Development of novel mass spectrometer to analyze solar wind noble gases

Ken-ichi Bajo\textsuperscript{1,*}, Itose Satoru\textsuperscript{2}, Matsuya Miyuki\textsuperscript{2}, Ishihara Morio\textsuperscript{3}, Uchino Kiichiro\textsuperscript{4}, Kudo Masato\textsuperscript{2}, Sakaguchi Isao\textsuperscript{5}, Yurimoto Hisayoshi\textsuperscript{1}

\textsuperscript{1} Hokkaido University, \textsuperscript{2} JEOL Ltd., \textsuperscript{3} Osaka University, \textsuperscript{4} Kyushu University, \textsuperscript{5} NIMS

Solar-gas-rich regolith breccia from asteroids has been studied \cite{goswami1984, wieler2002}, which were irradiated by solar wind (SW) on the parent body surface. Regolith breccia was lithified by compaction process from regolith soils. The compaction processes which were recorded in the breccias should reveal a migration, deposition, SW irradiation of the soil. To figure out the SW distribution in the breccia high spatial resolution is required because SW implanted layer is less than 100 nm \cite{wieler2002}.

LIMAS (Laser Ionization Mass nanoScope) \cite{ebata2012} is a time-of-flight sputtered neutral mass spectrometer (TOF-SNMS) with non-resonant laser post-ionization system which can observe in-situ distributions of all elements in solid materials down to tens nm level. LIMAS is mainly composed of Ga focused ion beam (FIB) for sputtering, femtosecond laser for post-ionization of sputtered particles, and multi-turn mass spectrometer (MULTUM II \cite{okumura2005}).

An n-type Si wafer, which was irradiated by 30 keV \textsuperscript{4}He of 2 x 10\textsuperscript{16} ions/cm\textsuperscript{2} was used to evaluate and confirm sensitivity for He. The sputtering crater was 6.4 x 15.2 um\textsuperscript{2} and measurement area is 2.1 x 4.1 um\textsuperscript{2} of the center. The detection limit of \textsuperscript{4}He for the system is about 10\textsuperscript{14} ions/cm\textsuperscript{3} for \textsuperscript{4}He The performance of LIMAS should be improved towards higher sensitivity and lower background noises because bulk concentrations of solar-He in gas-rich meteorite is 10\textsuperscript{-2}-10\textsuperscript{-4} cm\textsuperscript{3}STP/g \cite{goswami1984} which can be translated into 10\textsuperscript{16}-10\textsuperscript{18} atoms/cm\textsuperscript{2} for rocky material (density \textapprox 3 g/cm\textsuperscript{3}).

References: \cite{goswami1984, wieler2002, ebata2012, okumura2005}

Keywords: Noble gas, Solar wind, Microscopic analysis, Mass spectrometry

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超高速度極微量質量分析装置を用いた太陽風起源希ガスの分析
Development of novel mass spectrometer to analyze solar wind noble gases

馬上 謙一，糸瀬悟，松谷幸，石原盛男，内野喜一郎，工藤政都，坂口 Flor，岡本尚義
Ken-ichi Bajo, Itose Satoru, Matsuya Miyuki, Ishihara Morio, Uchino Kiichiro, Kudo Masato, Sakaguchi Isao, Yurimoto Hisayoshi

北海道大学，日本電子，大阪大学，九州大学，物質材料研究機構
Hokkaido University, JEOL Ltd., Osaka University, Kyushu University, NIMS

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