AUTONOUMOUS ELECTROSTATIC SAMPLING OF REGOLITH FROM ASTEROIDS.
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Introduction: After the great success of the Hayabusa project [1], JAXA plans to launch another spacecraft, Hayabusa-2, for returning a sample from another asteroid. NASA has announced that it will also launch a spacecraft in 2016 and collect samples from an asteroid for analysis [2].

To realize a technology for a reliable sampling of the asteroid regolith as an autonomous operation in space, we are developing a new sampling system that employs a combination of electrostatic capture and transport [3]. High voltage is applied between parallel screen electrodes present at the end of the collection device. Particles on an asteroid are captured after passing through the openings of the screen electrodes by means of electrostatic force. The captured particles are then transported by an electrostatic traveling wave through clearances between laminated plates and transferred to a capsule [4]. The system functions effectively in vacuum. Moreover, it is simple, consumes less power as compared to conventional mechanical methods, and has no mechanical moving parts, thus making it highly reliable.

System Configulation: Fig. 1 shows a schematic illustration of the system. The system has two primary functions: capture and transport of particles. When high voltage is applied between parallel screen electrodes of the sampling device, a resultant electrostatic force acts on particles in the vicinity of the electrodes, and the particles are captured. The captured particles are transported to a capsule through gaps between laminated sheets. Paralel electrodes are printed on the sheets perpendicular to the transport direction and four-phase rectangular high voltage is appled to the electrodes to generate electrostatic traveling-wave [4].

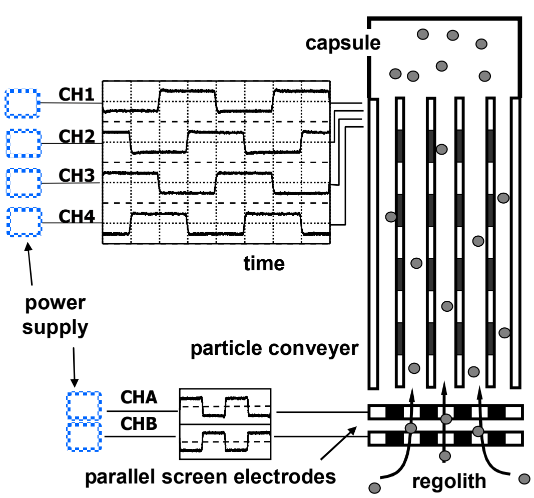

Fig. 1 Configuration of regolith sampling system.

Results and Discussion: As reported in the literature [3], it was demonstrated that 100 mg regolith can be capured within on-second operation even in the Earth's 1 G and 1 atm environment, and not only regolith particles but also the regolith mixed with crushed ice can be successfully transported by the electrostatic traveling wave.

In order to investigate the particle size that can be sampled by this device the stimulant was classified in five groups of particle size using sieves, and the device was operated in one second. The sampling device described in the literature [3] and the lunar soil simulant FJS-1 [5] were used in experiments. Fig. 2 shows the weight of the collected regolith versus the particle size. Although it was difficult to sample large particles on the Earth, it is expected that the performance of the system in a vacuum and extremely low-gravity environment on an asteroid will be much higher than that on the Earth.

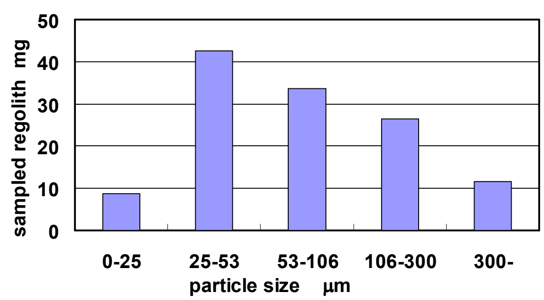

Fig.2 Weight of the collected regolith versus the particle size.

References: [1] JAXA (2011) http://www.isas.jaxa.jp/e/enterp/missions/hayabusa/index.shtml. [2] NASA (2011) http://www.nasa.gov/topics/ solarsystem/features/osiris-rex.html. [3] Kawamoto H. (2012) *Earth & Space 2012*. [4] Kawamoto H. et al. (2011) *J. Electrostat.* 69, 370-379. [5] Kanamori H. et al. (1998) *6th Int. Conf. on Engineering, Construction and Operations in Space*, ASCE, Albuquerque, 462-468.