Supplemental Material: Material-Engineered Near-Field Heating and Cooling with Drifted Plasmon-Phonon Polaritons

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1 Material parameters

The dielectric function and permeability of the host metamaterial can be given as

$$\varepsilon_h(\omega) = 1 - \frac{\omega_p^2}{\omega^2 + i\gamma_e\omega}, \tag{1}$$

$$\mu_h(\omega) = 1 - \frac{F\omega^2}{\omega^2 - \omega_0^2 + i\gamma_m\omega}. \tag{2}$$

Here $\omega_p = 1.5 \times 10^{14}$ rad/s, $\omega_0 = 0.3 \times 10^{14}$ rad/s, and $\gamma_e = \gamma_m = 3.0 \times 10^{12}$ rad/s. F is the volume filling factor of the interior cylinder cell of the host HMs.

For the inserted NWs, the dielectric function of SiC can be described by a simple Lorentz oscillator model,

$$\varepsilon_i(\omega) = \varepsilon_\infty \frac{\omega_L^2 - \omega^2 - i\Gamma\omega}{\omega_T^2 - \omega^2 - i\Gamma\omega}. \tag{3}$$

Here the longitudinal optical phonon frequency $\omega_L = 1.827 \times 10^{14}$ rad/s, the tranverse optical phonon frequency $\omega_T = 1.495 \times 10^{14}$ rad/s, the damping factor $\Gamma = 0.9 \times 10^{12}$ rad/s, and the high-frequency dielectric constant $\epsilon_\infty = 6.7$ [45].

Due to the uniaxial anisotropy of the $\boldsymbol{\varepsilon}$ and $\boldsymbol{\mu}$ tensor, the signs of the components in

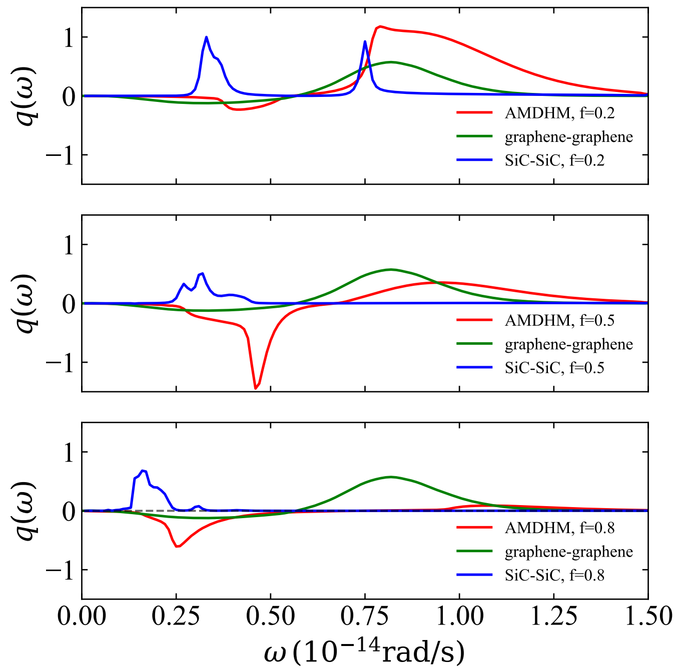

Fig 1 Spectral function $q(\omega)$ for different configurations.

different directions can be opposite. In hyperbolic frequency range ($\varepsilon_\perp\varepsilon_\| < 0$ or $\mu_\perp\mu_\| < 0$), the dispersion relation of the AMDHM can be expressed as [46]

$$\frac{k_x^2 + k_y^2}{\varepsilon_\| \mu_\perp} + \frac{k_z^2}{\varepsilon_\perp \mu_\perp} = (\frac{\omega}{c})^2, \quad \text{for } \varepsilon_\perp\varepsilon_\| < 0, \tag{4}$$

$$\frac{k_x^2 + k_y^2}{\mu_\| \epsilon_\perp} + \frac{k_z^2}{\mu_\perp \epsilon_\perp} = (\frac{\omega}{c})^2, \quad \text{for } \mu_\perp\mu_\| < 0. \tag{5}$$

Here k_x, k_y, k_z represent the x, y, z components of the wave vector, respectively, and c is the speed of light. Eq. (4) and (5) correspond to p polarization and s polarization respectively.

Although the structure presented in this work is very complicated. The magneto-optical properties of AMDHM are not important because the contribution of the s-polarized waves is three orders of magnitude smaller than that of p-polarized waves. As shown in Fig. 1, the resonance frequencies of heating and cooling modes are different from those of SiC-SiC and graphene-graphene when they work alone due to the influence of surface mode hybridization.

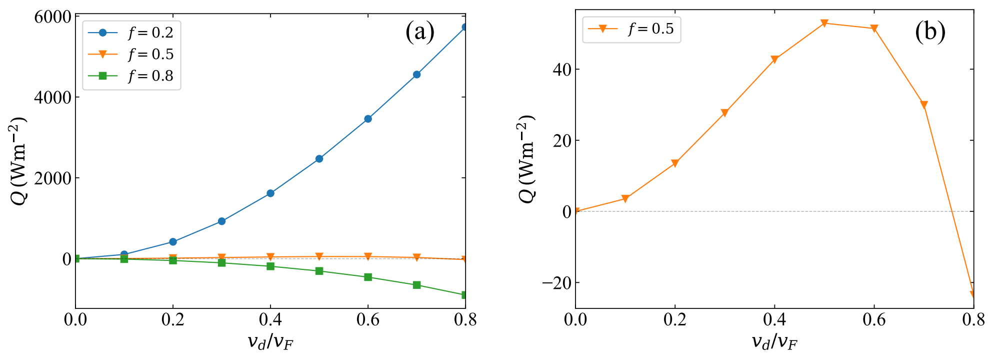

Fig 2 Dependence of radiative heat flux Q on electron drift velocity v_d (a) for filling factor $f = 0.2, 0.5, 0.8$. (b) For the enlarged image at f=0.5. v_F is the Fermi velocity of graphene

2 The effect of electron drift velocity on the radiated heat flux

We investigate the dependence of the radiated heat flux on electron drift velocity. As shown in Fig. 2, the heat flux is positively correlated with electron drift velocity. Specifically, around $v_d = 0.3v_F$, heat flux increases significantly. In this work, our focus is on studying the relationship between materials engineering and thermal radiation, so we fixed the electron drift velocity at $v_d = 0.4v_F$.