Development of intense THz pumping capabilities for MeV-UED at SLAC ASTA facility

B. K. Ofori-Okai[1,2], M. C. Hoffmann[1], A. H. Reid[1], R. K. Li[1], E. M. Mannenbach[3], X. Shen[1], S. P. Weathersby[1], J. Yang[1], Q. Zhang[1], M. Zajac[3], S. Edstrom[1], W. Polzin[1], A. M. Lindenberg[2,3,4], S. H. Glenzer[1,2], and X. J. Wang[1]

[1]SLAC National Accelerator Laboratory, Menlo Park, CA, 94025, USA
[2]PULSE Institute, SLAC National Accelerator Laboratory, Menlo Park, CA 94025, USA
[3]Department of Materials Science and Engineering, Stanford University, Stanford, CA 94305, USA
[4]Stanford Institute for Materials and Energy Sciences, SLAC National Accelerator Laboratory, Menlo Park, CA 94025, USA

We present the details of a newly developed apparatus for performing terahertz (THz) pump-ultrafast electron diffraction (UED) probe experiments at the SLAC ASTA facility. Compared to optical pumping, where the lattice is excited indirectly through electron-lattice coupling, intense THz fields can interact with the lattice resonantly through optic phonons, or indirectly through nonlinear field-mediated processes. This allows for experiments in which THz fields are used to directly drive lattice distortions, which are subsequently probed by electron diffraction. By taking advantage of the short wavelength of the relativistic electrons ($\lambda < 1$ pm), multiple orders can be observed in a single diffraction pattern.

By utilizing an upgraded titanium sapphire femtosecond laser system, which delivers up to 15 mJ of compressed (50-100 fs) pulses, the new system is capable of providing intense THz fields from one of two different THz sources, with frequencies exceeding 5 THz and with peak field strengths up to 600 kV/cm. In addition, the system retains the ability for intense optical pumping at either 800 nm or 400 nm derived from the fundamental or second harmonic of the titanium sapphire laser, respectively, thereby enabling optical-THz double-pump experiments. We also discuss some of the necessary facility upgrades required to accommodate interactions between the THz pulse and the electron beam required for obtaining and analyzing experimental results.