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STRUCTURAL AND OPTICAL PROPERTIES OF SPRAY DEPOSITED CdSe THIN FILMS

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Abstract. CdSe thin films have been deposited on glass substrate in aqueous solution by spray pyrolysis technique at increasing substrate temperatures. The effect of substrate temperature on structural properties has been investigated. The structural, optical and electrical properties of deposited films were studied using, X-ray diffraction (XRD), UV-VIS spectrometry. The XRD diffraction spectra show that the films are of hexagonal in structure. The thickness of film, grain size of constituents and optical properties are also reported.

1. Introduction

Cadmium Selenide (CdSe) has emerged as a promising material in recent years because of its potential technological importance. The synthesis of binary metal chalcogenide of groups II-VI semiconductors in a nanocrystalline form has been a rapidly growing area of research due to their important non-linear optical properties, luminescent properties, quantum-size effect and other important physical and chemical properties [1]. CdSe is suitable for solar energy conversion with a photovoltaic cell because it have band gap 1.7 eV which is suitable for the spectrum of sunlight [2]. CdS, CdSe and ZnS have received considerable attentions as photo-electronic materials [3]. The excellent optical properties make them suitable for the fabrication of solar cells. Several methods of the film processing such as vacuum evaporation (EV), chemical vapour deposition (CVD), chemical bath deposition (CBD), spray pyrolysis (SP), electrodeposition (ED) etc. have been employed for the deposition of thin CdSe films [4]. The grain size at the surface of the films is found to depend on film thickness [5]. Surface morphology of the CdSe films is strongly correlated with the amount of CdSe deposited [6]. In the present work spray pyrolysis deposition technique was successfully employed to prepare CdSe thin films by simple and low cost chemical spray pyrolysis technique (SP). The films have been characterised by X-ray diffraction (XRD) and UV-VIS optical measurement techniques. The results have been discussed.

2. Experimental

CdSe thin films were deposited onto preheated glass substrates from an aqueous solution bath containing $CdCl_2$ and SeO_2, each of 0.1 M were prepared in deionised water in separate beakers. Aqueous solutions of $CdCl_2$ and SeO_2 were used as the sources of Cd and Se, respectively. The $CdCl_2$ and SeO_2 solutions were mixed for 45 min with magnetic stirrer at the rate 50 rotations per minute. The glass substrates were cleaned with dilute hydrochloric acid, standard laboratory detergent thomaklin and also ultrasonically cleaned with double distilled water and dried well. The deposition of the film was carried out at various temperatures 240 ºC, 260 ºC, 280 ºC, 300 ºC, and 320 ºC. The deposition was carried out with spray pyrolysis technique (Model No. HO-TH-04). The other parameters which are air pressure (3 kg cm^{-2}), substrate to nozzle distance (15 cm) , spray duration (2 min) and precursor quantity (2ml min^{-1}) were kept constant throughout the experiment. The carrier gas was air. All the chemicals used in this work were of analytical reagent grade (99 % purity).

3. Results and discussion

Structural characterization. The structural characterization of the thin film was carried out by analyzing the XRD pattern obtained using a MiniFlex2 diffractometer with Cu kα radiation (λ=0.1542 nm). Optical measurements were carried out on Systronic Double Beam UV-VIS Spectrophotometer: 2201. X-ray diffraction patterns recorded for the spray deposited CdSe films on glass substrates at various temperatures 240 ºC, 260 ºC, 280 ºC, 300 ºC and 320 ºC are shown in Fig. 1a-e. The XRD studies revealed that the films of CdSe are polycrystalline in nature with hexagonal structure. The observed diffraction peaks of hexagonal CdSe films are found at 2θ values of 23.380, 27.097, and 35.520 corresponding to the hkl planes (002), (101) and (102) respectively. The different peaks in the diffractogram were indexed and the corresponding values of interplanar spacing ‘d’ were calculated and compared with the standard values [7]. CdSe thin films deposited at temperature 280 ºC are of a smoother textured and that of above 280 ºC are found to be poorly crystallized, as indicated by the broad XRD peaks represented in Fig. 1 of the curve (c). It is found that deposition temperature 280 ºC led to the formation of well – crystallized films. the height of (002) peak in X-ray diffraction pattern for CdSe thin films deposited at temperature 280 ºC has shown sharper peaks and small FWHM data resulted in the enhancement of crystallite size at temperature 280 ºC.

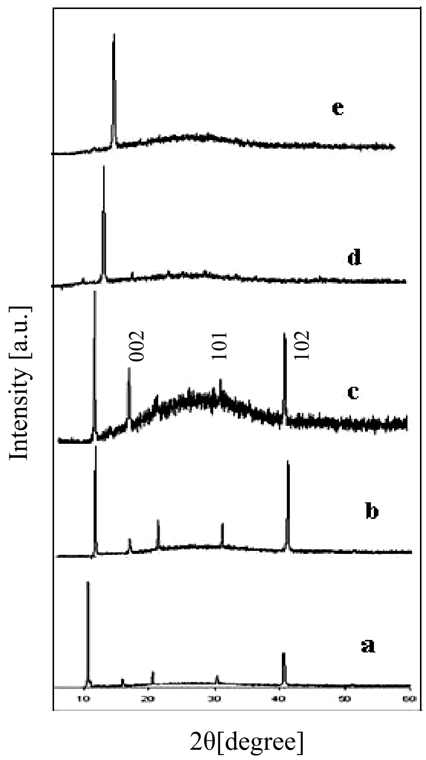

Fig. 1. XRD patterns of CdSe thin films deposited at various substrate temperatures: (a) 240 ºC, (b) 260 ºC, (c) 280 ºC, (d) 300 ºC, and (e) 320 ºC.

X-ray diffraction patterns of CdSe thin films synthesized at substrate temperatures from 240 ºC, 260 ºC, 280 ºC, 300 ºC and 320 ºC are recorded. Using FWHM data and Debye-Scherrer formula, the crystallite size of the films was calculated. The variation of crystallite size with substrate temperature for CdSe films deposited at temperature from 240 ºC, 260 ºC, 280 ºC, 300 ºC, and 320 ºC is shown in Fig. 2. It is observed from Fig. 2 that, the crystallite size increases with temperature and films deposited at 300ºC are found to have maximum value of crystallite size.

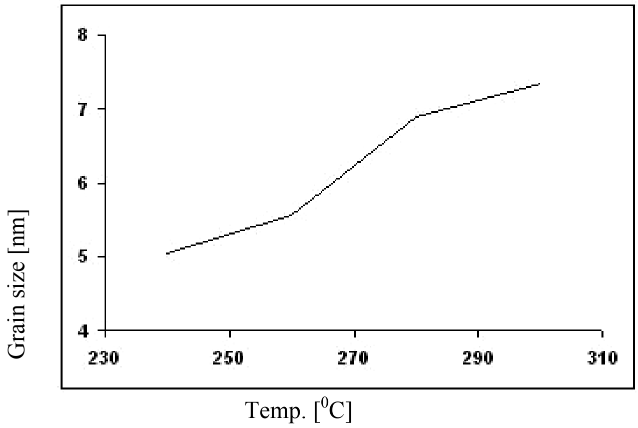

Fig. 2. Variation of crystallite size and strain with temperature of CdSe thin films.

Optical characterization. Optical transmittance measurements of the films were used to estimate the band energy from the position of the absorption coefficient edge. The absorption coefficient can be calculated using the relation:

$\alpha=A(h\nu)^{-1}(h\nu-Eg)^{-1/2}$,

where A is a constant (slope) and Eg is the energy gap.

A plot of $(\alpha h\nu)^2$ versus hν (Tauc's plot) for the calculated values of the absorption coefficients, where α is the optical absorption coefficient of the material and hν is the photon energy, gives the value of band gap energy Eg. Extrapolation of the plot to the x-axis gives the band gap energy of the CdSe films deposited at 280 ºC is shown in Fig. 3.

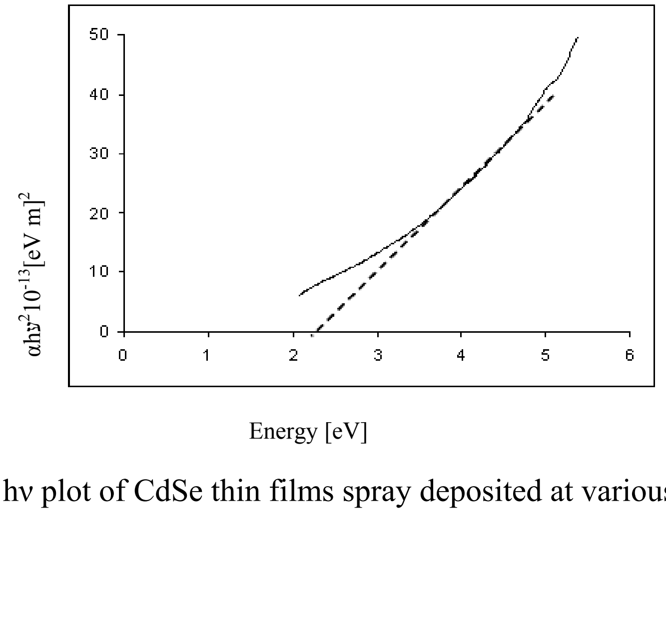

Fig. 3. $(\alpha h\nu)^2$ versus hν plot of CdSe thin films spray deposited at various temperature 300 ºC.

The optical band gap of energy of the CdSe films deposited at 280 ºC with optimized condition is 2.22 eV. This value is in good agreement with the value reported earlier [8-11].

4. Conclusion

The CdSe thin films were successfully deposited on glass substrates at temperatures from 240 ºC, 260 ºC, 280 ºC, 300 ºC, and 320 ºC employing spray pyrolysis technique. X-ray diffraction analysis confirmed that the deposited 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 from 240 ºC to 320 ºC. Optical transmittance measurements indicate that the deposited films have a direct band gap of 2.22 eV.

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