Electron-Phonon Transport in Graphene Devices

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ABSTRACT In this study, we develop a computational model to investigate the thermal transport mechanisms in graphene devices, including phonon transport in graphene, electron-phonon coupling in graphene, and phonon/electron transmission at the interface between graphene and its surroundings. We employ this model to simulate coupled electron-phonon transport in SiO_2-supported single layer graphene with metal electrodes at the two ends. The heat is generated using laser irradiation in the middle of the device. A two-temperature model is used for electrons, while the phonon transport is described by Boltzmann transport equations. The energy exchange between electrons and mode-dependent phonons is evaluated using the electron-phonon coupling strength determined from the first-principle calculations. The interfacial energy transfer is calculated using Landauer formalism, and the phonon and electron transmission is obtained from the Green's function calculations and the first principle calculations. We perform simulations with different graphene lengths and heating power, and analyze their effects on the heat dissipation through contacts of graphene. The work showed the relation between the dominated heat dissipation pathway and the important physical and structural parameters, which is critical for the thermal management and design of graphene nano-electronic devices.