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Imaging Acoustic Phonon Dynamics on the Nanometer-Femtosecond Spatiotemporal Length-Scale with Ultrafast Electron Microscopy DAYNE PLEMMONS[1], DAVID FLANNIGAN[2], University of Minnesota — Coherent collective lattice oscillations known as phonons dictate a broad range of physical observables in condensed matter and act as primary energy carriers across a wide range of material systems. Despite this omnipresence, analysis of phonon dynamics on their ultrashort native spatiotemporal length scale that is, the combined nanometer (nm), spatial and femtosecond (fs), temporal length-scales has largely remained experimentally inaccessible. Here, we employ ultrafast electron microscopy (UEM) to directly image discrete acoustic phonons in real-space with combined nm-fs resolution. By directly probing electron scattering in the image plane (as opposed to the diffraction plane), we retain phase information critical for following the evolution, propagation, scattering, and decay of phonons in relation to morphological features of the specimen (i.e. interfaces, grain boundaries, voids, ripples, etc.). We extract a variety of morphologically-specific quantitative information from the UEM videos including phonon frequencies, phase velocities, and decays times. We expect these direct manifestations of local elastic properties in the vicinity of material defects and interfaces will aide in the understanding and application of phonon-mediated phenomena in nanostructures.

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