Development of elastic wave velocity measurement technology for Hayabusa2 return sample.

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The physical properties of the materials that make up the solar system are as important as chemical and mineral properties in understanding the origin and evolution of the celestial body. In particular, they are expected to provide strong constraints on collisional processes during planet formation and thermal evolution after formation.
Among the physical properties, mechanical properties include hardness, Young's modulus, elastic wave velocity, bending strength, thermal expansivity and cohesion force. Especially, they are considered to be important as basic data to understand what the shape of Ryugu [1] and the formation mechanism of the craters obtained designed from the Hayabusa2 Small Carry-on Impactor (SCI) experiment [2], the mechanism of seismic wave propagation under microgravity objects [3] and the surface evolution caused by the resurfacing effect [4].

In this study, we developed an instrument and analysis method targeting elastic wave velocity of Hayabusa2-returned samples for the first time since the Apollo-returned lunar rock sample.
Although there was no estimate of the size, shape and physical properties of the collected sample before their return, we conducted a design study based on the assumption that the sample could be processed into a flat plate shape of several hundred microns in size. The ultrasonic pulse-transmission method was adopted.
Ultrasonic transducers ranging from 5 MHz to 100 MHz were prepared in order to accommodate various sample thicknesses. Since the sample is compressed by two ultrasonic transducers in the case of the transmission method, we designed the apparatus to monitor the compression force and to keep the ultrasonic transducers as parallel as possible so that the stress would not be concentrated on a part of the sample.

Discussions with the analysis team after sample confirmed, indicated that a sample with a diameter of 3 mm and a thickness of 1 mm was likely to be offered as a physical property measurement, so we developed a measurement technology targeted at this size. For this purpose, we conducted a preliminary test by processing the Murchison meteorite, which was thought to be similar to the Ryugu sample, to an equivalent size. Normally, a couplant is applied between the sample and the ultrasonic transducer. However, in order to eliminate contamination of the Ryugu sample by the couplant and to avoid increasing the thickness error factor due to the use of a thinner than usual sample with a thickness of 1 mm in this study, we decided not to apply the couplant.
Preliminary test results show that the ultrasonic transducer frequency is 20 MHz and the minimum pressure required for sample measurement is about 1.7-4.5 MPa. Since the hardness and Young's

modulus of the Ryugu sample are estimated by nanoindentation test in the initial stage, the feasibility of elastic wave velocity can be judged based on these data. We also obtained the possibility of estimating the information on the seismic quality factor (Q factor) of elastic waves from the relationship between the pressure data and the received intensity during the measurement.

For the method of estimating the elastic wave velocity from the acquired data, the delay time between the blank signal (without the sample between ultrasonic transducers) and the sample transmission signal (with the sample between ultrasonic transducers) was calculated at the position where the cross-correlation function was the maximum, and the elastic wave velocity was estimated by the thickness of the sample and the delay time. Based on these preliminary tests, we successfully measured the Ryugu sample and will report the results in this talk.

References:
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