Report for the Joint Use/Research of the Institute for Planetary Materials, Okayama University for FY2024

Month/Day/Year

Category: ☐International Joint Research ☑General Joint Research ☐Joint Use of Facility ☐Workshop

Name of the research project: High-pressure ultrasonic measurements in the lower mantle by use of tapered anvil.

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Collaborator

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Research report:

P- and S-wave velocities are unique tools to explore the structure and mineralogical composition of the inaccessible deep Earth and planetary interiors, which hold important clues to understand our planet's formation, evolution and internal dynamics. In this context, laboratory measurements play an important role to establish P- and S-wave velocity profiles as a function of depth for candidate mineralogical compositions, which can be thereafter compared with seismic data. Despite this importance, data at lower mantle P and T conditions are still scarce because those experiments are still very challenging owing to difficulty to maintain pressure higher than 30 GPa using tungsten carbide anvils while heating at mantle geotherm temperature.

In this project, we attempted to overcome such limitations by combining our ultrasonic techniques with newly developed tapered anvils (Ishii+ RSI 2016, HPR 2017, JGR 2019), which permits to generate pressures up to ~60 GPa using tungsten carbide anvils. A set of eight TJS01 anvils with a truncation edge length of 4 mm were tapered with a 1º slope at IPM. One anvil was subsequently polished to mirror-surface at GRC and a $LiNbO_3$ transducer was pasted to its back for ultrasonic measurements. The anvils and ultrasonic cell assemblies were transported to SPring-8, where elastic wave measurements at high-pressure were carried out on a Bridgmanite sample, at the beamline BL04B1. The cell assembly was first compressed to an intermediate load then heated up to 1300 K to reduce non-hydrostatic press. VP and VS were subsequently measured upon decreasing temperature down to 300 K. At the end of the first heating/cooling cycle, the pressure was about 25.9 ± 0.5 GPa for an applied load of 6 MN. Multiple cycles were conducted, until we reached the maximum pressure and temperature of 31.7 ± 0.5 GPa and 1900 K for an applied load of 14 MN. The new experimental set up allowed to measure sound velocities at pressures and temperatures relevant to the lower mantle, in a modestly large cell (e.g. TEL4). The success of this experiment offers some perspectives to further improve pressure generation for ultrasonic measurements beyond these pressures, using smaller TEL.