PROCESSES TO OPEN THE CONTAINER AND THE SAMPLE CATCHER OF THE HAYABUSA RETURNED CAPSULE IN THE PLANETARY MATERIAL SAMPLE CURATION FACILITY OF JAXA.

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Introduction: Japanese spacecraft Hayabusa, which returned from near-Earth-asteroid Itokawa, successfully returned its reentry capsule to the Earth, the Woomera Prohibited Area in Australia in Jun 13th, 2010, as detailed in another paper [1]. The capsule introduced into the Planetary Material Sample Curation Facility in the Sagamihara campus of JAXA in the early morning of June 18th.

Hereafter, we describe a series of processes for the returned capsule and the container to recover gas and materials in there.

X-ray computed tomography (X-ray CT) analysis on the returned capsule and container: A transportation box of the recovered capsule was cleaned up on its outer surface beforehand and introduced into the class 10,000 clean room of the facility. Then, the capsule was extracted from the box and its plastic bag was opened and checked and photographed the outer surface of the capsule.

The capsule was composed of the container, a backside ablator, a side ablator, an electronic box and a supporting frame. The container consists of an outer lid, an inner lid, a frame for latches, a container and a sample catcher, which is composed of room A and B and a rotational cylinder.

After the first check, the capsule was packed in a plastic bag with N_2 again, and transferred to the Chofu campus in JAXA, where the X-ray CT instrument is situated. The first X-ray CT analysis was performed on the whole returned capsule for confirming the conditions of latches and O-ring seal of the container. The analysis showed that the latches of the container should have worked normally, and that the double O-rings of the container seemed to be sealed its sample catcher with no problem.

After the first X-ray CT, the capsule was sent back to Sagamihara and introduced in the clean room to exclude the electronic box and the side ablator from the container by hand tools. Then the container with the backside ablator was set firmly to special jigs to fix the lid of container tightly to the container and set to a milling machine. The backside ablator was drilled by the machine to expose heads of bolts, which combined the ablator to the outer lid of the container, and after the drilling had been finished, all the bolts were unscrewed and the backside ablator was removed from the container.

Then, the container was sent to the Chofu X-ray facility again to examine in detail by a micro X-ray CT instrument in order to reconfirm that the condition of the latches of the lid of container was normal and that its double O-ring seemed to have been sealed after the last X-ray CT analysis.

The cleaning and introduction to clean chambers processes for the container: After the container was back to the clean room in Sagamihara from the second X-ray CT, a thermosensor, which had been attached bellow the outer surface of the container's flange, was removed with hand tools. Also, terrestrial dust and chips of the ablator which existed in the gap between the lid and the container's flange was cleaned up with a special vacuum cleaner.

Then the outer surface of the container was cleaned with a series of processes described bellow.

First, it was wiped with clean cloths wetted by isopropanol and ultra pure water. Second, the surface of the container was blown with a dry ice blast cleaner. Finally, its surface was cleaned with an air-pressure plasma cleaner. For the confirmation of cleanliness of the surface of the container, it was checked via swabs for clean cleaning and/or clean slide glasses with an optical microscope, a dynamic contact angle meter and a Fourier transform infrared spectroscopy. All the three tests showed no sign of contamination.

Next, the container was sent to class 1,000 clean room and fixed to the container opening jigs, which was designed to hold its inner lid keeping its seal and remove its frame for latches and its outer lid. After the series of processes related to the jigs, its inner lid was held with craw jigs, and the gap between the inner lid and the container's flange was cleaned up with the special vacuum cleaner.

Subsequently, the container with the craw jigs was removed from the opening jigs and fixed to the container opening system. After its inner lid was held to the container's flange with four shafts via a joint jig,

the craw jigs was removed from the container's flange. Then the container opening system with the container fixed joined the clean chamber #1, in which ultra pure N_2 was continuously purged during the joint. All the process described above had been finished until June 20th. The environment of the clean chamber #1 was purified with a circulated N_2 purifier equipped with the chamber for an all night of June 20th.

The opening of the container and residual gas sampling: Here we describe processes to estimate the pressure inside the container and set the pressure of the clean chamber #1 close to that of the container as much as we could, in order to minimize a disturbance caused by gas flow between inside and outside the container.

The container opening system contains sets of load cells and displacement sensors for four axes. Rehearsals of the opening of the container had been performed with the opening system and an imitation container in a positive, negative or equal pressure inside the container compared to the outside, before the actual container return. During the rehearsals, trend of data of the load cells and the displacement sensors had been recorded as shown in Fig. 1.

In the case of the actual returned container, the inner lid was pulled slightly with the sensors recorded on June 21st and the data was compared with the rehearsal data. As shown in Fig. 1, the comparison with the data obtained in rehearsals and those in the actual case indicates that the inner pressure of the container would be between vacuum and air pressure. Based on this estimation, the pressure condition of the clean chamber #1 was set to vacuum, not in a dynamic but a static condition.

Simultaneously, residual gas sampling cylinders which had equipped to the clean chamber #1 were prepared to capture gas released from the container at the timing of its opening. Since it was estimated that gas inside the container should contain terrestrial atmosphere to some extent, O_2 could be also a sign to distinguish the opening of the container. Therefore, the opening of the container was performed under monitoring the date of the load cells and displacement sensors of the opening system and those of a differential pumping quadrupole mass spectroscopy, which can detect >1ppm of O_2 in air pressure N_2, analyzing the environment of the clean chamber #1 in order to recognize the opening of the container. Just before and after both the monitored data showed the signs of the opening, the gas inside the clean chamber #1 was captured in the gas cylinders. The result of analyses of the sampled gas is presented in [2]. The processes to open the container had been finished in June 22nd, and the clean chamber #1 was evacuated for a whole day of June 23rd.

The opening of the sample catcher room A and the treatment of the particle inside:

On June 24th, the container was transferred to another chamber which attaches to the clean chamber #1 with a transfer rod, then the inner lid and the sample catcher was set to a catcher handling container. The inner lid, which is combined with a cover of the catcher room A, was removed, and its inner surface was observed and photographed.

The catcher was enclosed into a catcher handling container, and the container include the catcher was transferred to the clean chamber #2, which was designed for sample handling in purified N_2 condition and equipped with an electrostatic micro-manipulator combined with optical microscopes.

The inner surface of the catcher room A was observed in detail by the optical microscopes, and it is figured out that not many particles larger than a few hundred μm were found inside the room A.

The micro-manipulator, special Teflon spatulas and a silica glass plate for free fall recovery have been used to recover particles form the catcher room A, and some of the recovered particles were analyzed by a field emission scanning electron microscope equipped with energy dispersive X-ray spectrometer (FESEM-EDX), as mentioned in detail in [3].

References: [1] Abe M. et al. (2011), *in this volume.* [2] Okazaki R. et al. (2011), *in this volume.* [3] Nakamura T. et al. (2011), *in this volume.*

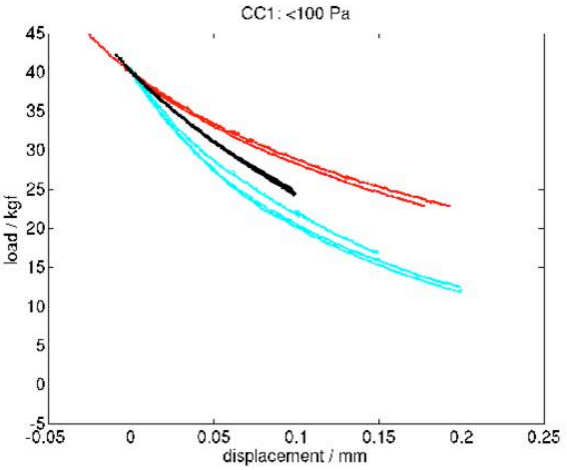

Fig. 1. Correlation curves between displacements and load for the container opening system in <100Pa pressure of the clean chamber #1 . Red curves represent those obtained when the container was atmospheric pressure, and blue curves represent those obtained when it was vacuum in rehearsals. Black curves represent those obtained when the actual container of unknown inner pressure was slightly pulled for its lid.