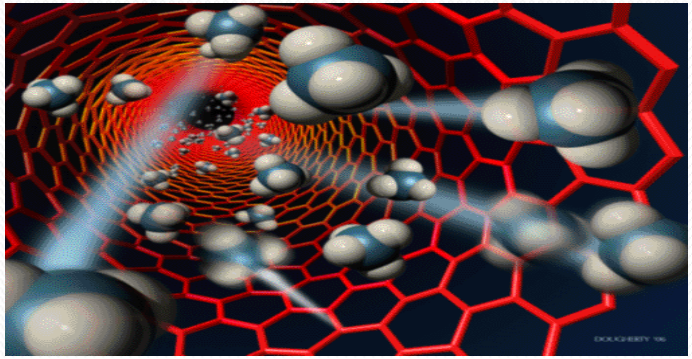
Topic : CARBON NANOTUBES



INTRODUCTION

What is a Carbon Nanotube?

- **Carbon nanotubes** (**CNTs**) are allotropes of carbon with a cylindrical nanostructure.

- Nanotubes have been constructed with length-to-diameter ratio of up to 132,000,000:1.

TYPES OF CNT'S

There are two types of CNT'S

1. Single walled Nanotubes(SWNT'S)
2. Multi walled Nanotubes (MWNT'S)

STRUCTURE

- Folded version of two dimensional graphite sheets
- Depending on the dimension of the graphite sheet and type of folding, different types can be created. Eg :SWNTS, MWNT'S.

Single-walled carbon nanotubes (SWNTs)

- Single-walled carbon nanotubes (SWNTs) are a type of nanoscale structure composed of a single, hollow cylinder made entirely of carbon atoms arranged in a hexagonal lattice. These cylindrical structures resemble rolled-up sheets of graphene, which is a two-dimensional carbon allotrope consisting of a single layer of carbon atoms arranged in a hexagonal pattern.

multi-walled carbon nanotube (MWNT)

- A multi-walled carbon nanotube (MWNT) is a type of carbon nanotube (CNT) structure composed of multiple concentric cylinders of carbon atoms. Carbon nanotubes are cylindrical nanostructures made entirely of carbon atoms arranged in a hexagonal lattice.

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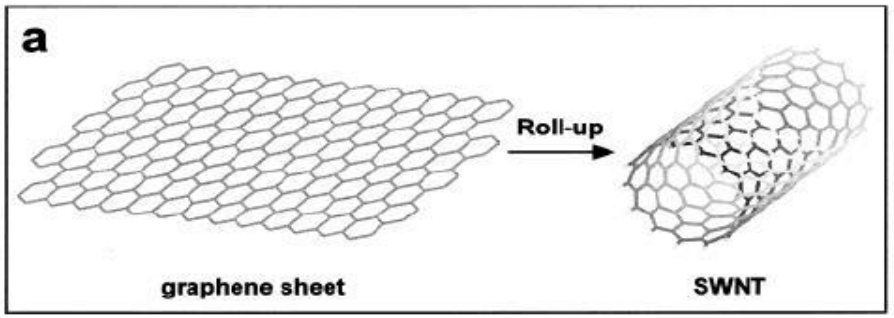
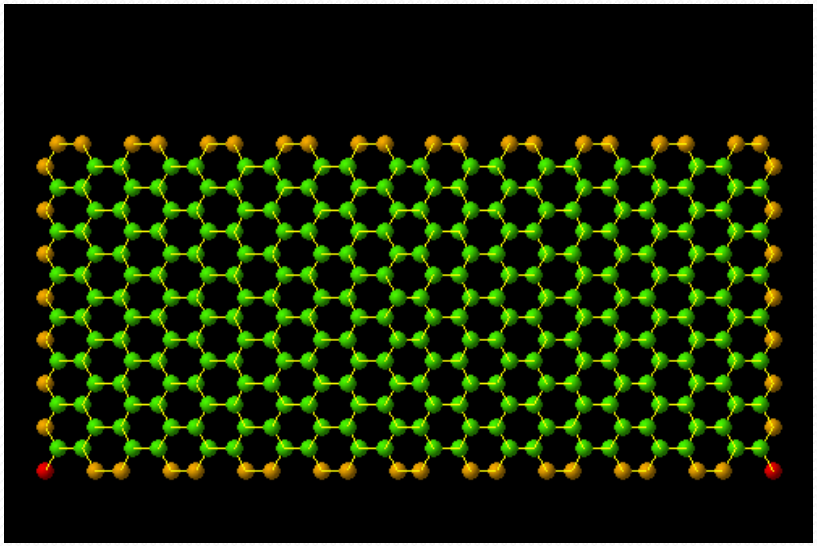
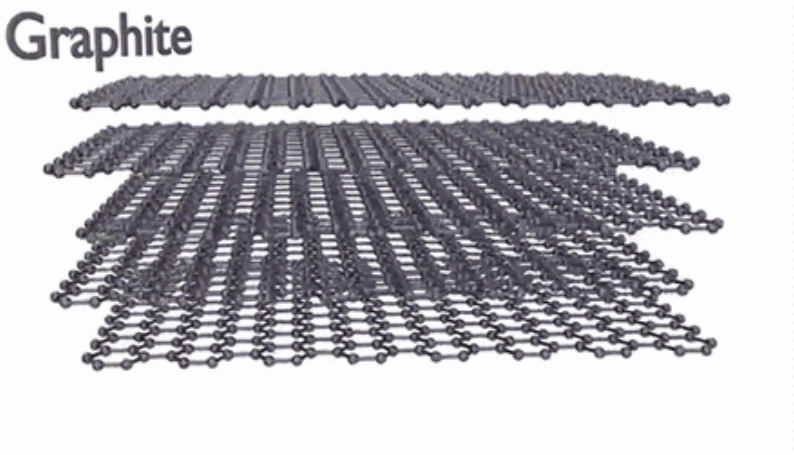
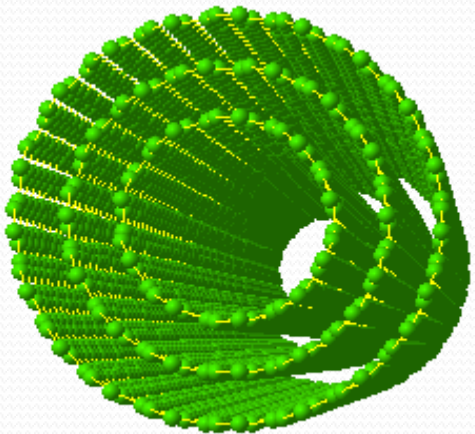
- CNT is configurationally equivalent to a two dimensional graphene sheet rolled into a tube.









Comparison between SWNT and MWNT

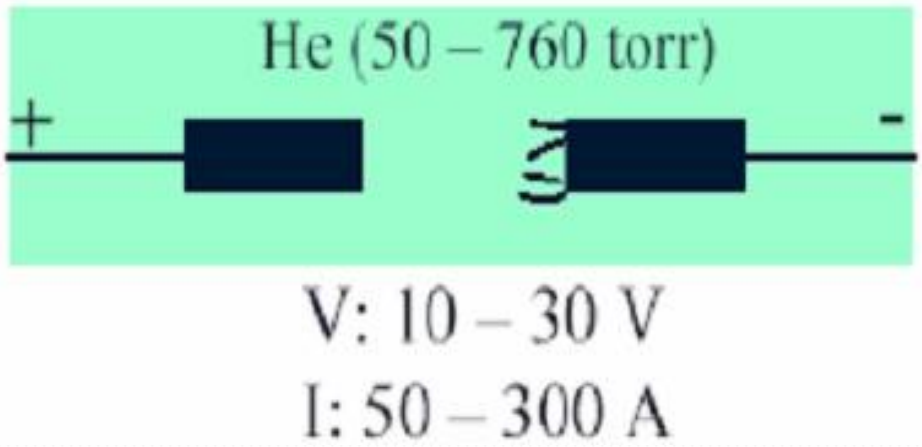
SWNT	MWNI
1 single layer of graphene	Multi layer of graphene
2. Catalyst is required for synthesis	Can be produced without catalyst
3. Bulk Synthesis is difficult as it is required proper control over growth and atmospheric condition	Bulk synthesis is easy
4. Purity is poor	Purity is high
5. Less accumulation in body	More accumulation in body
6characterization and evolution is easy	It has very complex structure
7 chance of defect is more during functionalizing	chance of defect is less but once occurred its difficulty to improve

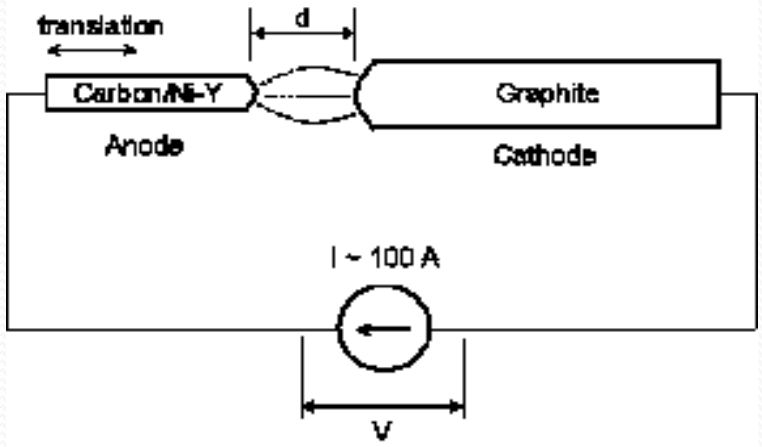
SYNTHISIS of CNT'S

There are three techniques to produced nanotubes

1. Arc discharge method
2. Laser Ablation method
3. Chemical Vapour Deposition (CVD) Method

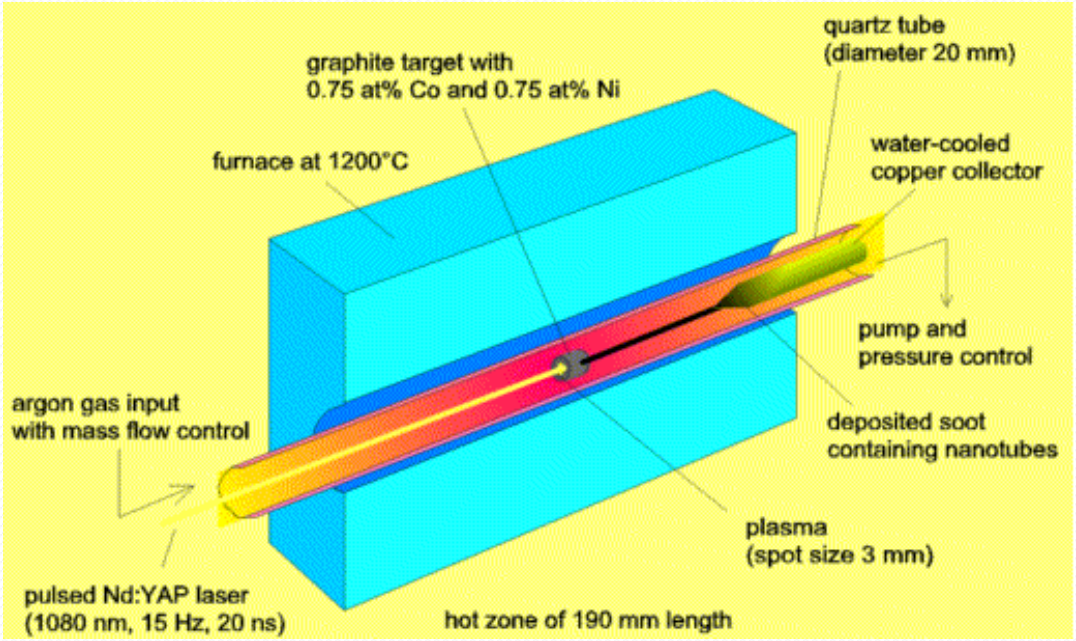
a)Arc discharge method





- Graphite electrodes placed in an inert Helium atmosphere When DC current 50-300amps at 20 volts to the rods and creates a high temperature discharge between the two electrodes.
- The discharge vaporizes the anode rod, and it forms carbon nanotubes For SWNT mixed metal catalyst is inserted into anode

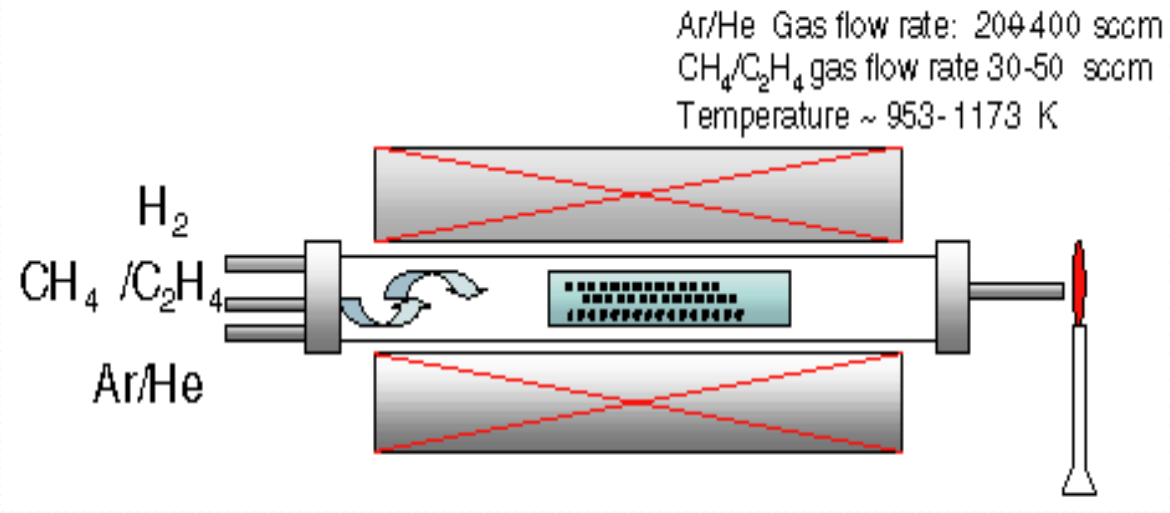
b) Laser Ablation method



- In this process, an oven filled with inert gas is brought up to a temperature of about 1200 °C, at high pressure, and a graphite target is placed inside.
- A laser is shot at the target, which vaporizes the graphite on the surface. Very hot vapor forms, expands, and then cools, leaving carbon nanotubes

c)Chemical Vapor Deposition

Hydrocarbon + Fe/Co/Ni catalyst $\xrightarrow{550\text{-}750^{\circ}C}$ CNT



- CVD is the most common method for producing carbon nanotubes .

- An energy source, such as resistively heated coil, transfers energy to carbon molecules that are in the gas phase.

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- Common gaseous carbon sources are methane, carbon monoxide and acetylene.

- The energy source causes carbon atoms to separate from the molecules and the carbon atoms attach themselves to the metal catalysts. After this, the carbon nanotubes start to grow

CNT PROPERTIES

a)Electronic and Electrical property

- Electrical conductivity is six orders of magnitude higher than copper.
- Very high current carrying capacity.

b)Thermal property

- The thermal conductivity of CNT'S is very high in the axial direction and very low in the lateral direction.
- Thermal conductivity, along the axial direction, has been found to be at least double thatof diamond(~3000 W/mK).

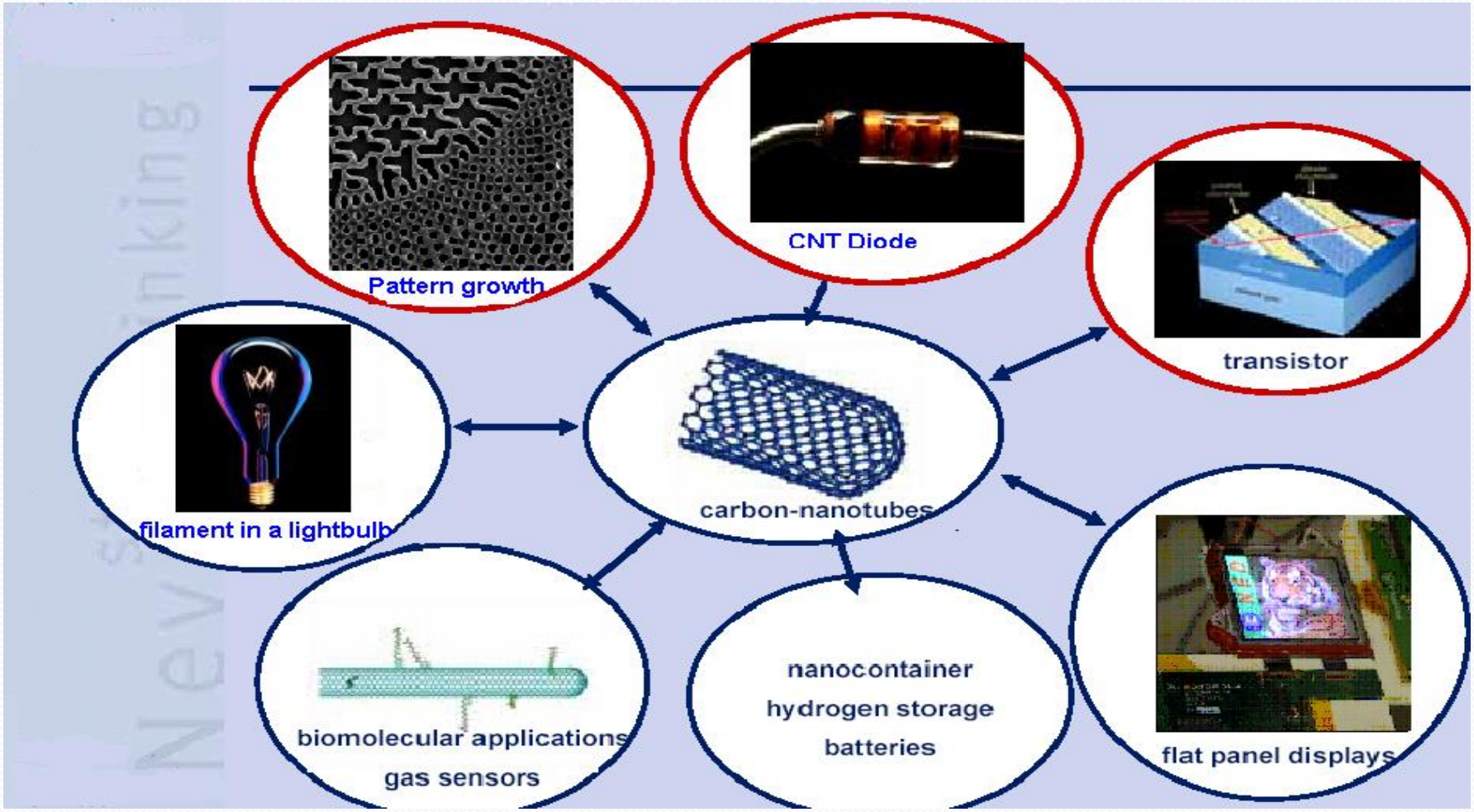
c)Mechanical property

- SWNT'S possess incredible mechanical resistance because their carbon atoms are united by the strongest bonds in nature .In addition, they are highly flexible, and can be bent repeatedly up to 90° without being damaged.
- They have a very low density, about 1/6 of the density of steel, but are much stronger than steel.
- They would have the highest Young's modulus (or stiffness) of any material—1 Tpa which is five times the stiffness of steel.

Advantages

- Ultra Strength
- Fast electron conductivity
- Very small with high frequency and low power consumption.
- Velocity of electrons in carbon nanotubes is equal to velocity of light.
- Mobility of electron in carbon nanotubes is 200 times that of silicon.

Applications



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1.IN ELECTRONICS

A) Flat Panel Display

- Low power consumption, High brightness
- Wide viewing angle
- Fast response rate
- Wide operating temperature range

B) As Conductors and Transistors

C) Ultra-capacitors

- High surface area to mass ratio of graphene.
- Greater energy storage density than currently available.

2.Electrical

(A)Field emission in vacuum electronics

(B)Nano lithography

3.Energy storage

(A)Lithium batteries

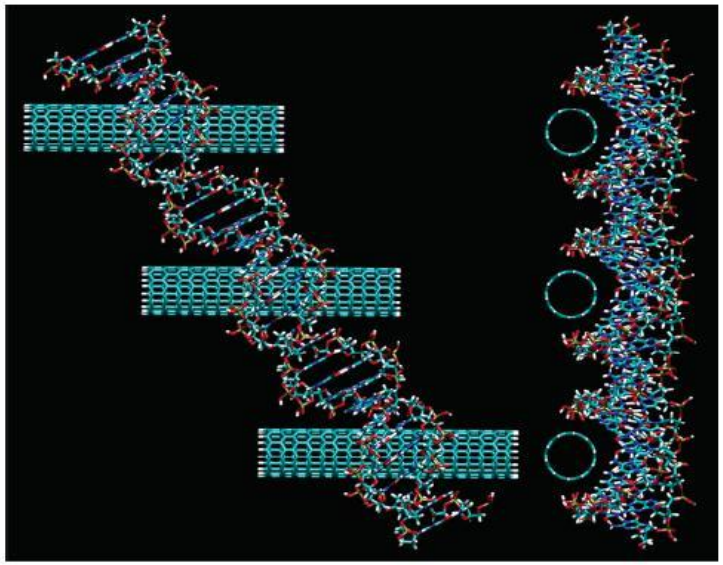
(B)Hydrogen storage

4.Biological

(A)Manufacture of Artificial muscles

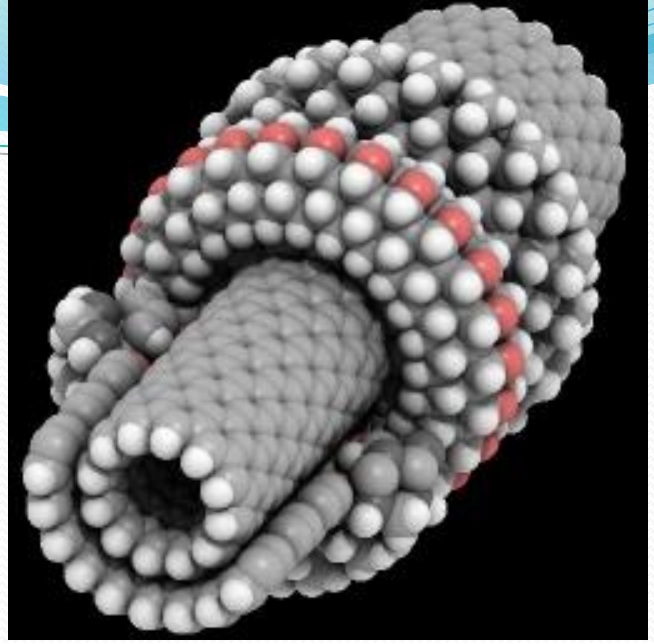
(B)DNA sequencing

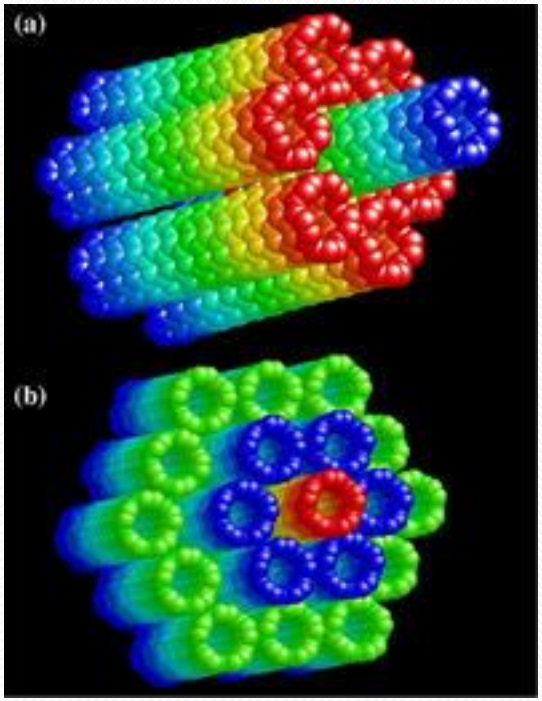
(C)Bio-sensors



5.Auto parts

- *60 percent of cars produced today now have fuel lines made* with carbon nanotubes.
- The carbon nanotubes inside the fuel lines are intended to reduce the risk of explosions by inhibiting static electricity.





The single-seater car's

6.Sporting Equipment

Carbon nanotubes have already been added to sports equipment such as **bats, bicycles, golf clubs, and hockey sticks** in order to impart more strength and absorb vibrations.

Carbon Nanotube hockey stick

Limitations of CNT'S

- High-Quality nanotubes can only be produced in very limited quantities -commercial nanotube soot costs 10 times as much as gold.
- Since these particles are very small, problems can actually arise from the inhalation of these minute particles.

FUTURE ENHANCEMENTS

- In future carbon nanotubes replaces **carbon fiber**.
- It is also used in **VLSI interconnections** and in water purification.
- It replaces **silicon based diodes** and **transisters** in future.

CONCLUSION

- Carbon nanotubes are the next step in miniaturizing electronic circuits**, replacing silicon transistors** and **diodes**, which are fast reaching the theoretical limits of size and speed of operation.
- Using CNTs, nanochips can be made with entire circuits on it. **Ideal diodes** can be made from CNTs, resulting in highly efficient electronic circuits. Further, CNTs have a number of other uses other than in the electronic industry, as seen here.