HEAT CAPACITY AND THERMAL CONDUCTIVITY OF SEMICONDUCTOR NANOFILMS AND NANOWIRES

Barinov A.A.,* Liu B.

BMSTU, Moscow, Russia

**barinovE6@bmstu.ru*

Semiconductor nanofilms and nanowires are a classic example of structures in which mean free path of heat carriers (phonons) is comparable to the characteristic size of the sample. This condition leads to the so-called size effect – dependence of properties on the characteristic size and geometry of the sample [1,2]. The method based on the solution of the Boltzmann transport equation in the relaxation time approximation is widely used to estimate the size influence on thermodynamic properties [3]. In this case, specific quantitative calculations required, firstly, the dispersion law (the dependence of phonon frequency on polarization and wave vector), and secondly, the relaxation times of phonons between consistent interactions.

In this paper, the dispersion relations are obtained from the solution of elasticity equation for continuous media for film and cylinder [4, 5] with free boundaries.

Relaxation time was determined according to the Matthiessen rule as a combination of 1) time between consistent phonon interactions (three-phonon processes), 2) time of scattering on inhomogeneities (impurities) of the crystal lattice and 3) time between successive interactions with the sample boundaries [3].

Dependences of heat capacity and thermal conductivity on temperature and characteristic size of the structure for semiconductor nanofilms and nanowires were obtained. Results of the research can be used for the estimations of heat-transfer processes in advanced semiconductor devices.

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