Synthesis of Nanomaterials
Course code: 601102

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Thin Film Technology

- A thin film technology is deposition of layer of materials ranging from a nanometer (monolayer) to several micrometers in thickness.
- Electronic semiconductor devices are fabricated through thin film technology.
- The semiconducting material in thin film form has particular interest owing to it has a enormous applications for example: transparent electrodes, photovoltaic devices, solar front panel display, surface acoustic wave devices, low emissivity coating for architectural glass, various gas sensors and heat reflectors for advanced gazing in solar cells.
- Due to surface and interface effects; properties of thin film are different considerably from the bulk and this dominates overall behavior of the thin films.
- Thin film plays an important role in the nanotechnology and nanoscience development. For example: Solar cell is an important application of thin film technology in respect of global energy crunch.
- In solar energy technology the solar radiation converts into useful and constructive electrical energy.
- Window material is the main condition for thin film solar cells, which allows passing through the visible region of solar spectrum but reflects the IR Radiation.
- A large number of different deposition techniques have been used for the construction of thin films for structural, morphological and optical applications.

Thin Film Technology

- Thin films are vital technology to improve the surface properties of solids.
- Transmission, reflection, absorption, hardness, abrasion resistance, corrosion, permeation and electrical behavior properties of a bulk material surface that can be improved employing a thin film.
- According to H. K. Pulker the thin film technology perpormed through two process which are physical vapour deposition (PVD), namely thermal vaporization and sputtering, and chemical vapour deposition (CVD).

PVD processes include:

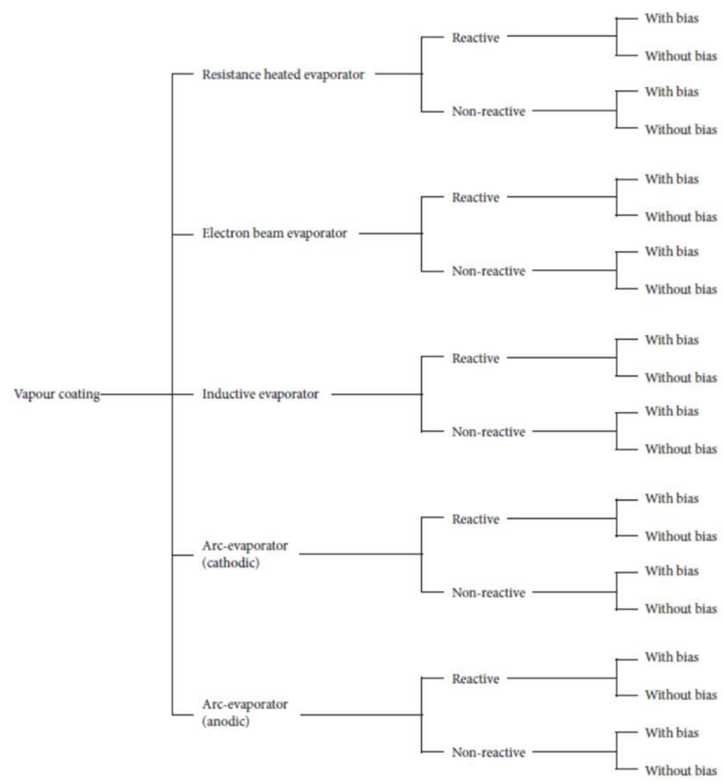
- High-vacuum evaporation, Cathodic sputtering, Ion plating, Ion implantation, Ion beam mixing, Plasma diffusion methods and pulse implantation, Plasma spraying.

Thin Film Technology

High-vacuum evaporation is used in five different evaporation sources:

- **Resistance-heated sources (heated directly or indirectly)**
- **Electron beam evaporators with water-cooled**
- **Copper crucibles or lined crucibles and different deflection angles of the electron beam**
- **Anodic arc evaporators**
- **Cathodic arc evaporators**
- **Induction evaporators.**

Vacuum evaporation methods



Ranges of Vacuum

Low or Rough Vacuum	760 Torr to 1Torr
Medium Vacuum	1 Torr to 10^{-3} Torr
High Vacuum	10^{-3} to 10^{-7} Torr
Ultra-high Vacuum (UHV)	Below 10^{-7} Torr

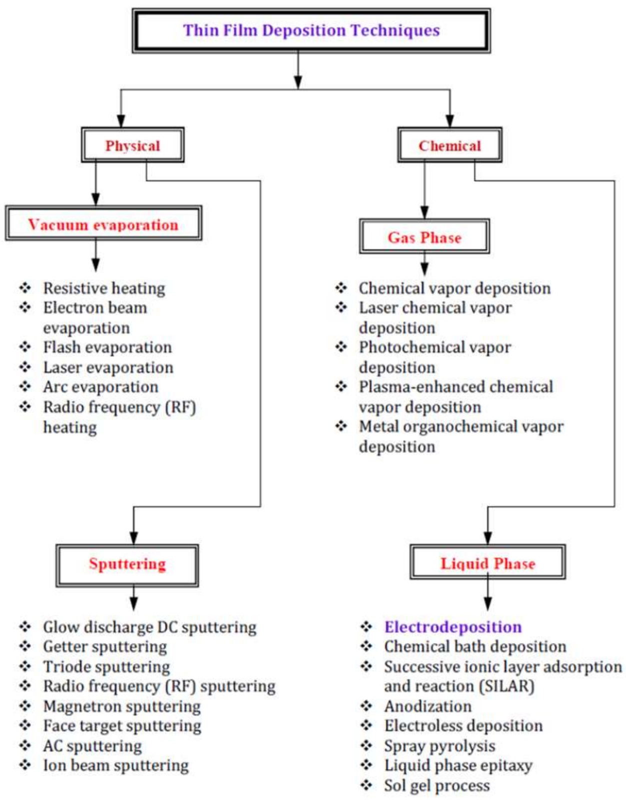
Physical Vapor Deposition Vs Chemical deposition

- **Michael Faraday pioneered the first PVD process in the early 1800's.**
- **Sub processes of PVD including electron beam, sputtering, thermal, and plasma arc deposition methods.**
- **The PVD process typically use of inorganic elements or compounds and gases.**
- **Where as the CVD process use of dip coating and spinning, liquid inorganic and organic compounds and gases.**
- **Liquid compounds and gases are normally purchased directly from the producer, because it needs no special preparation.**
- **Solid materials needs to be compact and in the suitable form or shape, free of gas inclusions or even are prepared according to a distinctive recipe.**
- **Targets must also fulfill structure requirements i.e. grain size, texture, precipitation.**

Summary of PVD process

Process	Deposition rates ($\mu m\ s^{-1}$)	Pressure (Pa)	Particle energy (eV)	Process temperature	Adhesion
Evaporation	0.05–25	10^{-3}	<2	T as required	+
Sputtering	0.0001–0.7	10^{-1}–1	10–100	$<T$ as required	++
Ion plating	0.01–25	10^{-1}–1	80–500	$\ll T$ as required	+++

Classification of thin film technology



CVD process

Process	Abbreviation
Atmospheric pressure chemical vapour deposition	APCVD
Low-pressure chemical vapour deposition	LPCVD
Metal-organic chemical vapour deposition	MOCVD
Plasma-assisted chemical vapour deposition or Plasma-enhanced chemical vapour deposition	PACVD or PECVD
Laser chemical vapour deposition	LCVD
Photochemical vapour deposition	PCVD
Chemical vapour infiltration	CVI
Chemical beam epitaxy	CBE

Rate Calculation

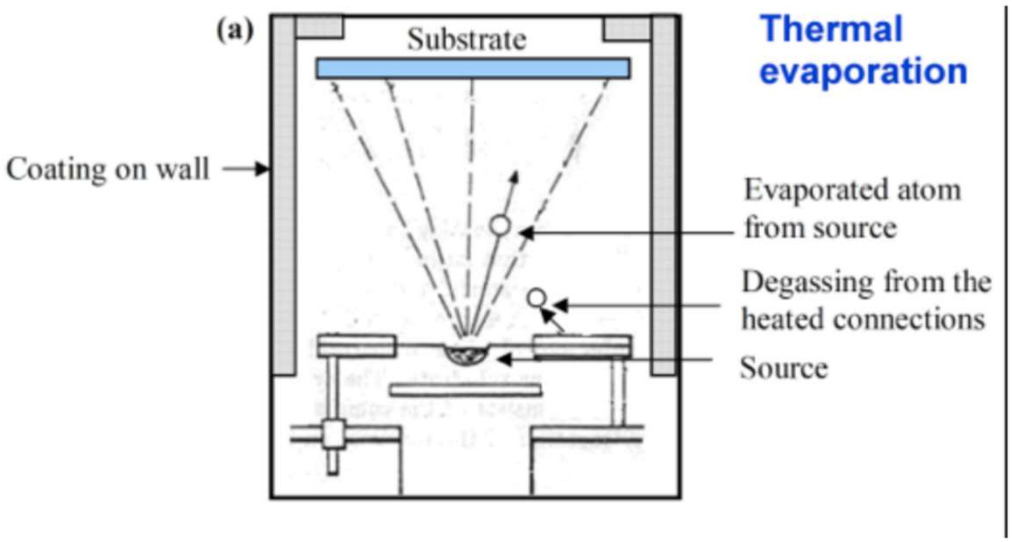
- **The rate calculated by the Langmuire-Knudsen equation gives the rate in units of grams per square centimeter seconds.**

- **The experimental rate should look like**

$$R_{exp} = \frac{m}{At}$$

The mass m in the equation is the change in mass, or the mass of Al deposited, of the slide. Measuring the slide pre and post deposition is an easy task, but the scale used needs to be capable of measuring differences of milligrams at minimum. Calculating the filmed area of the slide required a more creative approach.

Thermal Evaporation



Disadvantages: High melting point materials, uniformly heating, rapidly change of deposition rate, reactions between the source and the heating container.

Thermal Evaporation deposition

- Thermal evaporation deposition is the most basic method used to produce thin films.

To be continued------

Reference

- **Freyand, H. and Khan, H.R. Handbook of Thin Film Technology*, (2015)* Springer, Berlin, Heidelberg.**
- **Nicolaus, M. and Schäpers, M. Fundamentals of Thin-film Technology. Modern Surface Technology, (2006)31–50*.* doi:10.1002/3527608818.ch3**