Laser Surface Cleaning Combined with TXRF Analysis as a Novel Approach for Genesis Solar Wind samples

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High purity collector materials were used to collect solar wind in space during the Genesis mission between 2001 and 2004. The return of the spacecraft resulted in a crash landing shattering the collectors not only into small fragments, but also exposing them to environmental and spacecraft debris. However, accurate analysis of the embedded solar wind is only possible when the surface of the collector fragments is clean calling for quantitative removal of surface contamination. Until now this was mainly done by chemical means employing acids, bases, and/or solvents. But these methods are often time consuming, tedious, and are also only partially successful as many contaminants resist chemical treatment. Thus, novel cleaning methods are required, which do remove the contaminants resistant to chemical treatment, target only the surface, and can be applied for most collector materials rapidly.

Lasers are characterized by producing monochromatic and coherent radiation, which can be highly focused, making them one of the most versatile tools in science and technology. Among other interactions of lasers with solids, desorption and ablation occur on surfaces of materials irradiated by a laser beam. When directing at grazing angle, a laser can remove surface deposited materials without damage to the bulk. This has been utilized for non-invasive cleaning of delicate historic objects and also for the removal of surface contamination on wafers in the semiconductor industry. To test the suitability of laser cleaning for Genesis samples, we selected a silicon wafer fragment, contaminated it intentionally, and applied laser cleaning under grazing incidence angle to the fragment to remove the contamination. The wafer was analyzed by total reflection X-ray fluorescence (TXRF) before contamination, after contamination, and after laser cleaning to investigate the effectiveness of this method. Concentrations of surface contaminants were calculated at each stage of the experiment using external calibration curves. Spectral backgrounds were compared to evaluate whether surface damage occurred as a result of laser irradiation. The data show that laser surface cleaning removed most of the contaminants and did not compromise the wafer surface. Additional experiments involving different collector materials and optimizing laser parameter are currently underway.