Effect of embedding ErAs nanoparticles on thermal conductivity of $In_{0.53}Ga_{0.47}As$ semiconductors: Phonon scattering mechanism

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We evolve a theoretical model for quantitative analysis of decrease in thermal conductivity (κ) by embedding ErAs nanoparticles in $In_{0.53}Ga_{0.47}As$ crystalline semiconductors. Following a model Hamiltonian, the lattice thermal conductivity by incorporating the scattering of phonons with defects, grain boundaries, electrons, and phonons is evaluated. We found that ErAs nanoparticles provide an additional scattering mechanism for phonons, on inserting it in $In_{0.53}Ga_{0.47}As$. The phonon scattering with point defects and grain boundaries become more efficient which causes suppressed κ up to half of its value of pure crystal. The temperature dependent of κ is determined by competition among several scattering mechanisms.

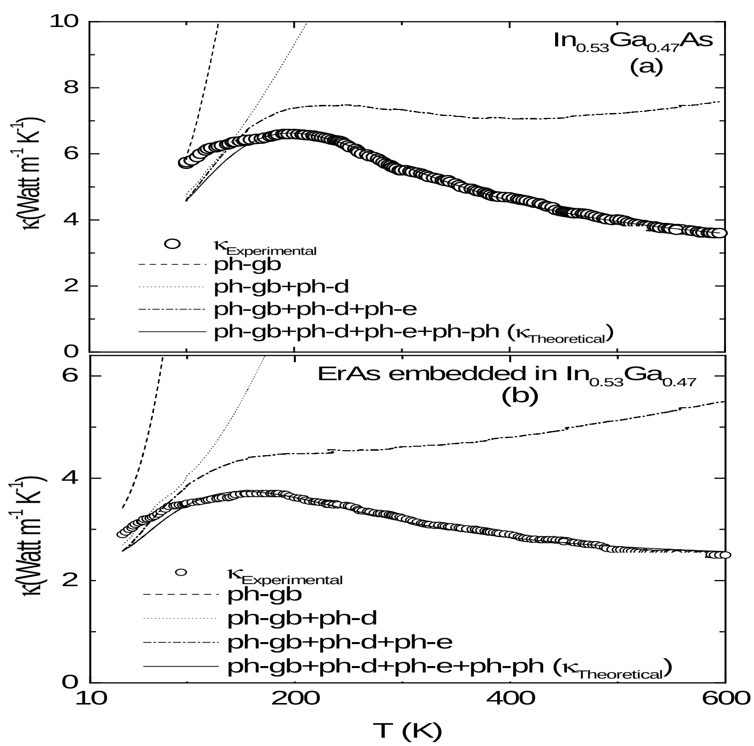

Figure: Variation of thermal conductivity as function of temperature for (a) pure $In_{0.53}Ga_{0:47}As$ (b) $In_{0.53}Ga_{0:47}As$ containing randomly distributed ErAs nanoparticles in the presence of various phonon scattering mechanisms. Open circles are experimental data, taken from Woochul Kim *et al.* 2006, compared with theoretical fit (Solid line).