Quantum Charge Transport in Ultrathin Noble Metal Films

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Rapid development of modern micro- and nanoelectronics requires the electrical circuits dimension geometry reducing and increase their reliability and efficiency. The reducing of conductor linear sizes will increase working elements density on working surface of integrated circuits. It will enhance the performance of these systems. Under such dimensional sizes the influents of size effects on electron transport will be predominant, because the impact of surface electron scattering will be commensurable with bulk. The influents of surface asperities on electron states and electron scattering peculiarity in metal film are highly important for quantitative description of the electron transport phenomena in such system. The exact solution of Schrödinger equation for metal film with corrugated boundaries is sufficiently difficult problem that is why we can only estimate the asymptotic solution of the problem [1-2]. This problem is the understanding key of electron-surface phenomenon in metal films electron transport. Quantum mechanical approaches based on investigation of electron subsystem Hamiltonian H. Electrons located in sample restricted between two inhomogeneity surfaces. The influents of surface inhomogeneities on electron transport dissipation were calculated with additive item δH to Hamiltonian H_0. The Hamiltonian H_0 describes electron subsystem located in sample restricted between two homogeneity surfaces. Calculations were conducted under perturbation theory with small inhomogeneity approximation $h \ll d$, where h – characteristics of surface asperities, which were used in TJT, TA, FC, SHW and mSHW quantum approaches [3]. That is why we developed one dimension model of metal films conductivity in Boltzmann approach for quantum electron transport. The fluctuation of film boundary has dramatic influents on electron spectra. It changes electron scattering under quantum size effect. In the frame work of developed model size dependences of metal films conductivity were calculated. The developed model was used for quantitative description of the experimental data of monocrystalline $CoSi_2$ films and fine-grained gold metal films. In the film thickness ranges of the quantum electron transport and transition to the semiclassical electron transport the comparison of calculations results of metal film size dependences conductivity were conducted for our model with others theoretical approaches. The developed quantum model of charge transport in films with metallic conductivity can more successfully describe the transition from purely quantum to semiclassical charge transport in comparison to mentioned theories [3]. This was possible because the proposed model considers the perturbation energy states in the whole volume of the film due to the existence of macroscopic inhomogeneities on the metal film surface. In consequence of this approach became possible to include a consideration of partial additive contributions of bulk and surface carrier scattering. When the film thickness is changed the relative value of the electron states only changes. Perturbation calculated in the linear approximation with assumption that Δh is d independent.

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