Deformation experiments of mixture of bridgmanite and ferropericlase using rotational diamond anvil cell

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Development of high-pressure (static compression) experiments enabled to increase pressure up to ~360 GPa, corresponding conditions to inner core of the Earth (e.g., Tateno et al., 2010). On the other hand, pressure is limited for a technical reason in high-pressure deformation experiments. Earth’s interior is dominated by ‘dynamic’ processes. Therefore, expansion of pressure range in deformation experiments is necessary to understanding the evolution of Earth’s deep interior. We developed rotational diamond anvil cell (rDAC) to conduct deformation experiments with large strain under ultra-high pressure conditions, corresponding to those of Earth’s core (Nomura et al., 2017; Azuma et al., 2018). We present the results of deformation experiments using rDAC and the status of development of rDAC.

In this study, existing diamond anvil cell (DAC) is modified to give torsional deformation to sample under ultra-high pressure conditions. In the developed rDAC, lower anvil is fixed and upper anvil can rotate relative to the lower anvil. The mixture of bridgmanite and ferropericlase was deformed using the rDAC. The experimental conditions are ranging 35–135 GPa, room temperature and strain-rate of 5.6×10^{-5}–1.7×10^{-4} s^{-1}. Starting material was grooved by FIB and the groove was deposited by Pt as strain-marker. Recovered samples were cut by FIB to observe the rotation angle of strain-marker, sample thickness, and shape of strain-marker in each cross-section. Deformation experiments were conducted also in Japan Synchrotron Radiation Research Institute (SPring-8) and 3D visualization of the internal structure of samples were performed using X-ray laminography (Nomura and Uesugi, 2016).

The geometry of strain-marker in recovered samples show nearly simple shear, indicating that this apparatus allows us to investigate the deformation with large strain under ultra-high pressure conditions, corresponding to those of core-mantle boundary (CMB). Recovered sample was observed using FE-SEM and we determined the 2D surface area and aspect ratio of each particle of ferropericlase. Microstructure of mixture of bridgmanite and ferropericlase showed that the ferropericlase highly deformed and connected each other, indicating that the ferropericlase dominate the deformation in the lower mantle. However, these deformation experiments were conducted under room temperature. We will carry on the development of rDAC for high-temperature deformation experiments.

Keywords: rotational diamond anvil cell, bridgmanite, ferropericlase, deformation experiment

