Review of Carbon Nano Tube

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Abstract: - Low power high-performance CNT FET combinational circuit which enhances computation performance. In this project we have design basic logic gates circuit and of arithmetic unit using carbon nanotube field-effect transistors (CNTFETs). The designed adder cell requires 42 transistors. Compare to other digital devices like the half adder, ripple carries adder a significant improvement in the output parameters like currents, threshold voltage, capacitances, power dissipation in the circuit has been achieved. Schematic and Simulations were carried out using cadence software with the Verilog-A model of CNTFET provided by Stanford University and initial results are carried out by open-source platform Nano hub. Fettoy and CNTFET tools have been used to find out different parameters like V_{DD}, V_{th}, scaling in the geometry of the semiconductor material and carbon Nanotubes.

Keywords: - CNTFET, Chiral, MOSFET, SWNCT, MWCNT

1. Introduction

B.N. SHOBHA el at in [1] presented CNT characteristics on mobility, speed, delay and the orientation of CNT and its uses like in the medical field as it can help in cancer diesis. Stanford university experimental research results. explain the combination circuit: full adder characteristics based on CNTFET technology and saw their improvement and comparing with MOSFET based technological circuit**.** In [2] paper editor has written about the CNT basic strictures and their characteristics that how CNT is used as a gate, drain and source terminals devices means that the simulation of CNT. Roberto Marani & Anna Gina Perri in [3] has explained about the Stanford university have developed Verilog-A compact model for Carbon Nanotube Field Effect Transistors (CNTFETs). Limitation of MOSFET is the short channel or the modulation of the geometrical parameters like length as well as width of the drain to source, then we have channel GCA (Ex >> *E***y**) is no longer true where Ex, Ey is the electric field direction. [4,5]

1) More complex (expensive) process
2) Latch-up problem Need p-regions (for NMOS) and n-regions (for PMOS)
3) Latch-up problem: If either BJT enters the active mode, the SCR will enter into the forward
Conducting mode (large current flowing between *VDD* and GND) if $\beta_{npn} * \beta_{pnp} > 1$, circuit burnout. Latch-up is triggered by a transient increase in current, caused by transient currents and voltage transients due to negative voltage spike
4) oxide thickness
5) Performance limit by effect on mobility the current in MOSFET depends upon the mobility of charge carriers (holes and electrons), the mobility degradation by current-potential difference, and Transconductance

2 CARBON NANOTUBE (CNT)

CNT are available in circular shape of carbon of smaller dia 1 nm and length from a few nm to microns. 2 categories of CNT are

2.1. Single wall nanotubes (SWNT)

Designed from a one rolled graphene. It is hard to synthesize shown in fig1, useful in biomedical.

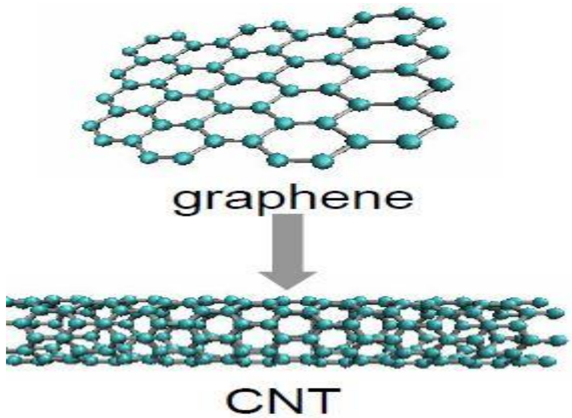

Fig.1 Single wall Nanotube

2.2. Multiwall Nanotubes (MWNT)

Carbon nanotubes possess high mechanical, electrical strength and comparable thermal properties. The Young's modulus of the tube is high as 1000 GPa. It's tensile strength up to 63 GPa. These properties combined with their low density, offer nanotubes huge potential to range of structural work. CNT found applications on nanometer and micrometer scales. SWNT-based transistors and chemical sensors are exponentially resining by absorption, electrostatic, covalent bonding. Its small size exploited to develop biosensors [6]. Target molecules will bind to the probe and produce a unique signal. CNTs are used because they are scale close to molecules. This increases the signal to noise ratio and renders high sensitivity to even a small amount of target molecules. So it is treated in FET material for channels:

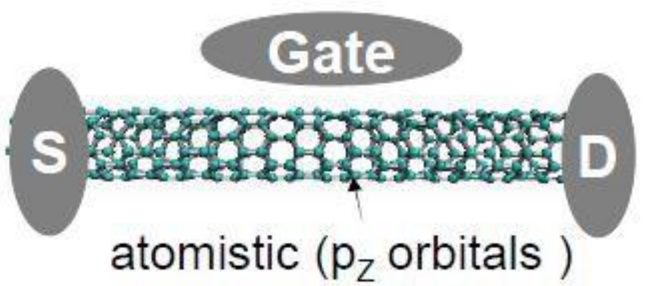

Fig2. Multiwall CNT

2.3 Relation with the diameter with a threshold voltage

The Vth depends on the W and dia of carbon nanotube (CNT) as these are expressed mathematically

$$V_{th} = \frac{E_g}{2e} = \frac{\sqrt{3}}{3}\frac{aV_\pi}{eD_{cnt}}$$

Where: Vth is the threshold voltage, a is the channel length, $a=2.49A^0$ is the carbon-to-carbon atom distance, $V\pi=3.033eV$ is the carbon π–π bond energy in the tight-binding model, e is the unit electron charge, and Dcnt is the CNT diameter, so diameter of CNT is proportional to the L, current.

2.4 Chiral Vector

The chiral vector represents the orientation of atoms or lattice structure of atoms in a molecule as shown in figure3, if we talk about carbon nanotube then the structure of carbon nanotube depends -upon the chirality of the carbon atoms [7-10]. A carbon nanotube viewed as a rounded sheet of graphene with a 1 or 2 nm diameter. The nanotube is type of either metallic or semiconducting, how it is rolled up. Orientation or arrangement of atoms inside the material. A carbon nanotube circumferential Direction, $c= n*a1 +m*a2$, where $a1$ and $a2$ are the basis vectors. With chiral vector CNTs are:

1. The zigzag CNT when $m = 0$, and
2. The armchair CNT when $n = m$.

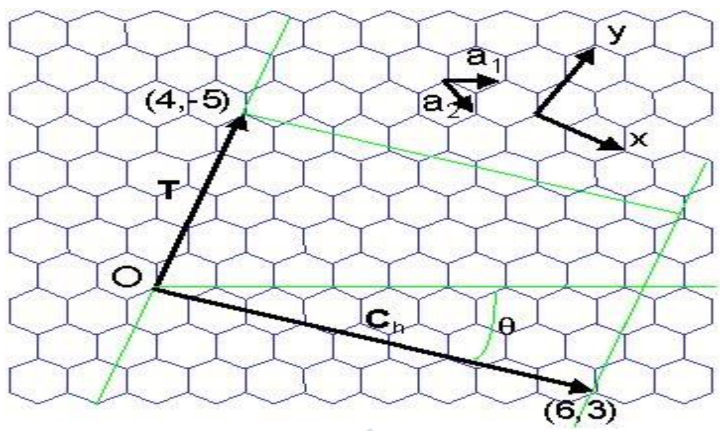

Fig3. Chiral vector

Ant the relation between them are as shown below:

$$\mathbf{a}_1 = (\frac{3}{2}a_{cc}, \frac{\sqrt{3}}{2}a_{cc})$$

$$\mathbf{a}_2 = (\frac{3}{2}a_{cc}, -\frac{\sqrt{3}}{2}a_{cc})$$

Where the chiral vector is $\mathbf{C}_k = n\mathbf{a}_1 + m\mathbf{a}_2$, $\mathbf{a}_1$ and $\mathbf{a}_2$ hexagonal lattice; $\mathbf{a}_1$ and $\mathbf{a}_2$ vectors with $120^{o.}$ $a_{c\text{-}c}$ is the bond length of carbon atoms 1.421 Å. $a_{c\text{-}c}$ = 1.44 Å is a better approximation.

Length of $\mathbf{a}_1$, $\mathbf{a}_2$ are $|\mathbf{a}_1| = |\mathbf{a}_2| = \sqrt{3}a_{cc} \equiv a$

$$\mathbf{a}_1 = (\frac{\sqrt{3}}{2}, \frac{1}{2})a$$

$$\mathbf{a}_2 = (\frac{\sqrt{3}}{2}, -\frac{1}{2})a$$

$$C_k = \sqrt{3}a_{c-c}\sqrt{n^2 + nm + m^2}$$

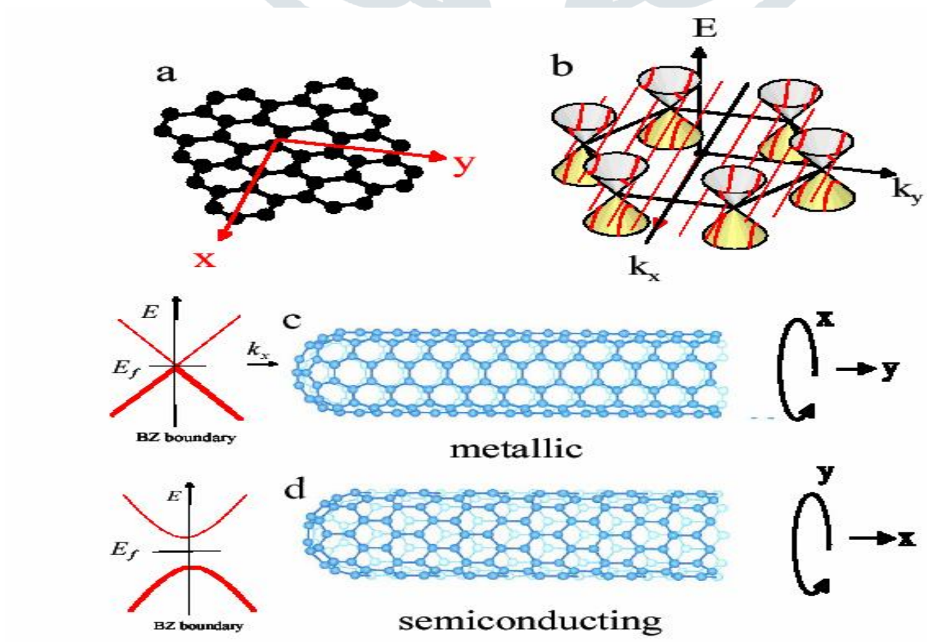

Fig4 Metallic and semiconducting orientation.

4. Conclusion

Limitation of Silicon based MOS technology arrived in a situatuiin if end, where requirement of new material highlighted. Quantum devices are better alternative. Special characteristics of CNT such as high mobility, large value of Ion/Ioff ratio and their chiral dimensional. CNT band structure suppresses backscattering and near ballistic operation is a potential success story. Voltage current characteristics of CNT are similar to silicon MOSFET. MOS circuits can be converted to CNTFET based design. Compare of MOS CNT have less size and better scalability cab replace the silicon technology.

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