The samples recoveries from the Hayabusa sample catcher in the past and the future

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Introduction:

Hayabusa spacecraft returned the first regolith samples from S-type near Earth asteroid 25143 Itokawa in 2010 [1, 2]. It had tried touchdown sampling twice on the largest smooth terrain called Muses Sea regio of the asteroid, although it did not shoot a Ta bullet to excavate its surface at that time [3]. After returning the recovered samples, they have been extracted from a sample container, handpicked one by one, analyzed with an FE-SEM/EDS for identification, and given ID [4]. Note that the samples have not been exposed to the atmosphere, handled in purified N_2 condtion and analyzed in low vacuum condtion. Here, we describe detail of processes and results of the sample extraction we did and also mention to their future plan and lessons learned from Hayabusa.

Sample extraction methods from the sample catcher:

The returned samples were situated inside a sample catcher in the sample container. The sample catcher is composed of room A and B (RA and RB) and rotational cylinder (RC) (Fig. 1). Those recovered by the first touchdown should be captured inside the RB, and the second one inside the RA, and both of them should be left inside the RC because it was a passage to both the RA and the RB. So far, samples inside them were extracted by four methods, partially described in [4]. At first, the particles inside the RA were directly handpicked with an electrostatically controlled micromanipulator, although it was so inefficient because of its uneven inner structure (Fig. 1). The next, a specially designed Teflon spatula was used for sample recovery from the RA to be scooped its inner surface and analyzed directly with the FE-SEM/EDS [2]. It was successful in recovering small particles inside the RA, although it was difficult to release them from the spatula because they were stuck to its surface made of Teflon tightly. The third method we tried was to put a quartz glass disk to the opening of the room of the catcher, turn upside down and tap it on its outside in order to let particles inside fall onto the disk. After the tapping, we reversed it to recover the disk by tweezers and place it in a quartz petri dish. We performed this method once for both RA and RB, and also recover the cover of RB, an original part of the catcher, in the same way. Then the particles on the disks were handpicked one by one with the micromanipulator to be analyzed with the FE-SEM/EDS for their initial descriptions. Practically, most of the samples distributed to preliminary examination, NASA and international announcement of opportunity (AO) have been recovered with this method. The total number of those described for RA and RB count up more than 700, and almost 200 particles have been distributed for 51 accepted research proposals in four times of international AOs.

Recently, we developed a metal disk for the sample recovery from the RC. The concept is basically same as the quartz disks, but a good thing about it is to be able to let the disk stay in the upright position, never turn it upside down in the recovery

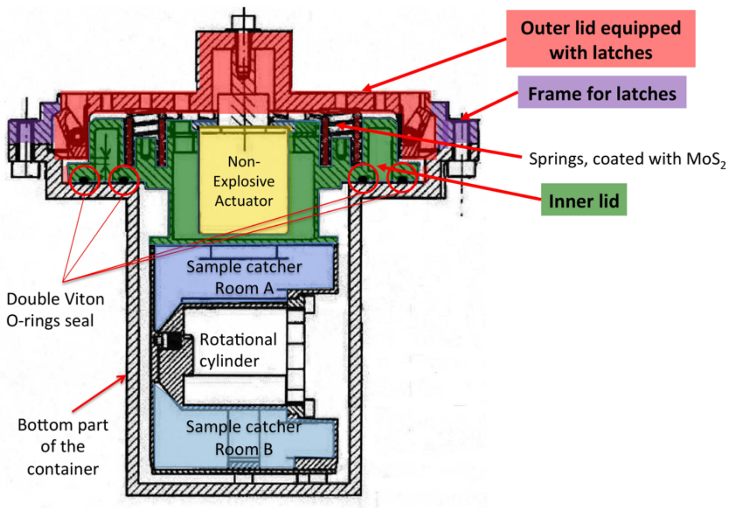

Fig. 1. A cross section of a sample container of Hayabusa. Blown-up samples entering its sampler horn go into a rotational cylinder at first and then captured in either Room A or B of the sample catcher.

process, so that large particles which might fall back into the catcher as it would be reversed must stay on the disk. We are now handpicking particles from the metal disk of the RC and analyzed them with the FE-SEM/EDS.

Future plan and lessons learned for the sample extractions:

Now, we are preparing new metal disks for the RA and RB, and will try final recoveries from them in the next year. Then we will continue to handpick from them to finish describing in 2020, until the sample return of Hayabusa2.

In the viewpoint of lessons learned from a series of implements of sample extractions experienced in the Hayabusa mission, we should consider a method to extract samples from a sample catcher in designing a new sampling system for a new spacecraft of a sample return mission. It is partially realized in designing Hayabusa2 sampling system, as three rooms of its sample catcher can be decomposed into each part, which is shaped like a container. However, detail processes of the sample extraction, which is partially mentioned in [5], was not discussed in its designation. Ideally, a whole sample extraction processes after its return to the Earth must be discussed and designed in developing a sample recovery system for the future sample return mission, such as the Martian Moons Exploration, MMX [6].

References:

[1] Abe M. et al. 2011. Abstract #1638. 42nd LPSC. [2] Nakamura T. et al. 2011. Science 333: 1113. [3] Yano H. et al. 2006. Science 312: 1350. [4] Yada T. et al. 2014. Meteoritics & Planetary Science 49:135. [5] Nakano Y. et al. 2017. in this symposium. [6] Kuramoto K. et al. 2017. Abstract #2086. 48th LPSC.