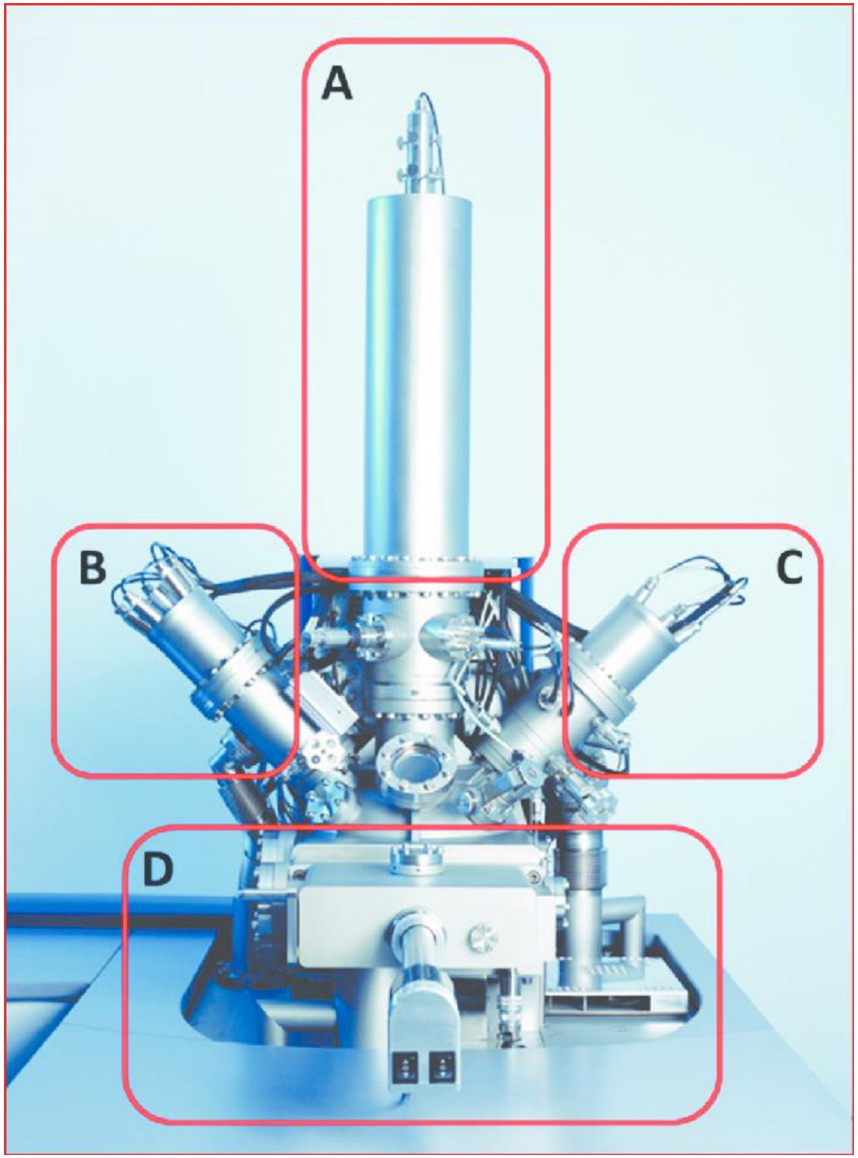
Time of Flight Secondary Ion Mass Spectrometry

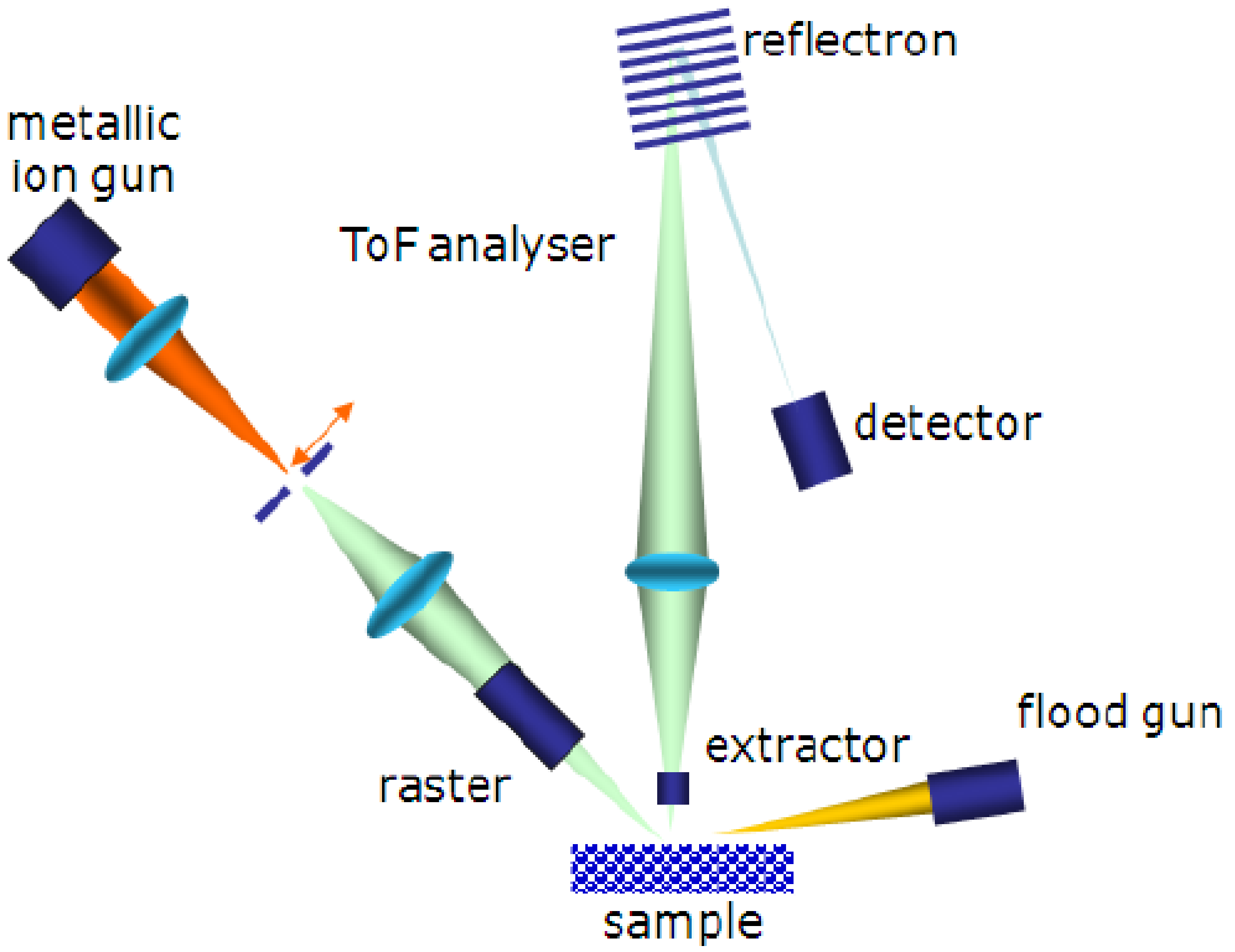
Somila & Nnamdi

Components



A- ToF analyser
B and C- Ion sources for sputtering and analysis
D- Load lock for sample introduction

Schematic Representation



https://serc.carleton.edu/research_education/geochemsheets/techniques/ToFSIMS.html

Strengths and Limitations

- High sensitivity (ppm/ppb).
- Can detect all elements including Hydrogen
- Isotope sensitivity
- High mass range (up to 10000 amu)
- Short image acquisition time (minutes vs. hours for XPS)

- Limited quantification (requires standards)
- Destructive*

Modes of Operation

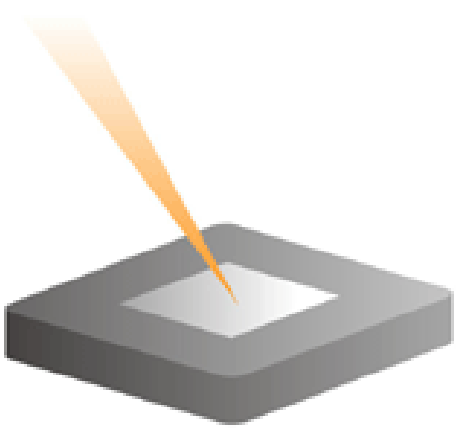
- **Surface Spectroscopy**
- **Surface Imaging**
- **Depth Profiling**
- **3D Analysis**

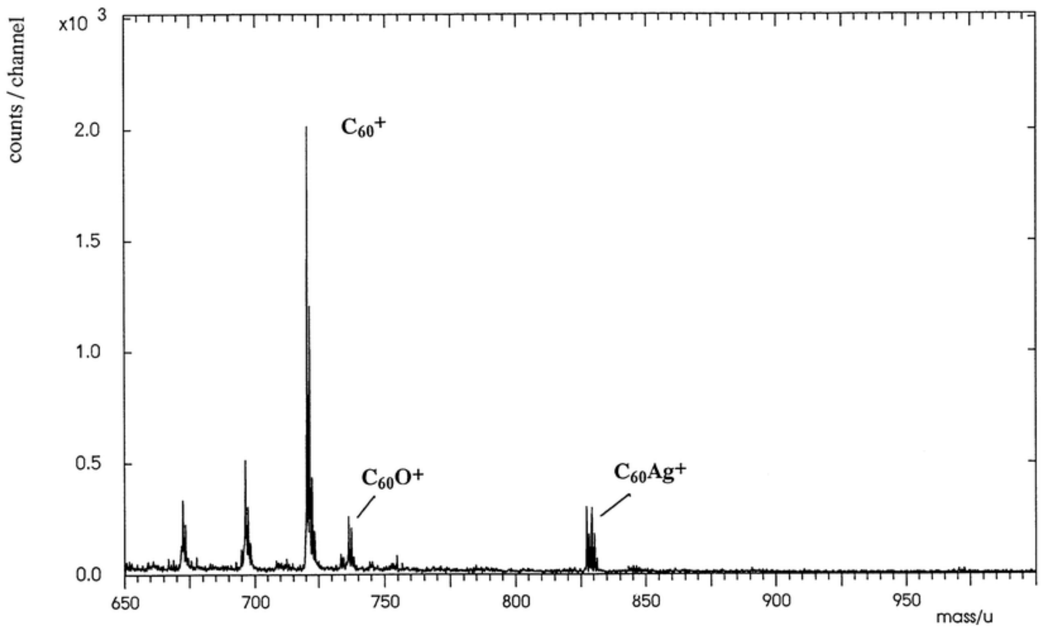
Surface Spectroscopy

A solid sample is bombarded with a pulsed primary ion beam. Atomic and molecular fragments are emitted from the outer layers of the sample and extracted. Measuring the **"time of flight"** for each ion allows the determination of its mass.

Surface Spectroscopy

Provides detailed mass spectral information about the outer monolayers of a surface.

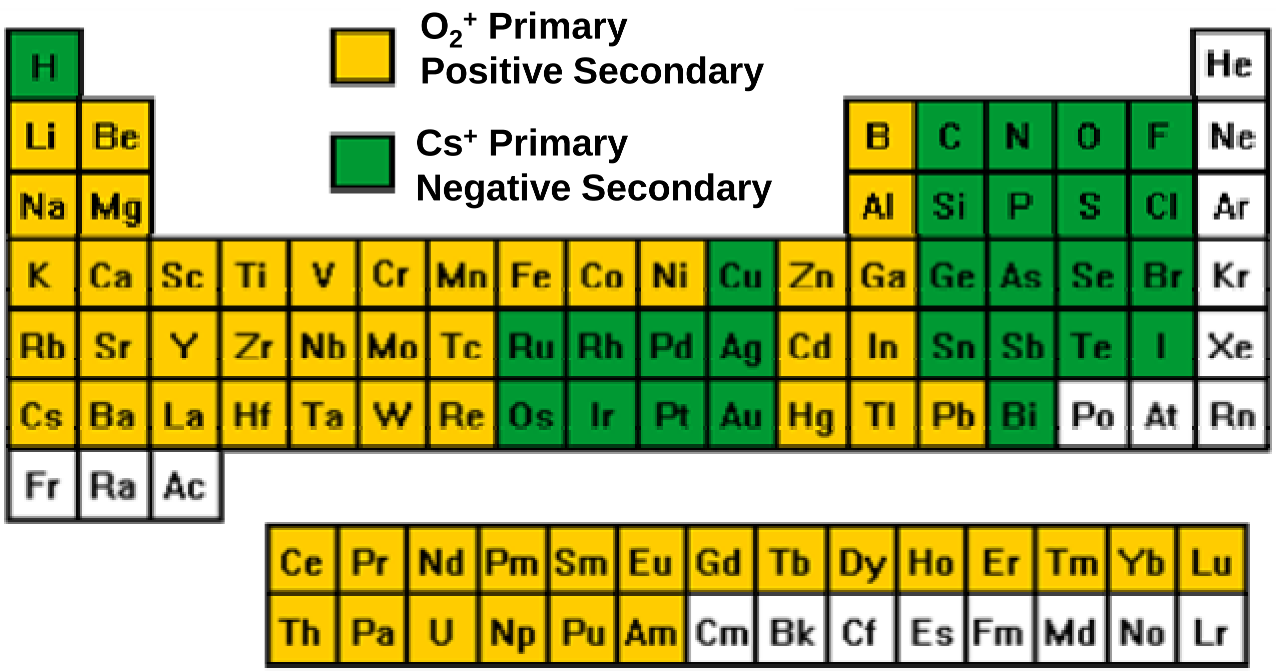




Spectrum

Saldi *et al*, **1995**. Eur. Mass Spectrom., vol 1, 487-492

Effects of primary beam on secondary ion yields



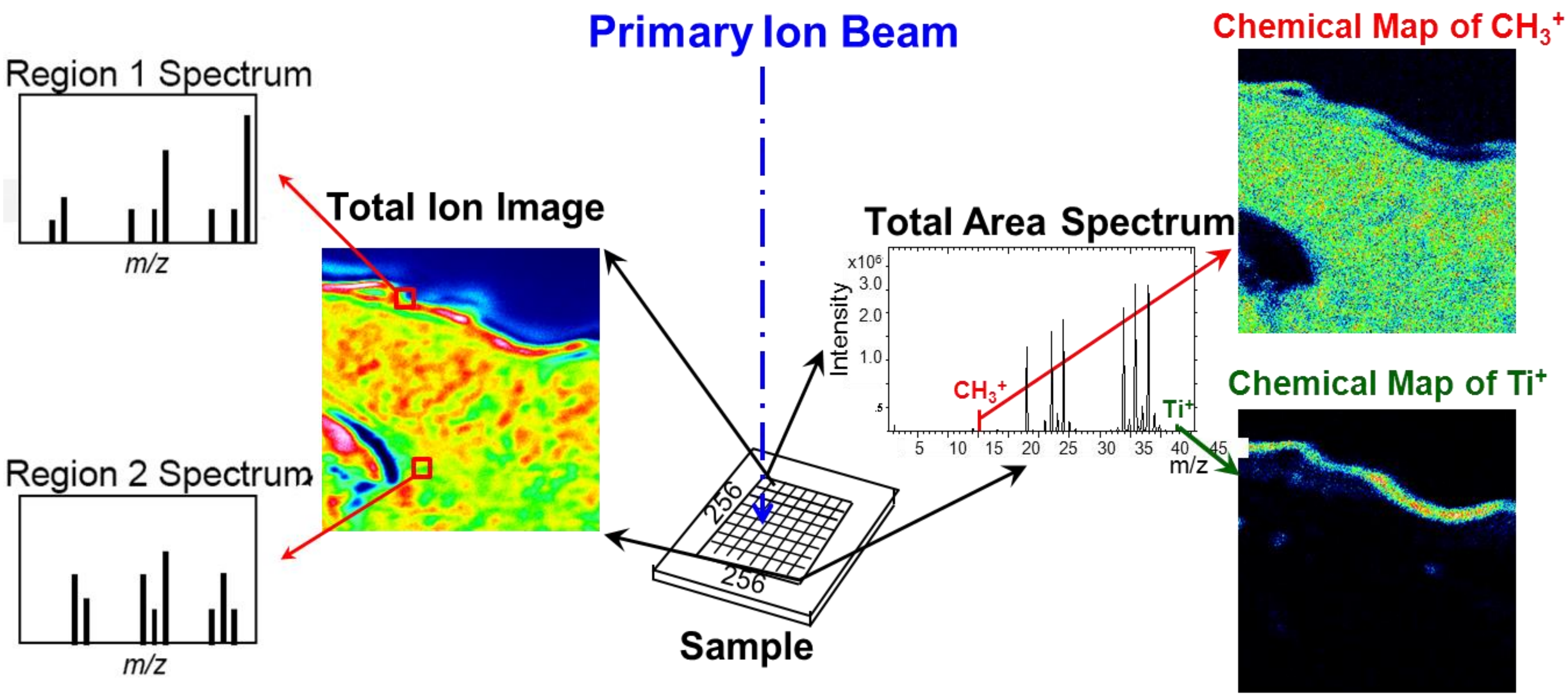
With an oxygen beam, the concentration of oxygen increases in the surface layer and metal-oxygen bonds are present in an oxygen-rich zone.

With a cesium beam, cesium is implanted into the sample surface leading to more negative ion formation

https://www.nrel.gov/docs/gen/fy04/36831n.pdf

Surface Imaging

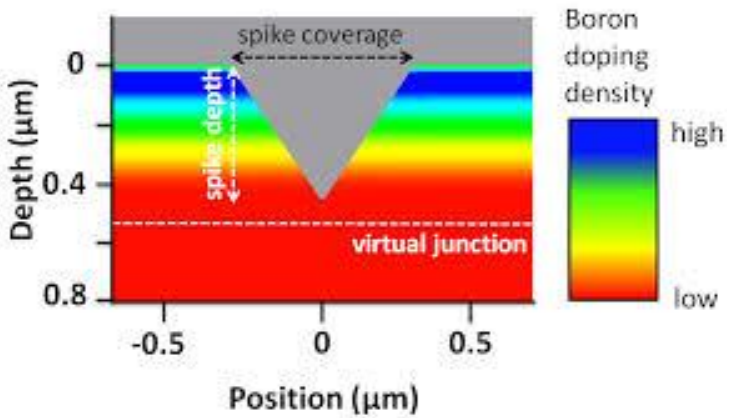
By rastering a fine focussed ion beam over the surface, a chemical map of the surface can be obtained simultaneously.

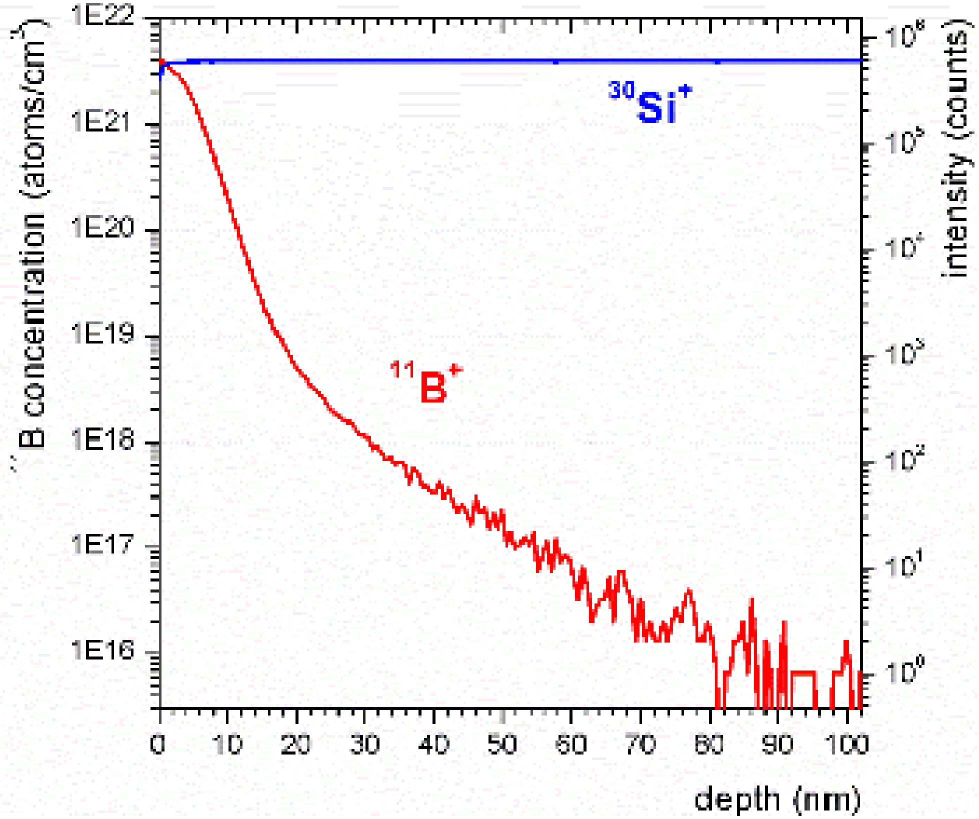


https://www.aif.ncsu.edu/tof-sims/

Depth Profiling

Depth profiling is achieved through the use of two beams: one beam is used etch the surface (C_{60}^{n+}) and the second beam (LMIG) continually analyses the crater.



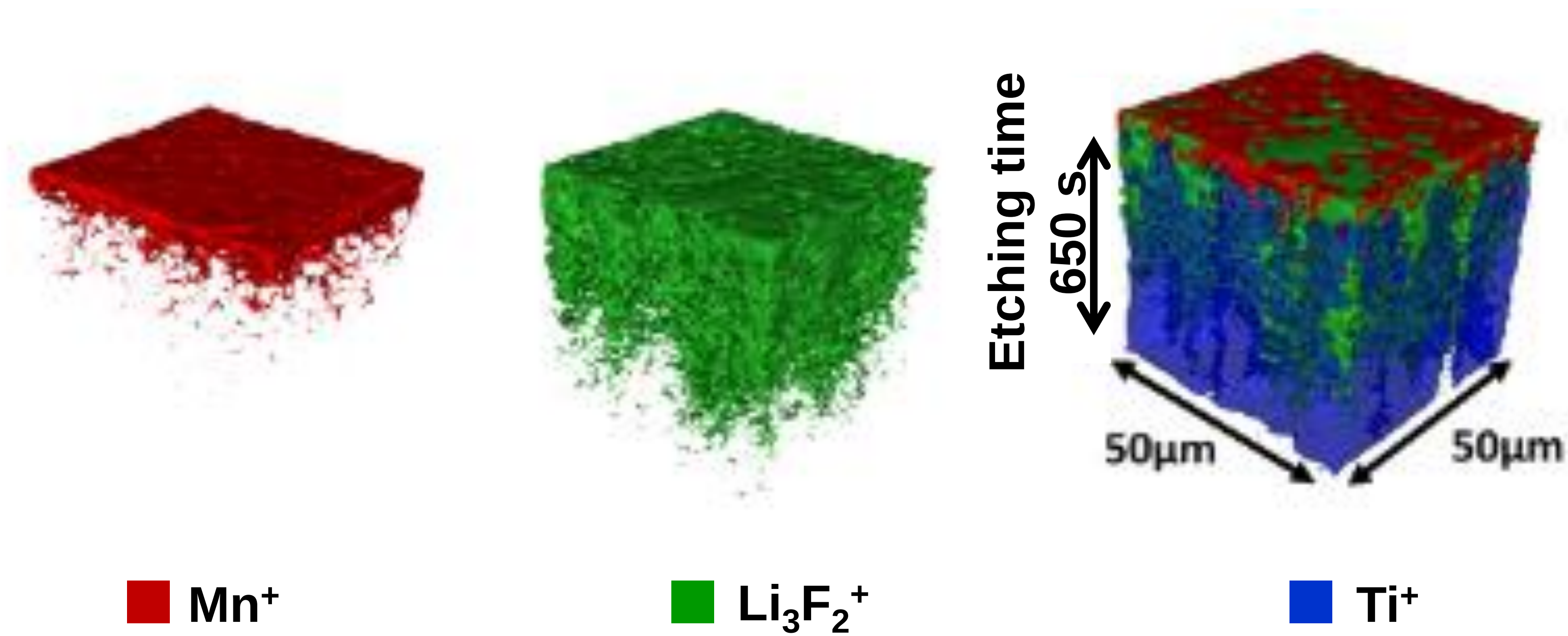


Depth profile of shallow B implant into Si wafer with 6 orders of dynamic range with detection limit below 1E16 at/cc

http://www.wintech-nano.com/services_mc_TOFSIMS

3D Analysis

Through the combination of the spectral information, depth analysis and imaging, 3D visualization of the sample is possible.



https://e2s-uppa.eu/en/research/instrumentation/tof-sims-time-of-flight-secondary-ion-mass-spectrometry.html

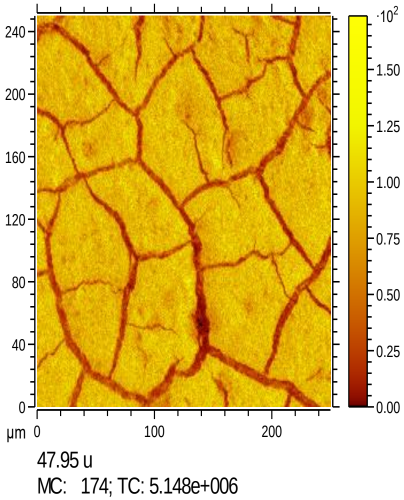
Papa Francis' Sample Analysis

- Characterize the anode surface before and after dye adsorption in order to determine the characteristic distributions of the different compounds and the quality of the anode.

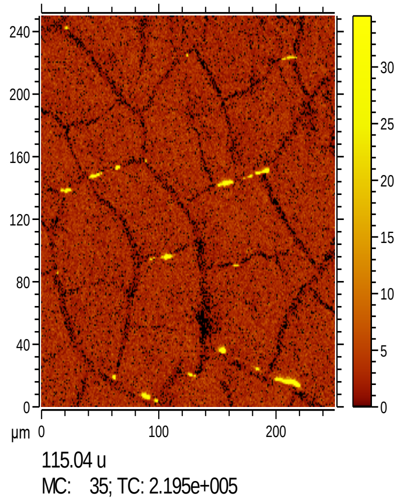
- Ion density maps or secondary ion images were acquired in both positive and negative ion mode.

- The secondary ion images represent "chemical images" showing characteristic distributions of the elements/ compounds.

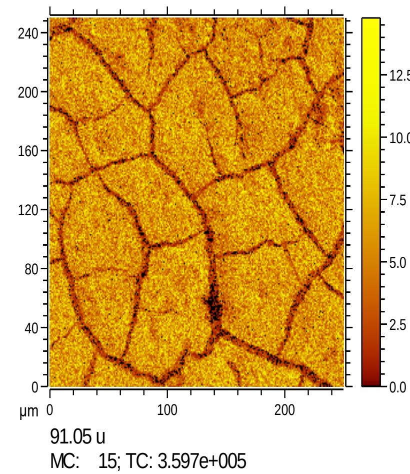
TOFSIMS positive ion mode images of anode before dye adsorption (ITO + semiconductor)



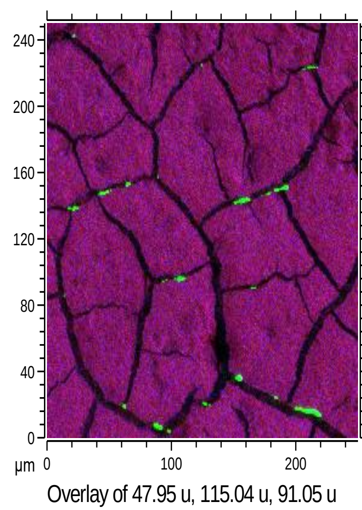
- m/z 47.95, titanium



- m/z 115.04, indium



- m/z 91.05, Benzene ring, fragment from rGONS



RGB plot

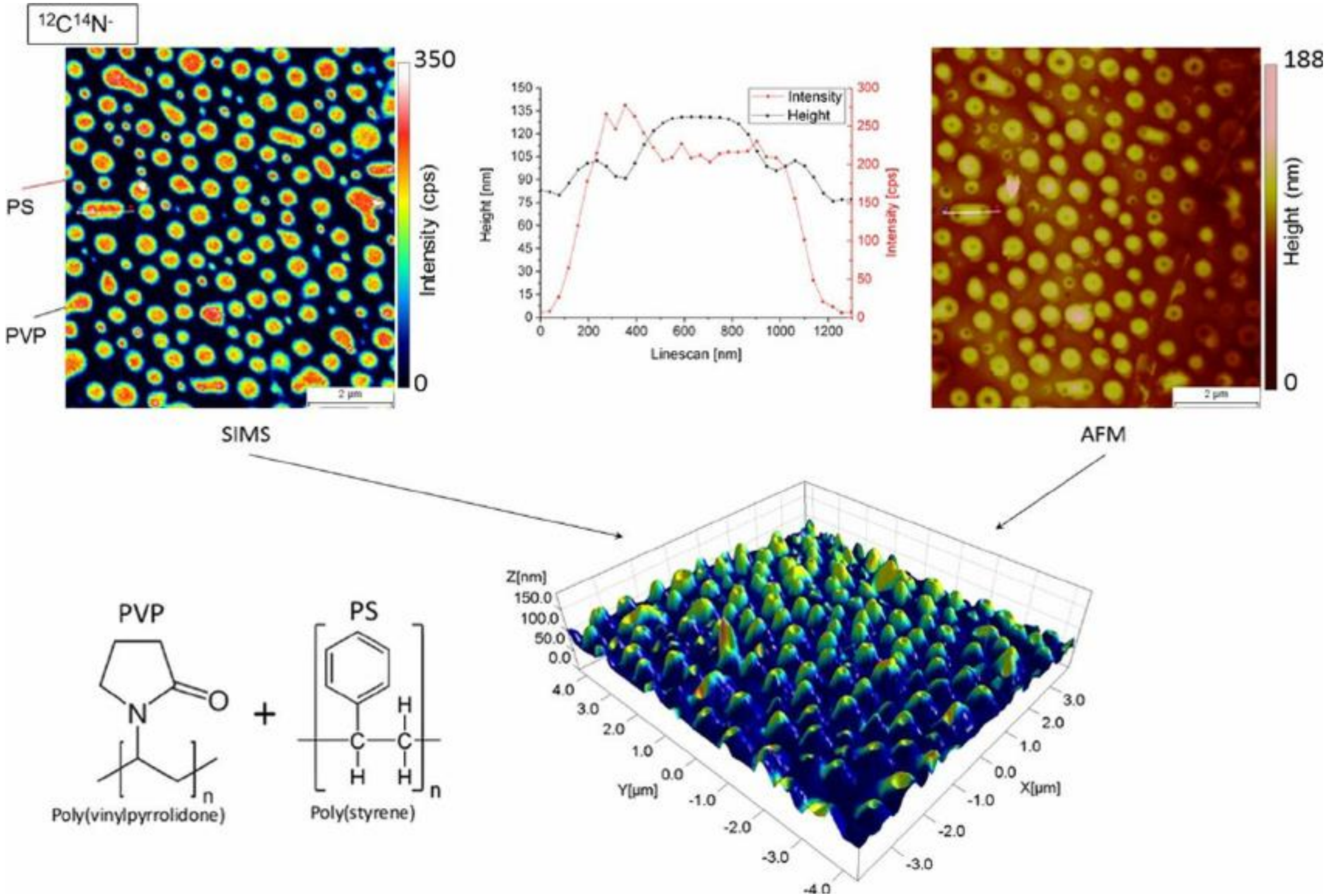
Data confirms that:

- rGONS and TiO_2 are homogenously mixed and appear where we expected.

Applications

Analyte Types

- **Paints and coatings**
- **Pharmaceuticals**
- **Forensics**
- **Biomaterials and polymers**



Fleming and Wirtz, **2015**, Beilstein Journal of Nanotechnology, 6(1): 1091-1099