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Weak localization and intersubbands transitions in δ-doped GaAs

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The magnetoresistance in weak localization regime was thoroughly investigated both for the classical and quantum two-dimensional (2D) electron systems. One or several 2D subbands may be occupied in the latter case. The role of multy-subband electron structure was usually considered for heterostructures and for structures with surface quantum well. In this cases the interband relaxation time (τ_{inter}) is less than the time of the phase relaxation of the electron wave function (τ_φ) and the existence of the several occupied 2D subbands leads to replacing the diffusion coefficient (D) and τ_φ in the expression for magnetoresistance by their effective values only.

There are some reasons that 2D electrons in δ-doping layers are the special case for weak-localization effects: (i) almost without exception more than one 2D subbands are occupied; (ii) the confined potential is symmetric therefore the electron wave functions have the fixed parity; (iii) the width of the impurity distribution is significantly less than characteristic width of the wave functions therefore the potential of the scattering centers is symmetric. These peculiarities have to lead to the fact that the transitions between the subbands with different parities are forbidden, so that the electrons in the odd and the even subbands have to give the independent contribution to the interference effects. As a result the prefactor in the expression for magnetoresistance have to be close to $2G_0$ ($G_0 = e^2/2\pi^2 h$ is the prefactor for the structures with one 2D subband).

In this report the results of the experimental investigations of the magnetoresistance of δ-doped (Si) GaAs layers with the electron concentration $(0.8-6) \cdot 10^{12}$ cm^{-2} in the temperature range 1.5–20 K are presented. There is shown that in the more perfect structures with electron concentration $(2-3.5) \cdot 10^{12}$ cm^{-2} and Hall mobility $(1-3) \cdot 10^3$ cm^2/V $\cdot$ sec the prefactors are equal to $(1.4-1.6)G_0$.

The causes of the fact that the prefactor is close or less than the value of G_0 in the most part of the structures investigated earlier are discussed. This may be the result of the large distribution width of Si or macroscopic inhomogeneity of the δ-doped layers.

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