

トンネルイオン化スパッタ粒子質量分析による局所希ガス同位体分析の現状 Present status for in-situ noble gas analysis by Sputtered Neutral Mass Spectrometry with tunneling ionization

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LIMAS (Laser Ionization MASS nanoSCOPE) was installed in 2011. In-situ analysis for trace elements in nanometer-scale is a concept of this apparatus. I have conducted a study on mechanism of solar wind (SW) implantation into extra-terrestrial materials such as Itokawa particles. Because depth profile of SW-He have not been determined by using conventional noble gas mass spectrometer (NG-MS) in a quantitative way, a depth profiling of the SW noble gas contributes to the great progress for understanding implantation and removing processes of the SW noble gases. The processes imply the space-weathering history of the materials on its asteroid surface.

LIMAS is mainly composed of Ga focused ion beam (FIB) system for primary ion, femtosecond (fs) laser for tunnel ionization of sputtered particles, and time-of-flight mass spectrometer. Depth profiling procedure is as follows. The FIB system exhibits high spatial resolution with large primary current. The smallest beam size is 8 nm at 3 pA, and the largest size is 600 nm at 30 nA. The fs laser can ionize the all element even He because of high energy density. The energy density is $8E15 \text{ W/cm}^2$ because the pulse energy and width is 6.3 W and 30 fs, respectively, and the laser pulse was focused on a volume of $50 \times 50 \times 50 \mu\text{m}^3$. This laser pulse induces tunneling ionization (Delone and Krainov, 1998). Helium depth profile analysis in a few micrometer has been developed with LIMAS and atomic force microscope for crater depth measurement.

LIMAS can detect tens ppm in number of atoms He in sub-micrometer area on solid surface. At present useful yield of He is 0.02% which should be up to 1% by optimizing laser focusing and irradiation position. The yield of 0.02% corresponds to 4000 He atoms for single He ion count. The back ground of He is much less than that of the NG-MS because LIMAS is used in dynamic operation under the ultra-high vacuum.

LIMAS can measure locally concentrated noble gas because the sputtered volume is quite small, which indicates that this measurement is almost non-destructive isotope analysis. This feature can play a role for analysis of tiny and precious samples such as the Itokawa particles. U,Th-He and K-Ar dating for single grain can be applied by the in-situ noble gas analysis. The in-situ dating may obtain a new insight of thermal history of igneous rocks by comparing conventional in-situ dating method such as U-Pb age.

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