Ultra-high temperature studies of materials in the Mbar pressure range combining XRD and pulsed laser heating at GSECARS

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Recent developments in continuous laser heating techniques, including application of fiber lasers and flat top laser beam shaping optics, result in significant improvement of the quality of x-ray data collected *in-situ* at high pressure and temperature in the DAC [1]. Nevertheless, the maximal static temperatures in the laser heated DAC, suitable for reliable *in-situ* high pressure synchrotron experiments, is limited. This is especially noticeable in the Mbar pressure range due to fundamentally thin pressure chamber (a few microns) and the lack of insulating layers between laser heated ultra-thin samples and highly thermal conductive diamond anvils. Standard continuous laser heating combined with x-ray diffraction at very high P-T conditions typically results in failure of the diamond anvils due to the relatively long exposure to very high laser powers of ~100W. This is especially true for thin samples containing hydrogen or helium, which can diffuse into the diamond, thus further weakening it. Using a microsecond pulsed laser-heating technique allows one to achieve a few times higher temperatures using less total laser power, due to the high laser power density of each pulse [2].

At GSECARS we have combined double-sided pulse laser-heating with our new CdTe Pilatus 1M detector (Dectris). A frequency-modulated laser beam with pulse widths of one microsecond was synchronized with the x-ray detector and temperature measuring spectrometer (PiMax detector, Princeton). Accumulation of 100k-500k pulses at a rate of 10 kHz (effective time of 10-50 ms) was required to record high quality XRD data with an x-ray energy of 37 keV from relatively low Z samples and sample thickness less than four microns. Application of this technique to study materials at ultra-high pressures and temperatures will be discussed.

References:

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