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Probing Material Dynamics with an SEM at Nanometer Length and Picosecond Time-scales

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A fundamental understanding of nanoscale phenomena in photonic and electronic materials will be critical to the development of the next generation of technologies needed to address problems in energy security, quantum information and climate change. New tools capable of probing and manipulating the electronic, optical, and physical properties of nanomaterials at sub-picosecond time scales and nanometer length scales will provide insights into their excited state dynamics and enable the realization of novel nanoelectronic and nanophotonic devices. We have developed an ultrafast scanning electron microscope that incorporates cathodoluminescence, photoluminescence, and electron-beam-induced deposition in a single user tool. This enables nanometer scale spatial resolution, picosecond time resolution and meV spectral resolution at temperatures from 8-300 K. I will begin by describing plasmon-plasmon and plasmon-exciton interactions in nanopatch antennas and plasmonic oligomers and explore the distinction between nanophotonic modes probed with all-optical spectroscopies, CL microscopy, electron-energy loss spectroscopies. I will also present the nanoscale energetics and dynamics of defects and grains in hybrid perovskites and CdSe photovoltaic devices. I will devote the last portion of the talk to the description of combined picosecond-pulsed electron and laser beam experiments that enable investigations of carrier diffusion and dynamics with nanometer resolution, greatly surpassing the optical diffraction limit associated with conventional time-resolved spectroscopies [1-4].

References:

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[4] The cathodoluminescence and pulsed electron beam experiments were conducted at the Center for Nanophase Materials Sciences (Oak Ridge National Laboratory), which is a DOE Office of Science User Facility.