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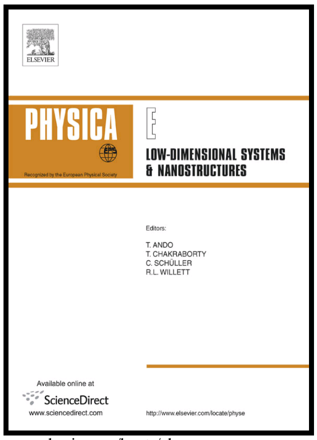

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Energy loss to intravalley acoustic modes in nano-dimensional wire structures at low temperatures

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Abstract

The theory of rate of loss of energy of non-equilibrium electrons due to inelastic interaction with the intravalley acoustic phonons in a nano-dimensional semiconductor wire has been developed under the condition of low lattice temperature, when the approximations of the well known traditional theory are not valid. Numerical results are obtained for narrow-channel GaAs-GaAlAs wires structures. On comparison with other available results it is revealed that the finite energy of the intravalley acoustic phonons and, the use of the full form of the phonon distribution without truncation to the equipartition law, produce significant changes in the energy loss characteristics at low temperatures.

Graphical Abstract

The finite energy of the acoustic phonons and the complete form of the phonon distribution function, affect significantly the energy loss characteristics of a quasi one-dimensional quantum wire structure at low temperatures. The Figure below describes the typical energy loss rate (ELR) characteristics of electrons for acoustic interaction at different lattice temperatures in the size quantum limit (SQL) for a quasi one-dimensional (Q1D) system with the transverse dimension a=b=10 nm. The curves 1, 2, 3 and 4 are obtained for the lattice temperatures of 1, 4, 10 and 20 K, respectively. The curves marked ‘a’ follow on taking due account of the inelasticity of the electron-phonon collisions, and also taking the full form of the phonon distribution function into account. The curves marked ‘b’ follow on assuming the interaction to be elastic, but taking the full form of the phonon distribution into account. The curves marked ‘c’ represent the ELR, which follow under the condition of high temperature, in the traditional framework, where the phonon distribution can be approximated by the equipartition law and the electron-phonon interaction can be assumed to be elastic.