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Development of Laser Ionization Mass Nanoscope: LIMAS

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Many sample-return missions are planned in the world (e.g. JAXA Hayabusa, NASA Stardust). Samples are collected on asteroids or comets, returned to the Earth, and then analyzed in laboratories. However, a very small amount of samples can be brought back because of the limitations on the space probes. Thus ultra-high sensitivity, lateral resolution, and resolving power are required for the mass spectrometer.

Here we have been developing a novel TOF-SIMS system; prototype in Osaka Univ. and new-type in JEOL Ltd.. This instrument consists of a FIB system with a liquid metal Ga ion source, a femto-second laser for post-ionization and a multi-turn TOF-MS 'MULTUM II'.

Firstly, in order to evaluate the performance of quantitative analysis, several alloys and standard glass JB-2 were analyzed using the prototype system. Alloys used for this evaluation were Constantan, Cupronickel, Brass, Inconel-625, SUS301, SUS310, and SUS321 (the Nilako corp., Japan).

Secondly, in order to evaluate the postionization efficiency and mass resolving power using the new-type system 'LIMAS', non-postionization (SIMS) and postionization mode were compared. Samples used for this evaluation were Al for SIMS mode and Ag substrate for postionization mode, respectively.

Chemical compositions of constantan, cupronickel, and brass were corresponded approximately to reference values in the error ranges. Chemical compositions of SUS301, SUS310 and SUS321 were slightly higher intensity of Cr and slightly lower of Ni than those of reference values. These results show this instrument was useful for quantitative analyses. On the other hand, Chemical compositions of inconel-625 was very higher of Cr than those of reference value.

The postionization efficiency and mass resolution using the new-type system 'LIMAS' were evaluated. By using post-ionization, the secondary ion signals of Ag were increased ˜6000 times compared with the conventional TOF-SIMS experiments. This result shows that the nonresonant multiphoton post-ionization experiments have superior sensitivity. Compared to the prototype experiments, the secondary ion signals of Ag were increased ˜3 times, because the pulse width of a femto-second laser was improved from 120 fs to 40 fs.

The mass resolution was achieved to ˜12000 by SIMS mode (flight length: ˜70 m at 50 cycles) and ˜15000 by LIMAS mode (flight length: ˜35 m at 25 cycles). These results show this instrument was useful for isotope analyses.

These results indicated that this instrument would be very effective for ultrahigh sensitivity analysis of nano-size particles such as Hayabusa mission return samples.

Keywords: Hayabusa, SNMS, Focused ion beam, Femto second laser, Multi-turn mass spectrometry