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Ultra-fast three-dimensional X-ray imaging and simulation of the deformation modes in ZnO nanocrystals MATHEW CHERUKARA, KIRAN SASIKUMAR, WONSUK CHA, BADRI NARAYANAN, Argonne Natl Lab, STEVEN LEAKE, ESRF-The European Synchrotron, ERIC DUFRESNE, TOM PETERKA, IAN MCNULTY, HAIDAN WEN, SUBRAMANIAN SANKARANARAYANAN, ROSS HARDER, Argonne Natl Lab — Imaging the dynamic behavior of materials following ultra-fast excitation can reveal insights into the response of materials under non-equilibrium conditions of pressure, temperature and deformation. Such dynamical behavior is extremely challenging to characterize especially at the nano to mesoscopic spatiotemporal scales. We demonstrate three-dimensional imaging of the structure and strain of the transient deformation of a ZnO crystal on sub-ns timescales following excitation by a laser 'pump' using stroboscopic 'probes' of X-rays. The excitation induced in the ZnO crystal from the laser pump is observed to excite characteristic resonant modes in the crystal at different time scales, corresponding to the propagation of acoustic phonons and the characteristic frequency of the crystal. By directly importing the experimentally reconstructed nanocrystal structure into a continuum deformation model, we elucidate the deformation mechanisms following laser excitation and the development of potential gradients across the nanocrystal with implications for nanoscale power generation.

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