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8.16 Single-shot, laser-driven x-ray powder diffraction measurements using polycapillary optics to improve laser-to-x-ray conversion efficiency

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Single-shot, x-ray diffraction measurements to characterize phase transitions of dynamically compressed, high-Z materials at Mbar pressures require both sufficient photon energy and flux to record data with high fidelity. Besides x-ray lasers and synchrotrons, large-scale laser systems are used to generate brilliant x-ray sources above 10 keV by utilizing line radiation of mid-Z elements. However, the laser-to-x-ray energy conversion efficiency at these energies is low, and broadband thermal x-rays or hot electrons may irradiate the sample and detector, resulting in deleterious background. Polycapillary x-ray optics were employed to both increase the flux on sample as well as the separation between source and sample, resulting in a 20-fold flux increase on the sample versus a conventional pinhole aperture and a reduced background. This facilitates diffraction measurements up to 16 keV at the few-photon signal level. X-ray diffraction measurements were performed using either the Z-Beamlet or Z-Petawatt laser systems at Sandia National Laboratories. This work is supported by Sandia's LDRD program. Sandia is a multimission laboratory managed and operated by NTESS LLC, a wholly owned subsidiary of Honeywell Int. Inc. for the U.S. DOE NNSA, contract DE-NA0003525. SAND2018-0188A.

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