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Abstract Details

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Abstract

TITLE: Ballistic effects on thermal conductivity in 1D and 2D configurations from single and multiple localized sub mean free path heat sources: a numerical investigation

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ABSTRACT BODY:

Abstract Body: The effective thermal conductivity of materials decreases when their dimensions are comparable to or lower than the mean free path of heat carriers (phonons in dielectrics) and when the influence of the thermal boundary conductance increases. Distinguishing the two phenomena is not experimentally straightforward, while the phonon Boltzmann transport equation (BTE) in the Relaxation Time Approximation (RTA) can be used to investigate this numerically. We solve a particular form of the BTE under the RTA, the Equation of Phonon Radiative Transfer, with the Discrete Ordinates Method (DOM) in one-dimensional and two-dimensional configurations for gray and non-gray media. The simulations give access to local effective temperature and conductive heat flux fields. We consider in particular the cross-plane and the in-plane thermal conductivities through 1D and 2D calculations, respectively. Diffuse, specular and diffuse-specular reflections of the heat carriers on the boundaries are implemented. The cases of extended and localized thermal sources are studied in 2D. Reduction factors associated to the effective thermal conductivities are obtained for the different cases and compared to the predictions based on the Fuchs-Sondheimer-Casimir-Ziman theory [1–4]. Constant temperature and adiabatic boundary conditions are also distinguished and their effects on the thermal transport are highlighted. Collective effects due to multiple localized heat sources are also considered. The competition between different characteristic length-scales (heat source size, distance between heat sources, sample size) is investigated. Finally, we discuss the obtained results in light of the recent thermo-optical and electrical experiments involving 2D heat spreading from sub-mean free path heat sources [5,6].

References:

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