

ARTIFICIAL IMPLANTATION OF NOBLE GASES ON GENESIS TARGETS. A. Grimberg¹, F. Bühler², P. Bochsler², H. Baur¹ and R. Wieler¹, ¹Isotope Geology, NO C61, ETH, CH-8092 Zürich, Switzerland, grimberg@erdw.ethz.ch, ²Physikalisches Institut in Bern, Siedlerstr. 5, CH-3012 Bern, Switzerland, fritz.buehler@phim.unibe.ch

Abstract: NASA's Genesis mission [1] is collecting Solar Wind (SW) samples at libration point L1 for approximately 2 years. The main objective is to determine the SW isotopic composition for various elements. SW ions are implanted into high-purity collection substrates.

We are simulating the implantation of various noble gas ions under SW conditions to test for implantation efficiencies and mass-fractionation of different collector materials. We irradiate these materials with ³He, ⁴He, ²⁰Ne and ²²Ne with energies between 0.6 – 2.7 keV/amu at CASYMS in Bern [2]. The irradiated samples are then analysed by noble gas mass-spectrometry at the ETH Zürich. Results are expected to provide a better understanding of the trapping behaviour of different materials and to allow to optimize analytical procedures.

Introduction: To provide precise isotopic data the trapping properties of collector substrates need to be known. The goal of this study is to determine backscatter losses, mass discrimination and diffusion rates of noble gases for different collector materials. For this we simulate the implantation of He and Ne isotopes onto different substrates.

One aim of Genesis is to study the so-called SEP noble gas compound (Solar Energetic Particles), found in solar-wind-irradiated lunar samples and meteorites [3]. Because SEPs apparently have higher energies than solar wind particles, we will analyse the samples by closed system stepwise etching (CSSE) to provide data about implantation depths. Heber [4] tested different materials for their etching behaviour and retention of noble gases. These experiments led to a metallic glass called AX1 [5] to be flown on Genesis. Besides this target we irradiated several metal foils. The implantation experiments were done at the University of Bern using the CASYMS (Calibration System for Mass Spectrometers) instrument [2].

Here we report on the experimental setup of the irradiation. At the meeting we will present first data. Calculations with the TRIM code [6] are predicting backscatter losses of up to 40 % for the heavier target materials. Preliminary analyses of He and Ne support this prediction. On the other hand they indicate minor mass fractionation, on the order of 5 ‰ per amu. Analyses of AX1 samples, into which we will implant ²⁰Ne and ²²Ne with two different ratios and energies, will allow to test the capability of CSSE to separate components residing at different depth.

Samples and Experimental: AX1 is a metallic glass alloy with the composition 58.5% Zr, 15.6% Cu, 12.8% Ni, 10.3% Al and 2.8% Nb. Metal foils of Au, Ag, Ni, Al and BeO on BeCu were chosen as additional sample substrates to cover a wide range of atomic masses. Substrates with different atomic masses are expected to show variable backscattering or mass fractionation. This was calculated with TRIM for ³He, ⁴He, ²⁰Ne and ²²Ne for the different materials, using implantation energies between 0.6–2.7 keV/amu.

The different noble gas ions were implanted separately onto the samples with an ion beam width of 10×10 cm² (Fig. 1). The flux is monitored at regular intervals during the whole implantation with a Faraday Cup and a Channel Electron Multiplier over a matrix of 49 points. This monitoring yields ion fluences with a precision of several percent only. We therefore determine relative mass fractionation factors between targets of different mean atomic masses by alternately mounting foil strips as shown in Fig. 1. BeO and Al were placed in-between the heavier substrates because they are expected to cause very little mass fractionation.

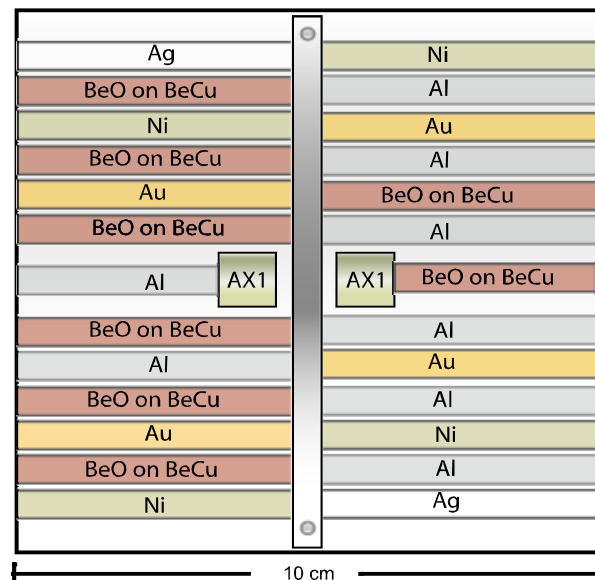


Fig. 1: Arrangement of target materials on sample mount. BeO foils are alternating with other materials on the left side, Al on the right. The ion beam came from the view direction.

The ion flux is not perfectly homogeneous over the beam area. At energies up to 1.0 keV/amu (Fig. 2, upper panel) the variation is 10-20 % from edges to center. At higher energies the variation gets larger and two maxima appear at 2.7 keV/amu (Fig. 2, lower panel). Notably, the variations are much higher in the vertical direction as in the horizontal one. We therefore moved the whole sample mount in vertical y-direction through the beam in 21 ~1cm-steps lasting 30 s each. This leads to constant implanted fluences, hence isotopic ratios, for samples mounted at the same x-axis position (Fig. 1).

The flux of the ion beam ranged from $2 \times 10^5 \text{ cm}^{-2} \text{ s}^{-1}$ (^{22}Ne) to $1.4 \times 10^6 \text{ cm}^{-2} \text{ s}^{-1}$ (^4He), chosen for all isotopes to be at least 100 times above the highest material blank. The implanted $^4\text{He}/^3\text{He}$ ratios are ~ 11 , $^{20}\text{Ne}/^{22}\text{Ne}$ are ~ 13 .

After irradiation He and Ne isotopes of the different samples were measured by mass-spectrometry at ETH Zürich. Noble gases were extracted by melting of the target materials.

Results and Discussion: TRIM simulations show widely varying backscatter losses for the different noble gas isotopes and different target materials. Losses, and hence mass fractionation factors, get larger with increasing atomic mass of the target material, decreasing implantation energy and decreasing atomic mass of the implanted ion. According to TRIM, $^{20}\text{Ne}/^{22}\text{Ne}$ values of Ne remaining in the sample after implantation at 0.83 keV/amu (average solar wind speed of 400 km/s) range from 0.982 in Au to 0.999 in BeO, with an initial $^{20}\text{Ne}/^{22}\text{Ne} = 1$.

The results of the first two measurements are in agreement with TRIM calculations. The measured $^{20}\text{Ne}/^{22}\text{Ne}$ ratio for Au normalized to that in BeO samples at the same x-axis position (Fig. 1) range from 0.983 to 0.988, slightly higher than the predicted TRIM value.

More generally, samples of the same material at identical x-axis positions show the same isotopic ratio within the analytical reproducibility. This shows, that the sample movement in the beam led to the desired homogenisation of fluxes in vertical direction.

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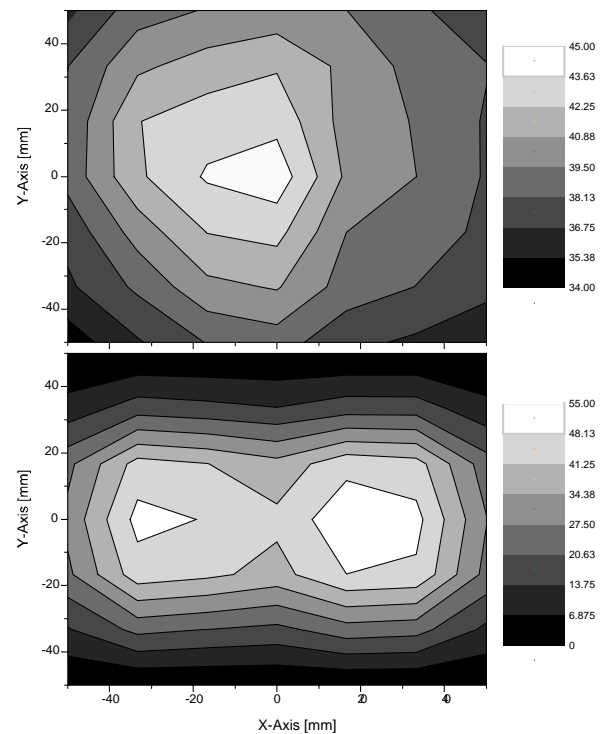


Fig. 2: Ion flux distribution for ^4He at 0.83 keV/amu (upper panel) and ^{22}Ne at 2.73 keV/amu (lower panel). Fluxes on the right are given in $\text{kHz}/(0.1\text{cm}^2)$. The flux at lower energies reveals minor variability with a small peak in the center. At higher energies, the flux distribution shows two peaks and relatively large differences in the y-direction (vertical direction).