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DEPARTMENT OF CHEMISTRY AND BIOCHEMISTRY COLLOQUIUM
UTAH STATE UNIVERSITY

*Near-field Optical Spectroscopy for the Study of
Semiconducting Nanostructures*

2021

Semiconducting nanostructures have been proposed as material platforms for a wide variety of photonic, electronic, and photovoltaic elements. In order to realize these applications, careful design and characterization of electronic properties such as dopant concentration, activation, and distribution are needed. I will discuss the use of near-field optical microscopy as a non-destructive method for chemical, structural, and electronic imaging in nanomaterials. Near-field optical techniques break the diffraction limit to access nanometer scale information through the lightning-rod properties of an illuminated atomic force microscope tip. Many nanoscale optical spectroscopies can be realized using this approach, but signal interpretation is often challenging due to convolutional effects between the tip and sample. I will discuss experimental and theoretical considerations in quantitative near-field optical microscopy in general, and then focus on two applications that illustrate the importance of understanding near-field interactions. In the first example, we use infrared near-field spectroscopy to resolve free-carriers in axially-doped silicon nanowires (SiNWs). We can detect local changes in the electrically-active doping concentration from the free-carrier absorption in both n-type and p-type doped SiNWs. The high spatial resolution (< 20 nm) allows us to directly measure dopant transition abruptness and charge carrier properties in the vicinity of interfaces in single and multi-junction SiNWs. In the second example, we use nano-Raman spectroscopy to study functionalized graphene, a derivative of graphene engineered to open a finite band gap. The high degree of chemical and physical disorder in these types of systems can be resolved with near-field spectroscopy, demonstrating its utility in understanding how local properties of nanomaterials affect functionality in optoelectronic and photovoltaic devices.

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