# Genesis: An Analysis of Molecular Contamination on Collectors through Spectroscopic Ellipsometry

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Before the Genesis spacecraft returned to Earth in September 2004, the mission designers had a preliminary assessment plan in place for the purpose of providing information on the condiBefore the Genesis spacecraft returned to Earth in September 2004, the mission designers had a preliminary assessment plan in place for the purpose of providing information on the condition and availability of collector materials to the science community as a basis for allocation requests. One important component of that plan was the evaluation of collector surfaces for molecular contamination. Sources of molecular contamination might be the on-orbit outgassing of spacecraft and science canister components, the condensation of thruster by-products during spacecraft maneuvers, or the condensation of volatile species associated with reentry.

Inspection of the interior of the Genesis science canister in Utah, and subsequently at Johnson Space Center (JSC), revealed a darkening on the aluminum canister shield and other canister components. Though there is no direct observation of film contamination on the collector surfaces, this might be difficult to observe with the naked eye and there is reason for concern regarding molecular contamination. To assess molecular contamination, collectors were examined using spectroscopic ellipsometry. The extension of the wavelength data to the near infrared becomes more critical as the identity of the molecular material may need to be determined.

Spectroscopic ellipsometry measures the change in phase and ellipticity of reflected polarized light as a function of incident angle and wavelength to determine film thickness, index of refraction, and extinction coefficients of contaminant layers on smooth surfaces. The results of the analysis are an extremely sensitive thickness and estimated optical properties of contaminant layers. For comparison with the flight samples, we measured pristine materials that have been stored in the Genesis Laboratory at JSC since the time of payload assembly.

The first flight samples analyzed by spectroscopic ellipsometry were an intact silicon on sapphire (SiOS) from the array and a gold on sapphire (AuOS) half hexagon on the same array. This array was selected because it is a bulk solar wind collector and is exposed at all times during science collection. The two specific samples were chosen to represent positions on opposite sides of the array for spatial variation. In addition, silicon surfaces represent the largest total area of collectors, and sapphire-based collectors have a statistically higher survival rate.

Several areas were measured on each of the flight wafers, and the models were applied to assess the presence of molecular contamination on the collectors. The results of this were as follows: Experimental vs. model fit for the optic parameter $\Psi$ for flight SiOS. The flight SiOS wafer is best fit to a model consisting of a sapphire substrate covered with an epitaxial layer of silicon that is 1814 $\pm$ 15 A thick, and an silicate layer with a

*Dr. Eileen Stansbery (right) and other members of the Genesis cleanroom team look at recovered samples.*

thickness of 35 ± 4 A. The flight AuOS collector is best modeled as a pristine gold surface with optical properties matching the flight reference sample and 8 A of surface roughness. Experimental vs. model fit for the optic parameter Δ for flight AuOS. The flight SiOS shows an increase in oxide thickness by a factor of two. This is consistent with the fact that flight collectors on the B array remained at elevated temperatures (as high as 200°C) for more than two years of science collection. Of course, no new oxygen is available; oxygen will diffuse under these conditions, however, forming a thicker layer of oxide with a sub-stoiciometric oxygen content. In fact, if one looks carefully at the fit to the oxide data there is a small deviation in the model and the experiment. This is a result of the optical anisotropy dielectric constant of the suboxide. The increase in index of refraction can also be related to the densification and increase in stress within the suboxide at relatively low growth temperatures or as a result of irradiation. The AuOS sample is an excellent match to the control sample. The only difference observed is a slight roughening of the surface, consistent with solar wind bombardment for two or more years. An attempt was made to fit the above data to a series of alternative models, including layers of hydrocarbon and silicone contaminants. No acceptable fits could be found.

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