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EFFECT OF GERMANIUM CONCENTRATION ON THE LATTICE THERMAL CONDUCTIVITY FOR SiGe ALLOY NANOWIRES

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ABSTRACT

The thermal conductivities of $Si_{1-x}Ge_x$ nanowires (NWs) synthesized with Ge concentrations of 0.0%, 0.4%, 4%, and 9% and different diameters were measured from 0 to 450 K using Debye-Callaway model modified to include both longitudinal and transverse phonon modes explicitly has been developed to describe the lattice thermal conductivity for SiGe alloy nanowires as a function of nanowire diameter, alloy concentration, and temperature, obtaining a satisfactory quantitative agreement with experimental results. The model uses nanowires boundary, defects and umklapp and normal phonon-scattering parameters that scaled in a consistent manner with Debye temperature and phonon velocity from their related melting point. The results indicated that the weaker diameter dependence of the thermal conductivity recently observed in $Si_{1-x}Ge_x$ nanowires (x<0.1), as compared to pure Si nanowires. The calculations present in the full range of alloy concentrations, ($0 \leq x \leq 1$), which may serve as a basis for comparison with future experiments on high alloy concentration nanowires.

Keywords: Lattice thermal conductivity; Debye-Callaway model; $Si_{1-x}Ge_x$ alloys

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