TRAPPING AND RELEASE DATA OF ARTIFICIALLY IMPLANTED NOBLE GASES INTO METALS – TESTS FOR GENESIS TARGETS. A. Grimberg[1], F. Bühler[2], P. Bochsler[2], V. Heber[1], H. Baur[1] and R. Wieler[1], [1]Isotope Geology, NO C61, ETH, CH-8092 Zürich, Switzerland, grimberg@erdw.ethz.ch, [2]Physikalisches Institut, University of Bern, Sidlerstr. 5, CH-3012 Bern, Switzerland

Introduction: The collection of Solar Wind (SW) on NASA's Genesis mission [1] has been achieved by the implantation of SW ions into high-purity collection substrates. The trapping efficiency of ions in any material is mainly controlled by losses due to backscattering. This in turn leads to mass discrimination for implanted isotopes. To correct for these effects, especially under SW conditions, it is necessary to simulate the irradiation and test modelling data with reality.

Therefore two different experiments were carried out: In the first, different target materials were artificially bombarded with noble gases to determine mass discrimination. The results of subsequent mass-spectrometric analyses were then used to test the validity of TRIM-calculated predictions [2]. In the second experiment, we implanted ^{20}Ne and ^{22}Ne with different energies into Ax1 metallic glass [3] to simulate the SW and the higher energetic SEP component [4]. This was to test whether the depth resolution of closed-system stepwise etching (CSSE) [5] on the glass is high enough to separate the two components.

Experimental: For the first experiment, the metallic glass Ax1 and five different metal foils, ranging from light BeO on BeCu to gold, were irradiated with ^{3}He, ^{4}He, ^{20}Ne and ^{22}Ne. The irradiation was carried out at the CASYMS calibration system in Bern [6]. All ions were implanted with 0.83 keV/amu, corresponding to a SW at 400 km/s, with fluence up to 1×10^{11} atoms/cm^2. To homogenise the ion distribution during irradiation, targets were moved up and down through the ion beam [7]. The implanted noble gases were extracted from the different targets using two methods: (1) heating of samples to temperatures just above their respective melting point and (2) melting of metal foils with a Nd/YAG laser (λ = 1064 nm). Due to a considerably large uncertainty of flux measurements at CASYMS (<10 %), all results were normalised to comparable Al data.

For the second experiment, Ax1 was irradiated with ^{20}Ne at 12.7 keV and ^{22}Ne at 60.0 keV. The purpose was to produce a varying ^{20}Ne/^{22}Ne ratio with implantation depth. 60 keV for ^{22}Ne was the highest implantation energy allowed by CASYMS, corresponding to a speed of ~880 km/s, slightly above that of the fast SW. The implanted Ne isotopes were extracted by CSSE in 36 steps.

Results and Discussion: TRIM simulations for the first experiment show that backscatter losses, and hence mass fractionation factors, get larger with increasing atomic mass of the target material, decreasing irradiation energy and decreasing atomic mass of the implanted ion. This leads to Al-normalised ^{20}Ne/^{22}Ne ratios of gases remaining in the target ranging from 1.004 in BeO to 0.985 in Au. These TRIM values are fully consistent with measured data, although the sample-to-sample variation for some materials is relatively large.

The variation between highest and lowest ^{3}He/^{4}He-ratios in a given material is considerably larger than for ^{20}Ne/^{22}Ne. This might be due to insufficient homogenisation of the ion distribution during irradiation. Nevertheless, the average measured ^{3}He/^{4}He-ratios are mostly lower than the values predicted by TRIM. This appears to show that the small predicted He isotopic fractionation is not real, which might be a result of a known problem [2] of TRIM at low irradiation energies.

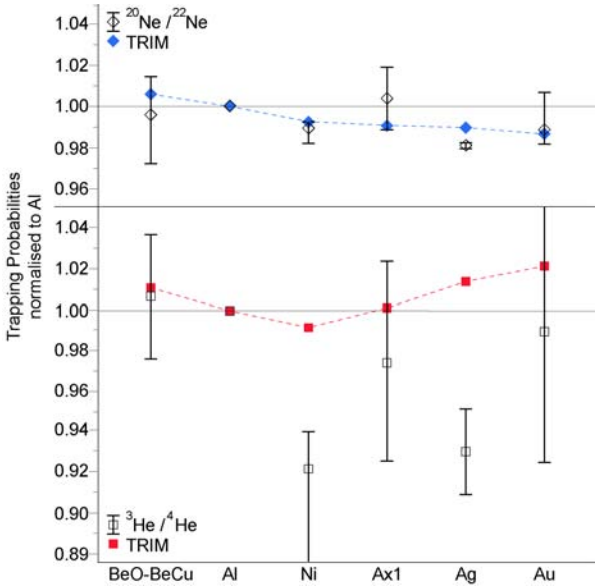

Fig. 1: Average Al-normalised ^{3}He/^{4}He and ^{20}Ne/^{22}Ne ratios (bars indicating the sample-to-sample variation) compared to TRIM predictions. Measured and calculated Ne data agree well with each other. Averages of ^{3}He/^{4}He ratios instead are up to 7 % lower than TRIM values.

In a future experiment the large ^{3}He/^{4}He-variation for each material will be considerably reduced by an improved homogenisation of the irradiation. This should allow us to verify whether TRIM indeed underestimates the He isotopic fractionation at low energies.

Panel (a) of Fig. 2 shows the ^{20}Ne/^{22}Ne release pattern for the CSSE experiment. The ratio decreases

monotonically with increasing etching time. This proves that etching of Ax1 with HNO_3 occurred gradually with a good depth resolution. Outliers in this graph represent the gas accumulated over night (the first measurement of each day). Their low $^{20}Ne/^{22}Ne$ ratios are most likely due to a combination of blank gas and gas released due to an ongoing reaction of residual HNO_3 and Ax1 at the contact of glass and reaction chamber. Panel (b) of Fig. 2 shows the TRIM-predicted $^{20}Ne/^{22}Ne$ release pattern. The measured pattern has a similar shape as the calculated one, which underlines the good depth resolution of the CSSE procedure. In absolute numbers, $^{20}Ne/^{22}Ne$ ratios measured in the first CSSE steps are lower than TRIM predicted ratios (~60 instead of ~100). This indicates that the etching behaviour is more complex, i.e. the first steps already etched some deeper layers of the metallic glass. Or, alternatively, the depth distribution of implanted ions might not correspond exactly to the TRIM predictions.

The total etch run released (94 ± 4.7) % of the implanted ^{20}Ne and (88 ± 4.4) % of the implanted ^{22}Ne.

Conclusion: The first experiment proved the consistency between measured $^{20}Ne/^{22}Ne$ ratios and TRIM predictions. This means that for Ne TRIM reliably predicts mass discrimination due to backscattering. On the other hand, the sample-to-sample variation of measured $^{3}He/^{4}He$ ratios for heavy targets has been too high so far for an accurate comparison with TRIM predictions. Additional implantations with an improved setup are needed to minimize He variations.

The $^{20}Ne/^{22}Ne$ release pattern of the CSSE experiment demonstrates that the depth resolution of the used etching procedure is capable to distinguish between low- and high-energy ions. Moreover, the measured $^{20}Ne/^{22}Ne$ release pattern is in agreement with the TRIM-predicted trend of Ne-release. Therefore, if Ax1 flown on Genesis contains solar energetic particles, we are confident to resolve this component.

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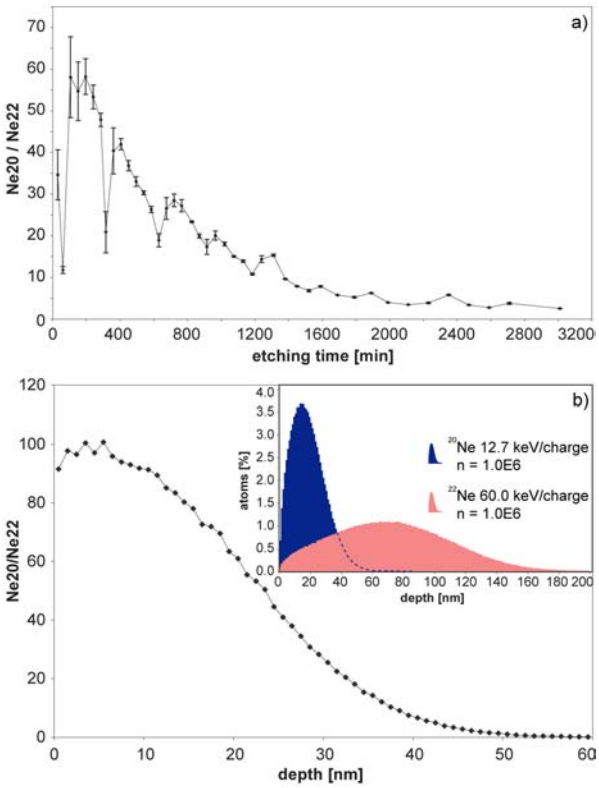

Fig. 2: The $^{20}Ne/^{22}Ne$ release pattern of the CSSE extraction (a) shows the depth resolution of CSSE on Ax1. Outliers represent measurements of gas accumulated in the sample chamber over night. Panel (b) presents TRIM-calculated gas release with increasing depth for ^{20}Ne (12.7 keV), ^{22}Ne (60.0 keV) and the resulting $^{20}Ne/^{22}Ne$.