## UNIT V

# **5.4.CARBON NANO TUBES**

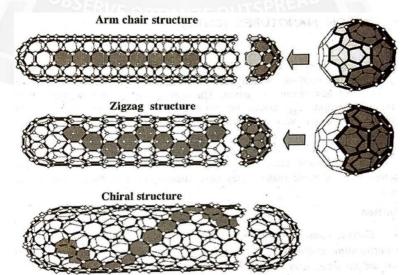
- The discovery of carbon leads to form stable, ordered structures other than graphite and diamond.
- $\blacktriangleright$  Researchers found that carbon-60 (C<sub>60</sub>) is used to produce carbon nanotubes (CNT).
- > The CNT have remarkable electronic properties and many other unique characteristics.
- Definition: Carbon nanotubes (CNT) are molecular-scale tubes of graphitic carbon with outstanding properties. They are among the stiffest and strongest fibers researched till date with remarkable electronic properties and application.

# **TYPES**

- Carbon nano tubes are of three types.
  - 1. Single walled nano-tubes (SWNTs)
  - 2. Multi walled nano-tubes (MWNTs)
  - 3. Single walled nano-horns (SWNHs)

# STRUCTURE

- There are three structures based on the rolling of a graphene sheets into tube with different orientations about the axis.
  - 1. Armchair structure 2. Zig-zag structure 3. Chiral structure



- → Here, the armchair and zig-zag structures have a high degree of symmetry.
- The terms "armchair" and "zig-zag" refer to the arrangement of hexagons around the circumference.
- > The "chiral" term means that it can exist in two mirror-related forms.

#### FABRICATION OF CARBON NANOTUBES:

Carbon nano tubes can be fabricated by any one of the following methods.

- (i) Pulsed laser deposition (or) laser synthesis
- (ii) Carbon Arc method
- (iii) Chemical vapour deposition

#### PULSED LASER DEPOSITION

**Principle:** The technique of laser heat treatment is used in the preparation of carbon nano tubes

## **Construction:**

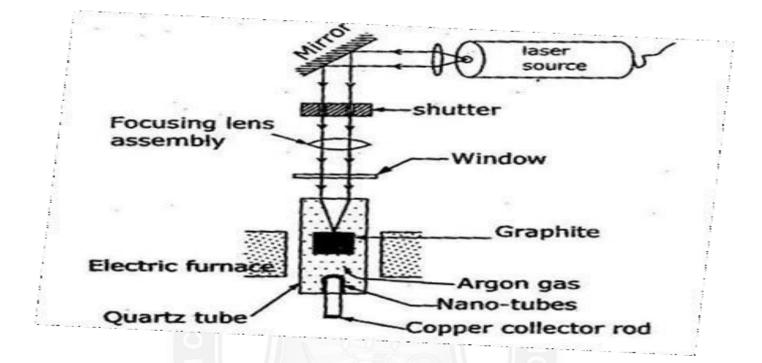
- The experimental setup consists of a quartz tube containing a graphite target.
- The tube is surrounded by electric furnace to heat the target.
- Along with this a laser source is used to produce laser beam.
- The intensity of the laser beam is controlled by a shutter and an assembly of lens is

used to effectively focus the laser beam on to the target.

• The graphite is heated upto 1200°C with the help of electric furnace. Then the laser

source is switched on.

## **Diagram**:



#### Working:

- The light reflected by the plane mirror is made to pass through the shutter.
- The intensity of the laser beam is controlled by the shutter.
- The lens assembly focuses the light on to the window and is made to incident on the graphite. Due to laser heating the graphite gets heated and evaporates carbon atoms.
- The argon gas present insides the quartz tube is used to sweep the carbon atoms towards the colder copper collector rod.
- Due to the movement of the carbon atoms from a higher temperature region to lower temperature region it gets condensed and hence carbon nano tubes are formed over the collector rod.

# PROPERTIES

- 1. CNTs have high electrical conductivity.
- 2. CNTs are good electron field emitters.
- 3. The energy band gap decreases with increase of diameter of CNTs.
- 4. CNTs have very high tensile strength.
- 5. CNTs are highly flexible (can be bent considerably without damage).
- 6. CNTs are very elastic.
- 7. CNTs have ability to withstand extreme strain.
- 8. CNTs provide high resistant to any chemical reaction.
- 9. CNTs have high thermal conductivity.
- 10.CNTs have a low thermal expansion coefficient.

# APPLICATIONS

- 1. They are used in aerospace because of its light weight and strength.
- 2. They are used in the construction of nano scale electronic devices.
- 3. They are used in battery electrodes, fuel cells and reinforcing fibers.
- 4. They are used in the development of flat panel displays in television and computer displays.
- 5. They are used as a light weight shielding materials for protecting electromagnetic radiation.
- 6. Semiconducting CNTs are used in switching devices.
- 7. Semiconducting CNTs are used as chemical sensors to detect various gases.
- 8. They serve as catalyst for some chemical reaction.
- 9. They are used in military and communication systems for protecting computers and electronic devices.
- 10.By using CNTs in future it is possible to produce nano-computers, plastic composite, etc.,
- 11. They are used as interconnects in chip.
- 12. They are used in the development of fuel cells.