GENESIS SOLAR-WIND SAMPLE RETURN MISSION: THE MATERIALS.

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Introduction: The Genesis spacecraft has two primary instruments which passively collect solar wind (fig. 1). The first is the "collector arrays", a set of panels, each of which can deploy separately to sample the different kinds of solar wind ("regimes"). The second is the "concentrator", an electostatic mirror which will concentrate ions of mass 4 through mass 25 by about a factor of 20 by focusing them onto a 6 cm diameter target.

When not deployed, these instruments fit into a compact canister (fig. 1). After a two year exposure time, the deployed instruments can be folded up, sealed into the canister, and returned to earth for laboratory analysis. Both the collector arrays and the concentrator will contain suites of ultra-high purity target materials, each of which is tailored to enable the analysis of a different family of elements.

This abstract is meant to give a brief overview of the Genesis mission, insight into what materials were chosen for flight and why, as well as "head's up" information as to what will be available to planetary scientist for analysis when the solar-wind samples return to Earth in 2004.

Overview of the Mission: The outer portion of the sun is believed to reflect the bulk composition of the original solar nebulae. Accordingly, measuring this composition precisely is important both for understanding the origins of all objects in the solar system.

One way to measure the composition of the outer portion of the sun is to analyze the solar wind. Data from spacecraft instruments performing *in situ* analysis are very valuable, but do not have the accuracy and elemental coverage required for planetary science applications, especially for isotopic measurements. The spacecraft instrument data have shown that there are three diffenent types of solar wind: interstream (low speed solar wind) coronal mass ejections, and coronal holes (high speed solar wind). In addition to bulk solar wind asmples Genesis will provide independent samples of the 3 kinds of solar wind.

The Apollo Solar wind Composition Experiment successfully collected solar wind by implantation into collector materials (Al-foil) for only a day [1]. The Genesis spacecraft will journey beyond the magnetic influence of Earth, and will collect solar wind by ion implantation into the collector materials for two years. Then, as per the Apollo experiment, the solar wind-implanted materials will be returned to Earth. The elemental and isotopic abundances of the solar wind will be analyzed in state-of-the-art laboratories, and a portion of the sample will be archived for the use of future generations of planetary scientists.

Technical information about the mission can be found at www.gps.caltech.edu/genesis.

Choosing "Flight-Rated" Materials: Clearly, a key to the success of the Genesis mission is choosing appropriate materials. It was not sufficient to find a set of materials with ultra-high purities: because the spacecraft will be in an extreme environment for four years, and there are other factors that we needed to consider:

Surface Cleanliness. Semiconductor industry standards are very high and many materials, e.g. Si, can be used as received. For other materials, testing is required to see if additional cleaning is necessary. Genesis materials will be loaded into the canister in a dedicated Curatorial Facility clean room and sealed until deployment. The canister is under N_2 purge until launch and immediately after recovery.

Physical stability. Materials have to survive extremes in temperature, repeated thermal cycling, the vibrations of launch, and the shock of landing without cracking, or flaking. These properties were checked during tests of an engineering model, as well as thermal-cycling and shock experiments on individual samples.

Chemical / thermal stability. Once implanted, the elements of interest in the solar wind must not diffuse out, even though temperatures may get to several hundred degrees celcius while the collector arrays are deployed. Layered materials must remain layered and can't interdiffuse or react to form intermetallics. Single phase materials can't recrystallize during the collection, nor tarnish while being stored prior to launch or post-flight recovery. In many cases we have had to perform our own thermal stability / diffusion measurements.

Stability with respect to radiation damage. The keV solar-wind protons can cause surface damage in some materials [2]. Exposure to the solar radiation must not cause blisters or bubbles to form, or coatings to delaminate. Conversely, if there is some minor radiation bubble formation, it must be clear that the elements being colleced will not diffuse into the bubbles or radiation-damaged areas, and then escape.

Analyzability. Implicitly, this mission not only requires material purity; but also at least one demonstrated technique for making each proposed measurement.

Availability. The materials must either be commercially available or, if developed specifically for Genesis, fabricated with consistent quality within our time and budget constraints. Most of our materials are being purchased from vendors to the semiconductor industry. They are undoped, commercial wafers which have passed our extensive qualification process. Some of the layered materials have commercially-made substrates, but are being coated at JPL in their Microdevices laboratory.

Materials of Choice: We currently have ten materials which have qualified for use as collector array materials, and three which have qualified for use as "target" materials for the concentrator. The passive collector materials include: float-zone silicon (FZ), Czochralski-grown silicon (CZ), sapphire single crystal (S), epitaxial-silicon-on-sapphire (SOS), single crystal intrinsic germanium (Ge), aluminum on silicon (AlOS), gold on sapphire (AuOS), diamond-like carbon on silicon (Sandia), a carbon-cobalt-gold on sapphire (CCo-AuOS), and Vitraloy (V - a true metal glass). The "target" materials approved for the concentrator are an amorphous diamond-like C film on Si (Sandia), free-standing CVD diamond (Diamond), and epitaxial silicon carbide (SiC). Both types of "diamond" use ^{13}C to allow for O isotope measurements as CO or CO_2.

Collector Materials:

Material	Primary Purposes
FZ	FZ Si is exceptionally pure. As far as we know, all elements except those which diffuse rapidly (Fe, alkalis) could be analyzed.
CZ	Same as FZ, except for C and O. CZ is used because it can be obtained with very clean surfaces.
SOS	C; epitaxial-silicon layer potentially simplifies extraction.
Ge	No detectable impurities. Ge complements Si for SIMS analysis because of greatly reduced molecular interferences.
S	We are unable to detect any impurities. Potentially useful for alkalis
AlOS*	Noble gases
AuOS*	N, Fe, alkalis.
Sandia	N, noble gas isotopes
CcoAuO S*	Layered film SEP-particles
V**	Noble gases, Higher energy particles

Note: * indicates coated at JPL/MDL; ** indicates specialty products. All else are commercially available from the semiconductor industry.

Concentrator "target" materials

Material	Primary Purposes
^{13}C Sandia**	O, N,
^{13}C Diamond**	O, N, F .
SiC	O,N, LI, Be, B

** indicates specialty products. SiC is commercially available from the semiconductor industry.

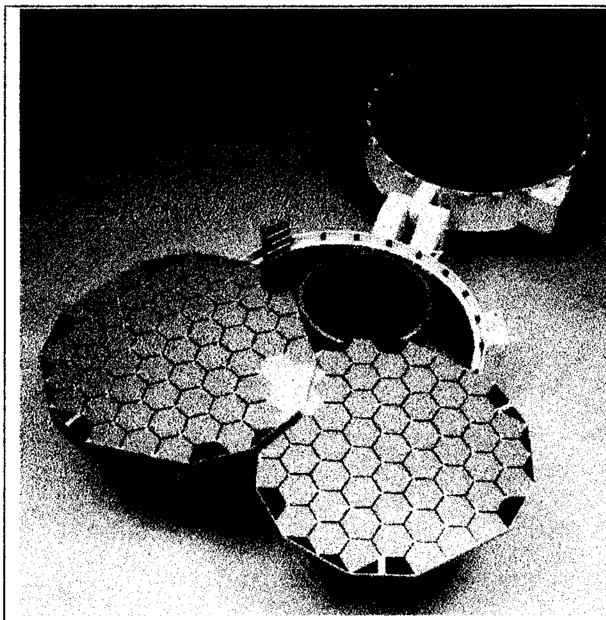

Fig. 1. Model of the two Genesis solar-wind collectors. First, the four deployable passive collector arrays (comprised of individual hexagon collectors; here, only dummy-materials shown). Second, the electromagnetic concentrator (round, inside canister of spacecraft). The collector arrays can be rotated to fit inside a canister, the base of which is in partial view next to the concentrator A 5th collector array is in the canister cover(upper right corner of the photo).

References: [1] Geiss J. et al. (1972) In *Apollo 16 Preliminary Science Report*, NASA SP-315, pp. 14-1 to 14-10. [2] Condon J. B. and Schober T. (1993) *J. of Nuclear Mater., 207*, 1-24.

Additional Information: Internet links to scientific information about the mission can be found at http://tiberious.jpl.nasa.gov as well as http://www.gps.caltech.edu/genesis. Basic information for the layman and teaching aids for K though 12th grade are available on the website http://genesismission.jpl.nasa.gov or by writing to: McREL Education and Public Outreach, 2550 S. Parker Rd., Suite 500 , Aurora, CO 80014.