ダイアモンドアンビルセルを用いた高圧その場X線ラミノグラフィー撮像法の開発
High-pressure *in situ* X-ray laminography using diamond anvil cell

*野村 龍一[1]、上杉 健太朗[2]
*Ryuichi Nomura[1], Kentaro Uesugi[2]

1.東京工業大学、2.高輝度光科学研究センター
1.Tokyo Institute of Technology, 2.JASRI/SPring-8

The diamond anvil cell (DAC) is a powerful tool to reproduce high-pressure (P) and high-temperature (T) conditions, corresponding to those of the deep Earth interior, in a laboratory. Various types of measurements such as in situ high-P-T spectroscopic measurements and ex situ chemical analysis have been conducted using DACs to understand the structure and evolution of the Earth's interior. Among these techniques, 3D visualization and textural/chemical characterization of the internal structure of samples at high-P-T is of great importance. Recently, the dihedral angle of molten iron between bridgmanite was investigated by imaging recovered DAC samples using X-ray computed tomography (CT), and the results provide important insights about the physical process of the Earth's core-mantle separation (Shi et al., 2013). In situ high-P X-ray CT has been developed by transmitting X-rays through a light metal gasket, such as Be, between diamond anvils. To date, the applications have been limited to physical purposes, such as the changes of the volume or shape of the sample with pressure (Liu et al., 2008; Wang et al., 2012).
On the other hand, Tsuchiyama et al. (2013) developed a 3D chemical imaging technique, known as analytical dual energy microtomography, in which two X-ray energies below and above the absorption energy of a key element, such as Fe, are used for CT. We applied this technique to recovered DAC samples to determine the solidus temperature of pyrolitic mantle, using incompatible Fe enrichment as a signature of melting (Nomura et al., 2014). This dual energy technique has an additional advantage that artifacts in the reconstructed images, which are a typical problem in CT, can be avoided. The next step should be to carry out in situ high-P-T dual energy X-ray imaging, which remains challenging because deep Earth is composed of light elements (e.g. Fe, O, Si, Mg) with an X-ray absorption edge far below the hard X-ray energy range, in which the light metal gasket absorbs the incident X-rays crucially.
A high-pressure in situ X-ray laminography technique was developed using a newly designed, laterally open diamond anvil cell. A low X-ray beam of 8 keV energy was used, aiming at future application to dual energy X-ray chemical imaging techniques. The effects of the inclination angle and the imaging angle range were evaluated at ambient pressure using the apparatus. Sectional images of ruby ball samples were successfully reconstructed at high pressures, up to approximately 50 GPa. The high-pressure in situ X-ray laminography technique is expected to provide new insights into the deep Earth sciences.

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