

Multi-Field Coupling Behaviors on Phonon and Thermal/Electrical Properties in Semiconductor Nanostructures

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Low-dimensional semiconductor structures such as nanofilms and nanowires have stimulated considerable interest due to their potential applications in nanoelectronic or nanomechanical devices. In this presentation, the effects of pre-stress field and surface stress on the phonon and thermal/electrical properties for semiconductor nanostructures are investigated theoretically. The continuum elastic model is employed to calculate the spatially confined phonon properties. The acoustoelastic effects and surface energy effects are taken into account in calculating the phonon properties of nanostructures. Since the thermal and electric properties are associated with phonon properties of semiconductors, the phonon thermal conductivity, electron-acoustic phonon scattering rate and the carrier mobility are obtained for nanofilms and nanowires under prestress fields and surface stress. The numerical results show that the stress fields have a significant influence on the phonon properties such as the phonon dispersion relation, density of state as well as the group velocity, leading to completely altering the thermal conductivity and the carrier mobility. It is also showed that the appearance of stress can adjust the sensitivity of phonon thermal conductivity and carrier mobility to temperature as well as to the physical size of the nanostructures. These results provide an approach of stress/strain engineering through tuning the phonon properties to control the thermal and electrical properties of nanostructured semiconductors in nanoelectronic devices.

Key Words: Phonon properties; thermal/electrical properties; elastic model; nanostructures