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Analysis of Coaxialdouble Gate Schottky Barrier Carbon Nano-Tube Field Effect Transistors

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***Abstract* – Carbon nanotubes have emerged as promising candidates for nanoscale field effect transistors The contact between metal and CNT may be of Ohmic or Schottky type. Schottky contact CNTFETs operate by modulating the transmission coefficient of the Schottky barrier at the contact between the metal and CNT,but the ambipolar behavior Schottky barrier CNTFETs limits the performance of those devices.we show by employing a double gate structure the ambipolar behavior of those devices may be suppressed.**

***Keywords*– Carbon Nanotube, Ambipolar behavior,, schottky barrier, Ballistic transport.**

I. INTRODUCTION

The contact between metal and CNT is of ohmic or schottky type . schottky contact CNTFETs operate by modulating the transmission coefficient of the schottky barriers at the contact between the metal and therefore the CNT ,but the ambipolar behavior of schottky barrier CNTFETs limits the performance of these devices. We have got presented the ambipolar behavior of those devices using double gate structures. For simplicity we considered a coaxial geometry where the gate covers all round the CNT.Schrodinger-poission is employed for the analysis of schottky barrier CNTFET.

II. ANALYSIS

We use a Schrodinger-poison solver for the analysis of schottky barrierCNTFETs

$$-\frac{\hbar 2}{2m*}\quad\frac{\partial 2\psi s}{\partial x2}+(U-\mathcal{E})\psi s=0\text{---(1)}$$

$$\frac{\partial\partial\emptyset}{\partial x2}=-\frac{q(p-n)\nabla(\rho-\rho cnt)}{2\Pi\rho}\text{---------------(2)}$$

$$Ns=4by2\Pi\int f|\Psi\ s\ |\ 2\ dks=$$

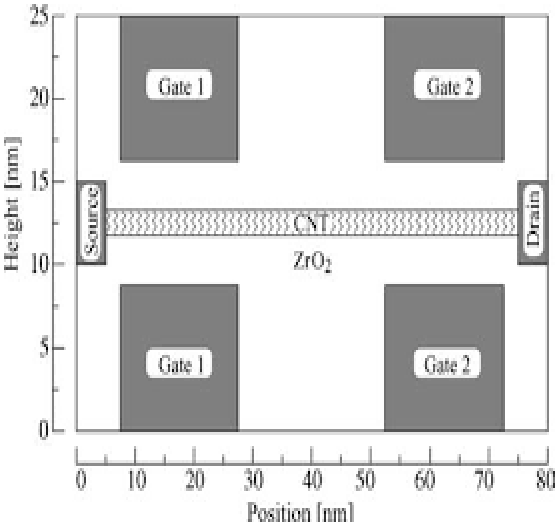
$$\int\frac{\sqrt{2m*}}{\Pi\hbar\sqrt{\mathcal{E}s}}fs|\Psi\ s\ |\ 2d\mathcal{E}s\text{----------------(3)}$$

$$I_d=\frac{4q}{h}\int[fs(\mathcal{E})-fd(\mathcal{E})]T_c(\mathcal{E})d\mathcal{E}\text{--(4)}$$

In (1) the effective mass was assumed to be m*=0.06mo.In (2) n=ns+nd and p=ps+pd represent the combination of the source and drain to the electron and hole concentration s calculated as (3), where □ is the Dirac delta function in cylindrical coordinate. Carriers were considered as charge sheets and because of cylindrical symmetry they were distributed uniformly over the surface of the CNT The drain current is calculated within the Landauer -Buttiker formula as in (3) where fs,d are equilibrium Fermi function at the source and drain contacts and Tc(Ɛ) is the transmission coefficient through the device.The factor 4 in (3) and (4) stems from the two fold band and two fold spin degeneracy .

In this work we focus on ambipolar devices, where the metal Fermi level is located in the middle of the CNTband gap at each contact .All our calculations assume a CNT with 0.6ev band gap, corresponding to a diameterof 1.4nm.First we consider a coaxial single gate CNTFETas in Fig.1 and Fig. 2 show the ambipolar behavior of this structure.

To understand this behavior thee band edge profile is shown in Fig.2.Applying positive voltages higher than the gate voltage to the drain of n-type devices suppress the schottky barrier near the drain and consequently increases whole injection at the drain. In the off regime this results in a high off-current and in the on regime the drain current increases with respect to the drain voltage instead of saturation.To avoid this phenomenon a coaxial double gate structure as in Fig.2 can be used. In the drain voltage is applied to the second gate, at any drain voltage the band edge profile near the drain would be flat, shown in Fig.3.



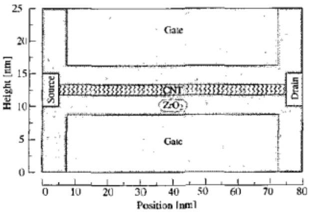


Figure 1: 2D Sketch of the coaxial single gate (SG) structure.

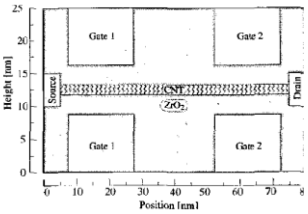
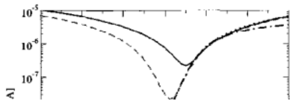
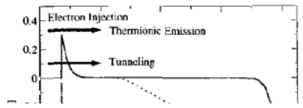
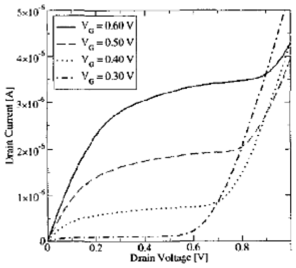


Figure 2: 2D Sketch of the coaxial double gate (DG structure.







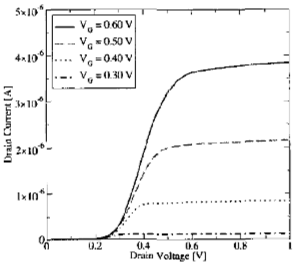


Figure 5: I-V characteristics of the coaxial SG

Figure 6: I-V characteristics of the coaxial DG

III. DISCUSSION

In consequence the tunneling current of holes at the drain is suppressed, and there is just some thermionic emission current of holes which is nearly independent of the drain voltage, shown in figure 3. While electron injection at the source contact can be controlled via the first gate, the second suppresses parasitic whole current at the drain.

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