Optimization of Schottky barrier carbon nanotube field effect transistors

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Due to the capability of ballistic transport, carbon nanotube field-effect transistors (CNTFETs) have been studied in recent years as a potential alternative to CMOS (complimentary metal-oxide semiconductor) devices. CNTFETs can be fabricated with Ohmic or Schottky type contacts. We focus here on Schottky barrier CNTFETs which operate by modulating the transmission coefficient of Schottky barriers at the contact between the metal and the carbon nanotube (CNT). We studied the behavior of Schottky barrier CNTFETs by self-consistently solving the Schroedinger and Poisson equations in three-dimensions. In agreement with experimental results simulations indicate low I_{on}/I_{off} ratio and high sub-threshold slope, which limit the performance of these devices. The low I_{on}/I_{off} ratio results from the ambipolar behavior of Schottky barrier CNTFETs. We show that a double gate design can suppress the ambipolar behavior of Schottky barrier CNTFETs considerably. In this structure for an n-type device the first gate located near the source controls electron injection, and the second gate located near the drain suppresses hole injection. For improving the subthreshold slope we used the optimization framework SIESTA along with the device simulator MINIMOS-NT for electric field distribution engineering. We show that by using a double gate design an I_{on}/I_{off} ratio of more than five orders of magnitude can be obtained, and by electric field distribution engineering a subthreshold slope below $100^{mV/dec}$, which is near the theoretical minimum, can be obtained.

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