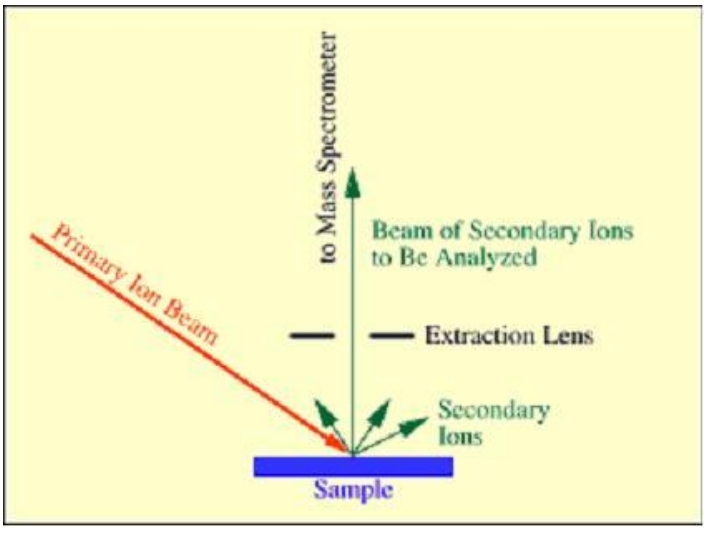
MSE 310 Lecture 11
Secondary Ion Mass Spectrometer (SIMS)

SIMS instruments use an internally generated beam of either positive (e.g., C) or negative (e.g., O) ions (primary beam) focused on a sample surface to generate ions that are then transferred into a mass spectrometer across a high electrostatic potential, and are referred to as secondary ions.

Fundamental Principle: The interaction of the primary ion beam with the sample (under vacuum) provides sufficient energy to ionize many elements. If the primary beam is composed of positively charged ions, the resultant ionization favors production of negative ions; primary beams of negative ions favor generation of positive ions. Although most atoms and molecules removed from the sample by the interaction of the primary beam and the sample surface (referred to as sputtering) are neutral, a percentage of these are ionized.



These ions are then accelerated, focused, and analyzed by a mass spectrometer.

In "dynamic SIMS" mode the primary ion beam exceeds the "static limit" producing a high yield of secondary ions. This technique is used for "bulk" analysis of elements and isotopes, and is particularly well-suited for analysis of isotopes and trace elements in minerals . Alternatively, "static SIMS" uses a much lower energy primary ion beam (usually Ga or Cs). This technique is typically used for analysis of atomic monolayers on material surfaces to obtain information about molecular species on material surfaces e.g. organic compounds.

Or in Short,Principle of SIMS Analysis: Bombardment of a sample surface with a primary ion beam (I_p) followed by mass spectrometry of the emitted secondary ions (I_s) constitutes secondary ion mass spectrometry.

SIMS is a surface analysis technique used to characterize the surface and sub-surface region of materials and based on m/e ratio measurement of ejected particles under ion bombardment.

Instrumentation and working

• Sample surface bombarded by primary ions (energy 1-25 keV) • Sample atoms and ions (only ~1 %) are removed by sputtering • Mass/charge ratio of the ions is analyzed • Mass spectrum is detected as a count or displayed on a fluorescent screen • High vacuum required

Most of these instruments are characterized by a source region in which the intensity, energy, and orientation of the primary beam (relative to the sample) are controlled. Ions generated by this process form the secondary beam and are subsequently transmitted within a continuous high vacuum environment to a mass spectrometer. Most SIMS instruments used for elemental and isotopic analyses

function by accelerating ions produced in the source along a potential gradient, typically 10 KV, and then transferring these ions into the mass spectrometer.

Analysis modes • Static SIMS • Surface sensitive: surface concentrations of elements and molecules without significantly altering the sample • Imaging SIMS • Similar to static mode, but generates 2D images or maps of samples based on concentration of ions with a certain mass • Dynamic SIMS • Primary ions with higher energy are used to dig a crater into the sample → depth profiling Summary-SIMS • Capable of detecting all elements as well as isotopes and molecular species • Most sensitive of all beam characterization techniques • Detection limit: 10^{14} -10^{15} cm^{-3} • Different ion sources and mass analyzers for different purposes • Static/imaging mode with low sputtering rate for surface characterization • Dynamic mode with high energy primary ion beam for depth profiling