Abstract:
Heterogeneity plays a critical role in chemistry, from the role of defect states in the carrier dynamics of organic semiconductors to interfaces and surfaces in heterogeneous catalysis. However, our ability to visualize nano-scale heterogeneity in materials – including ferroic domains and material edges – and their effect on electronic and phonon dynamics has been hampered by the simple challenge of our inability to meet the necessary nanometer and femtosecond timescales. In this talk I will discuss recent efforts by my group to determine the interplay of heterogeneity and morphology on the intrinsic optoelectronic and thermoelectric properties of materials. Using polarization-dependent photoemission electron microscopy (PD-PEEM) we have imaged the spatially dependent optical selection rules of black phosphorus,\(^1\) distinguishing edge-specific modes, and antiferroelectric domains of \(\beta'\)-In\(_2\)Se\(_3\),\(^2\) with spatial resolution as good as 25 nm. Using ultrafast transmission electron microscopy, we’ve been able to determine how the bond anisotropy and structural morphology of few-layer black phosphorus impacts phonon dynamics.\(^3\) Ultimately my group seeks to identify ways to modify the impact of structural heterogeneity in materials and rationally design energy efficient inorganic and organic/inorganic hybrid interfaces on the nanoscale using morphology and molecular interfaces.

