Two-Dimensional Nanostructures: Nanoparticles

Chemical Vapour Deposition (Chemical Vapour Condensation) CVD:

Chemical Vapour Deposition (CVD) is a well-known process in which a solid is deposited on a heated surface via a chemical reaction from the vapour or gas phase. The Fundamental CVD Processes are:

1. Convective and diffusive transport of reactants to the reaction zone

2. Gas phase reactions

3. Transport of reactants to the substrate surface.

4. Chemical and physical adsorption

5. Surface reactions leading to film formation

6. Desorption of volatile by- products

7. Convective and diffusive transport of by-products away from the reaction zone

In thermal CVD the reaction is activated by a high temperature above 900 °C. A typical device includes of a gas supply system, a deposition chamber and an exhaust system.

In plasma CVD, the reaction is activated by plasma at temperatures between 300 and 700 °C. In laser CVD, pyrolysis (thermal degradation) occurs when laser thermal energy heats an absorbing substrate. In photo-laser CVD, the chemical reaction is induced by ultra violet radiation which has sufficient photon energy to break the chemical bond in the reactant molecules. In this process, the reaction is photon activated and deposition occurs at room temperature.

Nano composite powders are also prepared by CVD method. For example, SiC/Si_3N composite powder was prepared using SiH4, C_2H_2 and NH_3 as a source of gas at 1400 °C.

Chemical Vapour Condensation (CVC) process was developed in Germany in 1994. The schematic diagram of CVC is shown in Figure 1. It involves pyrolysis (thermal decomposition) of vapours of metal organic precursors in a reduced pressure atmosphere. A metal organic precursor is introduced in the hot zone of the reactor using mass flow controller. The reactor allows synthesis of mixtures of nanoparticles of two phases or doped nanoparticles by supplying two precursors at the front end of reactor and coated nanoparticles by supplying a second precursor in a second stage of reactor. The process yields quantities in excess of 20 g/hr. The yield can be further improved by enlarging the diameter of hot wall reactor and mass of fluid through the reactor.

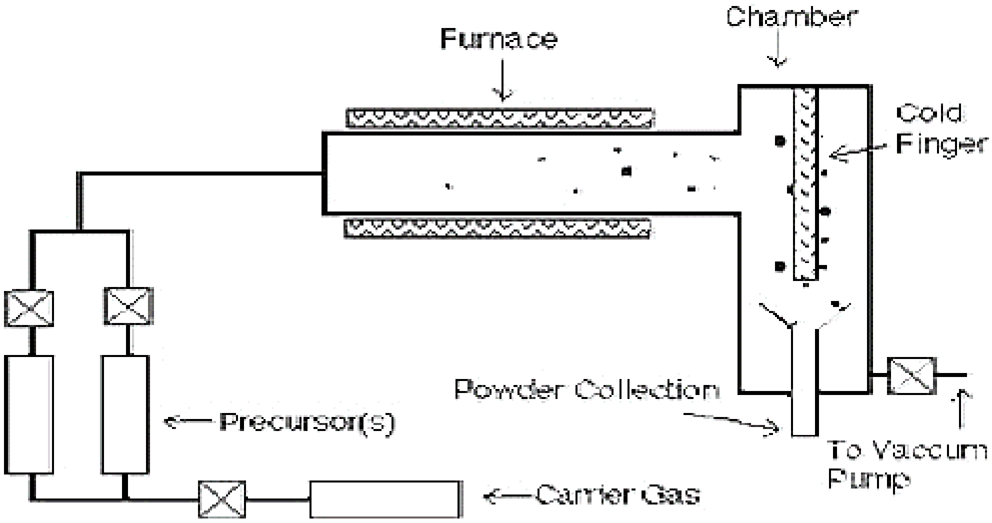

Figure 1: Schematic diagram of Chemical Vapour Condensation (CVC) process

Physical vapour deposition (PVD):

Physical vapour deposition processes are atomistic deposition process in which the material is vaporized from solid or liquid source in the form of atoms or molecules, transported in the form of a vapour through a low pressure gaseous (or plasma) environment to the substrate where it condenses. Ion embedding, vacuum evaporation and sputter deposition are various forms of PVD processes. All of these PVD processes are conducted in a vacuum or low pressure gaseous environment, Low pressure environment ensures the control and minimization of impurities in a given system as well as provides a long mean free path between original source of material and the location upon which the particles are deposited.

PVD processes are often credited with capable of coating anything on anything. Some of the advantages of the PVD based deposition techniques are:

1. High deposition rates.
2. Ease of sputtering any metal, alloy or compound
3. High-purity films
4. Extremely high adhesion of films
5. Excellent coverage of steps and small features
6. Ability to coat heat-sensitive substrates
7. Ease of automation
8. Excellent uniformity on large-area substrates

Evaporation method

Evaporation method is the simplest way of PVD and summarized by coat substrate with another material. Due to the simplicity in its application, this method is widely used upon its introduction. The original principle of this method is to evaporate the material in the vicinity of the substrate and it is the basis for various techniques like Thermal evaporation, Electron beam evaporation and Cathodic arc evaporation. In thermal evaporation, low melting materials are heated to the point of evaporation directly or by ohmically heated containers in low pressure. The low pressure ensures the long mean free path for the evaporated atoms such that they can transit to the substrate without being scattered by ambient gas molecules. In Electron beam evaporation, a directed electron beam is used to cause localized melting of the material and the evaporated material leave in the same direction as the incident electron beam. This method is particularly suitable for evaporation of high melting point material. Cathodic arc evaporation utilizes an electric arc to generate a localized region of extremely high temperature. The target material is vaporized as a result, and material is ejected as high velocity jet. It is then deposited at the substrate. However lack of uniformity and inability to deposit over large area substrate is the common disadvantage of such deposition process.