MAR16-2015-005764
Abstract for an Invited Paper
for the MAR16 Meeting of
the American Physical Society

Structure and Dynamics with Ultrafast Electron Microscopes

BRADLEY SIWICK, McGill University, Department of Physics, Center for the Physics of Materials

In this talk I will describe how combining ultrafast lasers and electron microscopes in novel ways makes it possible to directly 'watch' the time-evolving structure of condensed matter, both at the level of atomic-scale structural rearrangements in the unit cell and at the level of a material's nano- microstructure. First, I will briefly describe my group's efforts to develop ultrafast electron diffraction using radio- frequency compressed electron pulses in the 100keV range, a system that rivals the capabilities of xray free electron lasers for diffraction experiments. I will give several examples of the new kinds of information that can be gleaned from such experiments. In vanadium dioxide we have mapped the detailed reorganization of the unit cell during the much debated insulator-metal transition. In particular, we have been able to identify and separate lattice structural changes from valence charge density redistribution in the material on the ultrafast timescale. In doing so we uncovered a previously unreported optically accessible phase/state of vanadium dioxide that has monoclinic crystallography like the insulator, but electronic structure and properties that are more like the rutile metal. We have also combined these dynamic structural measurements with broadband ultrafast spectroscopy to make detailed connections between structure and properties for the photoinduced insulator to metal transition. Second, I will show how dynamic transmission electron microscopy (DTEM) can be used to make direct, real space images of nano-microstructural evolution during laser-induced crystallization of amorphous semiconductors at unprecedented spatio-temporal resolution. This is a remarkably complex process that involves several distinct modes of crystal growth and the development of intricate microstructural patterns on the nanosecond to ten microsecond timescales all of which can be imaged directly with DTEM.