TXRF ON GENESIS SAMPLES.

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Introduction: One of the primary goals of the NASA Genesis Mission was to obtain accurate measurements of solar elemental abundances in order to ultimately gain a better understand of the origins of the planets. Extremely clean wafers installed on the Genesis satellite were exposed to solar wind for 27 months. Solar wind is predicted to have 1 keV of kinetic energy per atomic mass unit (amu), so 75 keV As ions in silicon will implant to a depth of 55 nm with a FWHM of 35 nm. For 31 keV phosphorus in silicon, the implantation depth is 42 nm and the FWHM of the distribution is 46 nm. The expected solar wind fluences are approximately $1x10^{11}$ for Ni and $3x10^{12}$ atoms/cm^2 for Fe, with most transition metals having significantly smaller fluences.

Analysis: Total Reflection X-ray Fluorescence (TXRF) is an extremely surface-sensitive technique for measuring low levels of surface contamination. It uses the principle of total external reflection, i.e. that for x-rays incident on a flat surface below the critical angle (typically 0.2°) the beam is reflected rather than penetrating into the bulk. Thus it can be used both for measuring the surface contamination of the Genesis wafers post-crash as well as measuring the implanted solar wind, using angles of incidence above the critical angle. This method is greatly benefited by the use of a high-brightness synchrotron source, given the very small angles of incidence. Building on techniques we developed for the study of silicon wafer cleanliness in collaboration with the semiconductor industry, we have developed hardware and methodology which is capable of sensing surface contamination of $1x10^8$ atoms/cm^2 for a 1000 second measurement. For TXRF the most appropriate Genesis samples are the uncoated sapphire substrates, because they tend to be the largest pieces post-crash and are sufficiently robust that surface contamination can be effectively removed without affecting the implanted solar wind.

Results: We will present results of several methods of surface contamination removal as well as preliminary measurements of the bulk solar wind signals. Flight sample #30580 was cleaned using a variety of physical and chemical methods including megasonic cleaning, UV-ozone, and chemical etching which were able to remove much a significant fraction of the contamination. Due to the large number of peaks in the Genesis samples, we used the scatter peak to normalize the spectra to a standard Si wafer. Using this method, we obtained the following quantities for this sample: Al $9.9x10^{15}$, Si $5.0x10^{13}$, S $2.75x10^{12}$, Cl $1.85x10^{12}$, Ca $2.41x10^{12}$, Ti $2.27x10^{11}$, V $1.2x10^{10}$, Cr $2.95x10^{11}$, Mn $1.43x10^{11}$, Fe $1.13x10^{12}$, Ni $1.21x10^{11}$, Cu $1.50x10^{10}$, Zn $2.51x10^{10}$, Ga $4.7x10^9$, and Ge $7.5x10^{10}$. Fitting was done using PyMca[1]. The samples are now clean enough that meaningful angle dependent TXRF measurements of the implanted solar wind components can be made and analyzed as to their depth distributions.

References:

[1] Sole, V. A, Papillon, E, Cotte, M, Walter, Ph. and Susini, J. 2007. *Spectrochemica Acta B.* 62:63–68.