**SW Mg FROM GENESIS; NEW METHOD OF DATA REDUCTION AND IMPLICATIONS.** A. J. G. Jurewicz[1], C. Olinger[2], D. S. Burnett[3], K. D. Rieck[2], and D. S. Woolum[4], [1]ASU/CMS P.O. 6004, Tempe AZ 85287 Amy.Jurewicz@asu.edu, [2]LANL Los Alamos NM 87545, [3]GPS Caltech 1200 E. California Blvd Pasadena CA 91125 and [4]Physics, CSUF, Fullerton CA 92831.

Introduction: Solar wind (SW) Mg analyses of Genesis diamond-like carbon (DLC) on silicon (DoS) collectors give a fluence of 1.59E12 atoms/cm^{2}, with a $\pm$3.5% 1σ standard deviation of 8 analyses. This fluence is consistent with measurements in silicon using both front-side [1] and backside [2] SIMS depth profiling. Ion yield and instrumental mass fractionation (IMF) under SIMS analysis are variable; this new method quantifies previously problematic analyses. Consistency of the SW Mg fluence from DoS and silicon collectors confirms retention of Mg in Genesis silicon despite radiation-induced segregation [3]; however, preliminary calculations using this new method suggest that this may not be the case for SW Na.

Experimental: Two pieces of DoS were analyzed on the Cameca 6F at ASU. One DoS fragment was a flight-spare fragment implanted with $^{25}Mg/^{26}Mg$ at a ICPMS-calibrated ratio of 0.975 and whose ^{25}Mg fluence was determined to be 8.2E13 atoms/cm^{2} by SIMS analysis of co-implanted silicon. The other fragment was Genesis flight sample 20732,2. Details of the implantation, $^{25}Mg/^{26}Mg$ calibration, and SIMS analyses – both instrument conditions and the variation of ion yield with matrix properties -- are given in [4,5]. Variation of IMF with matrix properties are outlined in [5].

Methods: Background corrections (<<1% of total SW counts) were negligible. What is new is the method for recognizing and quantifying surface contamination and the resultant data reduction method used for determining the SW Mg fluence. Fig. 1 gives example corrections (previous and current) to a relatively clean SW Mg depth profile. The SRIM fit uses the SW velocity distribution measured *in situ* and does not require such a clean depth profile. All that is required is that a segment of the SW profile be clean of contamination. Fig. 2 gives an example SRIM fit correction
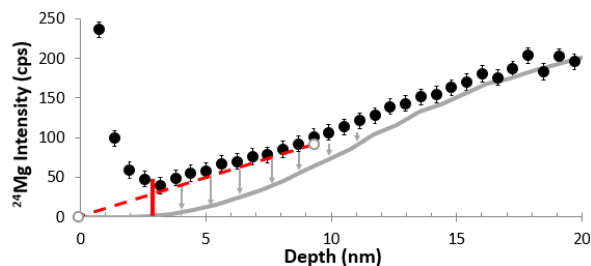
Fig. 1. *Surface corrections to depth profile. Dots: measured SW profile; red: previous methods (straight line fit to 0 (dashed) or truncation at minimum cps (solid)); gray line is SRIM fit; arrows emphasize the difference.*
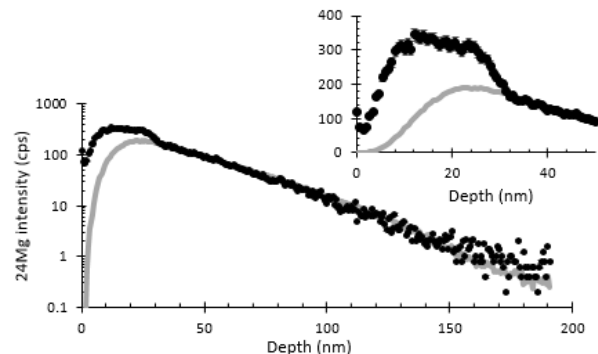
Fig. 2. *SRIM fit using only the tail of the profile as a near-surface particulate was sampled by the analysis.*

where a particulate is sampled along with the SW. Previously, this particular profile would have been considered useless; now the calculated fluence is within error of the other results.

Specific methodolgy for SRIM fits. All of the SRIM fits used the raw *__range3d.txt__* results for SW ^{24}Mg into carbon (density 2.85 gm/cc). These data were downloaded into a specialized spreadsheet and scaled in depth (density) and intensity in order to correct the measured data. The method is as follows.

For small changes in density the SRIM profile scales linearly, so the ion-depth data from the SRIM text file was multiplied by a scalar that could be changed iteratively in the spreadsheet. That is, if the measured data suggests that the DLC of the profile is 3.0 gm/cc (e.g., Fig. 3 of [4]), the ion depths calculated by SRIM are divided by 1.0526=3.0/2.85. If the measured profile was shallower than the model, 1.0526 might then be changed to 1.1=3.14 gm/cc, etc.

The scaled SRIM *__range3D.txt__* data (~999999 ions) are then "binned" to give the number of ions expected at the depths sampled by each SIMS duty cycle. Depth per duty cycle assumes constant sputtering; binning is calculated by Excel's Frequency(y, x) function, where y is the range of cells containing the *__scaled range3D.txt__* ion depths and x is the range of cells containing depths calculated for each duty cycle. The output range of cells (ions expected at depths of the SIMS duty cycles) is then multiplied by a second scalar. Again, both the first and second scalars can be changed iteratively to match the measured depth profile to enable the fit. The best fit is that having the minimum χ^2 value, where $\chi^2 = \Sigma((data - SRIM)^2)/ SRIM)$. Only measured data thought to be deeper than the ion-mixed surface contamination is used for the χ^2.

Checking validity of SRIM fits. The implants comprising the standard were much deeper than the SW profile, allowing direct observation of ion-mixed surface contamination for standard analyses. To validate the SRIM method for correcting measured SW profiles, contamination profiles from standard analyses were scaled and subtracted from SW depth profiles. Scaling entailed correcting the standard profile for density (to that of the SW SRIM fit) and intensity (an iterative fit). The calculation was validated when the mixed profile approximated the SRIM depth profile (e.g., Fig. 3).
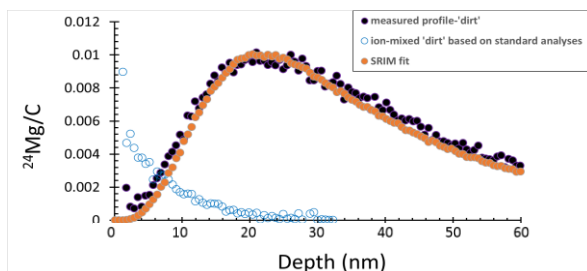
Fig. 3. *Duplicating SRIM fit by subtracting contamination measured in the standard from the raw SW depth profile.*

Calculating fluences from surface-corrected data. To calculate fluences, each SW analysis needed to be matched to a standard having similar matrix properties. This was done by parametrizing with the ratio of $^{12}C_2^+$ to $^{12}C^+$ ions [4-5] as follows. First, $\int(^{24}Mg*/C)dx$ of the standard profiles were calculated, where $^{24}Mg*$ is the measured ^{25}Mg x (terrestrial $^{24}Mg/^{25}Mg$) corrected for IMF. Then, $\int(^{24}Mg/C)dx$ for each corrected SW profiles and $\int(^{24}Mg*/C)dx$ for each standard analyses were plotted. Both showed linearity with $^{12}C_2^+/^{12}C^+$ over the range 0.11-0.14 and were constant at higher $^{12}C_2^+/^{12}C^+$ (Fig. 4). Then, the ^{24}Mg Fluence (F) is calculated by:

$$F_{SW} = (F_{STD})/(\int^{24}Mg*/C)_{STD} \times (\int^{24}Mg/C)_{SW}$$

where the matrix-matched $\int^{24}Mg*/C)_{STD}$ used was 2899.6492 x $(C_2/C)_{SW}$ - 92.63345 (see trendline Fig. 4).

Results: Calculated ^{24}Mg fluences for eight of ten SW profiles were 1.24E12 ($\pm$3.5%) atoms/cm^2, giving a fluence for total SW Mg of 1.59E12 atoms/cm^2. A ninth analysis gave a fluence > 1σ of the average if measured data were integrated, but within 1σ of the average if best-fit profile was integrated, suggesting that a subsurface contaminant was sampled. The final SW profile gave a totally anomalous fluence, but was anomalous in several other characteristics as well.

Summary and implications: This newly calculated fluence from DoS collectors confirms that SW Mg has been retained by silicon despite modification of the SW implant profile by radiation-induced segregation (e.g., [3]). It also confirms the method of calculating a
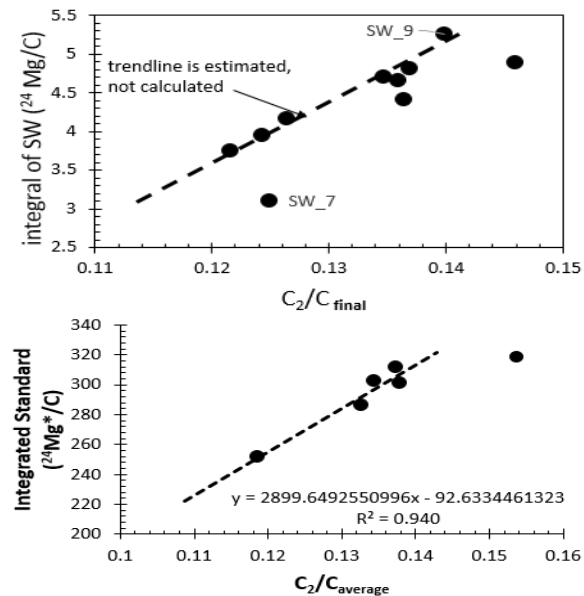
Fig. 4. *Results of surface correction giving parameterization by $^{12}C_2^+/^{12}C^+$. Top=SW bottom=standard.*

quantitative fluence from SIMS data in DLC, which is spatially variable in ion yield and IMF (measured at 3% -5% per amu). The shape of the transient sputtering zone in DLC must have previously masked the true extent of surface contamination in SW depth profiles.

Preliminary tests used these procedures on a front side SW Na profile [from 6]. The surface-corrected SW Na fluence (red point in Fig. 5) is significantly lower than that measured in Genesis silicon (Fig. 5). By inference, the radiation-induced segregation modifying the SW Na implant profile has a component consisting of Na originating from the collector's surface and diffusing into the silicon. Pre-flight, Mg was assessed to be stable in silicon while Na was not [7] so, in hindsight, this should not be a surprising result.
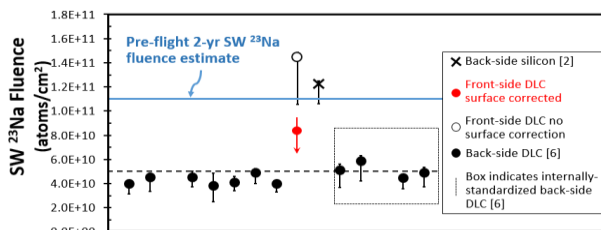
Fig. 5. *Effect of surface corrections on SW Na fluence.*

References: [1] Jurewicz A. J. G. et al. (2011) *LPS XLVII,* Abstract #1917. [2] Heber V. S. et al. (2014) *Chem. Geol.* 390 61-73. [3] Baryshev V. S. et al. (2012) *LPS XLVIII,* Abstract #2909. [4] Jurewicz A. J. G. et al. (2017) *J. Mater. Sci.* 52 11282–11305. [5] Jurewicz A. J. G. et al. (2017) *LPS XLVIII,* Abstract #2120 (e-poster). [6] Rieck D. S. dissertation repository.asu.edu. [7] Jurewicz et al. (2003) *Space Sci. Rev.* 105 535-560.