

THE NORMAL PHONON SCATTERING PROCESSES AND THE THERMAL CONDUCTIVITY OF GERMANIUM CRYSTALS WITH THE VARIOUS ISOTOPIC COMPOSITIONS.

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The influence of normal phonons scattering processes on thermal conductivity of germanium crystals with different degree of isotopic disorder has been considered. The redistribution of phonon momentum in normal three-phonon scattering processes both within each vibrational branch (generalized Callaway model [1]) and between different vibrational phonon branches (Herring mechanism [2]) has been taken into account. It has been shown that the generalized Callaway model [1] corresponds to the Simons mechanism of relaxation [3]. The drift motion contributions of longitudinal and transverse phonons to the thermal conductivity has been analyzed. The drift motion contribution of longitudinal phonons to the thermal conductivity of isotopically pure germanium crystals exceeds the diffusion one by three orders of magnitude for the generalized Callaway models [1]. This contribution determines mainly the maximum value of the total thermal conductivity. For the same parameters for the Herring mechanism [2] the drift motion contribution of longitudinal phonons to the thermal conductivity decreases by a factor of three and becomes less than the contribution of transverse phonons to the thermal conductivity in the region of the maximum. The contribution of transverse phonons to the thermal conductivity is determined by the diffusion motion. Thus, results of the thermal conductivity calculations for the two variants of phonon momentum relaxation in N-processes for the isotopically pure ^{70}Ge (99.99%) differ qualitatively. It has been shown that the redistribution of momentum between longitudinal and transverse phonons in Herring N-processes leads to the essential suppression of drift motion of longitudinal phonons and their contribution to the thermal conductivity for isotopically pure germanium crystals. As a result, the maximum values of the thermal conductivity decrease by approximately a factor of 1.5 as compared to the values obtained within the framework of the generalized Callaway model for isotopically pure samples of ^{70}Ge (99.99%) [1]. We were able to reach the agreement between thermal conductivity calculations for isotopically pure germanium crystals and the experimental data [1] using the same parameters of the scattering mechanism as those in [1] without invoking the additional scattering mechanism due to dislocations.

The results of the thermal conductivity calculations for the Herring mechanism of relaxation satisfactorily agree with the experimental data for germanium crystals with various isotopic compositions [1]. It has been shown that the increase in isotopic disorder degree in germanium crystals leads to the sharp suppression of the drift motion of longitudinal phonons and their contribution to the thermal conductivity. The contribution of transverse phonons to the thermal conductivity increases, and for germanium with the natural isotopic composition in the interval of temperatures 1K - 100K it is responsible for 80% - 90% of the total thermal conductivity. In this case the difference between the values of the thermal conductivity for the two variants of relaxation of the phonon momentum in N-processes decrease. The model of redistribution of phonon momentum in Herring N-processes between different vibrational phonon branches allows us to describe experimental dependencies of thermal conductivity on the degree of isotopic disorder for germanium crystals considerably better than the generalized Callaway model [1].

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