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CHILI: What's next?

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The Chicago Instrument for Laser Ionization (CHILI), a microbeam laser resonance ionization mass spectrometer, has measured the isotopic compositions of Fe, Ni, Sr, Zr, Mo, Ru, and Ba in presolar SiC and graphite grains, revealing much about *s*-process nucleosynthesis in AGB stars. In CHILI, atoms are removed from samples by sputtering with Ga^+ ions or ablating with a 351 nm laser. Both sampling methods are well-suited to presolar grains, but each have their specific limitations.

The Ga^+ ion gun produces a maximum DC beam current of 15 nA, but the beam current must be lowered when focusing to ≤1 μm. When operating at 1 kHz with 100 ns pulses, this corresponds to a maximum of 10^4 incident Ga^+ ions per shot. Sputter yields for 30 kV Ga^+ ions depend on the target material, but ~10 secondary particles are sputtered per primary ion. Thus, a maximum of 10^5 atoms per pulse can be desorbed, and elements at concentrations below one part in 10^4, or 100 ppm, will not be collected at the maximum count rate of the detector. Trace element concentrations in presolar grains are usually well below 100 ppm.

With CHILI's current 20 ns desorption laser, volatilization of neutral atoms occurs by surface heating. Successful samples must have strong absorption at 351 nm, and sample heating must not cause undesired internal diffusion. Most silicates and oxides are transparent at 351 nm. Even on well-behaved presolar SiC, small changes in laser pulse energy or sample absorbance can lead to large changes in signal, as vapor pressure is exponential in temperature. Fluctuating ion signals hamper high precision, since dead time correction relies on constant count rates.

We are currently installing a Light Conversion PHAROS femtosecond ablation laser with outputs at 1030, 515, or 343 nm. Pulse duration can be adjusted from 190 fs to 10 ps at 1030 nm and is fixed at 190 fs at the other two wavelengths. Short-pulse laser ablation has several advantages: (1) at fluences appropriate for CHILI, it is practically athermal; (2) it ablates materials irrespective of their optical properties; and (3) desorption yield is linear in pulse energy rather than exponential, allowing effective deadtime correction. The new laser will allow CHILI to expand its range of target materials to include presolar silicates and oxides, a wide variety of early Solar System materials, and will allow for more effective depth-profiling of presolar SiC, graphite, and other samples.

Session

Dust and presolar grains

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