MICRODISTRIBUTION OF SOLAR WIND HELIUM ON ITOKAWA PARTICLE SURFACES.

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Introduction: Recently sputtered neutral mass spectrometry succeeded to measure depth profile distributions of solar wind helium from a NASA Genesis target [1]. They used tunnel ionization by strong field to detect He neutrals sputtered from ~1μm^2 area on the surface. Nagao et al. [2] measured noble gasses from asteroid Itokawa particles of JAXA Hayabusa mission. They show that ^{36}Ar/^{20}Ne ratios and Ne isotopic compositions from the particles correspond to their solar wind compositions, but the ^{4}He/^{20}Ne ratios are 4-6 times smaller than the solar wind ratio. They infer selective escape of He from particles due to higher mobility of He compared with other noble gasses. Noguchi et al. [3] show that surface layers of Itokawa particles have been damaged for about ~50 nm in depth probably by solar wind irradiations and the textures are diverse. These results suggest that distribution of He on surfaces of Itokawa particles is quite heterogeneous in nano-meter scales. In this study, we measured solar wind He of Itokawa particles by sputtered neutral mass spectrometry (SNMS) with tunneling ionization.

Experimental: Itokawa particles of RA-QD02-0169 and RB-QD04-0055 and a 4 keV He ion implanted San Carlos olivine were used in this study. A SNMS instrument called LIMAS was used [4]. A pulsed primary beam of ^{69}Ga with 30 keV and 65 nA was focused on a sample surface of ~1 μm in diameter. The pulse period was set to 200 ns. Sputtered neutrals were ionized by a focused (50 μm in diameter) fs-laser beam under a strong-field ionization condition. The laser pulse was 35 fs with 6.3 mJ and 1 kHz repetition. We accumulated post-ionized ions for 10 000 primary beam pulses at one spot. The primary beam was rastered on the sample with a square pattern of 15 × 15 spots with a step of 500 nm interval. The raster covered an area of 7.5 × 12 μm^2 on the surface because the incident angle of the primary beam, formed by the optical axis of the primary beam on the surface and the normal to the surface at the point of incidence, was set to 55°. Positive ions were introduced into a multi-turn time-of-flight mass spectrometer by an acceleration voltage of -4 kV with 1 kHz repetition synchronized with the primary ion pulses. A flight path length for the mass spectrometer was set to 68 m for $^{4}He^{+}$. We measured $^{4}He^{+}$, $^{12}C^{3+}$, $^{16}O^{+}$, $^{24}Mg^{2+}$, $^{28}Si^{4+}$, $^{28}Si^{3+}$, $^{28}Si^{2+}$, $^{28}Si^{+}$, and $^{56}Fe^{2+}$.

Results and discussion: Three-dimensional He distribution maps in a volume of 7.5 × 12 × 0.5^{depth} μm^3 consisting of voxels of 500 × 800 × 3.3 nm^3) from the Itokawa particle surfaces have been obtained. The depth distribution has a peak at ~20 nm in average, which is consistent with solar wind projected range observed in Genesis [1], but the peak concentrations and the peak depth are variable within micrometer scales on surface. These might reflect escape features of He from the particles and heterogeneous feature of mechanical erosion for particle surfaces.

References: [1] Bajo K. et al. 2015. *Geochemical Journal* (in press). [2] Nagao K. et al. 2011. *Science* 333: 1128–1131. [3] Noguchi T. et al. 2011. *Science* 333: 1121–1125. [4] Ebata S. et al. 2012. *Surface and Interface Analysis* 44: 635-640.