NITROGEN ISOTOPIC COMPOSITION OF SOLAR WIND RETURNED BY THE GENESIS MISSION.

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Introduction: Previous measurements of nitrogen isotopes from a Au-plated cross of the Genesis solar wind concentrator target suggest that the nitrogen isotopic composition of recent solar wind is comparable to that of Jupiter's atmosphere [1]. In this study, we present further evidence from a concentrator target to support this result.

Materials and Methods: Genesis solar wind concentrator sample GCS60001 was used to measure nitrogen isotope depth profiles of implanted solar wind. GCS60001 is a silicon carbide target that was exposed to 27 months of solar wind irradiation on the Genesis spacecraft with additional enhancement provided by an electrostatic concentrator [2].

Nitrogen isotope ratios were measured with the UCLA MegaSIMS, which is a custom made hybrid secondary ionization/accelerator mass spectrometer [3]. Pre-accelerator mass filtering is made possible by an isotope recombinator, and the high energy mass analyzer is a double-focusing sector system with multicollection. Ultra-low vacuum and blank are achieved by a cryopump positioned directly beneath the sample, periodic baking of the sample chamber (over 2+ years), use of a liquid nitrogen cooled cold finger and surface cleaning of the sample by low-energy sputtering immediately prior to each analysis.

High concentrations of contaminant nitrogen are present on the surfaces of all silicon carbide test samples as a very thin layer. Although this layer can be sputtered away quickly, care must be taken to minimize the knocking-in of these surface atoms. We used low energy (+5 keV) Cs^+ sputtering to "clean" off the top 20 nm of the sample in 300x300 μm^2 raster areas, which reduces the amount of knocked-in surface contamination to undetectable levels during subsequent depth profiling [3].

The extraction of nitrogen from GCS60001 was done by sputtering with a 20 nA, 20 keV Cs^+ beam rastered over 150x150 μm^2 areas and centered in the previously made cleaning pits. The primary beam spot size was approximately 25-30 μm in diameter. The negative secondary ions were gated with a field aperture and a contrast diaphragm. The entrance and energy slits were wide open. Masses 26 and 27 were selected for injection to the accelerator using the mass selection slit of the isotope recombinator. This allows the inclusion of only $^{12}C^{14}N^-$, $^{12}C^{15}N^-$ and $^{13}C^{14}N^-$ for acceleration, and excludes all silicon isotopes already at this point. This is important since multiply charged silicon isotopes could interfere with nitrogen isotopes post-acceleration.

The injected CN^- ions are accelerated towards a +1.2 MV terminal where they collide with dilute argon gas. Collisions with argon in the strong electric field fragment the CN molecules and strip electrons, causing the now positive C and N ions to be accelerated again by the +1.2 MV potential. The resulting high energy positive ions occupy several charge states, *e.g.* C^+, C^{2+}, C^{3+} and N^+, N^{2+}, N^{3+} are present after the charge conversion.

The +2 charge state was determined to be the most suitable for nitrogen isotope measurements with the MegaSIMS. This represents a compromise between sensitivity/transmission and the ability to focus collision fragments with different energies in the mass analyzer. Higher charge states would reduce the energy difference between the two nitrogen isotopes but we are limited by the maximum attainable terminal voltage of +1.2 MV of the MegaSIMS accelerator. The pressure in the Ar-stripper was optimized to give the maximum transmission of $^{14}N^{2+}$ and $^{15}N^{2+}$ at +1.2 MV terminal voltage.

The high energy $^{14}N^{2+}$ and $^{15}N^{2+}$ ions were detected simultaneously with two electron multipliers using 5 second integration cycles. Secondary electron spray between detectors was eliminated by shielding the multipliers with aluminum boxes and covering the entrances to the detectors with thin carbon films which allow high energy ions to penetrate but effectively block secondary electrons.

Results: Two depth profiles from different radii ($\sim$10 mm and $\sim$21 mm) on GCS60001 are shown in Figure 1. The peak count rate of $^{14}N^{2+}$ from $\sim$10 mm radius is approximately 2.5 times higher than from $\sim$21 mm radius due to the variable concentration factor across the target. This effect has been documented before in detail for neon [4].

The contribution of background was 0.8 to 3.4 % of the $^{14}N^{2+}$ solar wind signals, as estimated by extrapolation from the deep tails of the depth profiles. This background represents the sum of instrumental background, any intrinsic nitrogen in the silicon carbide and possible steady state migration of surface contam-

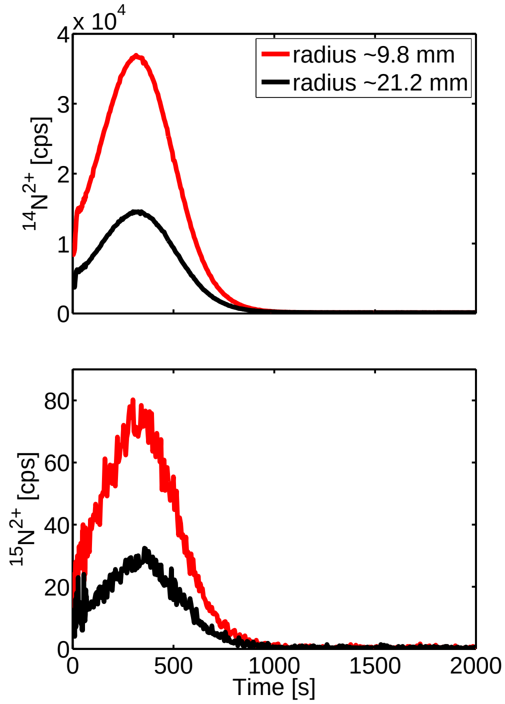

Figure 1: Solar wind nitrogen depth profiles from Genesis concentrator sample GCS60001, shown for two different target locations.

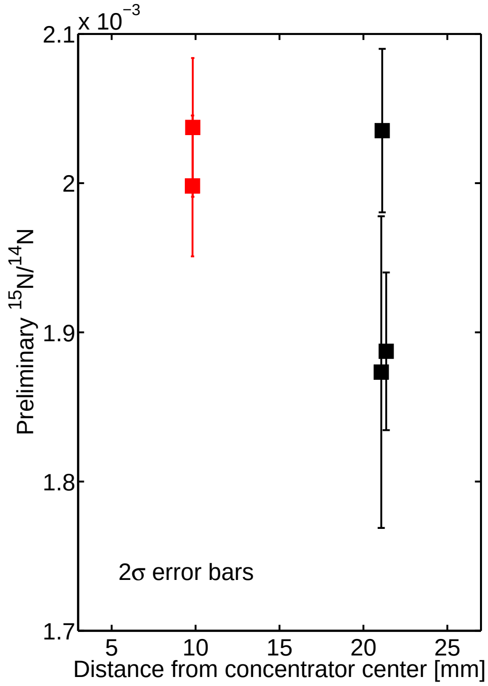

Figure 2: Preliminary solar wind nitrogen isotope ratios from Genesis concentrator sample GCS60001.

ination to the sputter pit during analysis. The proportion of background from total $^{15}N^{2+}$ signals was 1.4 to 6.1 %. The variability was caused by day-to-day variation of the absolute background level over the course of the analyses, and the variability of solar wind concentration with concentrator radius.

A nitrogen-doped silicon carbide with approximately 10^{18} atoms cm^{-3} nitrogen was analyzed as a standard before and after the depth profiles each day under the same analytical conditions. For the purposes of this preliminary calculation it was assumed that the nitrogen isotope ratio of this material is close to the terrestrial atmosphere's, but the exact value for this wafer will be measured later against other known materials.

The preliminary calculations of nitrogen isotope ratios from five measured depth profiles are shown in Figure 2. Although the calibration is still work in progress and the final uncertainties could be somewhat larger than the errors shown, our data are comparable with the values measured for Jupiter's atmosphere by the Infrared Space Observatory ($^{15}N/^{14}N=(1.9\pm1.0)x10^{-3}$ [5]), Galileo ($^{15}N/^{14}N=(2.3\pm0.3)x10^{-3}$ [6]) and Cassini ($^{15}N/^{14}N=(2.23\pm0.31)x10^{-3}$ [7]) missions.

Conclusion: The Earth's atmosphere is enriched by nearly a factor of 2 in $^{15}N/^{14}N$ compared to the solar wind. We agree with the finding of [1] for the $^{15}N/^{14}N$ of captured solar wind of $(2.26\pm0.67)x10^{-3}$, but not with [8] ($^{15}N/^{14}N\sim4.9x10^{-3}$). The low $^{15}N/^{14}N$ found here is consistent with SIMS analyses of implanted solar wind nitrogen in lunar grains ($^{15}N/^{14}N<2.8x10^{-3}$ [9]), and not too far from a composition analyzed from a high-temperature early solar system condensate by [10] ($^{15}N/^{14}N=(2.356\pm0.018)x10^{-3}$).

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