(4) Nanotechnology

Physics

1. Nanotechnology is the study of control of matter on an atomic or molecular scale. One nanometer is one billionth of a meter or 10^{-9} of a meter. Nano fabrication involves two ways. First one is "Top-down" fabrication is to start with a chunk of materials like gold and successive cutting it to nanoscale. The other is "bottom-up" fabrication is to start with individual atoms and building up to nano structure.

Tools of Nano technology

The two important tools are scanning tunneling microscope [STM] and Atomic force Microscope [AFM]. In STM the probe slides along a surface and it measures the electric current following between a scanning tip and the surface. Magnetic Field Microscopy [MFM] is the third method. The working of MFM tip is similar to the working of a reading head on a hard disk drive. Small molecules can be moved either by pushing or picking up them from the surface using the scanning tip.

Nano clusters

The size of clusters is in between bulk materials & their atoms or molecules. Their properties are different from those of discrete molecules and bulk solids. Depending upon the constituent particles there two types of clusters. They are atomic and molecular clusters. clusters consists of species in gas phase or in condensed phase or both. They can have either a net charge (Ionic clusters) or neutral clusters (having no charge). The atoms or molecules constituting clusters are bounded by forces which may be metallic, covalent, ionic, hydrogen bonded or Vander waal's in nature. These clusters are have regular shapes. They also exist in spherical shape. clusters differ from bulk materials in terms of the Magic numbers of atoms or molecules they contain. In the case of larger clusters "stability is determined by the structure and magic numbers.

Fullerenes

Fullerenes are molecular forms of carbon which are different from the extended form of carbon. They are spheroidal in structures. It has a chemical formula C_{60} containing 60 carbon atoms in the shape of a soccer ball. These ball like molecules of carbon form a crystal lattice having FCC structures. Each C_{60} molecule separated by its nearest neighbour by 1nm and bind together by weak Van der Waal's forces. 26% of the volume of this unit cell is empty. So alkali metals can easily fit into the empty space.

Carbon Nanotubes

They are made up of sp^2 hybridised state of carbon. In this category the important one is graphite. These two dimensional sheets made of sp^2 hybridised carbon can curl, just like paper and make cylinders. Only by using hexagons alone carbon can't make 3-dimensional structures. For that it needs pentagons also. At least six pentagons are needed on each sides of the cylinder.

thereby making a closed pipe. This is called carbon Nanotube. The tube can be closed or open and the length can be several hundred times of it's diameter.

A single graphite sheet is called graphene. Carbon Nanotubes can be produced by rolling the planed carbon sheets. Depending on the roll over, they can be classified in to three.

1. Arm-chair types.
2. Zig-Zag types
3. Chiral types.

The way graphene sheet is wrapped is represented by a pair of indices (n,m) called chiral vector.

If $m=0$, the nanotube is called Zig Zag

If $n=m$, Nanotube is called arm chair

Otherwise they are called chiral.

Synthesis of Carbon Nano tubes

Nanotubes are prepared using Carbon arc in the presence of helium at low pressure. A potential of 30V is applied across carbon electrode of 5-20 Nm diameter and separated by 1mm at 600 torr pressure of flowing helium. Carbon atoms are ejected from the positive electrode and, form Nanotubes. As the tube forms, the length of the positive electrode decreases.

Properties of Carbon Nano tube

(1) High strength, high strength-to-weigh ratio — It is 100 times greater than steel.
(2) high resistance
(3) Difficult to oxidise nanotubes.
(4) Surface area of nanotubes is higher than graphite.
(5) Have high thermal conductivity.
(6) In multi-walled nanotubes, multiple concentric nanotubes precisely nested within one another exhibit a striking telescoping property.

Applications.

1. Used as good electrical conductors.
2. Nanotube based transistors are used as digital switching using a single electron.
3. Nanotubes can used as CNT based field emission displays.
4. can be used for making paper batteries.
5. can be used as solar cells.
6. Used to form ultra capacitors.
7. can be used as high reliability touch screens.

Application of Nanotechnology

1. Nano medicine — cell Imaging, cancer treatment
   - diagnostic purposes.
   - can be helps to reproduction of damaged tissue.

2. Energy — Reduction of energy consumption
   - can Increase the efficiency of energy production
   - Can use environment friendly energy systems
   - Nanotechnological approaches like LEDs