Thermal Conductivity of Crystalline GaSb under Uniform Compression

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Measurements of the thermal conductivity of solids subjected to uniform compression permit us to study the features of the heat transfer processes, associated with crystal lattice dynamics, in crystals. This paper presents the results of investigations of the thermal conductivities of monocrystalline and polycrystalline samples of GaSb in the temperature range from 273 to 423 K and under hydrostatic pressures up to 0.35 GPa. The measurements were carried out using the absolute compensation method under steady-state temperature conditions and both isobaric and isothermal conditions. The investigated polycrystals had different mean crystallite sizes. In the investigated samples of GaSb, lattice vibrations are the dominant mechanism of heat transfer. The electrical conductivity measurements showed that the contribution of the electrical component to the thermal conductivity is negligible in the above mentioned pressure and temperature range.

The phonon thermal conductivity increases with an increase in pressure in both monocristalline and polycrystalline samples of GaSb. This is associated with an increase in the Debye temperature, a decrease in the lattice vibration anharmonicity, and an increase in the elastic anisotropy, with a rise in uniform compression. It was determined that the baric coefficient of thermal conductivity decreases with an increase in temperature. Under isothermal conditions, the thermal conductivity of monocrystals of GaSb raises linearly by 8 % at 423 K and by 22 % at 273 K, when the pressure is increased to 0.35 GPa. In polycrystalline samples, the pressure dependence of the thermal conductivity is nonlinear. In these samples, with increasing pressure, the thermal conductivity increase slows down. The baric coefficient of thermal conductivity is lower in polycrystals than in monocrystals. The difference in the absolute value of the thermal conductivity coefficient and its pressure dependence for monocrystals vs. polycrystals is associated with a phonon scattering processes in the vicinity of the crystallite boundaries. Under uniform compression, the boundary is a source of additional dislocations arising as a result of the deformation with pressure increase and the intensification of the thermoactivation processes there. The additional dislocations appearing at crystallite boundaries intensify the phonon scattering that leads to the weakening of the thermal conductivity increase under pressure growth. In large-grained polycrystals, the role of the boundaries decreases, and, consequently, the extra phonon scattering decreases. Hence, the increase of crystallite size promotes an increase in the baric coefficient of the thermal conductivity. After the pressure was removed, residual effects were not observed. This is evidence of the relaxation of the additional dislocations.