SAMPLE PREPARATION FOR ANALYSIS OF *GENESIS* SAPPHIRE.

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Introduction: Elemental abundances in CI chondrites are conventionally used as a proxy for the early Sun's bulk composition due to the similarity with the photosphere in the relative abundances of all but the most volatile elements. However, a recent reevaluation of solar photosphere abundances [1] shows small-scale differences with CI chondrites that appear to be correlated with condensation temperature. A third, independent method of measuring solar elemental abundances—the analysis of solar wind samples—can be useful to flesh out the nuances of solar composition. The study of solar wind in samples returned by the NASA Discovery Mission *Genesis* provides more precise isotopic and elemental abundances than those obtained through spectroscopic observations of the Sun's photosphere.

Genesis sampled the Sun by exposing a variety of ultrapure materials to the solar wind. Solar wind ions were implanted into the top few 10s of nanometers of these materials, which include sapphire (SAP, Al_2O_3), diamond-like carbon on silicon (DOS), aluminum on sapphire (AlOS), gold on sapphire (AuOS), silicon (Si), and silicon on sapphire (SOS). Terrestrial contamination and surface damage of the collector material, caused by the sample capsule's nonnominal return to Earth, remains a major challenge for the analysis of *Genesis* samples. Depth profiling the samples from the back side is a reliable method that avoids the front-side surface contamination [3] but requires extensive sample preparation. Backside depth profiling (BDP) has so far only been done for Si and DOS samples.

Sapphire is of particular interest for *Genesis* collector analysis as its superior hardness limited damage by the crash. So far, no sapphire samples from *Genesis* have been analyzed by secondary ion mass spectrometry (SIMS) or laser ablation noble gas release due to challenging sample preparation.

Methods and Materials: Due to the small amount of solar wind implanted into the *Genesis* samples, we intend to utilize resonance ionization mass spectrometry (RIMS) rather than SIMS to analyze elemental abundances. In RIMS, atoms are desorbed from the sample surface and then selectively ionized by lasers tuned to element-specific electronic transitions, thus ensuring a high useful yield and suppressesing isobaric interferences.

We have upgraded the Chicago Instrument for Laser Ionization (CHILI) [2], a RIMS instrument, with a femtosecond ablation laser (PHAROS, Light Conversion) which can output beams at wavelengths of 343, 515, and 1030 nm. Unlike laser desorption with pulses in the nanosecond range, femtosecond laser ablation (fs-LA) produces a spatially and temporally localized interaction between the laser beam and target matter. As such, fs-LA is nonthermal and less dependent on laser wavelength. The 343 nm ablation laser, focused to ~1 µm and with a pulse length of ~190 fs, was rastered over nonflight *Genesis* materials (AlOS, AuOS, and SOS) to form 20×20 μm^2 square craters.

The *Genesis* target materials have an initial thickness of 500–700 µm. We have been practicing mounting nonflight samples front-side down in epoxy and polishing them to suitable flatness and thickness (<1 µm) for BDP following established procedures [3]. Since purely mechanical polishing of hard sapphire is slow, we use a faster, chemically enhanced mechanical polishing process that uses alumina and silica slurries in sequence [4].

Results: Crater formation is monitored during laser ablation and characterized afterwards by scanning electron microscopy, stylus profilometry, and 3D optical microscopy. The raster size can be adjusted to cover larger areas, and, while the implanted solar wind will likely be within 600 nm from the front-side [3], the craters can easily reach >5 µm in depth. Initial fs-LA testing of sapphire produced a crater with a bottom surface roughness of 186 nm RMS.

We used aluminum stubs with angled-bottom (~1°) insets for mounting and polishing of non-flight *Genesis* SAP. A 30 µm alumina lapping disk was used to remove the majority of excess material, with a material removal rate (MRR) of ≤90nm/min (~315 nm RMS). This was followed by an intermediate polish using a 15 µm alumina slurry at pH 12 (5 nm/min MRR, ~290 nm RMS) and a final polish with 0.02 µm silica suspension (~3 nm RMS).

Discussion: *Genesis* SAP has yet to be analyzed for solar wind, however, we have been taking the first steps in preparation. BDP has been proven to be a reliable way to analyze the solar wind samples despite contamination concerns, and sapphire samples can be suitably prepared with chemical mechanical polishing. The hardness of sapphire may also permit more vigorous front-side cleaning procedures than can be used on other target materials, allowing for complementary analysis. Fs-LA has expanded the applicability of CHILI to SAP and all other *Genesis* collector materials. With future analysis of implanted standards and optimization of sample cleaning and mounting, CHILI will be ready to contribute elemental abundance measurements of solar wind from *Genesis* sapphire samples.

References: [1] Asplund M. et al. (2021) *Astronomy & Astrophysics* 653:A154. [2] Stephan T. et al. (2016) *International Journal of Mass Spectrometry* 407:1–15. [3] Heber V. et al. (2014) *Chemical Geology* 390:61–73. [4] Zhang Z. et al. (2010) *Journal of The Electrochemical Society* 157:H688–H691.