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Introduction to the SIMS facility: SIMS has long been an important component of the cosmochemist’s toolbox due to the tiny amount of sample needed to obtain a useful signal. Thus, a standard 30 µm thin section provides so much material that even after extensive SIMS analyses, the section can be returned to a collection with very little apparent damage.

In the secondary ion mass spectrometry (SIMS) facility at ASU we offer analyses on Cameca ims6f and NanoSIMS 50L instruments. The ims6f serves users perform a wide range of trace element analyses (from hydrogen to uranium) and isotope ratio measurements (typically H, Li, B, Mg, and selected other systems). The minimum effective lateral resolution achievable on the ims6f is around 4 µm. Precise depth profiling with few-nanometer resolution is routine, and detection limits typically range from ppm to ppb. The NanoSIMS allows elemental and isotopic imaging analyses for up to 7 species simultaneously, with ultimate lateral resolution near 200 nm (oxygen primary beam for detection of positive secondary ions) and 25 nm (cesium primary beam for detection of negative secondary ions). Adjacent masses can be detected simultaneously up to m/z 57 and 58; the mass range that can be addressed simultaneously is a factor of 22, e.g. 10−220 u.

Applications with the ims6f: Examples of recent work included: a) depth profiling analyses to support the determination of Cr diffusion in spinel, relevant to the resetting of 53Mn daughter products [1], b) Hydrogen isotope microanalyses of nominally anhydrous minerals in Martian meteorites increasing our understanding of different hydrogen reservoirs on Mars [2], c) partitioning of gold between metal and silicate liquid which revealed strongly decreasing siderophile behavior with depth in a magma ocean [3], and d) zoning of light lithophile elements (Li, Be, B) and lithium isotopes in Martian meteorites suggesting that one sample may have experienced degassing [4].

Our lab has quantified the “useful yields” (ions detected per atom of the species of interest removed from the sample) of many elements [5] allowing calculation of the amount of material that must be consumed to obtain a particular precision. Thus the feasibility of most research projects can be determined prior to damaging a sample. See, for example, Figure 1 where useful yields for the 4th row elements are presented, obtained under conditions that eliminate most cluster ion interferences. Cobalt, for example, shows a useful yield near 10⁴. At a concentration of 1 ppm Co, there are 10³ Co atoms in each cubic micron. A 20x20x1 µm deep crater would yield 4000 Co⁺ counts, with a statistical uncertainty of ~1.5% (1σ). Sampling several elements in an analysis can still result in a relatively shallow crater. Elements with lower positive ion useful yield often may be successfully analyzed using negative secondary ions (e.g., As, S).

**Figure 1. Useful yields for positive ions for 4th row elements determined on NIST 610 glass using the ims6f and applying energy filtering (detecting secondary ions with initial kinetic energy of ~80±20 eV).** Data from [5].

Applications with the NanoSIMS 50L: Examples of NanoSIMS work partially funded by NASA include: a) in situ discovery of presolar grains in pristine, unaltered meteorites [6], b) spatially resolved C and N isotopic measurements to identify isotopically anomalous organics in carbonaceous meteorites [6–8], c) high precision Al-Mg isotopic measurements of micron-sized minerals in the rims of CAIs [9: Figure 2], d) trace element zoning (Li, Si, Ti, Y, Ce, Nd, Sm, Dy, and Hf) in mineral phases e.g., zircons and pyroxenes with beam controlled profiles and step-scans [e.g., 10], e) and high-precision (~2‰ 1σ) Li isotopic analysis in zircons.

To explore the capability for high precision measurements while maintaining high spatial resolution using the O’ primary beam, we did preliminary measurements of lithium isotopes on NIST 612 and a zircon standard M257 with lithium concentrations of ~40ppm and ~0.86ppm, respectively. Analyses were performed by rastering an O’ primary ion beam over a 3×3 µm² square area, with measurements taken from the inner 25% of that area, i.e., 1.5×1.5 µm². Four consecutive measurements (~1 hour each) yielded preliminary data.
we can design protocols to support novel analyses of rare materials. Because of the potential for matrix effects, we also make extensive use of ion implantation into the phase of interest to provide matrix-matched quantification of the secondary ion signals [e.g. 13, 14]

**Instrumentation:** Instrumentation developments include exploration of analog electron multiplier operation for precise isotope ratio determination over a very wide dynamic range [15] and development of a new cesium ion source for the NanoSIMS producing a 25 nm diameter Cs⁺ beam with a factor of 4 greater current than the factory source allowing higher throughput and potentially lower user costs [16; Figure 3].

Our facility, current applications and instrumental developments will be presented at the meeting.


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