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Phase-space characterization and optimization of high-brightness electron beams for femtosecond imaging and spectroscopy near the single-shot limit[1] JOSEPH WILLIAMS, FARAN ZHOU, TIANYIN SUN, PHILLIP DUXBURY, STEVEN LUND, BRANDON ZERBE, CHONG-YU RUAN, Michigan State Univ — We describe a system and optimization method for generating high-brightness femtosecond (fs) electron beams for imaging, and spectroscopy near the single-shot limit. We study focusability in the energy-time domain through an active atomic grating driven by fs laser pulses and from which the energy and time dispersion, electron dose and coherence length can be simultaneously monitored over controlled parameters, including the electron numbers and focusing strength in transverse and longitudinal directions. We show with tuning of electron optics that conserve the source brightness high performance can be attained. In cases where we focus on the time response, we show ultrahigh speed lattice responses in VO_2 leading to phase transition on ~100fs timescale, and sub-100fs time resolution to image active modes is possible through a jitter correction scheme. When tuning the optics for coherent diffraction, transformations of 10nm scale domain structures in TaS_2 are transiently resolved, without sacrificing time resolution. Implementing the optics for energy compression leads to opportunities for high dose ultrafast spectroscopy. These results exhibit the abilities of multi-modality ultrafast imaging and spectroscopy in the next-generation ultrafast electron microscope development.

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