Engineering the Spectral and Spatial Dispersion of Thermal Emission using Phonon Polaritons

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Thermal emission
- Described by Planck’s law:
  \[ L_{BB}(T) = \frac{c^3}{4\pi^5} \frac{1}{e^{\frac{hc}{kT}} - 1} \]
- Thermal emission from a black body has broadband emitting energy distribution in both the spectra and spatial domains.

Waste-heat driven narrowband thermal emitter
- Low-loss localized surface phonon polaritons (LSPhP) from SiC nanopillar array can give rise to narrowband thermal emission [1].
- We demonstrated that the SiC narrowband thermal emitter can be potentially driven by waste heat: over 10 mW output LWIR power.

Phonon polaritons
- They are quasiparticles that comprise a photon and a coherently oscillating ionic charge in polar materials.
- Momentum mismatch: can’t be launched by free-space light.
- Lower loss compared to plasmons in the LWIR spectra region.

Spatially coherent emission from superstructure gratings
- Superstructure gratings (SSGs) can launch surface phonon polaritons (SPhP) with different wavevectors in a single grating [2].
- Multiple spatially coherent emission modes from SSGs fabricated into a 4H–SiC substrate:

Strongly coupled thermal emitter
- Strong coupling phenomenon can combine the corresponding virtues of both LSPhP and SPhP into a new, hybrid mode [3].
- Coupling to a third zone-folded longitudinal optic phonons (ZFLO) mode can make the emission electrically driven possible.
- We demonstrated a 5-fold improvement in the spatial coherence and 3-fold enhancement of the quality factor for coupled modes.
- Increasing the complexity of LSPhP unit cell can introduce a new degree of freedom with new collectively excited LSPhP modes [4].

References and Acknowledgements
1. Lu, G., et al., ACS Omega, (2020)

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