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AC PHOTOCONDUCTIVITY BEHAVIOUR OF ELECTRON BEAM EVAPORATED CdSe FILMS

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Cadmium selenide(CdSe) thin films were deposited by the electron beam evaporation technique on glass substrates maintained at different temperatures in the range 30 - 300°C using the laboratory synthesized CdSe powder as the source. The films were polycrystalline with hexagonal structure. Optical bandgap of 1.67 eV was obtained. Atomic force microscopy studies indicated increase of grain size with substrate temperature. AC photoconductivity studies indicated The photosensitivity increased with substrate temperature.

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1.Introduction

Cadmium selenide (CdSe) is well known as a II–VI compound semiconductor suitable for solar energy conversion with a photovoltaic cell because the bandgap, i.e. 1.75 eV, is fit to the spectrum of sunlight. Several methods of the film processing such as vacuum evaporation, chemical vapor deposition (CVD), chemical bath deposition, spray pyrolysis, electrodeposition etc have been employed for the deposition of thin CdSe films[1-5]. In this work, the electron beam evaporation technique was successfully employed for the deposition of CdSe films using the laboratory synthesized CdSe powder as the source material.

2.Experimental

High purity cadmium selenide powder has been prepared by the reaction of aqueous solutions of cadmium acetate with sodium seleno sulphate under optimum conditions of pH = 10, obtained by the addition of ammonium hydroxide. Normally selenium dissolves in hot aqueous solutions of alkali metal sulphites yielding alkali selenosulphate or selenosulphites. Selenosulphate is stable under high alkaline conditions (pH=10). As the pH is decreased gradually below 5.5, selenium is precipitated out. This selenium reacts with the cadmium ions to yield cadmium selenide. The obtained CdSe powder was annealed at 300□C in argon atmosphere for 20 minutes. This ensured the complete removal of excess selenium. The powders were stored in a vacuum desiccator.

Thin CdSe films were deposited using a Hind Hivac coating unit. A vacuum better than 8 x 10^{-6} Torr was used during evaporation. The source substrate distance was maintained as 15 cm.

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The CdSe powder synthesized in the laboratory was used for the deposition of films. Clean glass and titanium substrates were used as substrates. The substrate temperature was varied in the range of 30 - 250ºC. Indium ohmic contacts were provided on the edges of the surface of the films for photoconductivity measurements.

3. Results and discussion

Atomic absorption spectrometry was used to determine the purity of the powder. The purity of the synthesized powder was comparable to the commercially available AR grade Koch light powder. X-ray diffractograms (XRD) of the as-prepared and annealed CdSe powders exhibit all reflections corresponding to single phase hexagonal CdSe(Fig.1). The as deposited films were polycrystalline in nature possessing the hexagonal structure. As the substrate temperature increased from 30 – 250 C, the peaks became sharper and increased in intensity. This indicates that the crystallinity improves with increase of substrate temperature. The lattice parameters were determined from the XRD data. The lattice constants 'a' and 'c' were 4.31Å and 7.05 Å. These values are in good agreement with the literature values. The structural parameters, such as lattice constant, internal stress and dislocation density, were calculated from the XRD data for CdSe films, and their variation as a function of substrate temperature was studied.

Optical absorption studies were made on the films deposited at different substrate temperatures. An identical uncoated glass substrate was introduced in the reference beam to take care of the substrate absorption. Using the absorbance data recorded in the range of 300 – 800 nm, a plot of $(\alpha h\nu)^2$ vs hν was linear(Fig.2), extrapolation of the linear region to the energy axis indicated a direct band gap of 1.65 eV This value is in agreement with earlier reports[6].

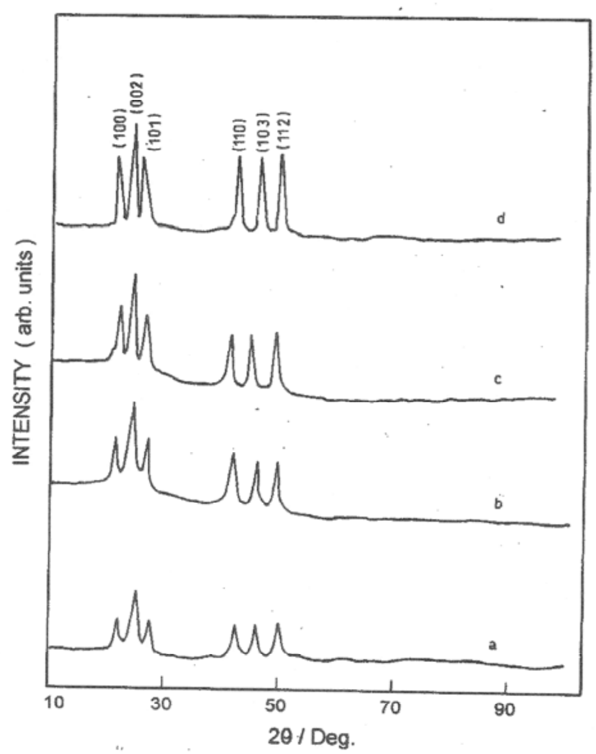

Fig. 1. XRD patterns of CdSe films deposited at different substrate temperatures (a) 30ºC (b) 100ºC (c) 200ºC (d) 300ºC.

The XPS spectra of the CdSe films deposited at 250ºC and post heated at 550°C (Fig.3) indicated the binding energies of the Cd ($3d_{5/2}$and $3d_{3/2}$) and Se ($3d_{5/2}$and $3d_{3/2}$) level. After annealing the area under the selenium binding energy curves decrease indicating a small amount of loss of selenium upon evaporation from the sample due to heat treatment. The peak energy levels associated with Cd ($3d_{5/2}$ and $3d_{3/2}$) appeared at 405 and 411.7 eV respectively, which are in good agreement with the literature [7].

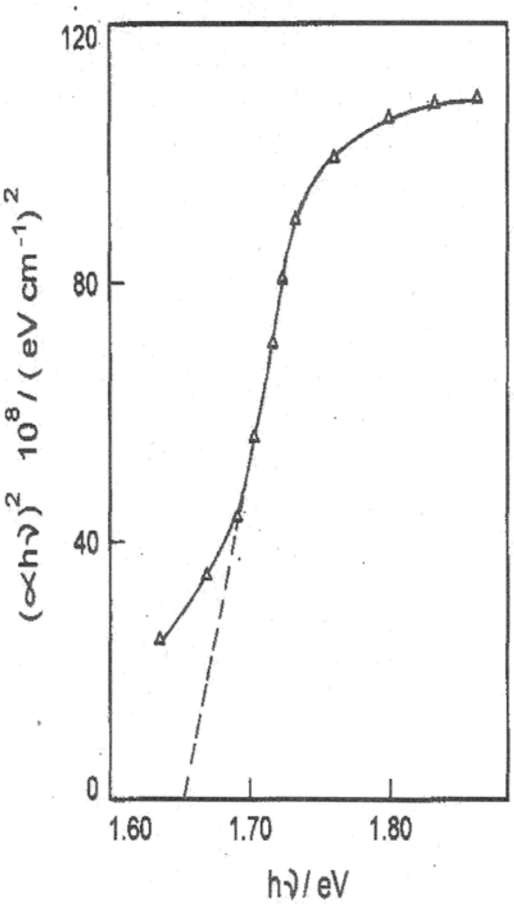

Fig. 2. $(\alpha hv)^2$ vs hv plot of the CdSe films deposited at a substrate temperature of 300ºC

These findings are characteristic of the Cd in CdSe and are in good agreement with the literature. The binding energies of the Se ($3d_{5/2}$ and $3d_{3/2}$) levels appeared at 53.9 and 59.2 eV respectively.

AC photoconductivity measurements were made with a chopper of 90 Hz for the films deposited at different substrate temperatures. The AC photosensitivity was calculated using the relation,

$$\% S = \Delta R_c/R_c = [E.\ \Delta V/V_1(E - V_2)] \times 100$$

Where ΔR_c is the change in resistance, R_c is the dark resistance, E is the applied bias voltage, V_1 is the load voltage when the photoconductor is in dark and V_2 is the load voltage on illumination.

$V_2 = (V_1 + \Delta V)$, ΔV is the signal voltage.

The sensitivity results are given in Table-I. It is observed from the table, for the films deposited at a substrate temperature of 300°C, the AC photosensitivity is maximum.

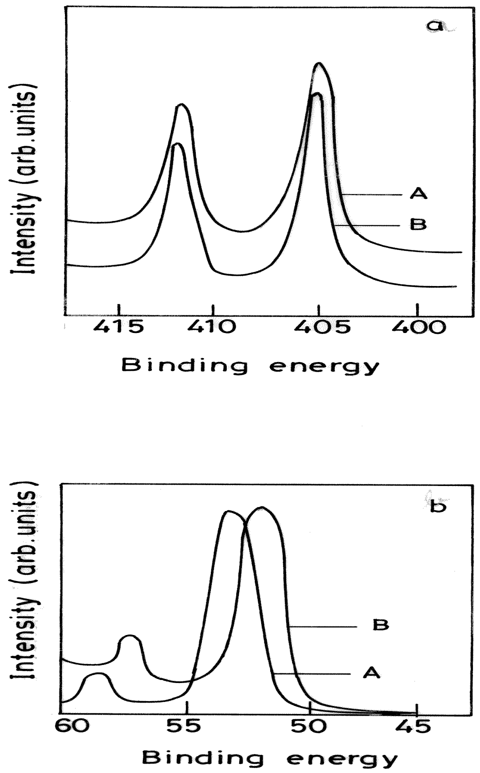

Fig. 3. XPS spectra of Cd and Se in CdSe films deposited at 300ºC and annealed in ait at (A) 500ºC (B) 550ºC.

Table 1. AC photosensitivity of CdSe films deposited at different substrate temperatures

Applied Bias: 170 V Intensity : 5000 lux		
Serial No	**Deposition Temp(°C)**	**S = $\Delta R_c/R_c$ %**
1	50	15
2	100	22.6
3	150	30.3
4	200	38.4
5	300	75.7

4. Conclusions

CdSe powder can be synthesized by a simple chemical precipitation technique. The purity of this material is comparable to that of commercial CdSe powder. Films with a band gap of 1.65 eV and with grain size in the range of 15 – 30 nm can be easily obtained by the electron beam evaporation technique. With this method films exhibiting AC photosensitivity can be deposited.

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