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Deposition and Characterization of CdSe Thin Films by Spray Pyrolysis Technique

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ABSTRACT

CdSe thin films have been deposited by spray pyrolysis technique. The glass substrate temperature was varied from 250°C to 340°C. Uniform growth of the thin film is observed at 300°C. CdSe thin films are characterized for Structural and optical properties. X-ray diffraction pattern shows that films are polycrystalline in nature with hexagonal crystal structure. Optical study of thin film shows energy gap similar to n type semiconductor and suitable for photovoltaic action.

Keywords: Spray pyrolysis, CdSe, thin films, X-ray diffraction, polycrystalline

INTRODUCTION

Now a day the research on nano scale has eventually exaggerated because of its anomalous behavior and different medical applications. In recent year's researchers having a closer look at nano-mechanisms, they are making significant improvements in different areas from delicate electronics to life-saving medical techniques [1]. Considerable attention has been given to the development of CdSe thin film compounds because of their important properties like optical, mechanical, thermal and electronic properties and their various important applications in industry and solar systems. Research on Thin film compounds is also an attractive and versatile field for their numerous applications in various electromagnetic devices. CdSe is an II-VI binary semiconductor compound.

Because of high absorption coefficient and nearly optimum band gap energy, CdSe is a promising photovoltaic material which is essential for efficient absorption of light and converting it into electrical power. A direct band gap range from 1.65 eV to 1.84 eV has been observed for the CdSe material in different studies of various researchers [2]. Because of intermediate energy band gap and reasonable conversion efficiency makes CdSe as one of the most widely useful materials for photovoltaic solar cells [3]. Semiconductor devices which are based on CdSe thin films strongly depends on the structural properties, optical properties and electrical properties of the films obtained from various experimental techniques. In recent years, CdSe nanoparticles have been synthesized by using spray pyrolysis method [4]. The grain size at the surface of the film is found to depend on thickness of the film [5]. Surface morphology of the CdSe film is strongly correlated with the amount of CdSe deposited on the surface [6]. In the present work spray pyrolysis deposition technique was successfully employed to prepare CdSe thin film by simple and low cost chemical spray pyrolysis technique (SP). The prepared film have been characterised by X-ray diffraction (XRD) and UV-VIS optical measurement techniques. The results have been discussed.

METHODOLOGY

$CdCl_2$ and Seleno-urea chemicals were used for synthesis of $CdCl_2$ & Se particles. Formula for molar solution

For seleno-urea:

$$W = N * M * \frac{V}{1000}$$

= 0.025*100*123.02/1000

=0.307 gm

For cadmium chloride:

$$W = N * M * \frac{V}{1000}$$

$$= 0.025 * 100 * 201.32/1000$$

=0.50 gm

First 0.307 ml of seleno-urea was mixed with the 20 ml double distilled water, stirred it for 5 minutes. Then in another beaker 20 ml of distilled water was mixed it with 0.50gm of $CdCl_2$ and stirred it. Both mixtures were taken in funnel on instrument. Air compressor was used to give pressure in spray pyrolysis unit (2 kg/m^3). Temperature was varied for different glass substrates by electronic controller. Different samples of glass substrates were characterized for UV-visible spectroscopy and X-ray diffraction (XRD) technique.

Characterization

UV–visible spectroscopy: Optical transmittance measurements of the films were used to estimate the band energy from the position of the absorption coefficient edge. The energy of light quanta near the fundamental edge for direct electron transition is given by $\alpha = (h\upsilon - E_g)^{1/2}$ or $\alpha^2 = h\upsilon - E_g$

Thus a plot of α^2 against $h\upsilon$ gives a straight line. A plot of α^2 versus $h\upsilon$ in the region deviates from being straight but extrapolation of the straight portion of the graph to $\alpha^2 = 0$ gives the band gap E_g of the CdSe thin films. Where α is the optical absorption coefficient of the material and $h\upsilon$ is the photon energy, gives the value of band gap energy (E_g). The optical band gap of energy of the CdSe films deposited at 300 ^oC with observed condition is 1.80 eV. This value is in good agreement with the nature of Semiconductor. The intercepts (extrapolations) of these plots (straight lines) on the energy axis give the energy band gaps. The direct band gaps for all the films were determined. With increasing selenium content energy band gap of CdSe thin films decreases.

X-ray diffraction:

The CdSe thin films fabricated at different substrate temperatures were characterized by analysis of X-ray diffraction (XRD) patterns. The (h k l) miller indices for each diffraction peak were calculated from corresponding observed and standard d-values. The XRD patterns revealed that films were polycrystalline in nature because these are having more than one peak. The high intense is observed for (002), (100) and for (110) peak while low intense (110) peak were identified for CdSe. X-ray diffraction patterns recorded for the spray deposited CdSe films on glass substrates at 300 ^oC temperature is shown in Fig. 2. The observed diffraction peaks of CdSe films are found at 2θ values of 23.5, 26, 27.5 and 42 corresponding to the hkl planes (100), (002), (101) and (110) respectively. CdSe thin films deposited at temperature 300^{o}c are smooth and uniform. The

height of (100), (002) and (110) peak in X-ray diffraction pattern for CdSe thin films deposited at temperature 300 °C has shown sharper peaks.XRD results shows that the deposited CdSe films are polycrystalline in nature having hexagonal structure with preferred orientation along (002) plane.

RESULTS AND DISCUSSION

Table 1 :

CdSe	Thickness=460nm				
λ(nm)	Absorption(αt)	α	hυ	αhυ	(αhυ)^2
500	0.7585	1.65E+04	2.48	4.08E+04	1.67E+09
520	0.7282	1.58E+04	2.39	3.78E+04	1.43E+09
540	0.6985	1.52E+04	2.30	3.49E+04	1.22E+09
560	0.6623	1.44E+04	2.22	3.19E+04	1.02E+09
580	0.6199	1.35E+04	2.14	2.89E+04	8.33E+08
600	0.5853	1.27E+04	2.07	2.63E+04	6.94E+08
620	0.5605	1.22E+04	2.00	2.44E+04	5.96E+08
640	0.5430	1.18E+04	1.94	2.29E+04	5.25E+08
660	0.5287	1.15E+04	1.88	2.16E+04	4.68E+08
680	0.5086	1.11E+04	1.83	2.02E+04	4.08E+08
700	0.4986	1.08E+04	1.77	1.92E+04	3.70E+08
720	0.4873	1.06E+04	1.73	1.83E+04	3.34E+08
740	0.4731	1.03E+04	1.68	1.73E+04	2.98E+08
760	0.4599	1.00E+04	1.63	1.63E+04	2.67E+08
780	0.4540	9.87E+03	1.59	1.57E+04	2.47E+08
800	0.4404	9.57E+03	1.55	1.49E+04	2.21E+08
820	0.4240	9.22E+03	1.51	1.40E+04	1.95E+08

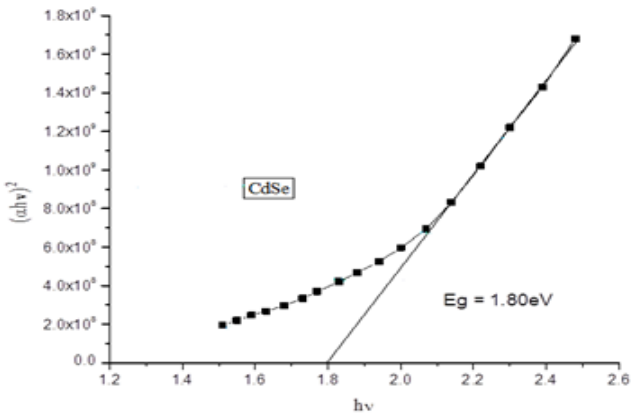


Fig. 1:

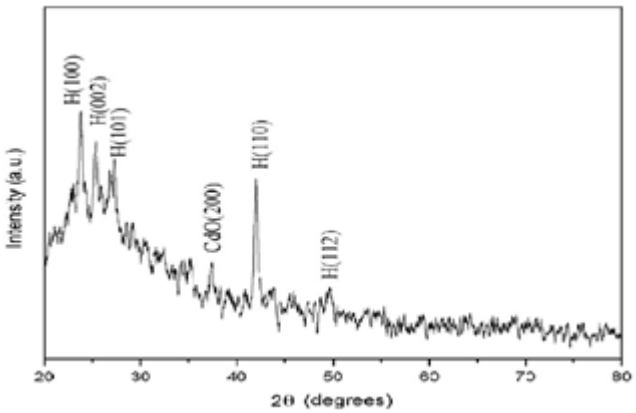
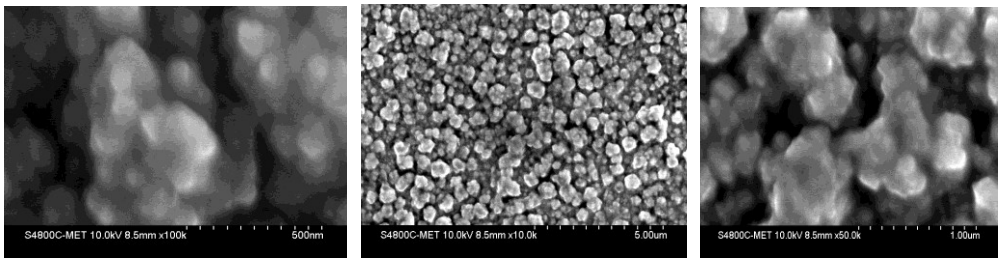


Fig. 2:

Fig. 1: Variation of $(\alpha h\nu)^2$ vs. Photon energy (hν) at temperature 300 °C

Fig: 2. XRD patterns of CdSe thin films deposited at substrate temperatures of 300°C



8.5mm×100k 500nm 8.5mm×10k 5 µm 8.5× 1µm 1 µm

Fig: 3. Scanning Electron Microscope images

CONCLUSION

Optical properties which were observed in this study depend on thicknesses of CdSe thin films and increase in band gap of the films corresponds to increase in thickness of films**.** The CdSe thin films deposited on glass substrates at temperatures 300 ^{o}C employing spray pyrolysis technique is uniform and smooth. X-ray diffraction pattern reveals that the CdSe films are of hexagonal in structure. Various structural parameters such as grain size of the films are found to be increased with increasing temperature. Optical transmittance measurements indicate that the deposited films have a direct band gap of 1.80 eV which means CdSe is n-type window layer suitable for photovoltaic action.

Conflicts of interest: The authors stated that no conflicts of interest.

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