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Eletrostatic micromanipulation system applied for the returned particles of the asteroid explorer Hayabusa

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The asteroid explorer Hayabusa successfully returned its reentry capsule back to the Woomera Prohibited Area on midnight of June 13th, 2010. Until the capsule was introduced into the planetary material sample curation facility in Sagamihara campus of JAXA, it experienced a series of processes to open the sample container and recover the returned particles in the sample catcher. The electrostatic micromanipulation system was playing a main role for the returned particle treatment during the processes.

The eletrostatic micromanipulation system was installed into the clean chamber 2 conditioned as highly purified N2 in the planetary material sample curation facility in January 2010, after around one year of development. It consists of a sample stage which is equipped with X, Y, Z and theta-Z axes macro- and micromotion and various types of stages, right and left probes stage which are equipped with X, Y, Z, theta-Y and theta-Z axes macro- and micromotion, and probe holders applicable for synthetic quartz glass needles involving Pt thin wire and an alpha-ray source holder for electrostatic neutralization. These stages is operated with gloves of the clean chamber 2 made of Viton, and the particle on the sample stage can be lifted up and released in the clean chamber filled with highly purified N2 with the quartz needle charged plus or minus voltage with a voltage controller outside the chamber, being observed with two optical microscopes equipped inside and outside the chamber.

The manipulation system was tested by simulated material(Ni olivine particles) from March to May, 2010, and the particle manipulation in the clean chamber was established before the Hayabusa capsule reentry.

The sample catcher is basically a small cylinder made of aluminum alloy coated by aluminum which is separated to three areas, that is a room A, a room B and a rotational cylinder. Because of the sequence of the sample catcher opening processes, the room A of the catcher was exposed, thus we firstly started particle manipulation from those found in the catcher room A. However, we mainly recovered aluminum flakes from there, and less translucent particles which would be possibly mineral grains, due to the difference of recognition easiness on its surface. Thus, we developed small spatulas made of Teflon which can be introduced into the sample chamber of the SEM. After the swipe of the spatula on the surface inside the room A, a lot of fine particles attached onto the edges of the spatula were observed with the optical microscopes. Then they were observed and analyzed with the SEM-EDX to be clarified that they contain $>$1500 silicate particles of $<$10 micron in size and that they are supposed to be originated from asteroid Itokawa because of their mineral compositions and combination including their relative abundances, as already informed by the press release of JAXA.

As a micromanipulation system for $<$10 micron particle was not established yet, we have to recover larger particles in easier handling condition. We prepared a synthetic quartz glass plate which fit to the opening of the catcher room A, and attached to the opening, turned upside down to let particles fall freely, turned back to the original position and recovered the plate to a synthetic quartz glass Petri dish. We recognized $>$1000 particles of $>$10 micron in size on it. Then we recovered the particles from the plate with the system, set the SEM holder, observed and analyze with the SEM-EDX. So far, around 50 of particles of $>$30 micron in size were recognized as silicate particles and supplied for the initial analyses.

The electrostatic micromanipulation system was utilized for a series of particle handling processes mentioned above, and it worked successfully with the least particle loss.

In this presentation, we plan to detail the configuration of the manipulation system, results of the test manipulation and up-to-date results of the Hayabusa returned particles manipulation.

Keywords: asteroid exploration, Hayabusa, Itokawa, curation, electrostatic control, micromanipulation