Contact barriers in nanotube field-effect transistors

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The recent advances in the field of single-walled carbon nanotube field-effect transistors (CNFETs) are remarkable. Several contributions helped in acquiring a much deeper understanding of the device physics and in achieving important performance improvement. Here we review some of the new results, and discuss the fabrication of complementary transistors. In particular, we will focus on the general properties of the nanotube-metal junctions.

The conditions at the contact of a CNFET greatly influence the operation of the transistor. A large number of experiments demonstrating this point will be discussed. In particular, drastic modifications of the barrier height at the contacts have been obtained by surface passivation and annealing procedures. This simple approach is efficient for fabricating p-type, n-type and ambipolar CNFETs. It also relaxes significantly the needs for selective doping of the nanotube channel.

The ambipolar CNFETs are especially interesting since both electrons and holes can access the devices depending on the gating conditions. This situation is unique and helps gaining further insights on the device operation. Here, the contact scheme is consistent with a mid-gap injection, which implies that the barrier heights for both electron and hole injection are significant (Eg/2~300mV). However, the observed IVs at room temperature are Ohmic. In the presence of such barriers, this result is surprising and implies that only thin Schottky barriers are present at the contacts. More precisely, this is strong evidence that the injection process is dominated by thermal assisted tunneling through the barriers and that the gate field effectively modulates the transmission by bending sharply the bands in close proximity of the junction. We will present the details of these studies and make comparison with other devices. Moreover, we will show that the characteristics of the CNFETs can be controlled to favor the simultaneous injection of both types of carriers.

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