Spectral Frustration and Spatial Coherence in Thermal Near-Field Scattering

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The thermal optical near-field in close proximity to a thermal emitter exhibits fundamentally distinct spectral, spatial, and coherence properties. Using thermal infrared near-field spectroscopy (TINS), we probe the electromagnetic local density of states (EM-LDOS), which is resonantly enhanced in the presence of molecular or polariton resonances. Using SiC as an example, we study the thermal spectroscopic response associated with its SPhP resonance and observe pronounced spectral frustration with variable red-shifts ranging from ~5 cm^{-1} to ~50 cm^{-1}. While modest spectral shifts can be attributed to tip-sample coupling, we propose an effective medium change by the tip responsible for large shifts. In addition, we find an exponential distance dependence of SiC TINS which we attribute to the preferential scattering of the spatially coherent thermally-excited SPhP field. We have recently implemented laser heating of the tips which enables studies at higher temperatures and with stronger tip-sample coupling. We observe an extreme red-shift of the SiC spectrum of up to 55 cm^{-1}, while the intrinsic molecular resonance of PTFE is unshifted, as expected. We extend these studies to the hyperbolic, van der Waals material hBN, and observe a strong peak at 1350 cm^{-1} associated with its in-plane SPhP resonance. Its highly tunable phonon modes and hyperbolic dispersion make hBN a promising candidate for applications such as control of thermal emission.