Materials Engineering.

Contributed Oral Abstracts

6. Nishan Sapkota (UBCV MECH) - Automated quantitative TEM image analysis of nanoparticle morphology using a deep learning workflow

Transmission electron microscopy (TEM) images provide direct information on nanoparticle morphology, but quantitative analysis remains labor-intensive, with image segmentation being particularly challenging for heterogeneous particles and complex grid backgrounds. Recent advances in machine learning have opened new opportunities for automated image processing. Here, we present a two-stage deep-learning technique combining You Only Look Once (YOLO) with Micro-Segment Anything Model (μ SAM) to address such challenges for TEM image analysis. YOLO identifies particle-containing regions of interest (ROIs) and classifies objects, after which μ SAM generates binary segmentation masks. An in-house morphology analysis toolbox then processes the segmented particles to extract particle size, shape, and morphology descriptors. The workflow is tested using nanoparticle aggregates and benchmarked against manual analysis. The segmentation achieved an intersection-over-union (IoU) score of 93%, while primary particle sizing showed a positive bias of around 15%. The extracted information is then used to determine morphology metrics, including fractal dimension and effective density, which are validated against in-situ measurements. Together, the workflow provides a novel end-to-end approach for extracting quantitative information on particle morphology from TEM images, reducing typical processing times from hours to a few minutes.

Contributed Oral Abstracts

7. Tianxiao Niu (UBCV PHAS) - Resolving the dispersion of a massless exciton in monolayer WSe₂ via q-EELS

At the atomically thin limit, transition-metal dichalcogenides (TMDs) host tightly bound excitons that are central to their optical responses. Due to two-dimensional Coulomb potential, some of these excitons are predicted to exhibit a rare non-analytic dispersion – their energy should increase linearly with momentum, fundamentally different from that of their massive constituent particles. Although crucial to the exciton valley dynamics and transport properties, such a dispersion has not been verified experimentally. In a Nion HERMES200 scanning transmission electron microscope (STEM) operated at 80 kV, we used momentum-resolved electron energy-loss spectroscopy (q-EELS) with an energy resolution ~ 20 meV and a momentum resolution ~ 0.006 Å⁻¹ to resolve the exciton dispersion in monolayer WSe₂. We find that a massless exciton branch exists near the Brillouin zone center, with the transition between linear and parabolic dispersions clearly observed. We discover that the dielectric environment can drastically renormalize the linear dispersion slope, i.e. the exciton's group velocity, by screening the repulsive exchange interaction. These findings highlight the potential for controlling light-like excitons in 2D semiconductors for integrated photonic applications.

8. Graeme Francolini (UBCV MTRL) - Developing a 3D Multi-Modal Analysis System using Scanning Electron Microscopy, Robotics, and Metallographic Polishing

Understanding the three-dimensional microstructure of materials is vitally important when developing and improving modern alloyed parts, increasingly so with the advancement of additive manufacturing techniques. Techniques such as Transmission electron microscopy (TEM), Scanning Electron Microscopy (SEM), and X-ray based tomography can be used to study the 3D microstructure of materials. The accessible volume (mm³) and limit of identification (μm³) of SEM-based methods sits between X-ray and TEM, providing a good middle ground for microstructural analysis. The system presented here aims to use this middle ground to perform even larger volume microstructural analysis using mechanical serial sectioning and SEM, Electron Backscatter Diffraction (EBSD), and Energy Dispersive X-ray Spectroscopy (EDS/EDX) for multi-modal characterization of samples. Repetitive serial sectioning is enabled through a modified off the shelf semi-automatic polishing system and custom developed cleaning, drying, and optical microscope inspection stations, with all sample transfers performed automatically using a 6 degree-of-freedom robotic arm. The completion of this system aims to allow for automated collection and reconstruction of microstructural and crystallographic information, chemical composition, and defect presence within 5x5x1 mm³ sample volumes.

Speaker Bios

The speakers are listed in alphabetical order by first name.



Dr. Anette von der Handt is a Scientific and Business Development Director in the Department of Earth, Ocean and Atmospheric Sciences, where she oversees the electron microprobe (EPMA) and scanning electron microscope (SEM) facilities in the EMXDF lab. With over 15 years of experience in microanalysis and a background in geology, she develops and applies advanced EPMA techniques for scientific and industrial applications, including ultralight element analysis, analysis of beam-sensitive materials, and quantitative X-ray mapping. She has managed microbeam labs in both Canada and the U.S. and supports collaborative research and training across disciplines. She is an active council member of the Microanalysis Society and is part of the management team of the Characterization @ UBC GCRC cluster.

Dr. Aparna Saksena is a Group Leader at the Max Planck Institute for Sustainable Materials in Düsseldorf, where she leads research in atom probe tomography and hydrogen-materials interactions. Her work focuses on how defects, interfaces, local chemistry, and microstructure govern the behavior of functional and structural materials. She combines material synthesis, microstructural engineering, atom probe tomography, electron microscopy, hydrogen/deuterium-sensitive characterization, and operando electrochemistry to study materials for hydrogen production and hydrogen-compatible infrastructure. Her current research spans electrocatalytic materials, hydrogen trapping and transport in structural materials, nanoporous materials, and dynamic interfaces under operating conditions. She obtained her Dr.-Ing. in Materials Science from RWTH Aachen University in 2020.



Speaker Bios



Dr. Arun Devaraj is Chief Scientist in PNNL's Integrated Discovery Sciences Directorate and leads PNNL's cross-directorate Laboratory Objective on Programmable Resilient Materials for Coupled Extremes. He has discovered principles guiding the mechanisms of non-equilibrium behavior and metastable phase transformations in alloys used for structural and nuclear applications, leading to better understanding of the microstructural control critical to establishing novel processing-microstructure-property relationships. He is also recognized for expanding atom probe tomography (APT) across alloys, batteries, catalysts, and biomaterials, and for correlating APT with electron microscopy and synchrotron X-ray methods. He is a DOE Basic Energy Sciences (BES) Early Career Awardee (2020), co-PI on a DOE BES core program, and co-director of the BES Microelectronics Science Research Center project, Accelerating Next-Generation UV Lithography (ANGEL). He has served as PI for NNSA Tritium Science Program projects for the past decade and is a co-PI leading advanced microstructural characterization for DOE vehicle-technology materials-development programs. He has authored more than 170 peer-reviewed publications and serves in international leadership roles, including as a Conference Chair for the 2026 MRS Fall Meeting, former Vice President of the International Field Emission Society, former Chair of the TMS Shaping and Forming Committee, and editorial roles with npj Materials Degradation, Microscopy and Microanalysis, and PLOS ONE.

Dr. Ben Britton is a Professor in the Department of Materials Engineering at the University of British Columbia and the Tier 1 Canada Research Chair in Multiscale Correlative Electron Microscopy. He leads the Experimental Micromechanics and Characterization Group and provides academic leadership for UBC's Electron Microscopy Laboratory and the Characterization@UBC research cluster. His research develops and applies advanced electron microscopy and microanalysis methods to understand the microstructure, deformation, and performance of engineering materials, particularly metals and ceramics used in transport, energy, manufacturing, and electronic applications. His expertise includes scanning electron microscopy, electron backscatter diffraction (EBSD), electron-channeling contrast imaging (ECCI), scanning transmission electron microscopy (STEM), analytical electron microscopy, high-resolution and three-dimensional electron microscopy and focussed ion beam machining, in situ mechanical and thermal experiments, and correlative microscopy workflows that connect electron microscopy-based observations to complementary characterization techniques.



Speaker Bios



Dr. Brendan Van Dyck is an Associate Professor in Earth and Environmental Sciences at the University of British Columbia, Okanagan. His research looks at how tectonic and metamorphic processes shape the evolution of planetary crust. A common thread is using e-beam microstructural techniques, especially electron backscatter diffraction (EBSD) and cathodoluminescence, to study mineral self-organisation processes. Brendan received his PhD from the University of Oxford and held a fellowship and faculty position at the University of Cambridge and Simon Fraser University before joining the FILTER lab at UBC Okanagan in 2021.

Dr. Cassady Harraden is an Assistant Professor in the Department of Earth, Ocean, and Atmospheric Sciences at the University of British Columbia in Vancouver, BC. Her research focuses on critical minerals, data fusion, applied mineralogy, and interdisciplinary orebody knowledge, with an emphasis on integrating analytical and core sensing technologies to improve how we explore for and extract mineral resources. Prior to her faculty appointment, Cassady completed postdoctoral research focused on porphyry exploration and vectoring in British Columbia, with a particular emphasis on mineralogy and mineral chemistry derived from LIBS data. In 2018, she earned her PhD in geometallurgy from the CODES research group at the University of Tasmania, where she developed methods for geotechnical rock mass and grain size assessment using multi-sensor core sensing systems and a variety of microanalytical techniques.



Dr. Claire Atkinson is the operational manager for the facility for high resolution macromolecular cryo-electron microscopy, located in the life sciences centre. She received her PhD from Rockefeller university, and did post-doctoral work at the University of Chicago before coming to UBC in 2017.

Speaker Bios



Dr. Cole Mauws obtained a BSc. in chemistry from the University of Winnipeg. He studied frustrated magnetism in charge disordered materials for his PhD in chemistry at the University of Manitoba. He was a postdoctoral researcher in condensed matter physics at the University of Oxford. He is now a Sr. Research Scientist managing X-ray diffraction in the Electron Microbeam and X-ray Diffraction Facility (EMXDF) in Earth Ocean and Atmospheric Science at the University of British Columbia.

Dr. Ismail El Baggari is an Assistant Professor in Physics & Astronomy and Principal Investigator at the Quantum Matter Institute at UBC. He received his PhD in Physics from Cornell University and previously led an independent research group at the Rowland Institute at Harvard. His research focuses on the development and application of in situ cryogenic electron microscopy for imaging quantum materials and devices at the atomic scale. El Baggari is a member and part of the management team of the Characterization@UBC Cluster.



James Drummond graduated from UBC a long time ago, with a B.Sc. in Wood Science. He gained many years of experience as a technologist in light and scanning electron microscopy at the Pulp and Paper Research Institute of Canada (now FPInnovations), imaging lignocellulosic materials, fibres and fibre products, composites, and cellulosic nanomaterials. He has been a microscopy technician at the

Pulp and Paper Centre, working with Mark Martinez, since fall 2020. At UBC, his primary role is operation of, and protocol development for, the Zeiss Xradia 520 Versa X-ray microtomograph. When James is not in the lab, you will find him wandering around outside with a camera in his hand—images are a big part of his life.

Dr. Jeremy Bougoure is an analytical chemist with the Rhizosphere Function Integrated Research Platform. He has extensive experience in the application of high-resolution nanoscale secondary ion mass spectrometry (nanoSIMS) to investigate nano/microscale processes in biological systems. His primary interest is understanding plant-microbe-soil interactions, but he has successfully employed nanoSIMS analysis in numerous other scientific disciplines. The application of nanoSIMS to specific research has three phases: sample preparation, analysis, and interpretation/display of results. He strives to optimize these three pillars for user projects to generate best possible outcomes.



Speaker Bios



Dr. Mark Button is the ICP Spectrometry Lab Manager and Research Scientist at the Fipke Laboratory for Trace Element Research (FiLTER) at UBC's Okanagan campus. He oversees the laboratory's ICP analytical facilities and supports researchers and students in developing methods for elemental, isotopic and spatially resolved analysis. His work includes instrument operation, method development, training and the application of laser-ablation ICP-MS to trace-element geochemistry, radiogenic isotope systems and materials characterization. Originally from Nottingham in the UK, Dr. Button earned his PhD in Geochemistry and Environmental Toxicology from the University of Leicester/British Geological Survey and he enjoys rock climbing in his spare time.

Dr. Miki Fujita is a Research manager at the UBC Bioimaging facility. Her responsibilities include providing expert consultation on imaging experiments and techniques, organizing workshops and equipment demonstrations with vendors, overseeing equipment purchases, assisting with grant writing, and coordinating the monthly seminar series, "Focus on Scientific Imaging." She meets every new user to discuss how BIF can help their project and works with staff to ensure users are comfortable using the equipment after completing the training. Throughout her research career, she has received invaluable microscopy training at the UBC Bioimaging facility and the Australian National University. To share her experience of troubleshooting and exploring various imaging tools, she began organizing imaging workshops, which became a microscopy course she taught to undergraduate and graduate students over the past decade.



Dr. Natalie Hamada is a Research Scientist at the Canadian Centre for Electron Microscopy at McMaster University, specifically assigned to the TEM work on a range of materials from mainly academic and industrial customers in Canada. She obtained her Ph.D. in Chemistry from Purdue University in 2018, studying biomimetic polymers under Dr. Jonathan Wilker. She joined CCEM not long after and has interest in electron microscopy of soft materials.

Speaker Bios



Dr. Renelle Dubosq is a Principal's Research Chair in Nanogeology and Assistant Professor in the Department of Earth and Environmental Sciences at the UBC-Okanagan campus. She uses a suite of material characterization techniques, including electron backscatter diffraction (EBSD), electron channelling contrast imaging (ECCI), and atom probe tomography (APT), to investigate the atomic structure and composition of natural geomaterials. Her research explores the feedbacks between element mobility, fluids, and structural defects in minerals, with the overarching goal of extrapolating micro- to nanoscale processes to better understand tectonic-scale phenomena. Her projects span from investigating earthquake nucleation mechanisms to characterizing critical mineral enrichment and remobilization. Dr. Dubosq is also affiliated with the Fipke Laboratory for Trace Element Research (FILTER) at UBCO, which houses a range of analytical equipment for material characterization.

Dr. Rhonda Stroud is the Director of the Buseck Center for Meteorite Studies and a Professor in the School of Earth and Space Exploration at Arizona State University. She received a B.A. in Physics from Cornell University in 1991, and a Ph.D. in Physics from Washington University in St. Louis in 1996. Prior to joining ASU, she spent over twenty-five years at the US Naval Research Laboratory developing and leading the premier facility for electron microscopy in the DoD. Her research addresses the relationships between nanoscale materials' structure, composition, and properties to their growth and processing histories, for both novel synthetic materials and natural materials from astrophysical environments. She served as President of the Microanalysis Society from 2018-2020. She is a Fellow of the American Physical Society, the Meteoritical Society, the Microscopy Society of America, and the Microanalysis Society. Asteroid 8648Rhondastroud was named in her honor by the International Astronomical Union in 2014.



Speaker Bios



Dr. Ruth Birch is a postdoctoral fellow at UBC developing FIB-SEM methods for advanced microstructural analysis, typically applied to high-value engineering alloys including steels for energy applications. Areas of expertise include FIB-SEM, advanced electron backscatter diffraction (EBSD) methods and data analysis, and use of energy dispersive X-ray spectroscopy (EDS/X). Prior to joining UBC, Dr Birch completed her PhD at Imperial College London and developed new in situ understanding of the microstructural evolution of nuclear materials with SEM-based heating experiments. In addition to her academic journey, Dr Birch has 6 years of experience working in industry to ensure systems safety for marine applications.

Dr. Suzana K. Straus is a Professor in the Department of Chemistry at the University of British Columbia (UBC). Straus is an expert in the elucidation of the mechanism of action of antimicrobial, antibiofilm and immunomodulatory peptides, in the design of novel peptides and in delivery strategies. Straus brings expertise in the application of biophysical techniques (i.e., NMR, CD, ITC, etc.), as well as biological assays (e.g. MICs, MBICs, MBECs), to relate peptide sequence to activity.



Dr. Yug Joshi is a Group Leader at the Max Planck Institute for Sustainable Materials (MPI-SusMat) in Düsseldorf, Germany. His research explores the interplay between microstructure, defect physics, ion transport, and mechanics in energy-storage materials, with a particular focus on understanding degradation and developing recovery strategies for next-generation batteries. Combining advanced operando and cryogenic characterization techniques with electrochemical analysis, his work spans lithium-ion, sodium-ion, iron-air, and solid-state battery systems. He received his PhD (summa cum laude) from the University of Stuttgart in 2021 and subsequently joined the Karlsruhe Institute of Technology (KIT) as a postdoctoral researcher working on large-scale battery manufacturing and applied energy-storage technologies, before establishing his research group at MPI-SusMat in 2023.

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Characterization @ UBC brings together experts leading major facilities across UBC Vancouver and Okanagan to foster collaboration, share knowledge, and support trainees through improved access to facilities, conferences, and workshops.

We support our community through training schools, workshops, technical clinics, and a regular seminar series. To translate shared best practices into practical outcomes, the cluster also organizes round-robin studies and produces collaborative reports that benchmark methods, compare results across facilities, and strengthen confidence in characterization data.

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