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Structural And Morphological Studies Of Microwave-Assisted Cds Thin Films

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Abstract: In this work, thin films of Cadmium Sulphide (CdS) deposited on glass substrate by microwave assisted chemical bath deposition was studied and reported. The structural and morphological properties of as-deposited films and the thin films annealed at 200°C were investigated using X-ray dffractometer (XRD) and scanning electron microscope (SEM) respectively. The diffraction pattern revealed the crystalline nature of the as-deposited and annealed CdS thin films. The films that were annealed exhibited better crystallinity and EDAX analysis confirmed the presence of cadmium and sulphur.

***Index Terms* -** CdS thin films, Structural properties, X-ray diffractometer, Scanning electron microscope.

I. INTRODUCTION

II-VI semiconductor compounds comprising of mainly zinc and cadmium chalcogenides exhibit a large range of electronic and optical properties due to the wide variations in their energy gap. Among these compounds, cadmium telluride has the least bandgap of about 1.45 eV (infrared region), while zinc sulphide has a bandgap of 3.66 eV (ultraviolet region) and the band gap of CdS (2.4 eV) [1, 2]. All these compounds have direct band gaps, which makes them highly efficient for optoelectronic devices. They also have high absorption co-efficient, which means that a tiny amount of the material can absorb relatively large amount of radiation energy. Because of these attractive electrical and optical properties, II-VI compounds have many potential applications, such as in the manufacture of solar cells, LEDs, photo detectors, phosphors in lighting and displays, protective windows and optical elements, nuclear radiation detectors etc. The synthesis of binary metal chalcogenides in crystalline form has been a rapidly growing area of research due to their key physical and chemical characteristics.

Considerable research efforts have been devoted to cadmium sulphide thin film in the last 20 years, owing to their promising uses. CdS has been used for electronic devices, like field effect transistors [3], photoconductors and solar cells. CdS thin films are extensively used as window materials for CdS/CdTe and $CuInSe_2$/CdS solar cells [4, 5]. Recently, the properties of CdS thin films have been widely researched by many researchers.

Various techniques have been employed to deposit thin films including microwave assisted method, electro deposition [6], chemical bath deposition [7,8,9], spray pyrolysis [10,11], vacuum evaporation [12], pulsed laser deposition [13] and sputtering [14]. Among these, the microwave assisted method is more attractive since the technique possesses a number of advantages over the conventional thin film deposition methods. Microwave assisted method does not require an expensive vacuum system as it involves a simple evaporation and condensation principle. This method allows for relatively easy control over the deposition parameters and may require the use of a catalyst. It is essentially based on microwave heating of the precursor solution and is quite fast, simple and efficient.

In this work, the structural and morphological properties of as-deposited and annealed CdS thin films is studied and reported.

II. Experimental Techniques

CdS thin films were grown using microwave assisted chemical bath deposition technique. The commercially available microscopic glass slides were used as substrate. Glass slides were placed in concentrated sulphuric acid solution for 24 hours, washed with distilled water, cleaned with ethanol solution and finally dried.The precursor solution was prepared from a solution containing 0.2 M Cadmium sulphate ($CdSO_4$), 0.6 M Thiourea ($SC(NH_2)_2$ and 1 M ammonia (NH_4OH). The pH of the solution was adjusted to 10 by adding ammonia. The cleaned glass slides were inserted vertically inside a clean beaker containing precursor solution. The deposition of the film was carried out in a microwave oven under optimum condition with the deposition time set at 120 seconds. After deposition, the films were rinsed in distilled water to remove the particles that are loosely adhered on the film and then dried in air. Additionally, the films were tempered at 200°C in an air atmosphere.

XRD of the as-deposited as well as annealed films were carried out to study the crystalline nature of the films. The surface of the thin films was examined using SEM, while the elemental composition of the films was analyzed through EDAX.

III. Results and Discussions

Structural characterization:

Fig.1 and fig. 2 shows the XRD pattern of as-grown and annealed CdS thin films. Both the as-grown films and the films annealed at 200°C were observed to be crystalline. From the figure, the intensity of the XRD peaks was observed to increase after annealing.

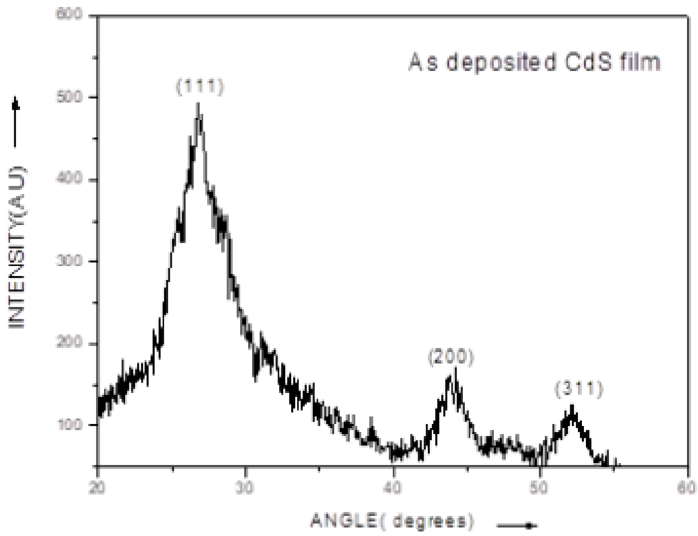


Fig. 1 XRD profile of as-grown CdS thin films.

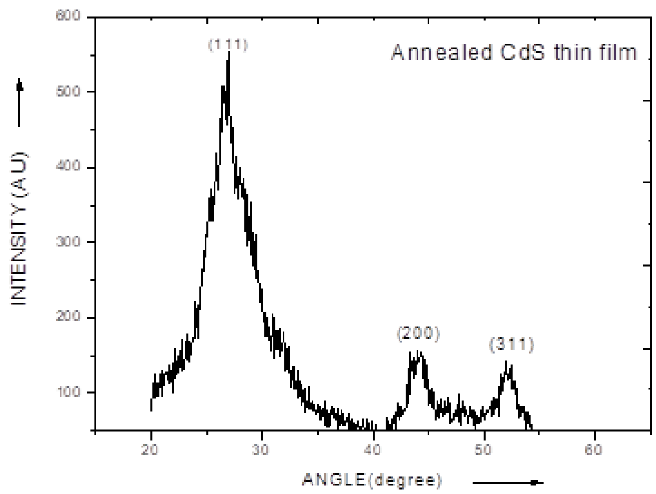


Fig. 2 XRD profile of annealed thin films.

The films were estimated to have a cubic crystal structure with three peaks at 2θ ~ 26.6°, 43.98° and 52.23° of (111), (200) and (311) reflections respectively. The intensity of (111) peak is much higher compared to the other two peaks, indicating a FCC crystal structure. The diffraction patterns of the films are found to match well with the JCPDS card No. 10-0454 [15, 16].

The average crystallite size (D) was estimated using Scherer's equation [17-19].

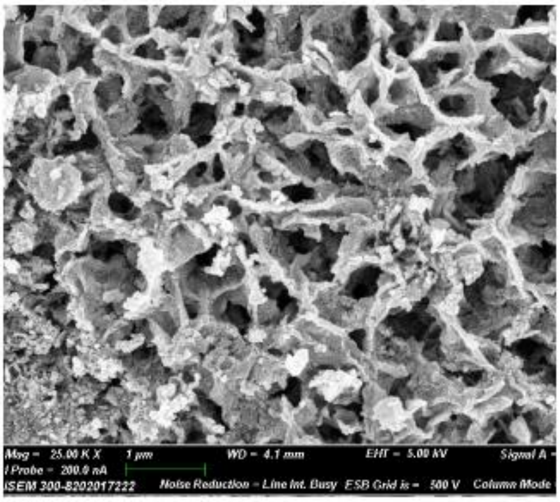
$$D = \frac{K\lambda}{\beta Cos\theta}$$

where the constant K is a shape factor usually = 0.94 [18,19], λ is the wavelength of X-rays (0.15418 nm), β is the full-width at half maximum value (FWHM) and θ is the Bragg's angle.

Crystallite size was observed to increase from 17.2 nm to 24.7 nm after annealing. The increase in crystallite size confirms the improvement in crystalline nature upon annealing.

Morphological studies:

As deposited CdS thin film



Fg. 3 SEM image of as-grown CdS thin film

Fig. 3 shows the SEM image of as-grown CdS thin film, where a fiber like structure is observed. Fig. 4 shows the SEM image of thin film annealed at 200°C. The surface texture of the films was found to improve after annealing, with some alignment observed on the rough surface.

Annealed CdS thin film

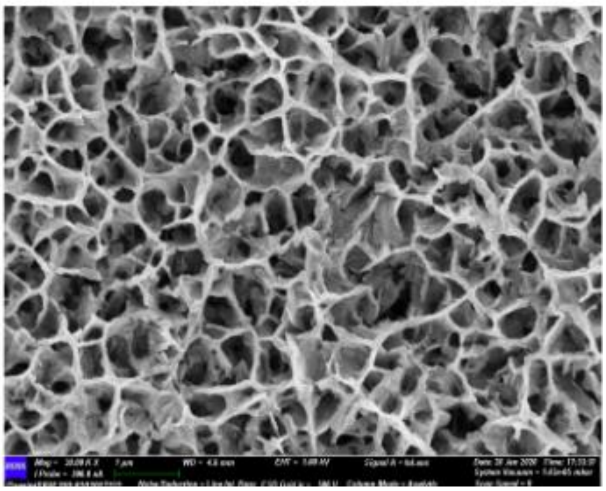


Fig. 4 SEM image of annealed CdS thin film

Fig.5 shows the EDAX spectrum of annealed CdS thin film. The analysis confirmed the presence of Cd (70%) and S (30%) component in the deposited thin film.

EDAX Analysis of annealed CdS thin film

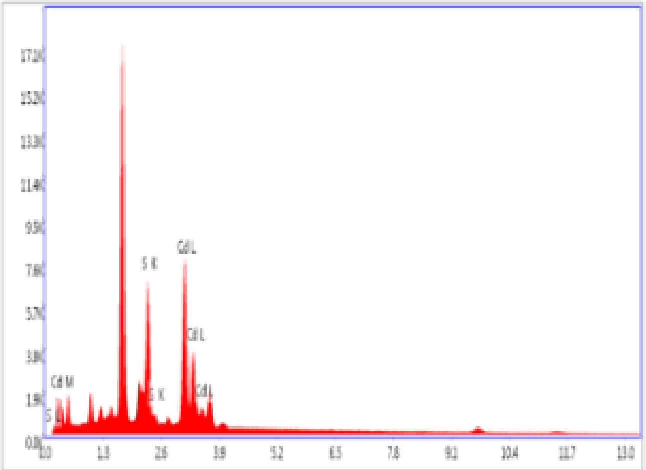


Fig. 5 EDAX Analysis of annealed thin film

IV. Conclusions

In this work, CdS thin films were prepared using microwave assisted chemical bath deposition technique. The as-grown and annealed CdS thin films were characterized by XRD, SEM and EDAX. The XRD pattern of the film revealed its crystalline nature, with a cubic phase with three peaks of (111), (200) and (311) reflections respectively. Crystallite size was determined using Scherrer's formula, based on full width at half maximum values. The crystalline size was found to improve after annealing. EDAX analysis revealed that the deposited CdS films were predominantly rich in Cd.

V. Acknowledgement

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