Toward the in-situ deformation experiments under the lower mantle conditions using D-DIA apparatus

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Rheological properties of lower-mantle forming minerals such as bridgmanite are important to understand the cause of seismic anisotropy and the viscosity structure in the lower mantle. To explore the creep behavior and crystallographic preferred orientation of high-pressure minerals, two types of deformation apparatus, namely, the D-DIA type (Wang et al., 2003) and the rotational Drickamer apparatus (RDA: Yamazaki and Karato, 2001) have been adopted to deformation experiments at high pressures. Even though the upper limit of confining pressure is 4 GPa in the Griggs rig (e.g., Rybacki et al., 1998), the upper limit is more than 18 GPa in the case of D-DIA and RDA (Miyagi et al., 2013; Kawazoe et al., 2016). Recently, Girard et al. (2015) and Tsujino et al. (2016) succeeded to deform bridgmanite at lower mantle pressures and temperatures using a RDA and a Kawai-type apparatus for triaxial deformation (KATD: Nishihara, 2008), respectively. Even though the pressure and temperature conditions available in a RDA and a KATD have been extended to the lower mantle conditions, in-situ D-DIA experiments are still limited to the conditions of lower part of the mantle transition zone (Kawazoe et al., 2016). The main cause disturbing further pressure generation using an in-situ D-DIA apparatus is relatively low toughness of the x-ray transparent anvils made from sintered diamond or cubic BN. In the geometry of cubic-type multianvil apparatus, the available press load needs to be low (< 0.6 MN) to avoid the breakage of the x-ray transparent anvils. Also, conventional WC anvils are not suitable for the generation of lower mantle pressures in the geometry of cubic-type multianvil apparatus. The advantages of D-DIA apparatus are as follows: i) sample deformation can be precisely controlled by two deformation rams (i.e., deformation with a constant strain rate) and ii) temperature can be monitored by using a thermocouple. To explore the quantitative deformation experiments at lower mantle conditions, we adopted the 'jacketed' 6-6 type anvils (Yamada et al., 2016) and optimized the cell assembly using preformed gaskets (e.g., Kawazoe et al., 2010). Combining these techniques, we succeeded to generate 24 GPa at room temperatures using a D-DIA apparatus. Pressures higher than 20 GPa are also available with our in-situ experimental setup, suggesting a possibility of quantitative deformation experiments at lower mantle conditions in near future.

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