Dielectric Optical Antenna Emitters and Metamaterials
JON SCHULLER, Stanford University

Optical antennas are critical components in nanophotonics research due to their unparalleled ability to concentrate electromagnetic energy into nanoscale volumes. Researchers typically construct such antennas from wavelength-size metallic structures. However, recent research has begun to exploit the scattering resonances of high-permittivity particles to realize all-dielectric optical antennas, emitters, and metamaterials. In this talk, we experimentally and theoretically characterize the resonant modes of subwavelength rod-shaped dielectric particles and demonstrate their use in negative index metamaterials and novel infrared light emitters. At mid-infrared frequencies, Silicon Carbide (SiC) is an ideal system for studying the behavior of dielectric optical antennas. At frequencies below the TO phonon resonance, SiC behaves like a dielectric with very large refractive index. Using infrared spectroscopy and analytical Mie calculations we show that individual rod-shaped SiC particles exhibit a multitude of resonant modes. Detailed investigations of these SiC optical antennas reveal a wealth of new physics and applications. We discuss the distinct electromagnetic field profile for each mode, and demonstrate that two of the dielectric-type Mie resonances can be combined in a particle array to form a negative index metamaterial [1]. We further show that these particles can serve as “broadcasting” antennas. Using a custom-built thermal emission microscope we collect emissivity spectra from single SiC particles at elevated temperatures, highlighting their use as subwavelength resonant light emitters. Finally, we derive and verify a variety of general analytical results applicable to all cylindrical dielectric antennas and discuss extensions of the demonstrated concepts to different materials systems and frequency regimes. [1] J.A. Schuller, et al., Phys. Rev. Lett. 99, 107401 (2007)