Genesis: Sorting out the pieces. K.M. McNamara[1], Andrew Westphal[2], A. L. Butterworth,[2] D.S. Burnett[3], NASA, Johnson Space Center, Houston, TX 77058; karen.m.mcnamara@nasa.gov;[1] ; [2]University of California at Berkeley, Berkeley. CA 84720; [3]California Institute of Technology, Pasadena, CA 91125.

Introduction: The Genesis mission returned to Earth on September 8, 2004, experiencing a non-nominal reentry. The parachutes which were supposed to slow and stabilize the capsule throughout the return failed to deploy, causing the capsule to impact the desert floor at a speed of nearly 200 MPH. The result is that instead of receiving 301 intact solar wind collectors, mission personnel recovered and documented more than 10,000 collector fragments. Most of the fragments were pieces of the collector arrays but were not recovered on their original array locations. These were classified by size (longest dimension), identity (sometimes a guess) and found location (when known). The work took more than one month in Utah, and details are discussed elsewhere[1] The samples were transferred to their permanent home at the Johnson Space Center on October 4, 2004.

One of the earliest goals of Genesis preliminary assessment has been to generate a summary with detailed information with respect to the type, quantity and condition of collectors recovered by the mission , as this information is critical to the scientific community and their ability to extract valuable information from the returned solar wind collectors. The shear volume of data generated at UTTR makes the task a daunting one. The fact that many of the assignments need to be validated, clarified or measured for the first time by additional assessment techniques makes the task a monumental one. The results of compiling and evaluating the collector documentation generated at UTTR to date is presented in another discussion.[2] The evaluations required to further sort the Genesis collector fragments include:

Identifying the array of origin or solar wind collection regime for each fragment;

Unambiguously identifying the composition of each fragment;

Determining if the fragments were originated on one of the few collectors that were not Sun-exposed;

Providing an assessment of the condition of the collectors in terms size, contamination, and physical wear.

The first three are addressed here.

Sorting by Thickness (Solar Wind Regime): Multiple arrays were used on the Genesis payload so that individual arrays could be exposed to the various different regimes of the solar wind. There were five arrays on the Genesis spacecraft: two, the B and C arrays, were exposed at all times to the bulk solar wind; while the L, H, and E arrays were exposed only during low speed solar wind, high speed solar wind, and coronal mass ejection events, respectively. It is an important goal of the mission to separate the materials exposed to these varying conditions in order to gain further insight into the composition of the sun and its variation over time and with solar activity. Unfortunately, very few col lectors, or fragments thereof, remained attached to the arrays after impact, so sorting collector fragments by solar wind regime becomes a more difficult and labor intensive task.

In an admirable display of foresight, payload designers mandated that the thickness of collectors on each of the five collector arrays within the Genesis payload differ by a substantial margin (~ 50 microns), so that in the event of collector mixing, such as we have experienced, the recovered collector fragments could be traced back to the array of origin.[2] Within a given array, the collector thickness is uniform to +/- a few microns. Though there are several options for determining the thickness of individual collector fragments, the large number fragments and the strong desire to avoid surface contact, warrants the selection of a non-contact technique that can be somewhat automated to improve sorting efficiency.

The system selected for thickness determination is a large area auto focus reflection optical microscope with a perforated motorized stage. The stage is sufficiently large to accommodate 50-100 of the smaller wafer fragments at discrete location which are programmed into the stage translation software. Samples are prevented from slipping during stage movement through the use of a vacuum chuck. Researchers at Berkeley have developed depth analysis software that allows thickness determination by focusing on the top and bottom edges of the fragment. The curation system will be built in collaboration with the Berkeley team to insure software transferability. Because of the large quantity of samples (> 10,000) to be processed, samples will still need to be prioritized for analysis. This prioritization will be driven by the allocation and sample request process. The collector database, available to the science community, will be updated on a continuing basis.

Sorting by Collector Type: The Genesis spacecraft carried 15 different types of collector materials. [1,2] Eight of these were housed on the collector arrays, which sustained most of the damage on impact. Many of these materials are visibly distinguishable, however there are three materials for which visual assessment may be ambiguous. These are FZ and CZ silicon and diamond on silicon. Two approaches to distinguishing these materials were employed: FTIR spectroscopy and backside reflectance. Since FTIR is the more reliable technique, it is discussed here.

The FTIR spectra of FZ and CZ silicon differ significantly in their IR absorption. There is a clear Si-O absorption line in the CZ spectrum at 1000 cm^{-1} that is essentially absent in the FZ samples. Diamond on silicon may show carbon related absorptions in this region, but also shows a characteristic absorption about 2000 cm^{-1} that is not present for silicon. Thus the three materials can be unambiguously separated. An example of the FTIR absorption of control FZ and CZ silicon samples as well as three undetermined flight samples is shown in Figure 1. It is clear that only one of the flight samples is CZ, while the others are FZ. There is no evidence of carbon on any of these samples.

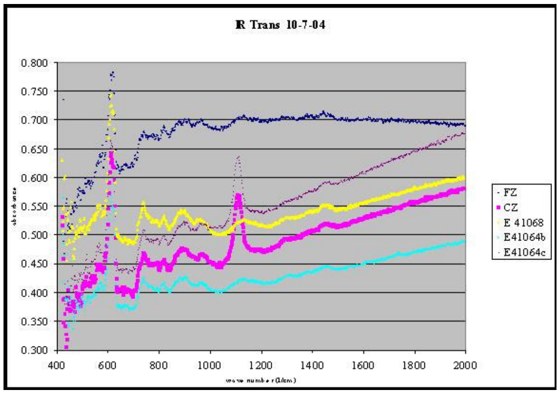

Figure 1. FTIR spectra of CZ and FZ control samples as well as three unknown pieces recovered from the Genesis payload.

Sorting by Exposure: As a result of the array geometry and stacking configuration, there a several collectors on the E, H, and L arrays which are obscured solar wind exposure by the arrays above. These samples were intended to be used as control coupons in the nominal case. In the present case, however, this means that there is a small but finite number of samples, which do not contain solar wind implants and may be mistaken for materials, which do. The materials which potentially fall into this category are Si, AuOS, and AlOS. It may be possible to detect a weak Si-H signal in the laser Raman of the exposed silicon, allowing it to be identified, but it is unclear how to differentiate exposed and unexposed AuOS and AlOS. This remains one of the largest unsolved sorting problems for the Genesis collectors.

References: [1] E. K. Stansbery *et al*. (2005), *LPSCXXXVI*, this volume; [2] J.A. Allton *et al*. (2005), *LPSCXXXVI*, this volume.