Comparison of solar wind He implantation profiles between Genesis collectors separately implanted fast-speed flow, low-speed flow, and coronal mass ejection flow components

K. Bajo[1], A. Tonotani[1], C. T. Olinger[2], A. J. G. Jurewicz[3], D. S. Burnett[4], I. Sakaguchi[5], T. T. Suzuki[5], S. Itose[6], M. Ishihra[7], K. Uchino[8], R. Wieler[9], and H. Yurimoto[1,10]

[1]*Department of Earth and Planetary Sciences, Hokkaido University. Sapporo 810-0060, Japan.*
[2]*Applied Modern Physics Group, Los Alamos National Laboratory, Los Alamos, NM 87545, USA.*
[3]*CMS/SESE, Arizona State University, Tempe, AZ 85287-1404, USA.*
[4]*Division of Geological and Planetary Sciences, California Institute of Technology, CA 91125, USA.*
[5]*National Institute for Materials Science, Tsukuba, Ibaraki 305-0044, Japan.*
[6]*JEOL Ltd., Akishima, Tokyo 196-8558, Japan.*
[7]*Department of Physics, Osaka University, Toyonaka, Osaka 560-0043, Japan.*
[8]*Graduate School of Engineering Sciences, Kyushu University, Kasuga, Fukuoka 816-8580, Japan.*
[9]*Institute for Isotope Geology and Mineral Resources, ETH Zurich, 8092 Zurich, Switzerland.*
[10]*Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, Sagamihara 252-5210, Japan*

NASA's Genesis mission collected samples of solar wind that can be analyzed with high precision in laboratories. Sputtered neutral mass spectrometry (SNMS) with tunneling ionization has been applied to measure ^{4}He profiles in Genesis Bulk collector [1], of which apparatus was Laser Ionization Mass nAno Scope (LIMAS). The instrument can quantify ^{4}He presented at tens of ppma from an area of few-microns across of a solid surface. Depth profiling was carried out for isotope analysis of He and Ne of solar wind from a Genesis diamond-like carbon film on a silicon (DOS) substrate, which was irradiated by bulk solar wind for 2.3 years. The depth profile of ^{4}He in deep (>100 nm) was comparable with a background ^{4}He as residual gas a sample chamber of LIMAS [1]. The residual gas corresponded to ~3×10^{-4} He^+ count per mass scan (cpms). Here we analyzed Genesis H, L, and E collectors of Genesis irradiated by high-speed or coronal hole flows, low-speed or interstream flows, and coronal mass ejection (CME), respectively.

Helium depth profiles for the three collectors should be different each other on the basis of ACE/SWICS data [2]. A measurement condition for the depth profiling was improved to distinguish each depth profile of the target isotopes. An ion pump of 410 l/s (Agilent Vaclon plus 500) and a non evaporation getter (NEG) pump were replaced to reduce residual noble gases in the sample chamber. To increase ion intensity, we installed high power Ti-sapphire fs laser (Astrella, Coherent, Inc.) of 6 mJ per 30 fs pulse to increase ionization efficiency for He [3]. As a result, the background He abundance, which was the same measurement for sample without the primary beam pulse for sputtering, decreased from ~3×10^{-4} He^+ cpms to ~2×10^{-5} cpms. The ion intensity of 2×10^{-5} cpms corresponds atom concentration of ~10^{17} cm^{-3} (~1 ppma) under the same measurement condition. A useful yield of He are increased from 9×10^{-5} [1] to 5×10^{-4}. Control timing for the mass spectrometer [3] were also refined to measure multi-isotopes at the same time. Mass resolving power for He depth profiling was ~13,000 in 99% valley after 95 multi-turn of m/z = 4 in MULTUM II to separate $^4He^+$ from $^{12}C^{3+}$ of the main element of the DOS.

Depth profiles for ^{4}He and ^{20,22}Ne of the DOS samples from the three Genesis collectors were measured at the same time. A ^{4}He depth profile of the H collector showed relatively symmetric with a peak of 35 nm. A profile of the L array showed that ^{4}He was concentrated less than 40 nm and the peak was 10−20 nm, which was close to the limit of the depth resolution of 30 keV Ga^+ beam. The E array demonstrated broad ^{4}He profile and observed ^{4}He in deep (>100 nm) as well as the bulk collector. On the other hand, He in deeper than 150 nm of the Genesis H and L arrays were equivalent to the background level. This He in deep indicates that the ^{4}He in deep should be derived from the questionable very high-speed flows (Halloween event of 2003) during October 23−November 3 2003 [2]. The depth of the 35 nm for the H collector corresponds to the speed of 600 km s^{-1}. The L collector profile should be corresponded to 400 km s^{-1} of the solar wind. The ^{4}He deeper than 100 nm of the E collector represents faster than 1000 km s^{-1} derived from the Halloween event of 2003.

References

[1] K. Bajo et al. (2015) Geochem. J., 49, 559-566. [2] D. B. Reisenfeld et al. (2013) Space Sci. Rev. 175, 125-164. [3] A. Tonotani et al. (2016) Surf. Interface Anal., 48, 1122-1126. [4] K. Bajo er al. (2018) Surf. Interface Anal., accepted.