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X-ray Diffraction on Shocked Solids: Past Results and Future Prospects at the Dynamic Compression Sector

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Real-time X-ray diffraction measurements in shocked solids represent an important development for understanding the response of shocked solids at the lattice and microscopic levels. Two examples of recent X-ray diffraction work on shock compressed single crystals will be reviewed. First, insight into shocked crystal microstructure was obtained through analysis of X-ray diffraction peak broadening caused by shock-induced microstructural heterogeneities. Second, macroscopic strength of single crystals shock compressed along an axis with 3-fold or higher rotational symmetry was determined from average longitudinal lattice strain (determined from X-ray diffraction) and macroscopic longitudinal stress (determined from continuum methods). The use of X-rays as a probe of the shocked state will be greatly enhanced by the Dynamic Compression Sector (DCS), currently under development at the Advanced Photon Source (APS). The DCS, a user facility, will be dedicated to understanding dynamically compressed condensed matter using X-ray scattering/diffraction and X-ray imaging measurements. X-ray measurement timescales will vary from about 100 ps to over a μs and multi-frame capabilities will allow time-dependent changes to be monitored. An overview of the planned X-ray beam characteristics at DCS will be used to show simulations of various material phenomena of interest in dynamic compression research. Simulation results will also be compared to single pulse X-ray diffraction measurements at the APS on ambient samples. Work supported by DOE/NNSA, and carried out in collaboration with Y. M. Gupta.