Preparation and Characterization of Cadmium Chalcogenide thin films by various methods: Review

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***Abstract* - In today's community, thin films have found immense use. Thin-film research has brought several new fields forward directly or indirectly. Due to their many characteristics, thin films provide a wide scope for tiny electronics. Multilayer thin films should show much more improved characteristics compared with monolayer thin films. This article examines the manufacturing methods, benefits, and uses of thin films with several layers. Continuous technical progress in the areas of optoelectronics and photonic devices is made on multilayer thin films. Different methods may describe thin, layered films. In this paper the preparation of strong thin films using CdX [X means S, Te] with properties.**

***Index Terms* - CdX, thin films, Characterizing Techniques, preparation methods, comparison.**

I.INTRODUCTION

Chemically important II-VI semiconductors with many outstanding physical and chemical features, cadmium chacogenide nanoparticles with promising application in several technical fields including photochemical catalysts, gas sensors, laser and infrastructure detectors, solar cells, nonlinear optical materials, various lighting equipment, and so on. They are also the most promising candidates for the detection of visual radiation between II-IV compounds. Cd chalcogenide was produced by different techniques in thin-film form ete [1]. The ability to adjust particles' characteristics by checking their sizes and nano-practical form-dispersions, For example, by solvothermal method with cadmium chloride and thiourea in cadmium solution, the nanoparticles of the CdS were assembled in Cds nanorods and bundles of nanorods in thioglic acid, cadmium-sulfide nanorods were also synthesized in micro-emulsions formed by nano mic surface, For example, sea-urchins were made like cadmium sulfide nanoparticles with nano mic architecture [2].

II. PROPERTIES OF THIN FILMS

A.Thickness

The thickness of a film is influenced by certain physical characteristics such as its quantum size, the color of the film, etc. With the deposition of several layers, the thickness of the film rises. Compared to the double layer and the multilayer, the monolayer thickness is smaller. It also relies on the method of filing and on the time of filing [3].

B. Optical characteristics

The CdS thin film is optically transmitted in the range of 40% to 50% for a wavelength of 500nm. Due to the ringing effect, the bandgap is decreased. Wide emission bands have been obtained, the green emission is doubled owing to annealing while the red emission is enhanced slightly [4]. Zn-CdS thin film optical transmitting properties were found at room temperature at wavelengths between 300 and 900 nm. For the Zn-CdS thin film, the measured optical transmission is approximately 85%. The optical edge of the stated large band gap value was likewise confirmed to be Blue.

C. Electrical Properties

The current fluctuation with temperature for CdS thin films exhibits a temperature-dependent current's exponential trend. CdS thin films showed 0.53 eV activation energy. Two probing methods were used for measuring ZnS thin film resistivity and found to be 0.46X104 /cm 0.89eV with activation energy at 5000K [5] [6].

D. Multilayer Thin Film Advantages

Thin films in multilayer have distinct physical characteristics than the thin films in a monolayer. Due to conversion performance, reliability and availability of low-cost multi-component device manufacturing are chosen. There are varying indices of refraction in various layers of the film. Two or more light wavelengths are also conceivable to provide the conditions for minimal reflective losses. Electricity is more important than the thin layers of a single film [7].

E. Small Film Applications

Semiconducting devices, wireless, integrated, telecommunications, rectifying, transitive, solar cell, light-emitting, light crystal displays, magneto optics, audio, and video systems, compact discs, electro-optic coating, memories, multi-layer condensers, flat panel displays, smart windows, computer chips, magneto-optic boutique are used in thin-film materials. Some additional uses include thin films for data storage, flat panels, optoelectronics, optical coatings, thin foil ion batteries, and so on [8]-[9].

III. TECHNICAL CHARACTERIZING

Principal characterization methods are available for the study of thin films. The interference fringe's width and height are measured using the multi-beam interferometer. In micro-meters and nano-meter lines, the interference fringe measures the thickness of the film [10]

Spectroscopy of UV-visible

A commercial spectrophotometer, which can record spectra within a visible range as well as near-infrared and UV, is used for absorption spectrum and transmission. Spectral investigations have reported valuable solid-state material information. Optical spectroscopy is presently used as one of the most powerful and extensively used analytical technology and offers a highly dependable approach for material characterization. The spectrum of optical absorption is a measure of absorption according to the length of waves of the incident light. If the light dispersion percentage is minimal, the light absorbed or transmitted should be taken into consideration. Additional information on the type of semiconductor materials bandgap (ie direct or indirect), and the magnitude of bandgap are also provided in absorption spectrum investigations. Such investigations assist in particular to establish optical constants comfortably in the thin films [11-12].

XRD

The X-ray diffraction of thin, fixed pH value and temperature films is XRD-pinned at various diffraction angles. The airplanes show the material structure. Airplanes can see the direction of grain development. The Scherrer's equation may also determine the average crystallite size from the most conspicuous point: The value of k is 0.94, the entire width at half the intensity in the peak is a radius, β is a Bragg diffraction angle, the full-width β is a radius of half the maximum intensity, β is the X radio wavelength (1.5406 Å) [13]. For morphological examination of thin film, the Scanning Electron Microscope (SEM) is employed. The microscope of the scanning probe is an electron microscope that produces high-grade surface resolution pictures. SEM magnification is the ratio of the final image display size to the scanned field on the specimen. In nanometers, the SEM magnification range may be. SEM is a product of high-speed compositional analysis from morphological and topologic investigations [14] to [15].

AFM Nuclear Force

The force between a tip and a sample is measured by microscopic action. The strength may be appealing or disgusting. The deflection of the cantilever as the tip is scanned through a sample or below the tip of the sample. A plot of surface topography is made of the measured cantilever deflection [16].

EDS

EDAX or EDX has also been recognized in energy dispersive spectroscopy. In this method, a sample in an X-ray tube is produced and electrons with appropriate energy are assaulted. X-rays emit characteristics for chemical analyses. An X-ray spectrometer is used to examine transmission rays and subjectively identify the components contained in the test by their wavelength characteristics. In the wavelength dispersion spectrometer, the energy dispersion instruments' resolution is 50 times lower [17]. The microscope of the transmission electron (TEM) displays nano-particles pictures. The transmitted electron beam through the examined material produces a 2D picture. The surface features within and beyond may be examined by TEM. It has a high resolution, e.g. to anguish [18].

IV. SEVERAL TECHNIQUES ARE USED TO PREPARE THIN FILMS

CdS and CdTe thin films have been successfully prepared using a variety of methods, including chemical bath deposition [19], spray pyrolysis [20], thermal evaporation [21], the sol-gel approach [22], and chemical vapor deposition , The effects of Ni doping on the structural and magnetic characteristics of CdS and CdTe thin films have been thoroughly studied. As far as current-voltage characteristics and optical property research are concerned, most studies focus on the absorption spectra of the films that have been deposited. This research only allows for the identification of the optical band gap. These thin Ni-doped CdS films will be examined to see how Ni-doping concentration impacts the electrical characteristics of Ni: CdS/p-Si hetero junctions, as well as their structural, optical, and electrical features.

Physical vapor deposition (PVD)

To quantify thin film deposition techniques that need condensation of vaporized solid material on solid material surfaces under partial vacuum, PVD is a general term. This atomistic deposition method uses a vacuum or low-pressure gaseous or plasma environment to discharge atoms or molecules onto a substrate and then condense and nucleate those atoms. The vapor phase typically contains plasma or ions as its components. Reactive deposition is the process of adding a reactive gas to a vapor as it is being deposited. The atoms or molecules are transported to the substrate's surface in the form of vapor in a vacuum or low-pressure gaseous or plasma environment for condensation. In most cases, PVD techniques are utilized to deposit very thin films (less than one nanometer in thickness)

Process of thermal evaporation

The vaporized target material from the thermal process sources reaches the substrate material with minimum interference during the thermal evaporation process. Line-of-sight trajectories are used when the procedure is carried out at high vacuum pressure (HV) with a straight route as the target material's path to the substrate. In a vacuum, vapor flux is generated by rapidly heating the surface of the source material to a high temperature. A thin film of the flux may be formed by allowing it to condense on the surface of the substrate material. By creating a vacuum, impurities in the deposition process are reduced to an acceptable and minimum level, and evaporated atoms may be transported from the source to the substrate without colliding [23]. According to the degree of contamination in the deposition system, the gas pressure ranges from 0.0013 to 1.3 109 Pa, and the mean free path (MFP, the average distance between species collisions) is no less than 5 mm. When compared to other PVD techniques, the thermal vaporization rate may be very high. Heating the target material to a high temperature is typically accomplished using tungsten wire coils or a high-energy electron beam.

Chemical Bath Deposition, Section

A glass substrate coated with FTO was used to implant CdS nano-particles produced using (CBD). This procedure removes undesirable chemicals and particles from the FTO substrate's surface that may lead to unstable growth or impure chemical ingredients by using acetone, methanol, and de-ionized water to clean the FTO ultrasonically, When the chemical bath was ready, the substrate was immersed vertically using a holder in it, and it contained varying concentrations of CdCl2with (0.0125), NH4Cl with (0.040), thiourea with (0.0125), NH3 with (0.035), and 15 ml of NH3 with constant stirring and a fixed temperature of 80^{oC} for the chemical bath.

Spray pyrolysis section

Creating thin cadmium telluride layers It’s important to note that the main function of spray pyrolysis is chemical deposition, in which tiny droplets of the necessary material are sprayed on an elevated surface. As the material droplets heat up, they decompose into thin films that cover the heated substrate. The equi molar (0.125 M) solutions of cadmium chloride and thiourea ((NH2)2CS) in cadmium chloride were made by dissolving appropriate quantities of salts in double-distilled water (CdCl2). Experimentally, these solutions were mixed in an equal parts ratio (1:1) and sprayed at constant temperatures between 275 and 350 degrees Celsius, every 25 degrees; on fluorine-doped tin oxide coated glass substrates (sheet resistance 10/cm2). The surface temperature was controlled using an iron-constantan thermocouple. The films adhered effectively to the substrates thanks to the electrolyte's aqueous polysulphide (this was determined by evaluating the stability of CdS film electrodes). A semiconducting layer will be formed no matter how finely you spray as long as there is sufficient contact time between your hot spray and your hot substrate.

V. CONTRAST BETWEEN THE CDC AND OTHER

A scanning electron microscope was used to examine the cadmium chalcogenide thin-film formations even further (SEM). Crystallites with a roughly spherical form are polycrystalline, with a relatively smooth surface and distinct crystallite boundaries. These morphologies with a single kind of tiny spherical crystallites were shown by SEM micrographs. As a result of Scherer's connection and their SEM tests, the average crystallite sizes had the same tendency.

Table 1:Cadmium chalcogenides thin-film characteristics

Cadmium Chalcogenide	Band gap energy, Eg, eV	Power factor, m	Carrier Density, n, 1019 cm-3	Carrier Mobility, µ, 10-5, cm2/ V.s
CdS	2.43	0.49	2.32	1.05
CdSe	1.72	0.47	3.82	1.2
CdTe	1.45	0.44	4.03	1.53

Table 2: The relative intensities of cadmium chalcogenide thin films have prominent peaks.

Cadmium Chalcogenide		No. of prominent peaks with their relative intensities					Lattice parameters, 1 2 3 4 5 A.U.	
		1	2	3	4	5	a	c
CdS	Peak	(111)	(200)	(220)	(311)	--	5.87	--
	I/Imax	67 %	100 %	84 %	36 %	--		
CdSe	Peak	(100)	(2)	(101)	(110)	(202)	4.28	6.98
	I/Imax	73 %	89 %	100 %	52 %	39 %		
CdTe	Peak	(2)	(110)	(211)	--	--	4.54	7,45
	I/Imax	100 %	65 %	41 %	--	--		

VI. CONCLUSIONS

It is confirmed by structural analysis that the prepared films are CdS and CdTe with the greatest preferred plane of orientation being (002) for Cadmium Sulfide (CdS) and (111) for Cadmium Sulfide (CdTe). Band gaps for CdS are found to be 2.2 eV, whereas those for CdTe are 2.29 eV, according to optical investigations. To create the Cadmium chalcogenide thin films, we used the chemical bath deposition method, which is simple, cost-effective, and scalable. It also allows us to deposit vast areas of material over time and in a variety of growth environments. All of these characteristics make these films ideal for usage on a variety of substrates. The optical band gap energies were also investigated, as well as the nature of the transitions in these thin films.

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