In situ X-ray observations of phase transitions using Kawai-type apparatus at pressures to 60 GPa and temperatures to 2500K.

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We have developed techniques to produce high pressures and temperatures in Kawai-type multianvil apparatus with sintered diamond (SD) anvils. Techniques for in situ X-ray diffraction observations have also been developed in order to study phase transitions and density changes in minerals under the lower mantle conditions.

In situ X-ray observations were conducted at BL04B1, SPring-8, using a 1500-ton multianvil apparatus (SPEED-MkII) combined with a CCD monitoring system and an energy-dispersive X-ray diffraction system with Ge-SSD. SD anvil cubes (supplied by Sumitomo Electric Co. Ltd.) of 14 mm edge and truncated edge length of 1.5 mm (TEL=1.5) were used in most of the runs, but we also tested the performance of newly produced c-BN anvils by the same company. The produced pressure was estimated by unit-cell volume of a gold powder, using an equation of state of Anderson et al. (1989).

So far, we have succeeded generation of pressure of about 60 GPa at room temperature, while pressure at high temperature (~1000K) has been limited to just over 50 GPa. Temperatures as high as 2500K are comfortably produced at pressures to 45 GPa, without any notable failures in thermocouple wires for more than several hours, so that accurate routine-basis measurements of phase transition boundaries and P-V-T relations in some high-pressure phases have been successfully made. It is also found that cBN anvils also perform well and we were able to produce temperatures to 2000K and pressures to ~35 GPa, by replacing some SD anvils with those of cBN as windows for X-ray beam. In fact, samples inside the pressure medium can be clearly identified via the cBN anvils both by the CCD camera and the X-ray diffractometer with these anvils.

Phase transitions and P-V-T relations of some minerals, such as $MgAl_2O_4$, $KAlSi_3O_8$, $CaSiO_3$, and $MnGeO_3$, have been successfully made using the present technique, and we found some new high-pressure phases and their stability fields based on in situ X-ray observations. Similar method was used to address the phase and density changes in a pyrolite, a representative mantle composition, at pressures and temperatures corresponding to the middle part of the lower mantle.