Detection of CME components of solar wind noble gas from DOS sample of *Genesis*

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Introduction: Noble gases in solar wind (SW) can be utilized as a tracer to investigate solar activity from the SW irradiated materials. Recently, *Genesis* spacecraft mission by NASA was carried out in order to determine the composition of the Sun and estimate that of the solar nebula. *Genesis*-returned sample was measured, and the energy distribution, flux of the SW, and isotopic and elemental composition of the SW noble gases are well determined by in-situ measurements (e.g. Heber et al., 2009; 2012). In order to discuss the solar activity, an interaction between the implanted SW and the substrate (ion-solid interaction) is important issue. A depth profile of the implanted particles into the substrate is correlated with the energy distribution of SW particles. However, depth profiling of noble gases was not established because (1) an implant depth of SW noble gases is much shallower than 1 μm and (2) a conventional depth profiling with secondary ion mass spectrum (SIMS) was hard to measure noble gases because of their high ionization potentials.
Recently, Laser ionization mass nanoscope (LIMAS) was developed to measure depth profiles for noble gases (Bajo et al., 2015).
LIMAS is a type of the secondary neutral mass spectrometer with strong-field photoionization (Laser power density: ~10^{20} W m^{-2}). LIMAS consists of a Ga liquid metal ion source and an aberration corrector for sputtering of nanometer scale area on samples, a femtosecond laser for tunneling-ionization of the sputtered neutrals, and a multi-turn time-of-flight mass spectrometer (MULTUM II) for isotope analysis (Ebata et al., 2012; Bajo et al., 2015).
Bajo et al. (2015) carried out depth profiling in the *Genesis* sample by using LIMAS. However, the ^{4}He concentration of sample deeper than 120 nm from the surface, corresponding to the implanted depth of CME particles, was equivalent to the residual He gas amount of 3 ×10^{18} atoms cm^{-3} in sample chamber of LIMAS. Therefore, the ^{4}He depth distribution of deep area (>120 nm) in *Genesis* sample has not been determined. In this study, we improved the method for the high precision depth profile of SW noble gases.
Experimental procedure: A diamond-like carbon-film on silicon substrate (DOS) sample of *Genesis* was prepared in this study.
LIMAS was used for the measurement of depth profile of SW. A pulsed primary beam of 1.5 μm in diameter with ~50 nA was used. The newly installed fs-laser with pulse energy was 5.6 mJ at the repetition rate of 1 kHz. Setting of the mass spectrometry of LIMAS was based on Tonotani et al. (2016).
Multi-turning of ^{4}He ions was set to 100 cycles and ion gates were used for the elimination of interfering ion such as $^{12}C^{3+}$. To reduce residual gases in sample chamber of LIMAS, we exchanged sputter ion pumps and added getter pumps. Raster area in *Genesis* sample for depth profile was set to 20 ×30 μm. After depth profiling, atomic force microscope (Asylum Technology, MFP-3D-BIO-J) was used for the measurement of crater shapes.
Results and discussion: ^{4}He background in this study was reduced to 4 ×10^{17} atoms cm^{-3} for DOS sample, which is one order of magnitude lower than that of Bajo et al. (2015) (i.e. 3 ×10^{18} atoms cm^{-3}). As a result, Depth profile of SW He was traced to the depth of 300 nm from surface. The profile deeper than 100 nm corresponds to CME components. Moreover, depth profile for SW ^{20}Ne was determined from the DOS

sample.

Keywords: Genesis, Solar wind, Noble gas, CME, SNMS, Depth profile

