Nanoscale physics

Spectrum of electron in quantum well with continuous position-dependent effective mass

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The rapid development of nanophysics stimulates the theoretical research of physical processes in multilayered heterostructures which are the elementary basis of modern nanodevices. For the deep understanding it is necessary do develop the adequate theory of quasiparticles states in nanoheterostructures in which the realistic models are to be used, in particular, the continuous position-dependent effective mass one, which takes into account the imperfect heterointerfaces. However, due to the mathematical problems arising when the Schrodinger equation is solved in the majority of papers [1] the simplified model of abrupt effective mass of quasiparticle at heterostructure interfaces is used.

In the present paper we obtain the electron energy spectrum in semiconductor quantum well with rectangular potential profile and continuous linearly-dependent effective mass in near-interface regions of nanoheterostructure and compare it with the known spectrum in the well known simplified abrupt model. Therefore, using the exact solutions of Schrodinger equation for $Al_xGa_{1-x}As/GaAs/Al_xGa_{1-x}As$ heterostructure, we studied the electron energy spectrum as function of the size of near-interface region and Al concentration (x). It is shown that the relative difference of energies does not exceed one percent independently of Al concentration in barrier and well width at physically correct size of near interface region till two lattice parameters of the respective material. It is also proven that the properties of electron energy spectrum in GaAs quantum well embedded into $Al_xGa_{1-x}As$ material-barrier are qualitatively similar at varying Al concentration (x). However, the difference between the spectra in both moth models becomes smaller when concentration decreases.

1. *Harrison P., Valavanis A.* Quantum Wells, Wires and Dots: Theoretical and Computational Physics of Semiconductor Nanostructures, 4th Edition, Wiley, 2016.