ELECTRICAL MODEL OF CARBON NANOTUBE TRANSISTORS

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Carbon nanotube field-effect transistors (CNT-FETs) are being the subject of very intense research as new devices for future electronic applications. This research is motivated by the technical and economic difficulties in further miniaturizing silicon-based transistors with the present fabrication technologies.

At present, an important issue is to dispose of electrical models describing the interplay between the observed phenomenology in CNT-FETs. These models are intended to serve as guidelines for the design and projection of CNT-FET performances. In this work we propose a physics-based model for CNT-FETs for computing the transfer and output characteristics. The model captures the observed phenomenology of CNT-FETs: (a) thermionic and tunnel emission through a Schottky barrier [1]; (b) ambipolar and bipolar conduction [2,3]; (c) ballistic transport [4]; (d) multimode propagation [5]; and (e) electrostatics dominated by the nanotube capacitance [6]. In the proposed model, the spatial band diagram along the nanotube consists of three parts: two injecting parts at the vicinity of the source and drain metallic contacts, and a midlength region where ballistic transport occurs. There are four operation modes depending on the presence of Schottky barriers for electrons and holes at the injecting parts. The Schottky barrier has been approximated by a triangular barrier, being the height determined by half the nanotube bandgap plus the workfunction difference between the source (drain) contact and the nanotube. The spatial band diagram at low drain-to-source bias in the midlength region is approximated by a *plateau*, being the position of this *plateau* essentially determined by the nanotube capacitance, which is supposed to dominate over the insulator capacitance (operation close to the quantum capacitance limit). The width of the Schottky barrier at high drain-to-source bias is calculated self-consistently with the injected carrier charge in the midlength region. The current is obtained by means of the Landauer formula for one-dimensional systems contacted with bulk reservoirs. The key information to compute the current is the transmission over all the energies. We have taken into account that multiple reflections can arise between both Schottky barriers at the interfaces, in the same way as a Fabry-Pérot resonator [7]. The proposed model has been tested against accurate self-consistent quantum mechanical simulations.

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