



## SYNTHESIS OF NANO – MATERIALS

### **Top-down (or) Physical (or) hard methods**

Top down process involves the conversion of bulk materials into smaller particle of nano-scale structure

1. Laser Ablation method
2. Ball milling

### **Bottom-up (or) Chemical (or) Soft methods (or) Small to Big methods**

It involves building-up of materials from the bottom by atom by atom ( $\approx 0.1$  nm), molecule by molecule or cluster by cluster.

This method is carried out by the following process

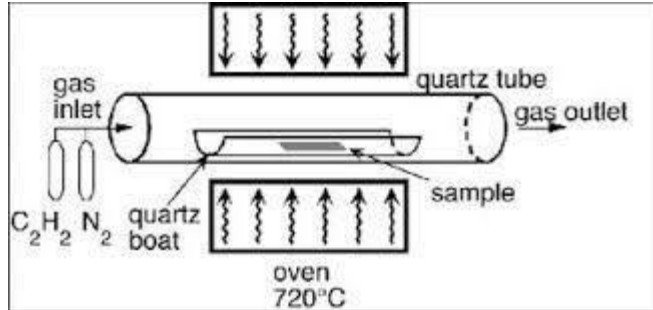
1. Chemical Vapour Deposition (CVD)
2. Sol gel Process
3. Solvothermal Synthesis

### **Chemical Vapour Deposition (CVD)**

It is a process of chemically reacting a volatile compound of a material with other gases, to produce a non-volatile solid that deposits automatically on a suitably placed substrate.

CVD reaction requires activation energy to proceed. This energy can be provided by several methods.

CVD reactor consists of a higher temperature vacuum furnace maintained at inert atmosphere. The solid substrate containing catalyst Ni/Co/Fe placed on a substrate material like silica, quartz is kept inside the furnace. The hydrocarbon such as ethylene or acetylene and nitrogen cylinder are connected to the furnace. Carbon atom produced by the decomposition at  $1000^{\circ}\text{C}$ , condense on the cooler surface of the catalyst. As this process continuous, CNT (Carbon Nano Tube) is produced continuously.



Various steps involved in synthesis of CVD

The various steps involved in synthesis of CVD are summarized as follows.

1. Transport of gaseous reactants to the surface.
2. Adsorption of gaseous reactant on the surface.
3. Catalyzed reaction occurs on the surface.
4. Product diffuses to the growth sites.
5. Nucleation and growth occurs on the growth site.
6. Desorption of reaction products away from the surface.

CVD Reactor are of generally two types

1. Hot-wall CVD
2. Cold-wall CVD

1. Hot-wall CVD reactors are usually tubular in form, and heating is accomplished by surrounding the reactor with resistance elements.
2. But in cold-wall CVD reactors, substrates are directly heated inductively by graphite susceptors, while chamber walls are air (or) water-cooled



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