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Development of Thin Films and study of electrical properties

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Abstract:
Thin films are playing a vital role in day-to-day life. Thin film technology has drawn considerable interest of the researchers due to their emerging applications in every field. Thin film technology is extended to versatile field like optical electronics, semiconductors, solid state etc. The different Physical and chemical deposition techniques of thin films are discussed.
And thin film electrical properties are discussed.

Introduction:

Thin film is a layer of material whose thickness ranges from nano to micro meters [ ]. Several properties like electrical resistivity, optical, electric and magneto properties of bulk materials are limiting their application. Thin film is macroscopically large in length and width, but its thickness is reduced to micron order. A drastic change is observed when the thickness of such materials is reduced. Thin films are such materials that are considered to be highly stable, hard and brittle. The variation in properties of thin materials is due to their reduce in thickness, surface to volume ratio, and a unique physical structure that depends on the deposition technique of the thin film. They can be either crystalline or non-crystalline in nature. Thin film technology are the basic elements for various technological advances in the field of magnetic, semiconductor devices and optoelectronic devices.
Thin film technology plays a crucial role in the high-tech industries due to their growing applications in microelectronics, communications, optical electronics and in energy generation and conservation strategies. A thin film can be defined as any solid or liquid layer with one of its dimensions much less than the other two. Usually the film thickness varies from a few angstroms to few microns. An ideal film can mathematically be defined as a homogeneous solid material contained between two parallel planes and extended infinitely in two directions, say x and y, but restricted along the third direction z, which is perpendicular to the x-y plane. The dimension along the z direction is known as the film thickness. But a real film does not conform exactly to the ideal one since its two surfaces are never exactly parallel even when formed in the best experimental deposition conditions. The most common phenomenon associated with thin films, which attracted the attention of physicists as early as the second half of the seventeenth century is that of interference colours on a thin film of oil spilled on water or on a wet pavement. Studies on thin film interferences provided the means for exact measurements of thin film thickness and found applications in optical and other fields. The interference colours are utilized in antireflection filters and various decorative coatings. The beginning of this century has led to the study of superconductivity as well 2 as the

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emission of electrons from the films. As a result, extraordinary rapid advance has been made in the film technology in recent years.

Advances in science and technology are demanding for different types of thin films to explore in various technological fields. Applications of thin films is extended to different devices like MEMS, lithography, LCDs, LEDs, ICs, rectifiers, transistors, Solar cells, as well as other emerging technological devices. Properties of thin films are controlled by its thickness depending on its deposition methods. Thin films are cost effective with less number of fabrication materials and occupy less space. There are vast methods of thin film deposition technologies. Every method has its own limitations with respect to substrate limitations. In view of the above in the current paper the author concentrates on the review of deposition techniques and characterization of thin films.

1.1 Preparation of thin films

Many deposition methods have been developed depending upon requirements such as thin filmpurity, structural quality, thickness and other factors [1]. Deposition of thin films is through two different techniques (i) Physical deposition method (PVD) (ii) Chemical Vapor deposition method (CVD)

If the vapor is created by physical means in the absence of a chemical reaction, the process is called as Physical vapor deposition. If the vapor is made through a chemical reaction, the processes are called as Chemical deposition method.

Physical deposition method (PVD)

Physical deposition uses mechanical, electro chemical (or) thermodynamic means to produce a thin film of solid. The material to be deposited is placed in an energetic, entropicenvironment, so that particles of material escape from its surface. Facing this source is a cooler surface which draws energy from these particles as they arrive, allowing them to form a solid layer. The whole system is kept in a vacuum deposition chamber, to allow the particles to travel as freely as possible. Since particles tend to follow a straight path, films deposited by physical means are commonly directional, rather than conformal.

In Molecular Beam Epitaxial (MBE) slow streams of an element is directed towards the substrate, sothat material deposits one atom layer at a time. Compounds such as gallium arsenide are usually deposited by repeatedly applying a layer of one element (i.e. gallium),then a layer of the other (i.e. arsenic),so that the processes is chemical, as well as physical this is known also as atomic layer deposition.

Pulsed laser deposition systems work by an ablation processes. Pulses of focused laser light vaporize the surface of the target material and convert it to plasma; this plasma usually reverts to a gas before it reaches the substrate [2]

In sputtering technique deposition is a physical vapor deposition method of thin films. Usually a noble gas such as argon knocks the material from a target. The target can be kept at relatively lowtemperature. It is especially useful for compounds or mixtures, where different components would otherwise tend to evaporate at different rates. Presently, Nitrogen and Oxygen gases are also being used in sputtering technique. It is also widely used in the optical media. The manufacturing of all formats of CD, DVDis done with the help of this technique. It is a fast technique and also it provides a good thickness control.

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Chemical Vapour Deposition (CVD)

A fluid precursor undergoes a chemical change at a solid surface, leaving a solid layer. An everyday example is the formation of soot on a cool object when it is placed inside a flame. Since the fluid surrounds the solid object, deposition happens on every surface, with little regard to direction.

Chemical solution deposition (CSD) uses a liquid precursor, usually a solution of organometallic powders in an organic solvent. It produces stoichiometrically accurate crystalline phases. Compare to other depositions it is inexpensive and simple thin film process. This technique is also known as the sol-gel method

Spin coating, uses a liquid precursor deposited onto a smooth, flat substrate which is subsequently spun at a high velocity to centrifugally spread the solution over the substrate. The speed at which the solution is spun and the viscosity of the sol determines the ultimate thickness of the deposited film. To increase the thickness of films as per requirement repeated depositions can be done .thermal treatment is often carried out in order to crystallize the amorphous spin coated film (3)

Dip coating is similar to spin coating in that a liquid precursor or sol-gel precursor is deposited on a substrate but in this case the substrate is completely submerged in the solution and then withdrawn under controlled conditions. By controlling the withdrawal speed the evaporation conditions such as temperature and the viscosity of the solvent, the film thickness, and homogeneity and nanoscopic morphology are controlled. There are two evaporationways: the capillary zone at very low withdrawal speeds and the draining zone at faster evaporation speeds (4)

Plasma enhanced CVD (PECVD) uses an ionized vapor, or plasma, as a precursor. Unlike the soot example above, commercial PECVD relies on electromagnetic means, rather than a chemical reaction, to produce plasma.

Atomic layer deposition (ALD) uses a gaseous precursor to deposit conformal thin films one layer at a time. One reactant is deposited first, and then the reactant is deposited, during which a chemical reaction occurs on the substrate, forming the desired composition As a result of the step wise, the processes is slower than CVD,however it can be run at low temperatures, unlike CVD

Electrical Properties:

Semiconducting behaviour was originally observed in the bulk phthalocyanines in 194832,33. In due course these measurements were followed by those on single crystals of H2Pc which showed space-chargelimited conduction (SCLC), a conduction mechanism previously described by Rose34,35. In SCLC, conduction occurs by direct carrier injection from suitable electrodes. When the applied voltage reaches a certain limit, the injected majority carrier concentration exceeds the thermally generated carrier concentration and hence the space charge limited current becomes dominant. SCLC requires an ohmic contact between the semiconductor and at least one of the electrodes, which must continuously supply carriers. An ohmic contact forms when the work function of the metal electrode is greater than that of the semiconductor. Sussman identified SCLC in CuPc thin films and described the sensitivity of CuPc films to ambient gases such as nitrogen, hydrogen and oxygen36 and effectively laid the foundations for much of the subsequent work on phthalocyanine gas detectors. More recently, it has been established that phthalocyanine thin films do not only exhibit SCLC, but may also display other high-field conduction processes such as the Schottky and Poole-Frenkel effects37,38. Schottky effect is an electrode-limited conduction process that arises when the film is too thick for tunnelling to take place. It is the field-assisted lowering of a potential barrier at the injecting electrode and a Schottky contact forms when the work function of the metal electrode is less than that of the semiconductor. Poole-Frenkel effect is a bulk-limited process and is often referred to as the bulk analogue of the Schottky effect. It is the field-assisted lowering of the coulombic potential barrier between carriers at the impurity level and the edge of the conduction or the valence band. Another bulk-limited conduction process, which has been observed in phthalocyanine thin films is known as hopping39. In non-crystalline materials, the lack of long-range 11 order gives rise to a phenomenon known as localization in which the energy levels do not merge into one another. The effect of this is that in order for carriers to be transported through the material and to contribute to the conductivity they have to proceed by a series of jumps or hops from one localized energy level to another. Since the localized levels are normally very close in energy, the thermal energy required is very small and therefore this process can occur at very low temperatures when other conduction processes are precluded.

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