MG PROFILE CORRECTION IN GENESIS SI COLLECTORS USING RASTERED ION IMAGING
A. J. Westphal[1], R. C. Ogliore[2], G. R. Huss[2], K. Nakashima[2], C. Olinger[3], [1] Space Sciences Laboratory, University of California at Berkeley, Berkeley CA 94720, USA, [2] HIGP, University of Hawai'i at Manoa, USA, [3] Los Alamos National Laboratory, USA

Introduction: An accurate measurement of the isotopic composition of Mg in the solar wind is one of the highest priority measurements to be carried out using the returned Genesis samples [1]. Since the Mg isotopic composition of the sun is highly likely to be chondritic to within $\ll 1$‰, a measurement of the deviation from chondritic values allows an accurate test of mass-dependent fractionation between the photosphere and the solar wind, thus allowing, for example, for an improved estimate of the isotopic composition of oxygen in the Sun. Here we demonstrate a new technique for measuring the depth profiles of Mg in Secondary Ionization Mass Spectrometry, in which images are recorded that allow for pixel-by-pixel correction for depth and elimination of pixels that are contaminated by terrestrial materials.

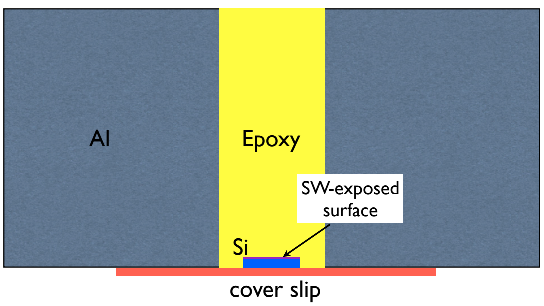

Fig. 1: Schematic of sample mounting prior to backside grinding and polishing.

Methods: We prepared Genesis Si sample 60633 by fixing it with cyanoacrylate to a glass coverslip, with the SW-exposed surface facing away from the coverslip. We aligned the chip to within $\sim 1^\circ$ of the coverslip by aligning the reflections of the pupil of the eye of the sample preparer in the Si chip and the coverslip, respectively. We then fixed the coverslip to a 25 mm Al round, so that the Si chip was inside a 9.5 mm diameter hole in the round (Fig. 1). We then filled the hole with EMBED 812 epoxy, and let cure for 48 hours at 60°C. We then ground the Si chip in its Al round to a wedge, and polished. Thus, with the sample mounted in the SIMS instrument, the implanted profile is approached from the backside, because the surface exposed to the SW is under the polished surface. After polishing, the sample was optically transparent in the red. Using the observed interference fringe spacing in the optical image, we estimated the wedge angle to be $\sim$1.0°.

We mounted the sample in the Cameca ims 1280 at the Hawai'i Institute for Geophysics and Planetary Physics (HIGP), and collected rastered depth profiles in several spots centered 30μm from the edge of the wedge. We used a 200 pA O_2^+ primary beam focussed to a 2 μm spot. We presputtered a 30 μm $\times$ 30 μm raster at 2 nA beam current before collecting 256 $\times$ 256 pixel raster maps over 30 μm $\times$ 30 μm areas. We collected H, then ^{30}Si, then ^{24}Mg-^{25}Mg-^{26}Mg by multicollection.

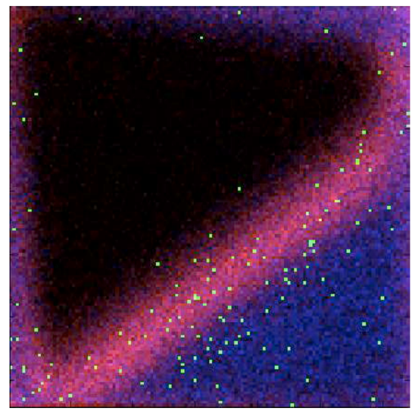

Fig. 2: A frame in the course of a depth profile in Genesis sample 60636. Blue = Si, Red = H, Green = Mg. The image has been downsampled from 256 $\times$ 256 to 128 $\times$ 128.

We analyzed the data independently at Hawai'i and at Berkeley by two methods. In the Hawaii method, we found the maximum positive slope of the H profile by its smoothed first derivative which we used to align all the pixels in the map by depth. We used the smoothed second derivative of the downsampled Si channel to determine the cycle at which we start to break through the Si chip and start collecting Mg contamination from Utahogenic Schmutz (UGS). At this point we cut off the profile for that pixel. This introduces a bias in the Mg isotopic composition because heavier solar wind isotopes penetrate deeper into the chip. We correct for this bias by using SRIM simulations of solar wind Mg isotopes. With the UGS well-separated from the implant profile, we use UGS as the isotope standard as its Mg composition is equal to the terrestrial value. In the Berkeley method, we used the barycenter of the H profile to determine the pixel depth correction, and rejected pixels which showed evidence for contamination from UGS. The result has larger error bars because of the lower statistics, but may be less contaminated with UGS.

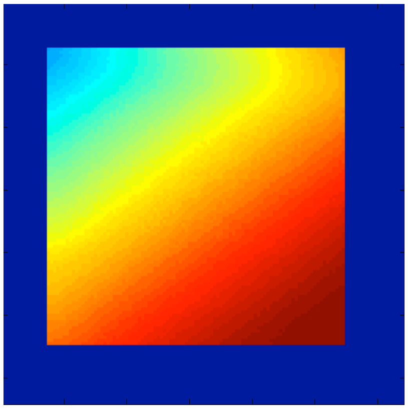

Fig. 3: The pixel-by-pixel peak position of the H profile, in the downsampled 128 × 128 image, converted to a color spectrum. The peak is reached first at the upper left (blue) and last at the lower right (red). We used to peak in the H profile to align the depth profile for each pixel such that the peak is reached in the same plane for all pixels. The blue regions are near the edges and have been excluded from the dataset.

Results: In Fig. 4 we show the depth-corrected Mg profiles for all three isotopes, using the Hawai'i method for depth correction. The Berkeley method gives a similar result. We get reasonably good separation between the solar wind and UGS, but it is not yet as good as we had expected. One problem is that our primary ion beam has a finite diameter ($\sim$2 μm), which, when convolved with the slope of the wedged collector, smears the solar wind profile in depth for each pixel. We are currently developing the ability to prepare sample with a smaller wedge angle ($\sim$0.3°) and will decrease the primary beam spot size (to $\sim$1 μm) to improve the separation between the solar wind and the UGS.

If Mg is fractionated similarly to O in the solar wind, we would expect a deviation from terrestrial of (δ^{25}Mg,δ^{26}Mg) = ($-$11.5,$-$23)‰ [2]. Our current 2σ confidence limits do not allow us to detect this deviation from terrestrial values. Approximately 30 scans equivalent to that shown in Fig. 4 would be required to reduce the statistical errors to the required level to distinguish the prediction from (0,0) at the 2σ level.

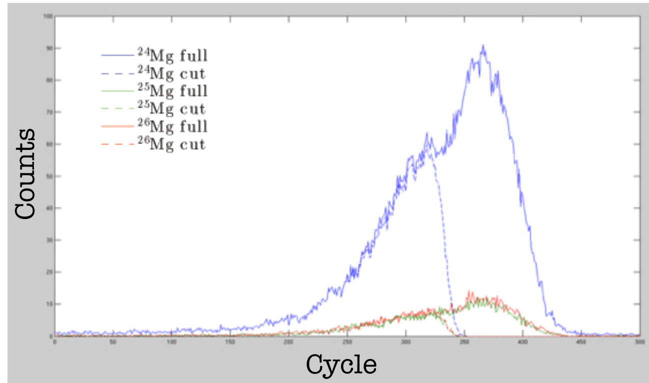

Fig. 4. Three isotope Mg profile (blue = ^{24}Mg, green = ^{25}Mg, red = ^{26}Mg), using the Hawai'i data reduction method. The solid lines show the summed, depth-corrected profiles with no cuts; the dashed lines show the profiles with cuts as described in the text.

References: [1] Burnett, D. S. (2013) MAPS **48**, 2351-2370. [2] Bodmer, R. and Bochsler, P. (2000) JGR **105**, 47-60.