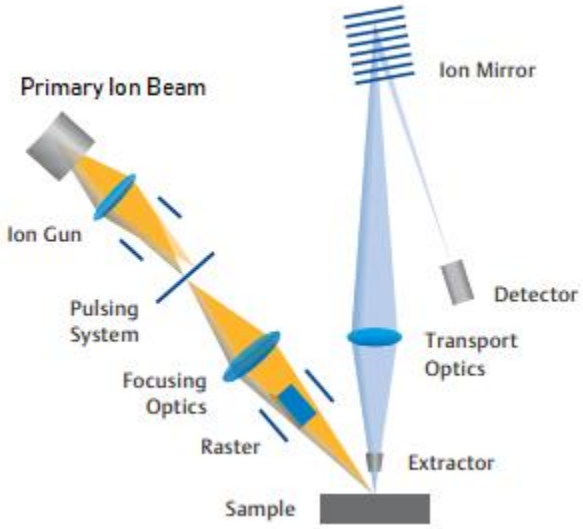
TIME-OF-FLIGHT SECONDARY ION MASS SPECTROMETRY

Time-of-Flight Secondary Ion Mass Spectrometry (TOF-SIMS) is a highly surface sensitive analytical technique used to obtain elemental, isotopic, and molecular information from the surface of solid materials. The surface of interest is bombarded with a pulsed ion beam that is rastered across the sample causing a cascading collision effect that ejects material such as ions (positive, negative, neutrals), photons, and electrons. For TOF-SIMS, we are only interested in collecting and measuring the positive and negatively charged ions that are ejected from the surface. These are considered 'secondary' ions. These secondary ions are extracted from the surface and then accelerated towards a highly sophisticated and specialize detector (mass spectrometer). The time it takes for those ions to leave the surface until they hit the detector tells us their mass (time-of-flight).



Each point of impact on the sample from the primary ion beam contains the entire mass spectrum, as well as the X, Y and Z coordinates of that point of impact. With this information, we can create detailed ion images of the distribution of any species of interest on our sample, both in 2D and in 3D (in depth profile mode).

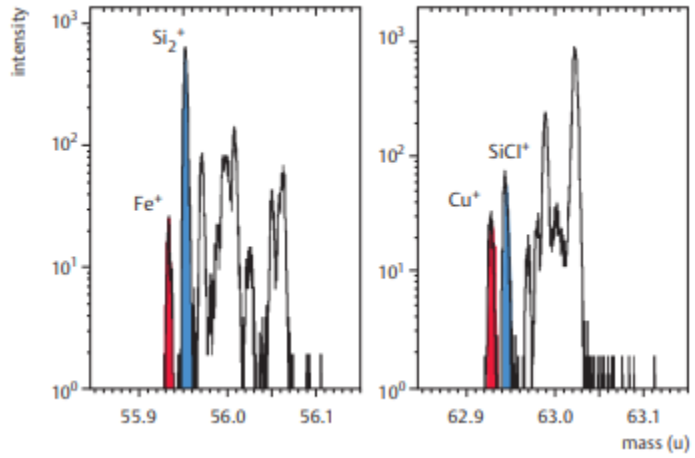
MODES OF OPERTATION

Static SIMS: In this mode, we can use a quasi-non-destructive technique called Static SIMS, where we graze the top 1-2 nm of the surface to glean information from. This typically causes less than 1% damage to the surface and can provide both elemental and molecular information about the sample of interest.

Dynamic SIMS: This mode is far more destructive, which involves sputtering away material as we analyze to create depth profiles. We can then plot the species of interest as a function of time or depth from the sample. Because of the destructive nature of this mode, most of the molecular information is lost. Only elemental, small cluster and lower mass molecules can be detected.

Tomography: In addition to creating 3D species distribution ion images with traditional depth profiling, the in-situ Focused Ion Beam (FIB) allows for serial sectioning of the crater sidewall where full three-dimensional tomography measurements can be performed. Not only does this allow for deeper examinations into a material than traditional depth profiling would allow, but also allows us to analyze extremely rough or porous samples that would otherwise be difficult or impossible to analyze.

Mass Spectra

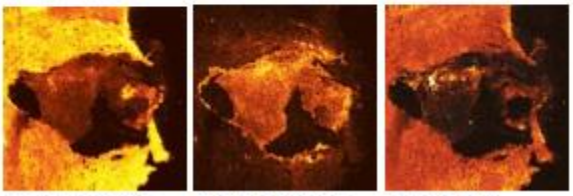


2D Ion Images

Hard disk read/write head.
Field of view: 25 x 25 m^2

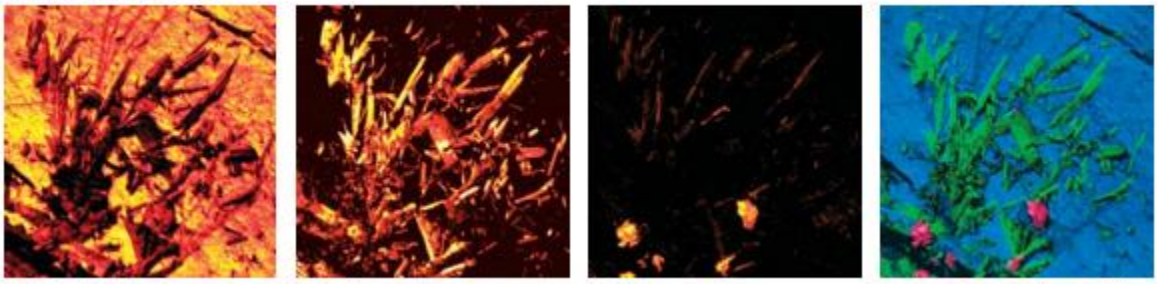
Al | Ti | Overlay: Cr, Fe, Ni

Animal brain tissue.
Field of view: 4 x 4 mm^2



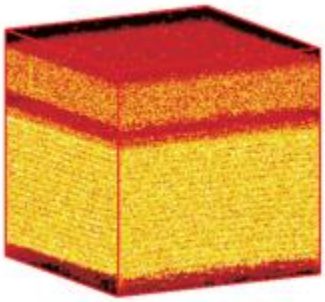
Fatty acid residues | Blood components | Phospholipids

Blooming effect of additives on formed polypropylene.
Field of view: 300 x 300 m^2



Polypropylene (PP) | Antioxidant | Stabiliser | Overlay: PP, Antioxidant, Stabiliser

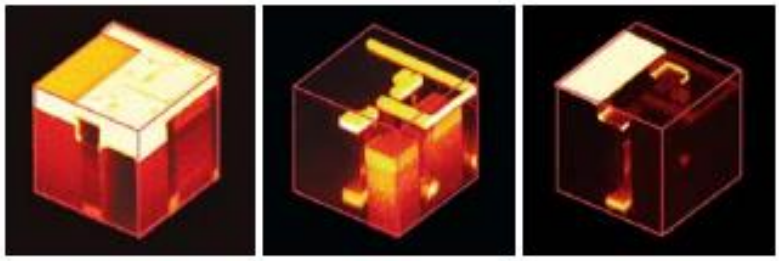
3D Ion Images



3D Image $Al+Al_2+GaAl$

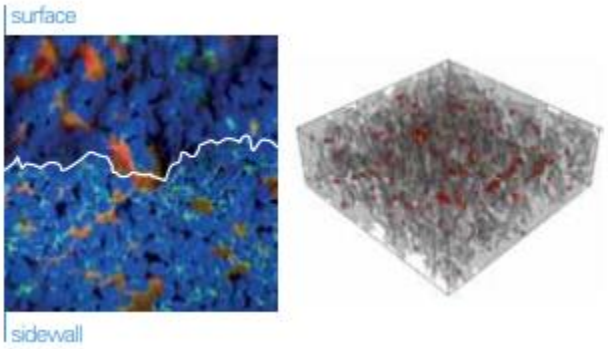
Mass resolved 3D view of a TFT display pixel

Analysed volume 100 x 100 x 1.7 m^3



Si Mo In

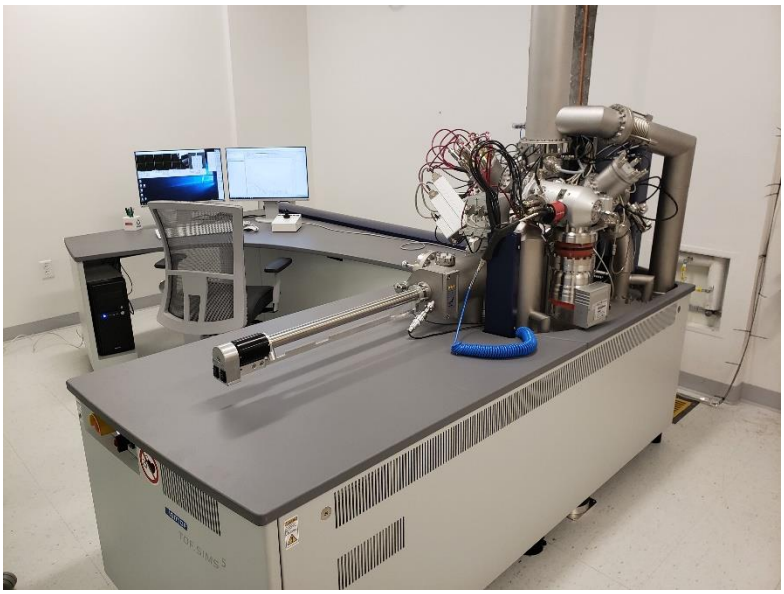
FIB Tomography Ion Images



Combined FIB crater sidewall and surface image of a lithium ion battery electrode showing the distribution of O (blue), F (green) and C (red).

Three-dimensional tomography analysis of a lithium ion battery electrode showing the distribution of Li (grey) and Na (red).

STRENGTHS



- High sensitivity with the ability to detect species in the parts-per-million (ppm) to parts-per-billion (ppb) range
- Can obtain elemental, isotopic, and molecular information from the top 1-2 nanometers of the surface of solid materials
- High mass resolution of ~0.00x amu
- Quasi non-destructive analytical technique – 1% or less surface damage (in Static mode)
- Capable of ~70nm spatial resolution
- Can obtain elemental and molecular information from a mass range of 0 to 10,000+ amu simultaneously
- Depth profiling with parallel ion detection
- Species mapping in both 2D and 3D
- Macro 2D species mapping
- Ability to analyze insulators and conductors
- Little to no special requirements for sample preparation
- Retrospective analysis

Academic Rate: $87.06/hr

Added features of Mine's TOF-SIMS makes it uniquely configured and exceeds all others currently in the US

- Argon Gas Cluster Source – provides the ability to detect high mass polymers and depth profile through complex organic materials
- In-situ Focused Ion Beam – can analyze extremely rough samples, samples with voids, or samples that exhibit strong local variations in density
- Extended Dynamic Range Analyzer – extends dynamic range up to 7 orders of magnitude allowing for simultaneous detection of normally saturated matrix species and trace species
- Hermetically Sealed Transfer Vessel – ability to analyze atmospheric or moisture sensitive samples

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