

SURFICIAL CONTAMINATION ON GENESIS FLIGHT SILICON ON SAPPHIRE (SOS) WAFER FRAGMENTS AND ITS IMPLICATION TO THE DETERMINATION OF SOLAR WIND TRACERS.

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Introduction: Solar wind tracers have been collected during the NASA GENESIS mission by exposing ultraclean wafers outside the Earth's magnetosphere in the ion flux from the Sun for 884 days. However, the sample canister crashed-landed into the Utah desert at a speed of ~200 km/h on return to the Earth. This accident destroyed the ultraclean environment inside the sample canister. The wafers were fragmented and seriously contaminated with the Utah desert mud, fragments from sample canister, and powered wafers and other collector materials. Since the solar wind is imbedded in the wafers at a depth of ~100 nm below the surface, in principle, it is possible to recover the chemical abundances of the imbedded solar wind tracers if the surficial contamination can be effectively removed. In order to both characterize and remove the surficial contamination on the GENESIS wafers and select target elements for high precision solution-ICP-MS analysis, following Huang et al. [1], we carried out a step-leaching procedure using hot aqua regia (3 parts HCl + 1 part HNO₃) on flight Silicon on Sapphire (SoS) wafer fragments 50030, and determined the leaching effect using ICP-MS at Florida State University. Compared to prior work [1], we analyzed a much broader range of elements.

Experiment: We applied step-cleaning procedure using hot aqua regia on flight wafer fragment 50030. The wafer fragment was heated to 110°C in aqua regia in a Savillex[®] beaker on a hotplate for 2 hours, followed by rinsing with de-ionized water. This step was repeated up to 16 times. The aqua regia leachates of wafer fragment 50030 were analyzed by ICP-MS for elemental concentrations using Finnigan Element[®] XR ICP-MS with an ESI Apex[®] nebulizer at FSU. The results are summarized in Figs. 1-3.

Results: The elemental analyses of each of the aqua regia leachates of SoS wafer fragment 50030 are presented in Fig. 1. There is significant amounts of contamination on the wafer surface. For example, there is on the order of 10¹⁵ Al atoms, 10¹⁴ Mg and Fe atoms, 10¹³ Ga and Ge atoms, 10¹² Au atoms and 10¹⁰ La atoms in the leachates, which is hundreds to billions of times higher than the estimated imbedded solar wind tracers. As shown in Fig. 1, the first aqua regia leach-

ing step removed the majority of the surficial contamination, such as Fe (Fig. 1), Ga, Ge and Au (not shown). However, there are still significant amount of Al, Mg and La shown in leachates in later leaching steps. Specifically, there are 10¹⁴ Al atoms, 10¹² Mg atoms and 10⁸ La atoms in a later step after leaching with hot aqua regia for 26 hours (Fig. 1). This observation is consistent with the presence of Al₂O₃ particles in the aqua regia leached (after 16 steps) SoS wafer fragment 60300 [2]. It is possible that some Utah desert mud was trapped beneath the embedded Al₂O₃ particles remaining after aqua regia leaching. Complete removal of particles may be necessary for recovering solar wind by bulk ICP-MS technique.

Discussion: The aqua regia leachates of SoS wafer fragment 50030 were analyzed for most elements in the periodic table. These data give us a big picture of the surficial contamination on the GENESIS wafers for the first time. With these data, we are able to characterize the surficial contaminants on the GENESIS wafers, and select target elements which are less affected by surficial contamination for high precision solution-ICP-MS analysis.

The pattern of rare earth elements (REEs) in SoS wafer fragment 50030 leachates shows enrichment of light REE, a typical characteristics of upper continental crust (Fig. 2). Moreover, aggregated 50030 aqua regia leachate has Zr/Hf=54 and Nb/Ta=9, similar to that in the upper continental crust [3]. These observations are consistent with the Utah desert mud being a major contaminant source for GENESIS wafers [1, 4].

The Utah desert mud has (Fe/Mg)_{atomic} of 0.1 [1]; therefore, (Fe/Mg)_{atomic} in the leachate can be used to estimate the relative proportions of Utah desert mud and stainless steel particle. Huang et al. (2007) [1] reported (Fe/Mg)_{atomic} of 9 in the aqua regia leachate from SoS wafer fragment 60303, and inferred that the high Fe/Mg is a result of embedded stainless steel particles. In contrast, the (Fe/Mg)_{atomic} in aggregated leachates of SoS wafer fragment 50030 is 0.3, implying that the distribution of contaminants is uneven and ranges from wafer to wafer.

Although the GENESIS wafers are highly contaminated, we noted that not all elements were contaminated to a same level. The element abundance in

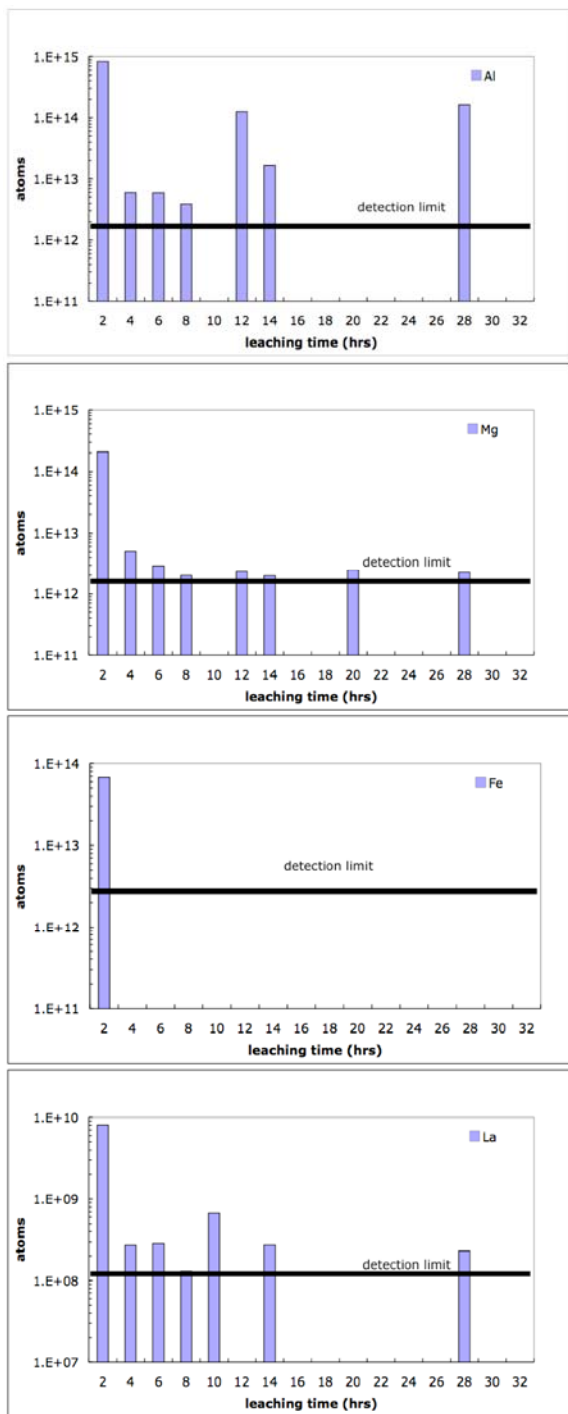


Fig. 1 Al, Mg, Fe and La in SoS wafer fragment 50030 aqua regia leachates in atoms recovered.

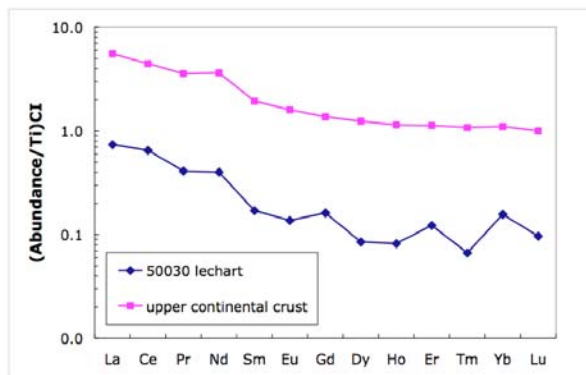


Fig. 2 Rare earth element abundance in aggregated leachates from 50030, normalized to Ti and CI chondrite composition. Average upper continental crust composition is shown for comparison.

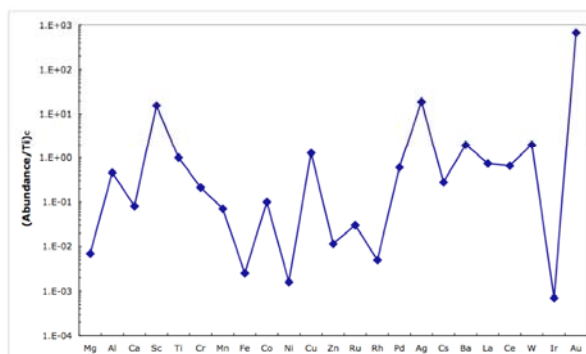


Fig. 3 Multiple elemental abundance in aggregated leachates from 50030, normalized to Ti and CI chondrite composition.

the aggregated leachates, normalized to CI chondrite composition, is shown in Fig. 3. Some elements are less abundant in the leachates, and maybe absent in the surficial contamination. These elements, including Ni, Rh and Ir, are unlikely to be affected by surficial contamination, and constitute target elements in our future high precision solution-ICP-MS analysis.

References:

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- [4] Huang S. et al. (2006), *LPSC XXXVII*, Abstract#2440.