

GENESIS CONCENTRATOR TARGET: ISOTOPIC AND ELEMENTAL FRACTIONATION OF IMPLANTED SOLAR WIND CHARACTERIZED AND QUANTIFIED BY NE ISOTOPES AND THE NE/AR RATIO IN SiC.

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Introduction: The determination of the O isotopic composition of the solar wind (SW) is the highest priority objective of Genesis [1] and measurements are about to be finalized [2]. To increase the fluence for precise O isotope analyses, SW ions were concentrated on a special target. This concentration process, however, induced severe mass fractionation of the implanted ions, which was first modeled [3] and then quantified by [4, 5] based on Ne isotope measurements along the radial distance of the Au-plated stainless-steel cross, used to mount the “real” concentrator targets onto the baseplate. Accordingly, $^{22}\text{Ne}/^{20}\text{Ne}$ monotonically decreases from center to edge, with a maximum fractionation of 3.8% per amu (Fig. 1). The concentration factor monotonically decreases from 50 (center) to 5 (edge). These measurements were performed on all 4 arms of the Au cross and revealed that the entire concentrator target was radially symmetrically irradiated, which excludes any major misalignment of the concentrator assemblage during operation [4]. This is an important finding for O and eventual N isotope measurements, as the restricted concentrator target area does not allow extensive control analyses with these elements directly.

The measured isotopic fractionation, however, is different from that obtained by an ion optical simulation of the concentrator performance [4, 5]. The rough surface of the Au cross was considered as one reason for this difference, as it led to a considerably larger backscatter loss and related isotopic fractionation [4] than predicted by SRIM [6]. The disagreement of measured and simulated data, however, renders it difficult to determine the isotopic fractionation of O in the SiC target through analyses of Ne implanted into the Au cross. Therefore, we decided to directly measure the concentrator-induced Ne isotopic fractionation on the SiC target. These analyses, along with modeled differences in Ne and O trajectories in the concentrator, will be used to obtain the definitive O isotopic composition of the SW.

We present here the objectives of these analyses as well as new results from simulation runs of Ne and O in SiC. We also discuss an implantation experiment of Ne in SiC that was carried out to study backscatter losses and related mass fractionation as a test of the SRIM correction. At conference we will present the Ne isotopic composition and Ne/Ar ratio measured in the concentrator SiC target.

Objectives: (1) We will measure $^{20}\text{Ne}/^{22}\text{Ne}$ along a radial traverse in SiC. This will enable us to confirm the models of instrumental mass fractionation as function of the radial position on the concentrator to be applied to O [2] and N isotopic measurements. (2) For some analyses we will include ^{21}Ne in order to unambiguously test that isotopic fractionation induced by the concentrator is mass-dependent as indicated by [7], however, within relatively large uncertainties. (3) The measured concentration factors on Ne, together with the modeled values for O and Ne and the Ne fluence measured in the bulk SW targets, will allow us to determine SW fluences of O and possibly other elements from fluences measured in the concentrator target. (4) We will analyze the Ne/Ar ratio on a few positions along the traverse. Ne/Ar ratios measured in the Au cross by [7] indicated that Ar might be nearly completely admitted to the concentrator target, in contrast to the originally expected range of elements (mass/charge ratios: 2-3.6 equal masses of 4-28) [3]. If Ar suffered no more than minor losses, this could expand the range of elements that can be analyzed in the concentrator target to include Si, S, P, and Cl.

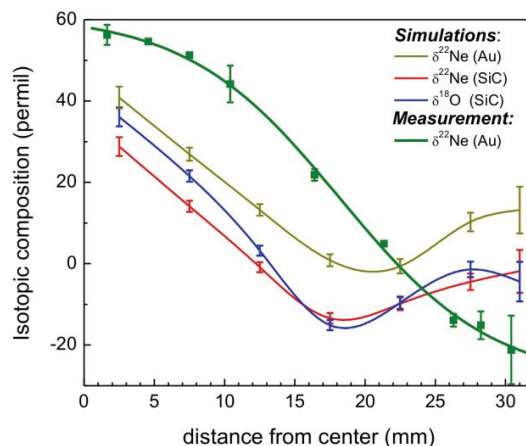


Fig. 1. Simulated (Ne and O in SiC, Ne in Au) and measured (Ne in Au cross) isotopic fractionation as function of the distance from concentrator target center.

Experimental: Ne isotopes will be measured at about 10 positions equally spaced along the radius of the SiC target. Gas will be extracted by UV laser ablation and measured with a very sensitive mass spectrometer [8] that allows us to consume only $(80 \times 80) \mu\text{m}^2$ per analysis. Expected blank contribution will be $\leq 1\%$ for all Ne isotopes. The SiC quadrant fits in our conventional sample holder. Analyses will be done in Jan-

uary 2010 at ETH Zurich with a similar procedure as [4, 5]. As this mass spectrometer is not suitable for elements heavier than Ne, Ar (together with He and Ne) will be analyzed in a conventional mass spectrometer on about 5 positions each with a $(200 \times 200) \mu\text{m}^2$ raster. Based on measured Ne abundances in the Au cross, expected Ar amounts in SiC range between 8×10^7 and 4×10^8 atoms per raster ($4 \times 10^4 \mu\text{m}^2$). Ar blank contribution is expected to be no more than a few percent, and corrections can be done via ^{40}Ar as ^{40}Ar is not detectable in SW.

Simulated Ne and O isotope fractionation in SiC: The models indicate that Ne and O in SiC should be similarly mass-fractionated since they have similar mass/charge ratios, as well as only minor backscatter losses (Fig. 1). The simulations predict an overall maximum isotopic fractionation of 42‰ for $\delta^{22}\text{Ne}$ and 51‰ for $\delta^{18}\text{O}$. The fractionations for both elements show a minimum at about 17-20mm radius. Also simulated concentration factors of Ne and O in SiC are similar. We included in this figure also the measured and simulated Ne isotopic composition as obtained from the Au cross, as both curves reflect the difference between measured data and the models [see above and 4]. In contrast to the simulations, which show a fractionation minimum, the measured data indicate a monotonic isotopic fractionation trend. The new Ne measurements will elucidate whether the pattern of isotope fractionation suggested by the simulations agrees better in SiC than it does in Au. At this point, it is not clear whether the minimum around 17-20mm predicted by the simulations is a real feature of the SiC target (in contrast to the measured pattern in the rough Au cross) or an artifact due to effects in the concentrator not accounted for in the modeling.

Artificial implantation of Ne into SiC: We studied backscatter loss and isotope fractionation of Ne implanted into SiC at different angles of incidence (vertical 0° , 45° , and 55°), to verify whether the SRIM code [6] can accurately reproduce the original Ne abundance and isotope composition (Fig. 2). SRIM-based backscatter correction factors are incorporated into the simulations presented above. The high angles of incidence and implantation energies were chosen to approximate implantation conditions in space (median angle of incidence of ions onto the concentrator target is $\sim 50^\circ$ - 55°) [3]. SiC and diamond-like C on Si (DOS) were implanted with ^{20}Ne (72keV) and ^{22}Ne (74keV). Gas was extracted by a UV laser. Backscatter loss was determined for ^{20}Ne and ^{22}Ne for each target and angle of incidence by SRIM. The measured ^{20}Ne abundance (9.74×10^{13} ions/cm 2) and the $^{20}\text{Ne}/^{22}\text{Ne}$ (10.27 ± 0.02) of the irradiated DOS (0°) serves as reference in Fig. 2 as backscatter loss of Ne from this light-element target is negligible at these

energies. Backscatter loss of Ne vertically implanted into SiC should also be negligible according to SRIM (^{20}Ne : 0.1%, $^{20}\text{Ne}/^{22}\text{Ne}$ fractionation 0.3‰). The slightly lower (1%) Ne concentration in SiC is not significant as uncertainties of the area determination are $\sim 1\%$. The $^{20}\text{Ne}/^{22}\text{Ne}$ is within 2σ uncertainty identical with the DOS value.

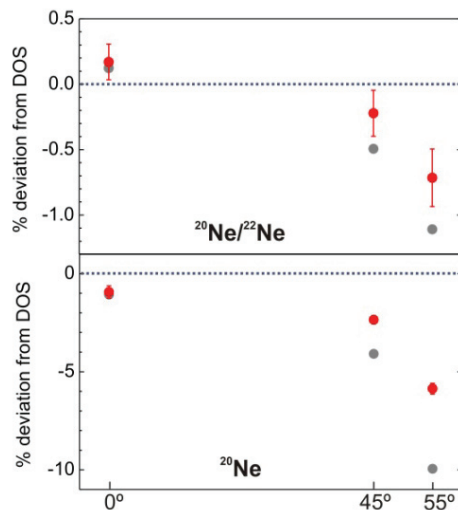


Fig. 2. $^{20}\text{Ne}/^{22}\text{Ne}$ and ^{20}Ne abundances in SiC irradiated at different angles of incidence as % deviation from DOS- 0° -data (dashed lines). Gray dots represent measured, red backscatter-corrected data. Errors (omitted on the measured data) are 1σ -standard deviation of 5-9 measurements.

At larger angles of incidence backscatter loss of ^{20}Ne (4% (45°) and 10% (55°)) and fractionation of the $^{20}\text{Ne}/^{22}\text{Ne}$ ratio increase (0.5‰ (45°) and 1.1‰ (55°)) relative to DOS- 0° . SRIM-based backscatter correction accurately produces $^{20}\text{Ne}/^{22}\text{Ne}$ ratios within 2σ (45°) and 3σ (55°) error. However, backscatter loss is underestimated for absolute ^{20}Ne abundances, at 45° by 2% and 55° by 6%. In general, SRIM can correct for isotopic fractionation in SiC, even at large angles of incidence, however, it significantly underestimates the absolute Ne loss from the SiC target, a finding in contrast to respective Au data [4].

Conclusion: We expect that the noble gas analyses in the SiC concentrator target will allow to determine the instrumental mass fractionation of the concentrator, a necessary quantity to determine the definitive O isotopic composition of the SW.

References: [1] Burnett, D.S., et al. (2003) SSR. 105: 509-534. [2] McKeegan, K.D., et al., *41th LPSC*. 2010 [3] Wiens, R.C., et al. (2003) SSR. 105: 601-625. [4] Heber, V.S., et al. (2009) *40th LPSC*.#1485. [5] Heber, V.S., et al. (2007) SSR. 130: 309-316. [6] Ziegler, J.F. (2004) Nucl. Inst. Meth. Phys. Res. 219/220: 1027-1036. [7] Marty, B., et al. (2010) GCA. 74: 340-355. [8] Baur, H. (1999) *AGU*. Vol. 46: F1118.