Probing structural dynamics in charge-density-wave $TaSe_{2-x}Te_x$ using ultrafast electron diffraction

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The attempt to understand the interplay between spin, charge, orbital, and lattice and their relationship with material properties represents a key effort in condensed matter physics. The Brookhaven ultrafast electron diffraction (UED) instrument has unique capability to unravel the role of these competing degrees of freedom in materials functionality. By using a pump-probe method of the UED, the material sample is driven out of equilibrium condition by femtosecond laser pulses and the material's structure evolution can be recorded by femtosecond electron pulses in time-domain. This UED system, using relativistic MeV electron beams accelerated by a radio frequency field, has demonstrated single-shot electron diffraction with an electron bunch of 50 fC electrons and ~100 fs width. Located in a new environmental room with accurate temperature control, the BNL UED provides remarkable stability, temporal resolution and beam brightness for dynamic exploration in correlated materials.

Here we report the study of structural dynamics in charge-density-wave (CDW) materials using UED. Te-doped $TaSe_2$ materials were found to be one of the rare cases that layer-stacking sequence play significant role on materials' functionality, i.e., superconductivity in Te-doped $TaSe_2$, with the underlying physics remained untouched [1]. From the structural point of view, the CDW electronic phases in Te-doped $TaSe_2$ with different polytypes show distinct measurements in electron diffractions patterns, in terms of the wave vector, real-space coherence and temperature dependence of the superlattice reflections from CDW. Pump probe measurements with UED were made at various doping levels and temperatures. The temporal characteristics of the CDW reflections are correlated to the electron-lattice interactions, which are essential in understanding the CDW mechanism in this system.

[1]. H. X. Luo et al., *PNAS*112, E1174-1180 (2015)