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Investigation of the electrical characteristics and sensitivity analysis of a nanoscale double gate metal source drain transistor with InAs as the channel material via Green's function formalism

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Abstract

In this paper, the electrical characteristics of a nanoscale double gate metal source drain transistor is thoroughly investigated. Since reduction of the channel thickness results in the variation of energy level in sub-bands and increment of band gap energy, the bandstructure of the device is calculated via employing $sp^3d^5s^*$ tight binding formalism in 2D Hamiltonian with one atomic layer precision. Next, the effective mass of carriers is derived from the related bandstructure as a function of different channel thicknesses. Based on the obtained results, the carrier effective mass considerably increases in comparison with the related bulk values as the channel thickness scales down. Following that, the drive current of the device is calculated via Green's function formalism. Furthermore, a statistical analysis was conducted to calculate the sensitivity of the main electrical measures with respect to the variation of critical physical and structural design parameters. By scaling down the channel thickness and increment of the effective Schottky barrier height, a potential well is created in the channel along the source and drain, which makes resonant tunneling occur at low temperatures and as a consequence, results in the occurrence of negative differential resistance in the transfer characteristics of the device. The impact of critical design parameters on the resonant tunneling phenomena in the proposed device is thoroughly investigated.

Keywords: metal source drain transistor, Schottky contact, tight binding formalism, resonant tunneling, Green's function formalism

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