Earth & Planetary Science

Developments in both scientific instruments and techniques are vital to advance experimental studies. Great efforts have been directed toward developing high-pressure technology combined with synchrotron radiation at some beamlines related to Earth & Planetary Sciences, and *in situ* X-ray diffraction measurements under P-T conditions approaching those of the Earth's core are now possible using the laser-heated diamond anvil (LHDAC) system. Researchers at the Tokyo Institute of Technology and JAMSTEC have largely contributed to constructing such a system and to developing relevant techniques at BL10XU.

On the basis of this technology, Hirose, Murakami and coworkers reported a new polymorph of $MgSiO_3$-perovskite, the most important high-pressure phase in the lower part of the mantle, at pressures greater than 120 GPa, equivalent to those near the mantle-core boundary (136 GPa). An independent study by Ono *et al*. at the same beamline also confirmed the formation of this new phase at similar pressures. The discovery of the "post-perovskite (PP) phase" has attracted researchers in wide fields of Earth Sciences, including mineral physics, seismology, geochemistry, mantle dynamics simulation, etc., and the roles of the PP phase in the Earth's deep interior have been actively discussed in some recent international conferences.

Technological progress has also been made using a combination of sintered diamond (SD) anvils and a large-volume multianvil apparatus (MA) at BL04B1, mostly by researchers at ISEI, Okayama University and GRC, Ehime University. Ito and coworkers reported the generation of pressures exceeding 60 GPa at room temperature, and have been working on the determination of phase transition pressures of some materials. They demonstrated that the wurtzite to rocksalt transition in GaN occurs at pressures of approximately 50 GPa, with a negative Clapeyron slope, based on *in situ* X-ray diffraction observations conducted at room temperature and also at high temperatures up to 850 K.

The stable generation of higher temperatures in MA with SD anvils has been challenged by Irifune, Sueda *et al*., and temperatures up to 2400 K are now comfortably produced for a long duration (e.g., several hours) at pressures up to ~45 GPa. They found that hollandite-type $KAlSi_3O_8$, an important constituent in subducted crust or sediment materials, transforms to a new structure in the upper part of the lower mantle, on the basis of this technique. This result is in contrast to earlier results with LHDAC, demonstrating the advantage of using MA with sample volumes far larger than those available in DAC.

The relatively large volume in MA permits precise measurements of some physical properties and of materials structures under high pressure. Ohtaka, Arima, Yoshiasa and coworkers made XAFS spectra measurements of GeO_2 melt under high pressure (up to 15 GPa) and temperature, and found a rather abrupt change in Ge-O distance, suggesting the occurrence of an oxygen coordination change from four- to six-fold at about 3 GPa. This method can be applied to evaluate structural changes in silicate melts under high pressure, which should provide important information on the viscosity changes in magmas in Earth's deep interior.

Technological development in computer tomography (CT) using synchrotron radiation allows three-dimensional imaging of very small (< 0.1 mm) materials. Tsuchiyama and coworkers developed a microtomography technique, named SR-based projection microtomography (SP-μCT), and first applied it to minute cosmic dusts collected from ice and snow or in the stratosphere. Based on the SP-μCT imaging of a variety of cosmic dusts at BL20XU and BL47XU, they evaluated the nature and origin of the three-dimensional shapes of some microspherules. This technique has also been applied to quantitatively evaluate the porosity of some micrometeorites. These results should provide important constraints on the origin of such cosmic dusts, leading to a deeper understanding of the physical and chemical processes in the interplanetary space of our solar system.

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