Thin films

Lecture (1)

Nanomaterials:- are structures at the nanometre-scale (a nanometre is 10 power of -9 of one metre), a scale, comparable to that of atoms and molecules and almost a hundred thousand times smaller than the diameter of a human head's hair

How nanomaterials are classified according to the effect of Quantum confinement

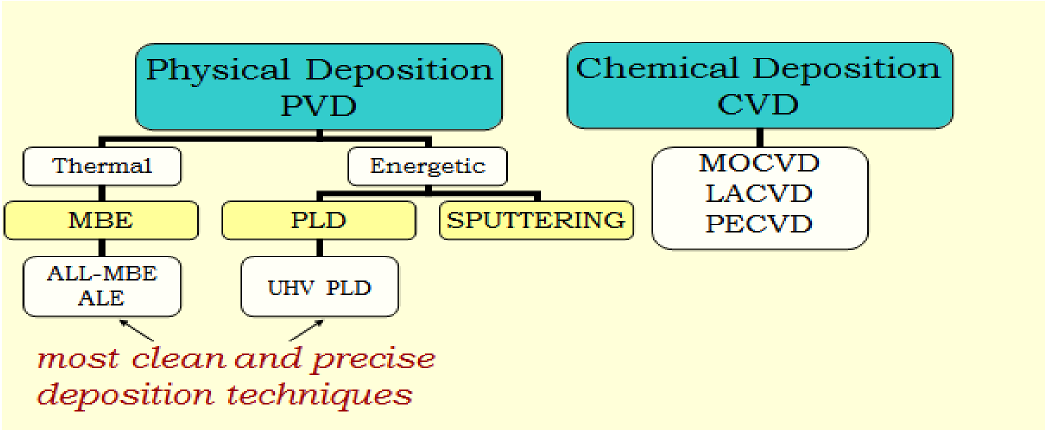
1. Zero-dimensional (0D) structure or quantum dot: The extreme case of this process of size reduction in which all three dimensions reach the low nanometre range is called a quantum dot. Such as nanoparticle Typical dimensions: 1-10 nm ny nz nx.
2. One-dimensional (1D) structure or quantum wire: If two dimensions are reduced in to the nanometre range and remain large the structure to as a quantum wire. such as nanorods and nano tube (1D structures)1-100 nm range (Typical nano- scale dimension) kx nz ny.
3. Two-dimensional (2D) structure or quantum well: Quantum confinement in nanostructure-If one dimension is confined or reduced to the nanometre ranges while other two dimensions remain large then we get a structure called quantum well. Such as thin films.
4. Three dimensional (3D) structure or bulk structure: No quantisation of the particle motion occurs. Such as cube.

What is a "thin film"

thin = less than about one micron (10,000 Angstroms, 1000 nm) film = layer of material on a substrate

(if no substrate, it is a "foil")

A thin film is defined as thin layer built up on a solid support by controlled condensation of the individual atomic, molecular, or ionic species, either directly by a physical process, or via a chemical and / or electrochemical reaction. Since individual atomic, molecular, or ionic species of matter may exist either in the vapor or in the liquid phase, the techniques of the thin film deposition can be broadly classified under two main categories



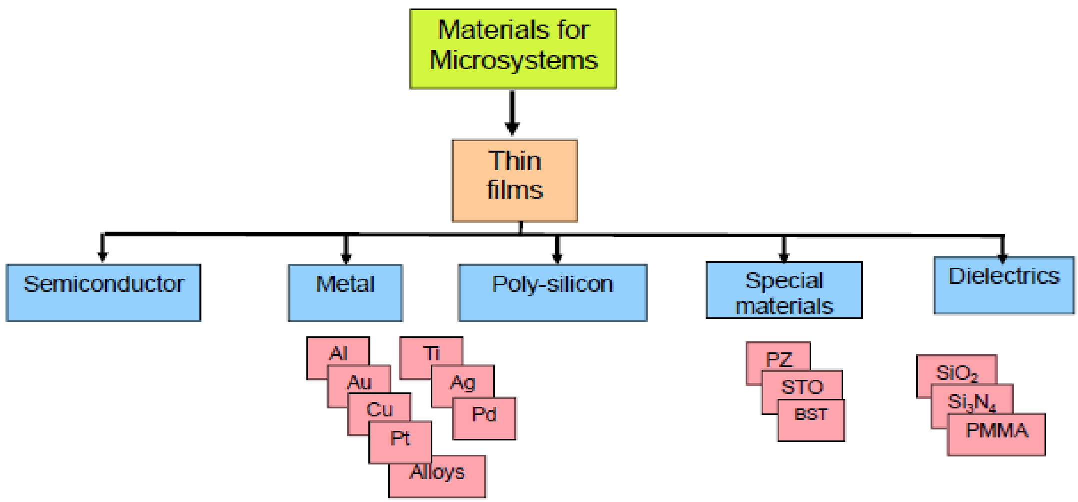
Others types to deposition films

- Electroplating (for very high thickness films, fast process, less control on thickness)
- Spin-cast
- epitaxial

Thin films technique is one of the most fledged technologies that greatly contribute to developing the study of semiconductors by giving a clear indication of their chemical and physical properties. Thin films are also particularly important for their use in a great number of the optical field such as manufacturing of ordinary and thermal mirrors of high specialized filters, photo detectors and solar cells.

Investigation on the basic properties of the thin films can be grouped roughly into two categories. The first is concerned with change of the physical properties as thickness decreased, mean free path effects on the electrical conduction of thin metal films, studies of magnetization of thin films of ferromagnetic materials as function of film thickness, electron tunneling effects and effects due to the adsorption of gases are example of this category. These investigations all have the film thickness as the principle parameters. The second category of investigations is the study of the film structures.

Most, optical, magnetic, chemical, electrical properties of films are of importance in an ever widening sphere of industrial, scientific and technical applications. At the same time studies of the fundamentals of film formation and of the basic reasons for differences in behavior of films and bulk materials are being pursued with increasing vigor. The structure and properties of many films are known to depend considerably on the state of the surface on which they are deposited to know exactly what kind of surface is being used for deposition of films, whether it is crystallographically oriented or not.



Typical steps in making thin films

- emission of particles from source (heat, high voltage . . .)
- transport of particles to substrate
- condensation of particles on substrate
- Favorable conditions are created to transfer the material from the source (target) to the destination (substrate).

The nature of the film deposited depends on process parameters like substrate, deposition temperature, gaseous environment, rate of

deposition etc.

Special Properties of Thin Films

Different from bulk materials

Thin films may be:

- not fully dense
- small thickness
- different defect structures from bulk
- quasi - two dimensional (very thin films)
- strongly influenced by surface and interface effects

This will change electrical, magnetic, optical, thermal, and mechanical property

Film composition

- Grain size
- Thickness
- Uniformity
- Adhesion
- Corrosion resistance

Selection of Materials for Microsystems

- Mechanical properties
- Elasticity (Young's Modulus)
- Chemical and electrochemical properties
- Bio-compatibility issues
- Electrical characteristics
- Conductivity
- Mobility
- Thermal properties
- Heat conductivity,
- Expansion coeff.
- Processing issues
- feasibility
- Optical properties
- Roughness, crystalline