Real-Time Monitoring of Shock-Driven Phase Transitions with Synchrotron X-ray Diffraction

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Understanding the behavior of compression-driven phase transformations, their pathways, and kinetics, lies at the core of contemporary static and dynamic compression research at advanced light sources. Traditionally, shock compression research infers phase transitions from continuum-level measurements and uses corresponding static compression experiments, shock-recovery studies, or calculations to deduce the resulting phase. The advent of synchrotron facilities where shock compression is coupled with real time x-ray diffraction (XRD) now allows for microstructural identification of phase transitions.
We present recent work that follows phase transitions in an ionic compound and in a metal with synchrotron x-ray diffraction coupled with dynamic loading, and separately with static compression, carried out at two sectors of the Advanced Photon Source. The ability to combine in situ XRD measurements with well-characterized shock loading experiments now allows for Rietveld, full-profile structural refinements of XRD data. This in turn opens the door for in situ quantitative monitoring of the evolution of phase transitions over the tens of nanoseconds timescales of a typical shock compression experiment. These methods and results can be used to develop improved kinetic models for complex, solid-solid phase transitions.

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