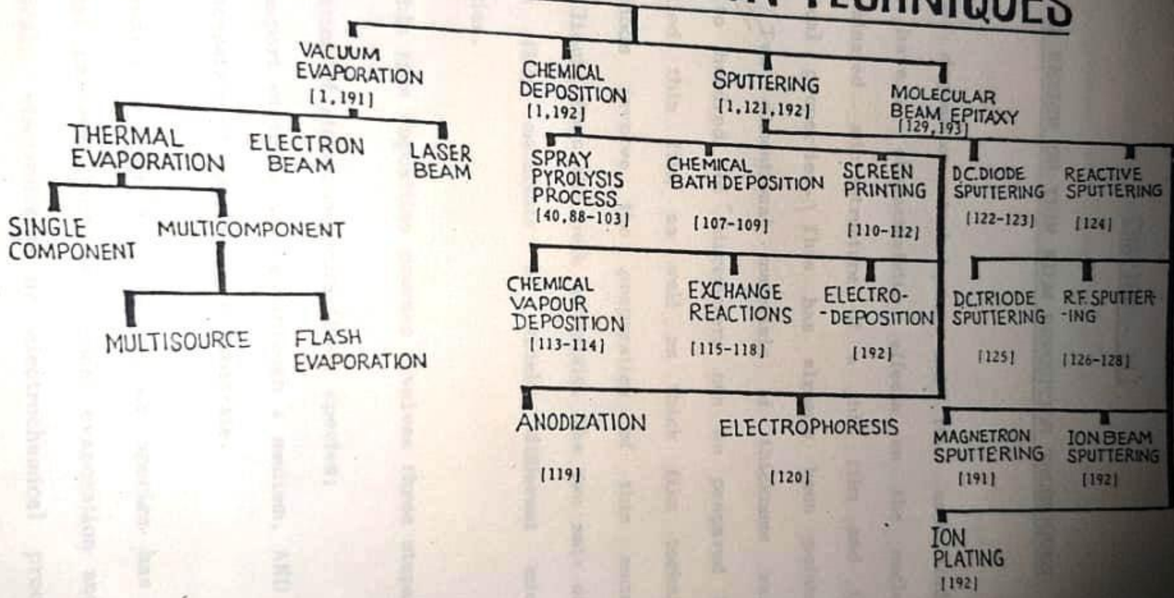
THIN FILM DEPOSITION TECHNIQUES



where P_e is the equilibrium vapour pressure (in torr) of the evaporant under saturated vapour conditions at a temperature T and M is the molecular weight of the vapour species. The vapour atoms traverse the medium and are made to condense on a substrate surface to form a thin film. The rate of condensation/deposition of the vapour atoms depends on the vapour-source-substrate geometry and the condensation coefficient on the surface under given physical conditions.

The vapour atoms are scattered by collisions with residual gas atoms in the vacuum system. The scattering probability is exp. $(-d/\lambda)$, where d is the source substrate distance and is the mean free path of the gas atoms. In addition, the gas molecules impinging on the substrate surface at a rate given by equation (3.1) where of course the parameters P_e, T and M refer to the gas molecules at temperature T. It was found from experiments that vacuum of the order of 10^{-5} torr to 10^{-6} torr is good enough for deposition of clean films except those readily oxidizable in which case relatively much better vacuum conditions are required.

B. Why Vacuum is needed :

Solid materials are heated upto sufficiently high temperature to vapourise them then these vapours are condensed onto a coller surface form a thin solid film. The vacuum evaporation is advantageous due to following reasons:

(a) The material will boil at a lower temperature in vacuum.

(b) There will be reduction of the number of impurities in the deposit material.

(c) There is reduction of the effect of oxides formed on the boiling of the surface.

(d) It is possible to put a mask between source and the substrate and obtain a sharp pattern on the substrate.

(e) The main advantage of the vacuum is that the adhesion of the film increases due to increase in (mean free path) and better film can be formed. The grain size of the atom also increases and the film formed will again be a better film. When there is vacuum then there is less number of atoms or ions are present and the successive time of the two collisions increases. Due to this there will be less number of collisions and the atoms and ions will have more energy (Loss of Energy is less). Finally the atom and ion will strike at the substrate with more Kinetic Energy (or velocity) so that the adhesion will be better.

C. Heating Methods in Vacuum Evaporation Technique :

The evaporation of the material in a vacuum system

(2) Chemical vapour deposition (CVD);

(3) Electrodeless or solution growth and

(4) Electrochemical deposition (ECD).

By combining PVD with CVD hybrid techniques such as reactive evaporation/sputtering and plasma deposition have been established. The physical term 'evaporation' describes the phenomena when a surface atom which by thermal heating has gained a vibrational energy exceeding its binding energy, leaves the solid or liquid and enters the gas phase. Thin film preparation by evaporation involves the creation of vapours or clusters of atoms by heating a material. The transportation of vapours and subsequent condensation on a substrate maintained at lower temperature than that of vapours. The temperature of the source is an essential parameter for determining the rate of évaporation.

1. VACUUM EVAPORATION :

A. Kinetics :

The evaporation of a material requires that it be heated to a sufficiently high temperature to produce the desired vapour pressure. The rate of free evaporation of vapour atoms from a clean surface of unit area in vacuum is given by the Langmuir–Dushman Kinetic theory equation;

$$Ne = 3.513 \times 10^{22}\ Pe/(MT)^{1/2} \text{ molecules cm}^{-2}\ S^{-1} \quad (3.1)$$

The deposition techniques and it's associated process parameters have characteristic effects on the nucleation and growth dominated microstructure of a thin film and thereby on its physical properties. This has already been pointed out in Chapter-I. Two dimentional materials of thickness ranging from Angstroms to hundred of micrometers can be prepared by a host of so called thin film as well as thick film techniques. The latter methods involve the preparation of thin materials from a paste or liquid from the bulk materials. The two sets of techniques yield thin film materials of widely different microstructures and properties.

A thin film deposition process involves three steps

i. Creation of atomic/molecular/ionic species;

ii. Transport of these species through a medium, AND

iii. Condensation of species on a substrate.

Depending on whether the vapour species has been created by a physical process (such as thermal evaporation and sputtering), by a chemical, electrodeless or electrochemical process, we can broadly classify the deposition techniques under the following headings :

(I) Physical vapour deposition (PVD):