

DEPTH PROFILING OF GENESIS SOLAR WIND COLLECTORS WITH LASER POST-IONIZATION SNMS

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The samples returned to Earth by the Genesis Mission of NASA's Discovery Program contain a record of the elemental and isotopic abundances of the solar wind. This record is implanted in the near-surface region of the sample collectors allowing the solar wind material to be distinguished from terrestrial contamination, which occurred due to the abrupt landing of the Genesis spacecraft. At Argonne National Laboratory, we have recently developed a new Laser Post-Ionization Secondary Neutral Mass Spectrometer (LPI SNMS) called SARISA, which is capable of accurate measurements of ultra-trace concentrations of many metallic elements implanted in Genesis solar wind collectors. In this work, we will report results of our measurements of abundances of Mg in two types of such collectors, silicon and diamond-like carbon (film on silicon). These depth profiling measurements were conducted in Resonance-Enhanced Multi-Photon Ionization (REMPI) regime, in two-color scheme with two Ti-sapphire post-ionization lasers tuned to 285.30 nm and 375.66 nm wavelengths, with the repetition rate of 1 kHz.

In order to make our analyses quantitative, we used two specially prepared standard reference samples, made from exactly the same materials as the flown Genesis collectors and implanted with a known fluence of 43 keV Mg ions: 2×10^{13} at/cm² in diamond-like carbon and 1.1×10^{13} at/cm² in silicon. The ²⁵Mg isotope was significantly enhanced in these reference samples in order to help to distinguish the implant from any terrestrial surface contamination (where ²⁴Mg has the highest abundance). The measurements of these standards allowed us to characterize the actual efficiency and detection limits of the new SARISA instrument: the useful yield of the instrument peaked at about 20% with a mass resolution of ~2000 and detection limits corresponded to < 50 part-per-trillion.

We measured concentration vs depth profiles for Mg in solar wind collectors (Si and diamond-like carbon, respectively) and compared them to Mg implant standards. One apparent feature of the solar wind implants was that maximums of their profiles were broad, with apparent diffusion of the implanted atoms towards the surface. Since the Genesis solar wind collectors were subjected in space to intense bombardment by protons and alpha-particles, and solar light heated them to the temperature of ~200 °C for nearly 2 years, this feature can be explained by radiation-enhanced thermal diffusion processes. The total fluences of Mg in solar wind determined from our measurements were: $(2.74 \pm 0.20) \times 10^{12}$ and $(2.46 \pm 0.20) \times 10^{12}$ at/cm² for Si and diamond-like carbon collectors, respectively (at 2 σ error level). More detailed studies of diffusion processes in these collectors are needed to determine in what extent this minor discrepancy in fluences is caused by losses of the collected material due to processes of diffusion and surface sputtering by solar wind.

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