ISOTOPE FRACTIONATION OF SOLAR WIND IMPLANTED INTO THE GENESIS CONCENTRATOR TARGET DETERMINED BY NEON IN THE GOLD CROSS AND IMPLANTATION EXPERIMENTS.

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Abstract: Neon abundance and isotopic composition measurements are now done for all 4 arms of the Genesis concentrator gold cross (consisting of gold on stainless steel; AuSS). The data prove that the entire concentrator target was radially homogeneously irradiated (Fig. 1). An implantation experiment showed, however, that AuSS, characterized by a rough surface, experienced a significantly larger backscatter loss of Ne than a shiny Au target and as predicted by SRIM [1] (Fig. 2). Backscatter loss in AuSS was also largely independent from the angle of incidence. These observations will rule out a successful determination of isotopic fractionation of oxygen and nitrogen in the real concentrator targets through analyses of Ne implanted into AuSS. We conclude that the mass fractionation caused by the Genesis concentrator must be determined by Ne measurements on one of the concentrator targets directly. Preliminary experiments on SiC are underway.

Introduction: The concentrator onboard the Genesis spacecraft increased the fluence of solar wind (SW) ions on a special target to allow for high precision analyses of isotopic composition of oxygen and nitrogen [2, 3]. The SW is a proxy of the solar nebula composition and therefore important to understand origin and evolution of the different O isotopic reservoirs observed in different solar system objects. The concentrator was an electrostatic mirror. The concentration process caused isotope fractionation as function of the radial distance from the center of the target on the order of up to 3.8% per amu as measured with Ne isotopes along the gold cross used to mount the single concentrator targets onto the base plate [4]. However, measured data disagreed with simulations of the concentrator performance. Here we present, first, Ne data from all 4 arms of the gold cross testing the radial homogeneity of the irradiation throughout the entire concentrator target. Second, an artificial implantation experiment was carried out to study backscatter loss and isotope fractionation of Ne implanted into AuSS to elucidate the observed discrepancy between measured and simulated data.

Experimental: In the gold cross arms Ne concentration and isotope composition were analyzed on single spots (≤ 100µm) by UV laser ablation along all 4 arms as shown for the first 2 arms in [4]. The analysis of small spot sizes was permitted by a very sensitive mass spectrometer equipped with a molecular drag pump that almost quantitatively conveys the gas into the ion source [5].

For the implantation experiment ^{20}Ne (1E+14/cm^2 at 72keV) and ^{22}Ne (1E+13/cm^2 at 74keV) were implanted into flight spares of AuSS, AuoS (Au on sapphire, a target with shiny surface) and DOS (diamond-like carbon). Targets were irradiated at 3 different angles of incidence: 0°, 45°, and 55° during one experiment (Fig.2c), in order to approximate implantation conditions of the concentrator in space (main angle of incidence 50°-55°). Gas was extracted by a UV laser (213nm) from areas of 350 x 350µm and measured in a noble gas mass spectrometer. The amount of expected backscatter loss was determined by SRIM for ^{20}Ne and ^{22}Ne for each material and angle of incidence. Besides the comparison of measured abundances in rough and smooth Au, this experiment allows also to test SRIM predictions of backscatter losses.

Results and Discussion: *a) Genesis concentrator gold cross.* Fig. 1 shows the ^{20}Ne concentrations and the ^{22}Ne/^{20}Ne ratio, given as permil deviation from unfractionated SW [6], for all arms of the gold cross. Both quantities agree in all arms along the entire radius within their 95% confidence limits. ^{20}Ne concentration monotonically increases from edge to center by a factor of 10. Concentration factors range from 5 (edge) to 50 (center), determined relative to ^{20}Ne implanted into the bulk solar wind AuoS collector (6.8E+11atoms/cm^2). The ^{20}Ne/^{22}Ne ratio at the edge (14.05) is light compared to the unfractionated SW value of 13.77 and monotonically decreases towards the center of the target to 13.04. At 22.4 mm radius the unfractionated solar wind Ne isotopic composition is encountered. The agreement between all 4 arms suggests that the entire concentrator target was radially symmetrically irradiated, which excludes any major misalignment of the concentrator assemblage during operation. This is an important finding for the O [7] and eventual N data measured in the concentrator targets, since restricted target areas do not allow extensive tests and analyses are not feasible using other elements than Ne. Fig. 1 also shows the simulated ^{20}Ne and ^{20}Ne/^{22}Ne curves. As discussed in [4] one possible reason for the disagreement between simulated and

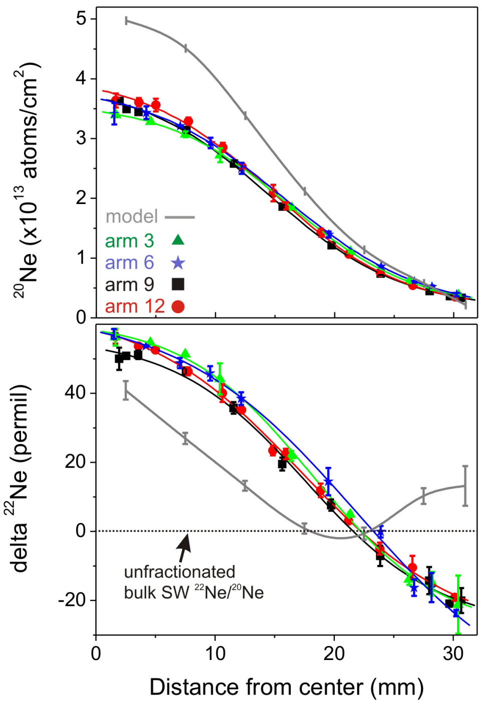

Fig. 1: *Genesis concentrator target analyses: ^{20}Ne abundances and $\delta(^{22}Ne/^{20}Ne)$ measured in all arms of the gold cross and plotted as function of distance from concentrator target center. For comparison model results are given. Confidence limits were omitted for clarity.*

measured data could be a difference between the actual and the SRIM-predicted backscatter loss that is included in the simulated data, due to the roughness of the AuSS target. To test this hypothesis the following experiment was carried out.

b) Implantation experiment (Fig. 2)*:* Measured abundances in vertically irradiated **DOS** (0°), 1.10E+14 ^{20}Ne/cm^2 and 1.06E+13 ^{22}Ne/cm^2, reflect the total amounts of implanted Ne as loss due to backscattering is expected to be negligible at the chosen experimental conditions. DOS 0° data will therefore serve as baseline for all other data. In **AuoS** ^{20}Ne backscatter loss ranges from 22 to 37% for angles of incidence of 0° to 55°. Isotope fractionation is, however, relatively small, at maximum 1.7% (55°). SRIM-based backscatter correction factors successfully reproduce the 0° implantation for both, abundances and isotopic composition. At oblique angles (larger backscatter loss), SRIM tends to overestimate abundances by up to 4% at 55°. The rough **AuSS** shows an overall 24% larger ^{20}Ne backscatter loss than AuoS. As SRIM backscatter correction factors were the same for both types of Au targets (SRIM does not distinguish between surface properties) the amount of backscattered Ne from AuSS is considerably underestimated. This leads us to conclude that abundances of implanted ions into AuSS cannot be corrected for by SRIM. Fig. 2 shows further that in AuSS the amount of backscatter loss and the angle of incidence do not correlate. Presumably the micro-peak and -valley structure of the AuSS surface has influenced backscatter losses more than the general tilt of the sample. Finally, the isotope fractionation is larger in AuSS than in AuoS. In AuSS the measured ^{20}Ne/^{22}Ne ratio is 5-10% (0°-55°) lower than the DOS 0°-value, in contrast to AuoS where it is only 1.3-1.7% lower. Using the same argumentation as above, it is clear that isotope ratios measured in AuSS cannot be corrected for by SRIM either. In summary, this experiment showed that Au with a rough surface experienced larger backscatter loss and isotope fractionation than the same material with a shiny surface that cannot be sufficiently corrected for by SRIM. In opposite, SRIM predictions are quite accurate for polished/shiny gold, despite the large backscatter loss caused by the heavy mass of Au.

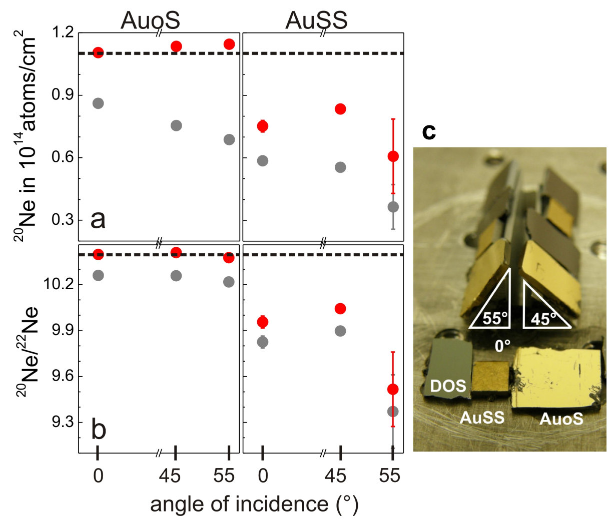

Fig. 2. *Implantation experiment: Comparison of (a) ^{20}Ne abundances and (b) ^{20}Ne/^{22}Ne between AuoS and AuSS. Gray dots represent the average measured, red the SRIM-based backscatter-corrected data. Dashed lines mark the originally implanted Ne derived from DOS 0° target. Error bars of 55° AuSS reflect very variable single measurements. (c) shows the target arrangement for implantation experiment.*

References:

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