

COMPARING SIMS DATA FOR SOLAR WIND Na IN TWO COLLECTORS USING MULTIPLE APPROACHES. K. D. Rieck¹, A. J. G. Jurewicz^{2,3}, and R. C. Ogliore⁴, ¹New Mexico Consortium, 4200 W. Jemez R., Suite 200, Los Alamos, NM 87544, krieck@newmexicoconsortium.org, ²Arizona State University, CMS/SESE (Visiting ³Dartmouth College), Tempe, AZ, ⁴Washington University St. Louis, Phys., Washington University in St. Louis, St. Louis, MO.

Introduction: Solar wind (SW) was returned to Earth for analysis by the Genesis spacecraft so that matter directly from the Sun could be used to model the solar nebula and the formation of solar system objects, including chondritic meteorites [1]. The Genesis SW collectors comprise a variety of different materials [2], allowing options for selecting a collector well-suited for measuring each SW element or isotope of interest.

Ion implant profiles measured by secondary ion mass spectrometry (SIMS) revealed deviations from SRIM implant models for elements in Genesis silicon (Si) collectors, but not in Genesis diamond-like carbon (DLC). Some researchers have postulated that SW movement in Si collectors results in exchange of SW ions with the collection surface (e.g., [3]). But, for SW Mg, that inference has been shown to be erroneous ([4] and references therein). However, both our results for SW Na in Si and those of [5] (Fig. 1) are suspicious because the SW Na profile intersects “contamination” before simultaneously analyzed SW Mg. Although this may be “up-mixing,” diffusion of Na towards the ion beam, etc., the retention of Na in Si must be verified.

Accordingly, most of our measurements of SW Na are in a second collector material, DLC. SW Na measurements in Si and DLC showed a disparity which is variable, by up to a factor of 2 lower in DLC (e.g., [6]). Because DLC is not an easy material to analyze, it was necessary to verify the results multiple ways.

Experimental: New and newly reprocessed data presented here were collected using a CAMECA IMS 7f. Both front-side and back-side depth profiling (FDP and BDP, respectively) analyses of SW Na were performed using O_2^+ at Caltech. Only BDP analysis of SW Na was performed using O_3^- (from a Hyperion source) at WUSTL. We also collected ion imaging data (a technique pioneered by [7]) at WUSTL for ongoing work.

Details for experimental conditions at Caltech are given in [6]; but, new data reduction techniques [8] were used. At WUSTL, our set up conditions were as follows: -13kV O_3^- primary source, 3kV sample voltage, 5.3keV impact energy per O, 18nA, 1705 mass resolving power (MRP), 125 μ m raster. A back-side calibrated Na implant was used to quantify the depth profiles. Both C_2^+ and C^+ were collected throughout to check for small changes in sample charging after the methods of [4]. Because several depth profiles showed buried Na-rich contaminant particulates, we began collecting ion images

for each analysis cycle to enable contamination removal using the methods of [8].

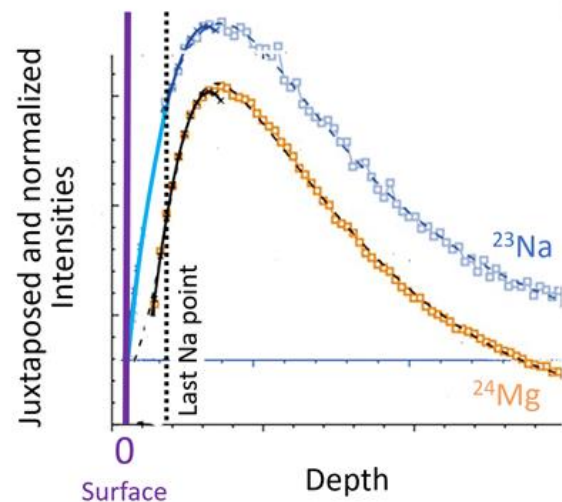


Fig. 1. Back-side depth profiles of SW ^{23}Na and ^{24}Mg in Genesis Si modified from [5]. The total depth represented here is 150nm. Both profiles were analyzed in a single Cameca IMS 1270 profile. Note that the last ^{23}Na (before surface contamination, not shown) is ~ 3 duty cycles prior to the last ^{24}Mg . The early “breakthrough” of ^{23}Na relative to ^{24}Mg was also observed in depth profiles from this study. Squares are data; black and cyan lines are [5]’s models; purple line indicates collector surface.

Results: The results of reprocessing a subset of SW Na profiles are presented in Fig. 2 along with the result of our first measurement using O_3^- . Although the results of both FDP and BDP analysis of DLC with the IMS 7f had fairly large uncertainty, there is a fairly narrow range at which these results all agree (approximated by the yellow box, $\sim 7.5 \times 10^{10} \text{ cm}^{-2}$; Fig. 2). The Na fluence in Si calculated from Fig. 1 is less than our average result in Si [9], but still higher than that in DLC. Our first profile using O_3^- and ion imaging is in Fig. 3. Quantification of ion image data is currently in progress, and so is not included in Fig. 2.

Discussion: If we exclude the least precise measurement of Fig. 2, the remaining SW Na from DLC are all significantly lower than for Si. Because results from the DLC FDP and BDPs overlap, our interpretation is that the SW Na is artificially high in Si, both [9] and [5], supporting the idea that the “early breakthrough” of SW Na in the Si analyses (Fig. 1) is due to exchange with

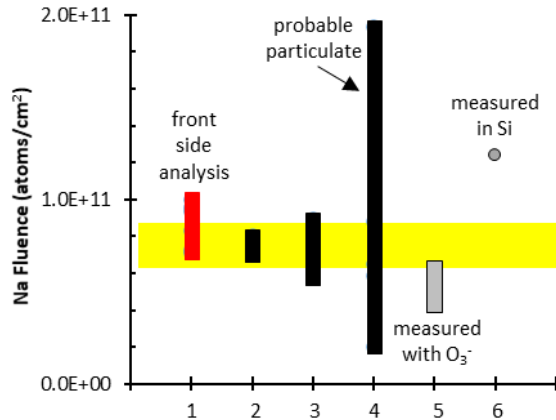


Fig. 2. SW Na fluences from DLC vs. Si. Numbers 1-5 indicate individual analyses; bars indicate different assumptions for data reduction. Ranges are large, but the yellow box (centered at $\sim 7.5 \times 10^{10}$ Na/cm²) includes all DLC analyses. Circle is the SW Na fluence in Si after [5] calibrated to our implant.

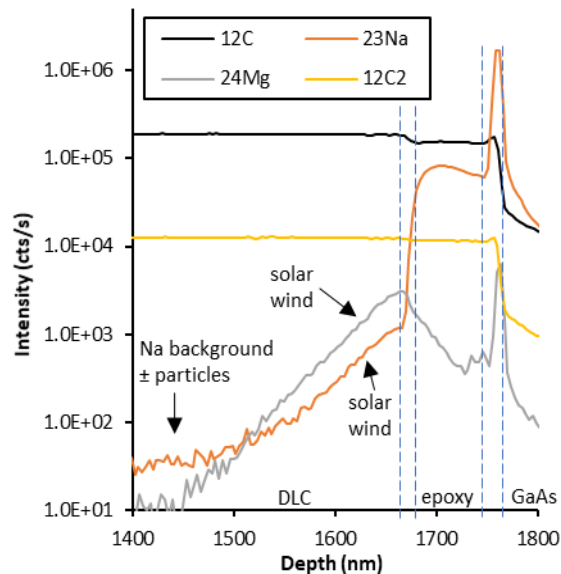


Fig. 3. Back-side depth profile into DLC (mounted on GaAs using epoxy) using ion imaging (raw data) on IMS 7f. Pairs of vertical dashed lines bound transitions between Genesis DLC, underlying epoxy, and GaAs substrate. Depth was estimated using the DLC thickness measured using interferometry. Note: log scale intensity. Some contaminants and crater edge effects have been excluded from this integration, following the methods of [9].

surface Na (e.g., the model of [3]). If this interpretation is accurate, then Na and Mg are not behaving the same way in Si. Further investigation is needed to check this interpretation.

Another possibility is that a portion of the sputtered crater breaks through to the epoxy-silicon boundary before the analyzed area, releasing Na contamination that

could migrate to the analyzed area prematurely, driven by the charge of the primary ion beam. This contamination could look like diffusion from a constant source of Na for a few cycles. If true, it is possible that a lateral Na gradient might be visible in the ion imaging.

Note that, although the [5] fluence is 65% higher than our DLC fluence, the peak of the “SW” implant is distinct (Fig.1). So, any up-mixing of Na from the epoxy needs to be significant in Si sampled deeper than the peak to account for the error in the SW fluence.

Low impact energy O_2^+ is commonly recommended for high resolution SIMS depth profiling, but many labs with new Hyperion sources are not set up for this primary beam. Based on the analyses presented in Fig. 2, the choice of an O_2^+ vs. O_3^- low-impact energy primary beam was not seen to make a significant difference in the Na fluence estimate in DLC, but additional data at higher MRP are needed to confirm this. The fluence from O_3^- does appear to be slightly lower; the sputtering rate per nA was slightly higher than expected (vs. our O_2^+ and Cs^+ of [10]). The lower fluence may indicate the presence of hydrides (no H was present in the reference implant). We will be carefully investigating slight variations in C^+ count rates in the SW H zone of ion image data to see if they represent a matrix effect, uneven breakthrough, or other feature. Most DLC measured using O_2^+ did not show significant hydride formation [4]. Matrix ion yields showed lower C_2^+ ion yield relative to C^+ when measured using O_3^- vs. O_2^+ .

Synopsis: Measurements of SW Na are inferred to be high in Si, but it is unclear if the cause is exchange with the surface or an analytical artifact. SW fluences from FDP and BDP measurements in DLC are consistent within error, as are fluences from O_2^+ and O_3^- . The O_3^- has a different sputtering yield for several species. Future work will entail more precise data reduction and extend that knowledge to other SW species.

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