The Thermal Near-Field: Coherence, Spectroscopy, Heat-Transfer, and Optical Forces

Markus Raschke [C, S]
Department of Physics, Department of Chemistry, and JILA, University of Colorado, Boulder, CO, U.S.A.
markus.raschke@colorado.edu

One of the most universal physical processes shared by all matter at finite temperature is the emission of thermal radiation. With its origin in thermally driven fluctuations of charge carriers, thermal radiation reflects the resonant and non-resonant dielectric properties of media, which is the basis for far-field thermal emission spectroscopy. However, associated with the underlying fluctuating optical source polarization are fundamentally distinct spectral, spatial, resonant, and coherence properties of the evanescent thermal near-field. Using scattering scanning near-field microscopy we have been able to spectroscopically and spatially characterize the thermal near-field associated with molecular and surface phonon polariton (SPhP) resonances. In agreement with theoretical predictions we observe a dramatically enhanced electromagnetic local density of states (EM-LDOS) in close proximity to the sample surface. This technique of thermal infrared near-field spectroscopy (TINS) provides for broadband chemical nano-spectroscopic imaging, where the thermally driven vibrational optical dipoles provide their own intrinsic light source. Furthermore, we study the spatial and spectral characteristics of the thermal near-field SPhP response in SiC and hBN. In contrast to the strongly surface-confined thermal near-field of localized vibrational modes, an extended exponential distance dependence reflects the spatial coherence of the SPhP thermal field. The combination of intrinsic materials resonances and extrinsic optical antenna or metasurface modifications provide for local spectral and spatial control of radiative heat transfer or light-matter interaction using thermal near-field radiation.