Phonon-Polariton Thermal Waves

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Based on the Boltzmann transport equation, we derive and analyze analytical expressions for the temperature and heat flux profiles of thermal waves propagating along nanofilms supporting the propagation of phonons and polaritons. In contrast to the typical temperature amplitude decreasing monotonically as the modulation frequency increases, we show that the amplitude of the phonon-polariton temperature field exhibits a peak whose intensity and frequency of occurrence increase with the polariton thermal conductivity of the film. This peak thus represents the fingerprint of the polariton contribution to the in-plane heat conduction, and therefore it can be used to measure the polariton thermal conductivity through photothermal and electrothermal techniques. In particular, the developed theory together with the 3w method is applied to measure the polariton thermal conductivity of SiO2 nanofilms deposited on a silicon substrate. For a 50-nm-thick SiO2 film at 400 K, we find a polariton thermal conductivity of 0.7 $Wm^{-1}K^{-1}$, which represents 50% of its phonon counterpart. This enhancement of heat conduction is well-predicted by fluctuational electrodynamics and an analytical model based on a two-dimensional gas of polaritons. The obtained results are thus expected to open a new research avenue for the polaritonic thermal characterization of nanostructures via modulated temperature fields.