# Femtosecond Mega-electron-volt Electron Microdiffraciton

X. Shen1, R. K. Li[1], U. Lundström[2], T. J. Lane[1], A. H. Reid[1], S. P. Weathersby[1] and X. J. Wang[1]
[1] SLAC National Accelerator Laboratory,2575 Sand Hill Road, Menlo Park, CA 94025, USA
[2]Brinellvägen 8, 114 28 Stockholm, Sweden

To understand and control the basic functions of physical, chemical and biological processes from micron to nano-meter scale, an instrument capable of visualizing transient structural changes of inhomogeneous materials with atomic spatial and temporal resolutions, is required. One such technique is femtosecond electron microdiffraction, in which a short electron pulse with femtosecond-scale duration is focused into a micron-scale spot and used to obtain diffraction images to resolve ultrafast structural dynamics over a localized crystalline domain. We report the experimental demonstration of time-resolved mega-electron-volt electron microdiffraction which achieves a 5 μm root-mean-square (rms) beam size on the sample and a 110 fs rms temporal resolution. Using pulses of 10k electrons at 4.2 MeV energy with a normalized emittance 3 nm-rad, we obtained high quality diffraction from a single 10 μm paraffin ($C_{44}H_{90}$) crystal. The phonon softening mode in optical-pumped polycrystalline Bi was also time-resolved, demonstrating the temporal resolution limits of the instrument. This new characterization capability will open many research opportunities in material and biological sciences.