Recent developments in high-pressure x-ray diffraction using synchrotron radiation

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Synchrotron sources with high-brilliance, high-energy, low-emittance provide powerful micro-sampling probes for minute high-pressure samples and resolve weak sample signals from the massive surrounding vessel materials. In particular, high pressure x-ray diffraction probes have been well established in a number of synchrotron facilities worldwide for materials research under extreme conditions. Recently, notable developments have been undertaken in several areas. For examples, (1) *in operando* characterization synchronized with controlled pressure-temperature pathways, which probes the materials' processes along the designed experimental pathways with high frame-rate (to MHz), revealing important information such as on materials' synthesis and recovery, kinetics of phase transformations or chemical reactions, and materials metastability. (2) Scanning X-ray diffraction microscopy (SXM) in 2D or 3D with high spatial resolution (sub-micron). Similar to the importance of the scanning electron microscopy (SEM) for materials' composition distributions, the SXM promises an in-depth understanding of matter under extreme conditions across a large hierarchy of length scales from atomistic structure, grain boundary distribution, to bulk deformation. (3) Multigrain crystallography. Coarse grains, relative to the small probing size, may be induced by phase transitions or by heating samples in experiments. The multigrain approach treats each individual grain as a single crystal and collects data from tens to thousands of grains, with data quality comparable to those from single crystal. A few examples in each area will be presented, based on the recent experiments at the High Pressure Collaborative Access Team (HPCAT), at the Advanced Photon Source.