Development of rotational diamond anvil cell for deformation experiments under high pressure conditions corresponding to the lowermost mantle

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Abstract

A pressure range enabled to perform the deformation experiments has been limited due to a technical reason. Extending the pressure range is necessary to understand the dynamics and evolution of Earth's deep interior. A rotational diamond anvil cell (rDAC) is the most suitable deformation apparatus to investigate the rheological properties of deep-Earth materials such as conditions corresponding to the lower mantle and core. The upper anvil of the rDAC rotates relative to the lower anvil and gives the torsional deformation to a sample (Nomura, Azuma et al., 2017). Therefore, the rDAC can theoretically produces an infinite strain to the sample. We report the development of the rDAC and its availability as a deformation apparatus.

In this study, we attempted to improve the pressure range and the prevention of a slip between the sample and the anvil in the deformation experiments using the rDAC. The starting material was a mixture of bridgmanite and ferropericlase. This starting material was grooved by FIB and a platinum strain marker was embedded into each sample. The experimental conditions were $P = 35$–137 GPa, room temperature and strain-rate of 5.6×10ˆ-5–1.7×10ˆ-4 sˆ-1. Four types of the diamond anvil designs were tested to evaluate the performance with respect to slip between the sample and the diamond anvils. These deformation experiments were conducted in Japan Synchrotron Radiation Research Institute (SPring-8) and 3D visualization of the strain-marker in the samples were performed using X-ray laminography (Nomura and Uesugi, 2016).

The geometry of strain-marker in the deformed samples showed a nearly simple shear deformation, indicating that this apparatus can deform the sample with large strain under high pressure conditions, corresponding to those of core-mantle boundary (CMB). The rotation angle of the strain-marker in the deformed samples was compared to the rotation angle of the upper anvil. This comparison indicated that the one of the optimizing anvil (the diamond anvils with deep grooves) can prevent the slip between the upper anvil and samples.

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