Electron-beam nanophotonics: when free-electrons meet ‘nano’

In this talk, I will discuss 1) how nanophotonics can be harnessed to control the interaction between free electrons and photons at the nanoscale and 2) how the subwavelength optical excitations provided by focused electron beams can be used to study quantum materials at the relevant length scales.

Unlike bound electrons in solid-state systems, free electrons moving in vacuum have been seldom associated with nano-scale interactions, rather they are often found in giant facilities such as km-scale accelerators and free-electron lasers. However, recent years have seen that bringing free electrons into nano-scale interactions can lead to the full control of free-electron light emission, electron wave packets, and strong coupling between free-electrons and photons. I will review on our recent efforts toward the full control of free-electron light emission with the application of nanophotonic principles, which led to the demonstrations of plasmonic amplification, Purcell enhancement, and holographic control of free-electron light emission.

Optical characterization of quantum materials often requires spatial resolution below diffraction limit and this can be resolved by creating optical excitations with subwavelength probes such as scanning probes or focused electron beams. I will discuss how cathodoluminescence can contribute to the understanding of quantum materials such as perovskites, 2D transition metal dichalcogenides, and gallium nitrides.