Pyrometry in the Multianvil Press: New approach for temperature measurement in large volume press experiments

Takeshi Sanehira*, Yanbin Wang, Vitali Prakapenka, Mark L. Rivers (Consortium for Advanced Radiation Sources (CARS), the University of Chicago)

Temperature measurement in large volume press experiments has been based on thermocouple emf, which has well known problems, e.g., unknown pressure dependence of emf, chemical reaction between thermocouple and materials related on cell assembly, and so on. There have been several attempts to measure temperature in large volume press experiments using techniques other than thermocouples. Here we report a new development using pyrometry in the multianvil press, where temperatures are derived on the basis of spectral radiometry.

Several high pressure runs were conducted using the 1000 ton press with a DIA module installed at 13 ID-D GSECARS beamline at Advanced Photon Source (APS). The cubic pressure medium, 14 mm edge length, was made of soft-fired pyrophyllite with a graphite furnace. A moissanite (SiC) single crystal was built inside the pressure medium as a window for the thermal emission signal. An MgO disk with 1.0 mm thickness was inserted in a gap between the top of the SiC crystal and thermocouple hot junction. The bottom of the crystal was in direct contact to the tip of the anvil, which had a 1.5 mm diameter hole drilled all the way through the anvil axis. An optical fiber was inserted in this hole and the open end of fiber was in contact with the SiC crystal. Thermal spectral radiance from the inner cell assembly was obtained via the fiber and recorded by an Ocean Optics HP2000 spectrometer. The system response of spectrometer was calibrated by a tungsten ribbon ramp (OL550S, Optronic Laboratories, Inc.) with standard of spectral radiance. The cell assembly was compressed up to a target load of 15 tons, which was close to ambient pressure and then temperature was increased up to 1573 K. Radiation spectra were mainly obtained above 873 K and typical integration time was 1 ms.

Two different calculations were made to derive temperature based on pyrometry. One was made based on Planck radiation function and the other was made by the J-function which is defined based on Wien’s law (Yagi and Susaki, 1992, High Pressure Research: Application to Earth and Planetary Sciences, eds., Y. Syono and M.H. Manghnani, pp. 51-54). Calculated temperatures above about 1200 K were generally consistent with those obtained from the thermocouple emf within less than about 25 K. In addition to these measurements, new results using smaller cell will be also discussed.

Keywords: pyrometry, large volume press, thermocouple

*Corresponding author: sanehira@cars.uchicago.edu