GENESIS SODIUM AND POTASSIUM BULK SOLAR WIND FLUENCES. K. D. Rieck[1], A. J. G. Jurewicz[1], D. S. Burnett[2], R. L. Hervig[1], I. V. Veryovkin[3], and C. S. Miller[3], [1]ASU, SESE, PO Box 871404, Tempe, AZ 85287-1404. (E-mail: Karen.Rieck@asu.edu), [2]Caltech, GPS, m/c 100, 1200E California Blvd, Pasadena, CA 91125, 3ANL, CNM, Argonne, IL 60439.

Introduction: We present preliminary measurements of solar wind (SW) Na and K abundances measured by secondary ion mass spectrometry (SIMS). Genesis B/C (bulk SW) array silicon (Si) and diamond-like-carbon (DlC) on Si (DoS) collectors were analyzed using backside depth profiling (BDP). This is the first reported use of SIMS for BDP of thinned Genesis DoS collectors.

Background: It is thought that the outer convective layer (OCZ) of the Sun is decoupled from nucleosynthetic processes leaving it essentially unchanged in composition from that of the early solar nebula for elements heavier than 3 amu *[1]*. The solar wind (SW) is generated as particles are ionized and accelerated by the solar magnetic field out of the solar photosphere (our spectroscopic view of the OCZ). Thus, SW samples the solar photosphere, and the solar photospheric composition is a proxy for the protoplanetary disk that ultimately formed the planets. A Genesis baseline has a better founding in theory than the current use of CI chondrites, and has potential for much more accurate numbers for volatile or chemically mobile elements.

In situ spacecraft data suggests that SW formation causes elemental fractionation relative to the solar photosphere for elements with high first ionization potentials (FIP) and long first ionization times (FIT) (e.g., *[1]*,*[2]*), but low FIP, short FIT elements are expected to show minimal to no fractionation relative to photospheric abundances *[3]*. However, this hypothesis needs to be tested.

SW Na and K abundances are of interest in two ways. First, their FIP and FIT values will help to define the details of SW fractionation necessary for understanding photospheric composition. Second, precise Na and K abundances are needed for cosmochemical models; Na and K abundances in CI chondrites vary by almost 20%.

Measurements of Na were performed previously by SIMS *[4,5]* and RIMS *[6,7]*. In all cases, surface contamination interfered with the SW signal. Only one preliminary measurement on Genesis Na abundance was reported *[5]*. There are no prior reports for K. Here we present results for Na and K SW measurements.

Backside Approach: Ubiquitous and pervasive presence of surface contamination and the length of time required for the analysis to reach steady state have interfered with previous analyses, so all SW measurements for this study used backside depth-profiling. This method is relatively common for SIMS analysis of electronic devices; services for thinning silicon wafers are commercially available. This technique had already been successfully applied to Genesis Si samples *[cf., 8,9]*, however BDP of SW through DoS is a new technique, and Genesis-specific issues preclude commercial thinning. In particular, to mitigate incorporation of contaminates in the near-surface of the DlC collector, an annealing step was skipped in the flight material. Accordingly, the Genesis DlC is extremely fragile, neither gentle grinding nor solution etching (ammonia) of the Si-backing were successful. On approaching the Si-DlC interface the DlC would inevitably and spontaneously fragment and curl. Here, we mechanically thinned our DoS Genesis-flown fragment (60630), but well before reaching the DlC-Si interface we implemented a technique currently under development at ANL, whereby DoS wafers are etched with XeF_2 to gently remove the Si-backing, leaving the ~1μm layer of DlC intact (Fig.1).

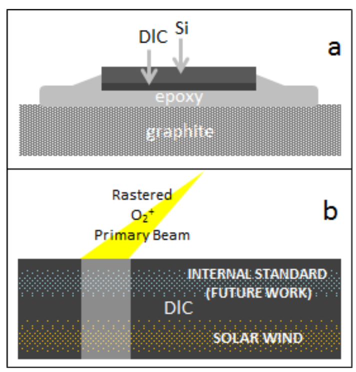

***Fig. 1. (a)** DoS Genesis fragment is affixed face-down onto a substrate (e.g., a graphite planchet). **(b)** XeF_2 etching has removed all of the Si, leaving DlC, as well as epoxy and carbon (not shown) completely intact. The new front surface can, in theory, be implanted with a reference fluence - even for monoisotopic elements like Na - without interfering with SW analysis.*

Procedures: Two thinned B/C array samples were analyzed: 60630 (DoS) and 60824 (Si). A 200Å coating of Si was applied to the surface of 60824 to reduce signal contamination from Na and K in the underlying epoxy resulting from ion beam mixing during analysis. Later this was found to be unnecessary. A reference implant was prepared: flight-spare DoS was implanted with 3e13 atoms/cm^2 of ^{23}Na at 66keV, and 3e13 atoms/cm^2 of ^{41}K at 129keV. It had been predicted before flight that Na and K would likely diffuse in silicon, thus no flight-spare Genesis Si was implanted. However, a 100keV implant having 1e14 atoms/cm^2

each of ^{23}Na and ^{39}K was provided by F. Stevie (NCSU).

Secondary ion mass spectrometers were used at two facilities: (1) a Cameca IMS 6f at ASU, and (2) a Cameca IMS 7f-GEO at Caltech. Sputtering with O_2^+ helped maximize depth resolution, as did a 2keV/nucleon impact energy on Si (at Caltech). ~4keV/nucleon impact energy was used for DlC. Color changes during sputtering were monitored to ensure uniform break-though at the collector/epoxy interface.

Results: In all cases, we were able to sputter-clean the backside surface and reach low-Na, steady state conditions before sampling SW ions (e.g., Fig. 2). The SW signal was integrated and normalized to a matrix species (^{12}C or ^{28}Si) to correct for variations in primary current. Relative sensitivity factors from the reference implants were used to quantify the SW measurements. Results are in *Figure 3*. Note that ^{39}K abundances are upper limits, as a potentially important NaO interference was not fully resolved.

Discussion: Based on the solar abundance estimates of *[10]* and an average SW proton flux of ~3e8 cm^{-2} s^{-1}, *[3]* estimated the 2-year fluence for Na to be ~1.1e11 atoms/cm^2. The data from DlC are lower by ~2x, but the data from Si agree within error. This difference is much greater than counting statistics, and was reproduced at both ASU and Caltech. We find it unlikely that this difference could be caused by processing errors, although we continue to explore different approaches to background subtraction. We infer two primary explanations: 1) the reference implants require calibration, 2) the relative sensitivity factor for DlC may require internal standardization (e.g. *[11]*). In addition, there is a possibility that Na diffused *into* the radiation-damaged Si (an explanation consistent with the pre-flight predictions), or out of the DLC, but no peak broadening was observed.

We are in the process of testing 1) and 2) above. Having the SW at the "bottom" of the sample (so that pristine collector material must be sputtered before measuring the SW) gives us an added opportunity. Instead of having separate "typical" frontside reference implants for study, reference elements can, in theory, be implanted from the backside without interfering with the SW. Our first attempt at a "backside internal reference" implant is in progress. By including a NIST SRM (or materials with known Na and K concentrations) in the cocktail of materials undergoing simultaneous ion implantation, we can also standardize the implant. The concentrations of K and Na in these implants are too low for standardization using RBS.

Conclusions: Backside depth profiling in Genesis DoS is possible. However, preliminary results for Na in DlC and Si do not agree, similar to *[11]*, but opposite in direction. We are implementing techniques for (a) internally standardizing our measurements and (b) correcting for NaO interferences in K abundance. If Si and DLC results do not converge, Na diffusion will be invesigated. Once defined, we will apply the Na and K results to studying the relative effects of FIT and FIP on SW generation.

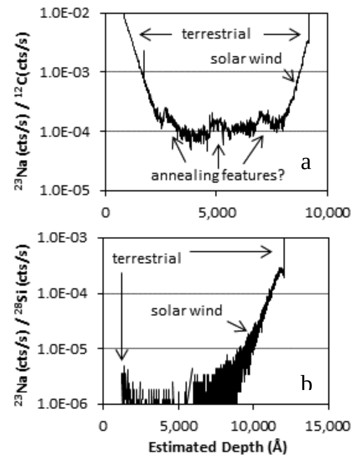

Fig. 2. Typical backside depth profiles. ***(a) DlC****. Na on XeF_2 etched surface is primarily contamination from handling and is likely avoidable in the future. In most cases, background levels were reached prior to SW analysis. Sawtooth stepwise annealing pattern in the DlC background is apparent.* ***(b) Si.*** *Low impact energy produced better depth resolution. Minor terrestrial Na was sputtered away before the start of the SW analysis.*

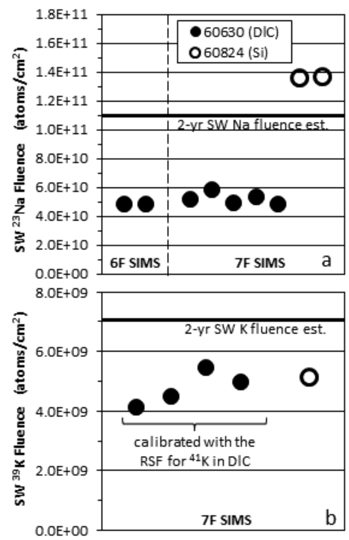

Fig. 3. *SW fluence measurements from ASU and Caltech. DlC (filled circles) and Si (open circles). Compare with the 2-year fluence estimates (thick horizontal lines).* ***(a)*** *Results for ^{23}Na in DlC are reproducible between the two instruments, but are not consistent with the results for Si.* ***(b)*** *Results for ^{39}K. Note: the mass resolving power used was too low to fully resolve NaO. We are working to correct these ^{39}K data accordingly.*

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