PHONON THERMAL CONDUCTIVITY INHIBITION IN CROSS-SECTION-MODULATED SI/GE NANOWIRES

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Phonon-mismatched nanostructures, i.e. nanostructures consisting of layers made from materials with different phonon properties, open up a wide range of possibilities for engineering of their phonon and thermal characteristics due to combining of materials, their thicknesses, shapes and interface qualities [1]. In these nanostructures new types of phonon modes appear: core-like modes, which are concentrated mainly in heterostructure or heterowire core, cladding-like modes, which are localized in coating layers and propagated modes, which propagate both in core and claddings [1-2]. Up to 2 orders of a magnitude suppression of the phonon heat conduction in comparison with bulk Silicon or Germanium have been demonstrated both theoretically and experimentally for homogeneous thin Si nanowires (NWs), Si NWs with germanium claddings, segmented NWs, consisting of acoustically-mismatched materials and Si cross-section-modulated nanowires (MNWs) [1]. In the talk we will show that stronger up to 700 times decrease of the phonon thermal conductivity (TC) can be achieved in Si MNWs, covered by several monoatomic layers of germanium [2]. The effect is explained by the interplay between two effects: suppression of TC due to the cross-section modulation and suppression of TC due to the shell effect. As a result many phonon modes are localized in MNWs segments and are removed from the heat transfer. The rest of modes possess smaller group velocity than in generic Si nanowires due to a hybridization of phonons from core and shell, and also weakly participate in the heat transfer.

References:

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