Impact of Gate length and Temperature variation on VI characteristics of Carbon Nanotube FET

Project report submitted

In partial fulfilment of the requirements of the degree of

Master of Science

in

Physics

By

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July 2023

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CERTIFICATE

It is certified that the work contained in the project report titled **"Impact of Gate length and Temperature variation on VI characteristics of Carbon Nanotube FET"** by the following student:

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has been carried out under my/our supervision and that this work has not been submitted elsewhere for a degree.

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DECLARATION

I declare that this written submission represents my ideas in my own words and where others' ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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ABSTRACT

Carbon nanotubes (CNTs) have emerged as one of the most promising materials for various applications due to their exceptional mechanical, electrical, and thermal properties. In this study, we investigate the fundamental characteristics of CNTs with a focus on current and voltage parameters VI characteristics. we examine the unique structure of CNTs, which consists of graphene sheets rolled into seamless cylinders. We analyze different types of CNTs, including single-walled and multi-walled CNTs, and investigate their dimensions, chirality, and symmetry. Also we explore the electrical properties of CNTs, which make them ideal candidates for nanoelectronic devices. The IV (current-voltage) characteristics of carbon nanotubes (CNTs) play a crucial role in understanding their electrical behavior and potential applications in nanoelectronics. In this study, we investigate the IV characteristics of CNTs, focusing on their conductivity, doping effects, and transport mechanisms.

Overall, this study provides a comprehensive overview of the fundamental characteristics of CNTs, highlighting their potential for a wide range of applications and paving the way for further research and development in this exciting field of nanotechnology. Overall, this study provides a comprehensive understanding of the IV characteristics of CNTs, shedding light on their electrical behavior and paving the way for their integration into advanced nanoelectronic devices. The insights gained from this research contribute to the ongoing development of CNT-based technologies and open up new possibilities for innovative electronic applications. The further exploration of temperature dependence on IV characteristics and the Ion/Ioff ratio.

Topic:

Impact of Gate length and Temperature variation on VI characteristics of Carbon Nanotube FET

Chapter 1 Introduction

Gordon Earle Moore, or we know as **Moore's law** predicted that transistor over a chip will double every year. Since 1975 this law has proved to be true till now. This has proved to be benchmarking in various research and semiconductor industry for decades now. But now things are moving at very rapid speed, semiconductor industry at nanoscale sees a slow down due to limitation of PPA (power, performance, area) & yield. Due to increased innovation required in automotive industry, and mobile application the industry experts do not deny Moore's law but we need high performing devices at nanoscale level which save area and easy at integration with promising performance.

MOSFET: Metal Oxide Semiconductor Field effect transistor has gate, drain, source, body .

We must know flow of current first, positive to negative terminal of battery. The electric field will flow from negative to positive. the electron flow from negative terminal to positive terminal. Mosfet are made from semiconductive material: silicon. We introduce some impurities in semiconducting material to make them good conductors.

The semiconductor has conducting property between conductor and insulator. Though we know mosfet has proved that high scale computing is possible. VLSI (Very large scale integration) and ULSI (Ultra Large scale integration).

Though at very lower nodes or anno scales 5nm or less and increase in innovation needs a high performing , less power consuming device. Carbon Nanotubes is nothing but single layer graphene sheet rolled into a tube like structure. This single walled carbon Nanotube was discovered by Lijima and Ichihashi in 1991. It is also called Bucky tube is a class of nanomaterials, which is of 2-D carbon atoms arranged in hexagonal lattice. It is generally bend in 1D and forms a cylindrical which hollow type in visualization. It is allotrope of Carbon, 0D fullerene, 2D graphene.

In this research , I will be using the Nanohub materials and available software to simulate CNTFET and observe the I-V characteristics.

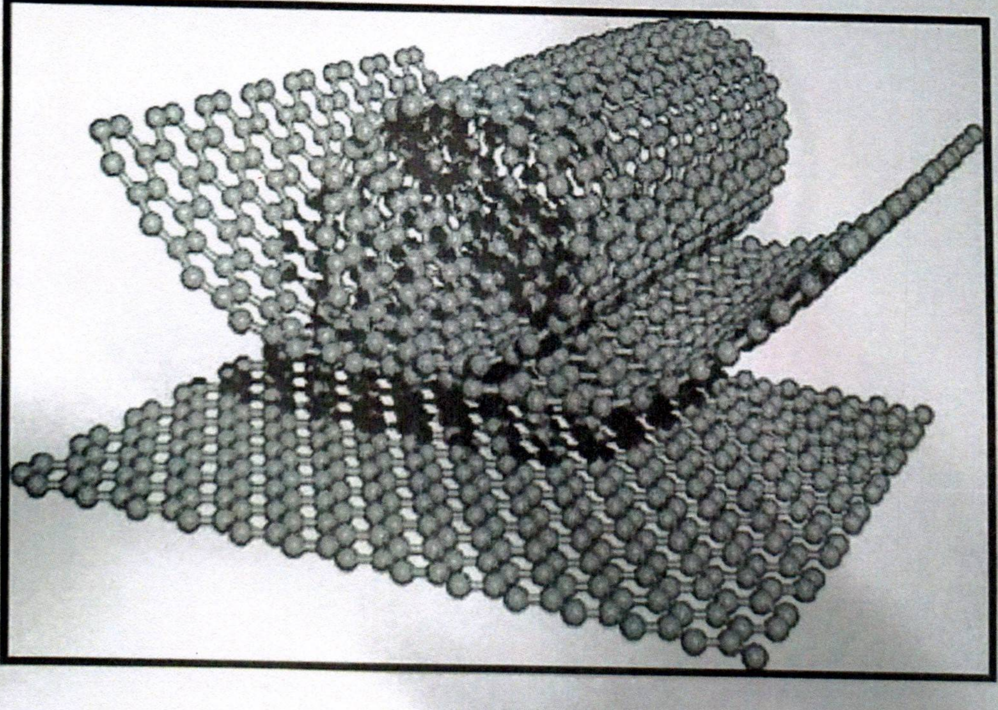
Carbon Nanotubes

A carbon nanotube (CNT) is one of the most prominent nanomaterials. Before 1991, only two head allotropes of carbon were known. In 1991, a Japanese physicist, Sumio Lizima made CNT (another allotrope of carbon). Permit us to inspect the carbon nanotubes definition, carbon nanotube is an unfilled chamber included carbon of nanoscale broadness. Thus, it is tended to as CNTs. Carbon nanotubes are similarly called buckytubes.

Carbon nanotubes (CNTs) are tube shaped particles that comprise of rolled-up sheets of single-layer carbon molecules (graphene). They can be single-walled (SWCNT) with a width of under 1 nanometer (nm) or multi-walled (MWCNT), comprising of a few concentrically interlinked nanotubes, with breadths arriving at in excess of 100 nm. Their length can arrive at a few micrometers or even millimeters.

Like their structure block graphene, CNTs are synthetically fortified with sp2 bonds, an incredibly impressive type of atomic connection.

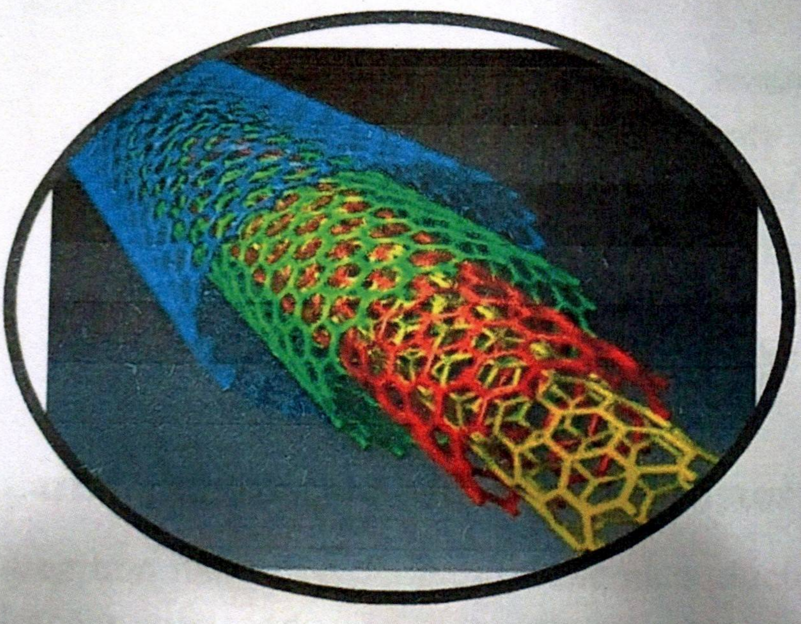
This component joined with carbon nanotubes' regular tendency to rope together by means of van der Waals powers, give the valuable chance to foster super high strength, low-weight materials that have profoundly conductive electrical and warm properties. This makes them exceptionally alluring for various applications.



Source: Nanotech works

Single wall CNT

Multiwall CNT



Carbon nanotubes offers great properties like electrical, mechanical, optical and chemical, for this purpose we will focus on Electrical properties , and why it made possible to build a Field Effect Transistor using a rolled sheet of CNT.

Electrical properties of carbon nanotubes

The rolling-up bearing (rolling-up or chiral vector) of the graphene layers decides the electrical properties of the nanotubes. Chirality portrays the point of the nanotube's hexagonal carbon-iota grid.

arm chair nanotubes - purported due to the rocker like state of their edges - have indistinguishable chiral files and are exceptionally wanted for their ideal conductivity. They are not normal for crisscross nanotubes, which might be semiconductors. Turning a graphene sheet a simple 30 degrees will change the nanotube it structures from rocker to crisscross or the other way around.

While MWCNTs are continuously leading and accomplish essentially similar degree of conductivity as metals, SWCNTs' conductivity relies upon their chiral vector: they can act like a metal and be electrically directing; show the properties of a semi-conduit; or be non-directing. For instance, a slight change in the pitch of the helicity can change the cylinder from a metal into a huge hole semiconductor.

Carbon Nanotube-Field Effect transistor: CNTFET

A carbon nanotube field-impact semiconductor (CNTFET) is a field-impact semiconductor that uses a solitary carbon nanotube or a variety of carbon nanotubes as the channel material rather than mass silicon in the conventional MOSFET structure. First showed in 1998, there have been significant advancements in CNTFETs since.