

# Chapter 3

## Thin film deposition techniques

### 3.1: Thin film deposition process & its general types

Thin film deposition is a process in which we coat very thin layer of any required material on a substrate to form functional devices e.g,

- ❖ In the semiconductor industry to grow electronic materials
- ❖ In the aerospace industry to form thermal and chemical barrier coatings to protect surfaces against corrosive environments,
- ❖ In optics to impart the desired reflective and transmissive properties to a substrate
- ❖ Elsewhere in industry to modify surfaces to have a variety of desired properties.

The deposition process can be broadly classified into:

- 1) Physical vapor deposition (PVD)
- 2) Chemical vapor deposition (CVD).

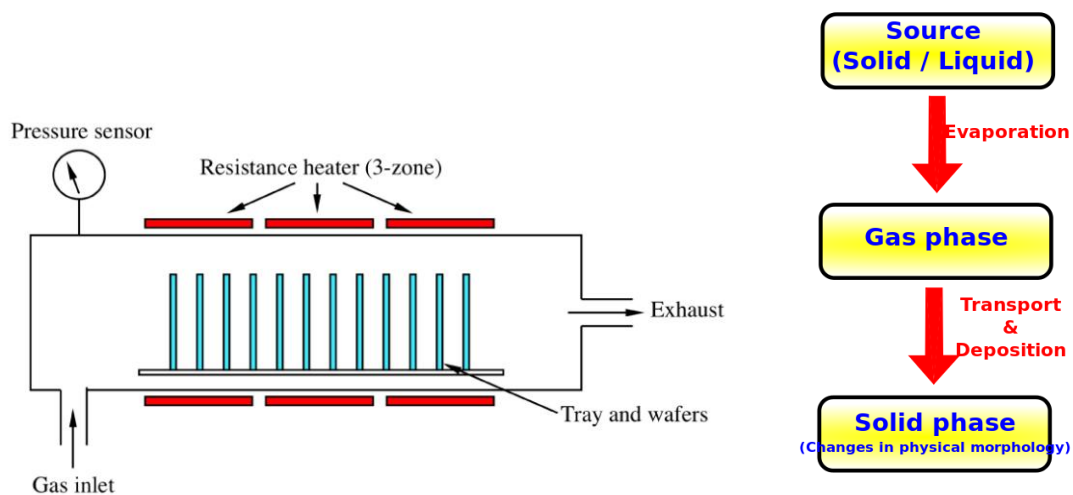


Fig. 3.1: Schematic diagrams of CVD (Left) and PVD (Right) process

In **CVD process** substrate is exposed to one or more volatile precursors, which react and/ or decompose on the pre-heated substrate surface to produce the desired thin film deposit.

In CVD, the film growth takes place at high temperatures, leading to the formation of corrosive gaseous products, and it may leave impurities in the film but deposition rates are very high.

In **PVD process** material goes from a condensed (solid or liquid) phase to vapor phase and then back to thin film condensed phase.

The PVD process can be carried out at lower deposition temperatures and without corrosive products, but deposition rates are typically lower.

### 3.2: Epitaxy & Epitaxial thin film growth modes

**Epitaxy:** If thin film grows with same crystallographic orientation as that of substrate, that type of growth is called epitaxial growth and process is called epitaxy, e.g,

FCC(111) orientation thin film grown on FCC(111) orientation substrate. Or FCC(100) orientation thin film grown on FCC(100) orientation substrate etc.

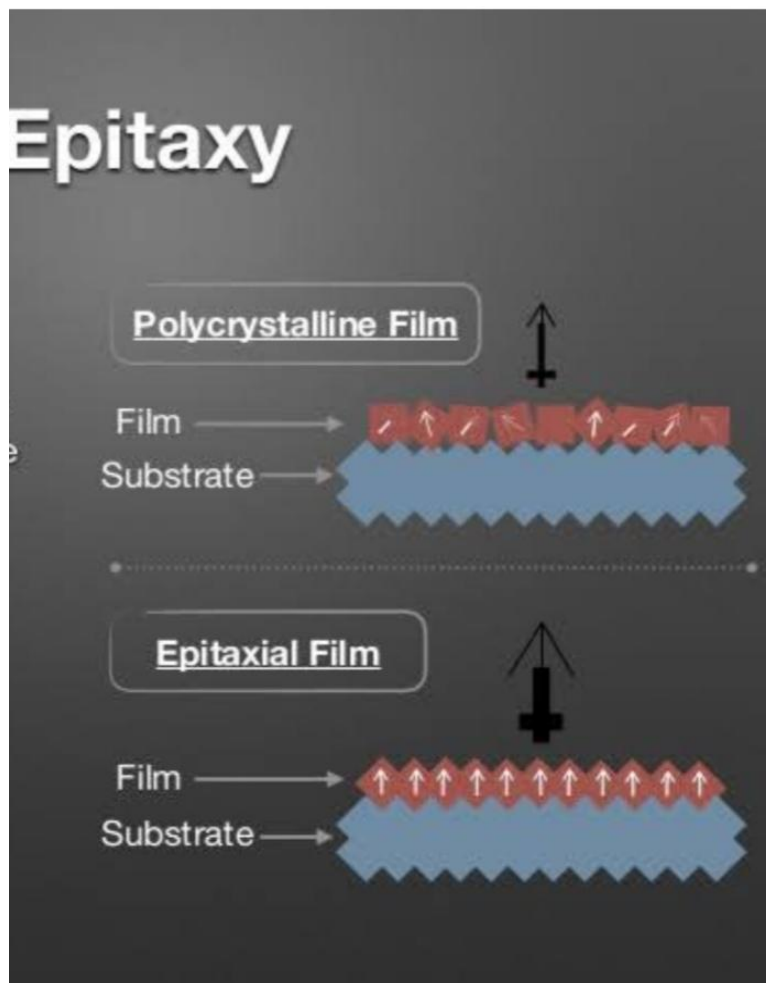


Fig. 3.2: Schematic Thin film Epitaxial growth Process

### 3.3: Thin films Epitaxial growth modes

The growth of epitaxial thin films under thermodynamic equilibrium at higher temperatures during the initial stages is determined by the balance of the different surface free energies involved and follows one of the three well-known mechanisms: The schematic representation of these growth modes is shown in Fig. 3.3.

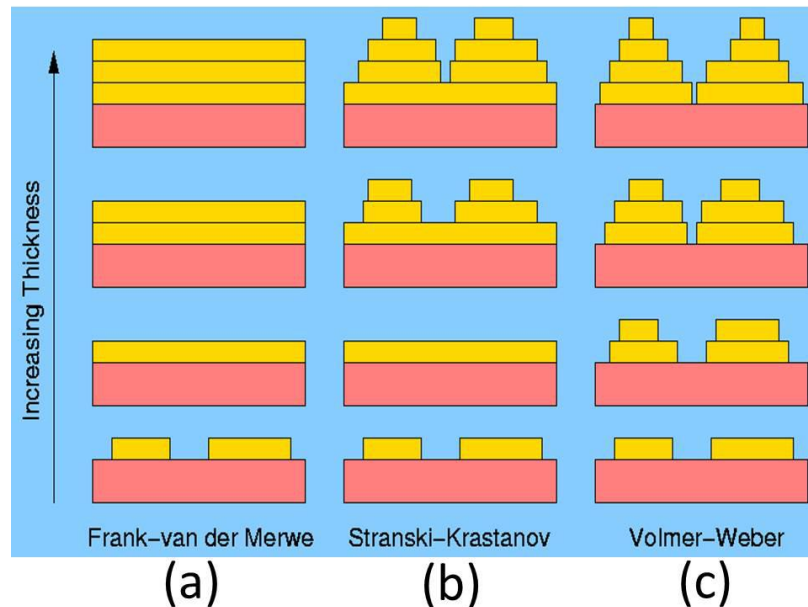


Figure 3.3: Schematic representation of three epitaxial growth modes. (a) Frank-van der Merwe, layer by layer growth (b) Volmer-Weber, island growth (c) Stranski-Krastanov, layer by layer plus island growth [J.J. de Miguel].

#### Frank-van der Merwe mode :

This growth mode is characterized by a layer by-layer deposition. Each monolayer starts to grow after the completion of the previous layer. The interaction between the atoms of the deposited material and the substrate is stronger than the mutual interaction of deposited material atoms. This mode is favourable for materials with same lattice parameters or small lattice mismatch with the substrate.

#### Volmer-Weber mode :

This growth process corresponds to the formation of three-dimensional (3D) islands. The interaction between the atoms of deposited material and the substrate is weaker than the mutual interaction of the deposited material atoms.

#### Stranski-Krastanov mode :

This growth mode corresponds to the nucleation of 3D islands after a layer-by-layer growth of one or several monolayers. However, at lower temperatures in non-equilibrium conditions this is not the case. In this case some roughness, so-called "mounds", is created which can be overcome by tuning the temperature.