



Studies on Effect of Precursor Concentration on Electro-Optical and Photosensing Properties of Spray Pyrolyzed CdS_xSe_{1-x} Thin Films.

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ABSTRACT

CdS_xSe_{1-x} thin films were prepared by chemical spray Pyrolysis technique. Substrate temperature was optimized and kept constant at $275^{\circ}C \pm 5^{\circ}C$. Cadmium Chloride, Selenourea and Thiourea each of 0.05 M concentration was used as precursors. Thin films were characterized by X-Ray diffraction spectra, SEM and EDS. Present investigation describes the effect of increase in concentration of Se on TEP and optical properties of as formed films. Optical properties shows high coefficient of absorption with blue shift in absorption edge from 520 nm to 320 nm. A linear increase in band gap is observed for increase in Selenium concentration (From $E_g = 2.33$ eV , for $X = 0$ to $E_g = 3.51$ for $X = 1$) for the step of 0.25.

Keywords: CdS_xSe_{1-x} , Spray Pyrolysis, Thin Films, Structural, Electrical, Optical and Photosensing Properties.

I. INTRODUCTION

From several years it has been focused that, II-VI group materials are becoming technologically useful material in the region of visible solar spectrum [1] It has been considered to be a promising alternative to be more widely used silicon devices [2]. It is reported that CdS and CdSe are wide band gap materials ($E_g = 2.4$ eV for CdS and $E_g = 1.7$ eV for CdSe) thus by diffusing Se in CdS we can synthesize the CdS_xSe_{1-x} material with varying band gap energy. Thus by adding suitable concentration of Se in CdS material, band gap can be tailored at desired level.

The deposition of these type of thin films has been explored by different techniques like thermal evaporation [3, 4] chemical bath deposition [5] molecular beam epitaxy [6] and spray Pyrolysis. Out of these spray Pyrolysis is most promising technique for producing large area as well as large number of inexpensive thin films of good quality with various dopents.

The aim of this work is to synthesize CdS_xSe_{1-x} thin films by spray Pyrolysis to study physical, electrical and optical properties thin films.

II. EXPERIMENTAL

The CdS_xSe_{1-x} thin films were synthesized by taking 0.05 M aqueous solutions of Cadmium Chloride, Selenourea and Thiourea The major preparatory parameters in the spray pyrolytic process are substrate temperature, the concentration and mole ratios of starting solutions and the pressure provided in atomization of reaction solution. In present work the films were grown at temperature $275^{\circ} \pm 5^{\circ}C$, The spray rate was 1.5 ml/min and distance between the spray nozzle and substrate was 27.5 cm.

III. RESULTS AND DISCUSSION

Optical and Electrical Study:

1. UV-Visible spectroscopic study Figure 1

From the U. V. Vis spectrophotometric study It is observed that, the band gap energy increases with increasing concentration of Se CdS_xSe_{1-x} , which shifts

towards lower wavelength side. From the Table 2, it is clear that the values of energy band gap are varying from 2.43 eV to ~1.74 eV indicates that the as synthesized material is direct band gap semiconducting material [7,8].

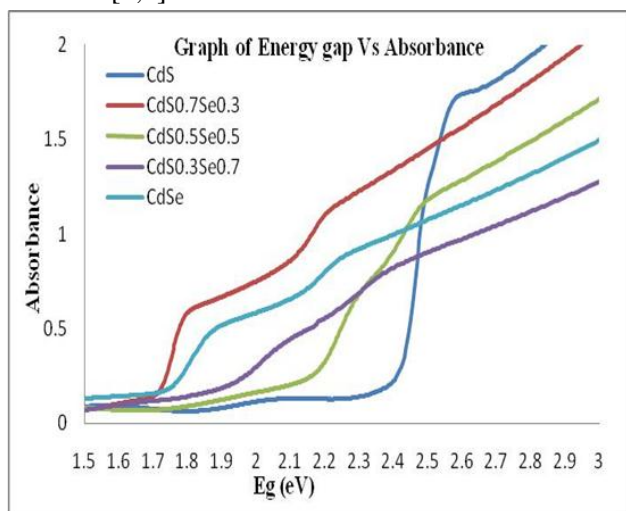


Figure 1. Figure UV-Vis spectrograph of Film 1 through Film 5

The energy band gap of CdS sample (film T1) was obtained to be 2.43 eV. This value of energy band gap decreases with increase in Selenium gradually, and finally in film T5 (CdSe), energy band gap was observed to be 1.74 eV. These values are comparable to the reported values of CdS, (2.4 eV) and CdSe (1.7 eV). This agrees with the results of Patil L.A. et. al, This also indicates that synthesized material is semiconducting with direct bandgap. This Figure clearly shows that absorption edge goes on shifting towards longer wavelength side with increasing wt % of Selenium content in the composition. This also indicates that synthesized material is semiconducting with direct bandgap [14].

Table 1. Band gap as a function of elemental composition

Film	Composition	Edge Wavelength λ nm	Energy gap eV = $1240/\lambda$
T-1	CdS Se 1.0 0.0	510	2.43
T-2	CdS Se 0.7 0.3	556	2.23
T-3	CdS Se 0.5 0.5	618	1.99
T-4	CdS Se 0.3 0.7	685	1.85
T-5	CdS Se 0.0 1.0	712	1.74

2. Thermoelectric power (TEP) measurement

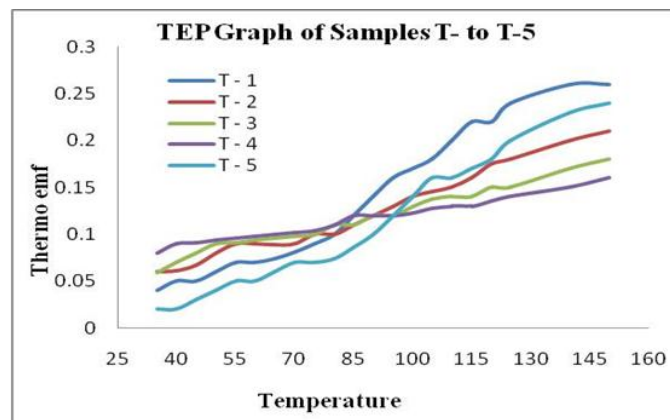


Figure 2. TEP performance of as deposited thin films

TEP measurement determines n or p-type semiconducting nature of the synthesized materials and operates on the principle of generated thermo-emf, which is proportional to direct temperature difference. The polarity of thermo-emf gives idea about majority charge carriers (electrons or holes). In present investigation, TEP measurement was carried in the temperature range 308°K to 423°K . The polarity of thermally generated voltage at the hot end was positive, indicating that the films were of n- type. During observations of present investigation, the polarity of thermally generated voltage at the hot end was positive, indicating that the films are of n- type. This agrees with the results of S. H. Pawar et.al [9].

3. Photosensing properties of $\text{CdS}_x\text{Se}_{1-x}$ thin films

When light radiations incident on the semiconducting sample, excess electron hole pairs are created in semiconducting materials, thereby results in increase in conductivity. This gives important applicability to the material as sensors of radiations. During present investigation, the samples were illuminated by hundred-watt tungsten filament lamp as source of light. Incident from 12 cm, distance from as deposited $\text{CdS}_x\text{Se}_{1-x}$ films, and the photosensitivity was measured by the equation as shown below:

$$\text{Photosensitivity } (P_s) = \frac{I_{\text{illuminated}}}{I_{\text{dark}}}$$

Intensity of the light radiation was varied by dimmerstrat. The observations were taken for the intensity of light radiations at 60 V a. c. to 230 V a. c. mains by the step of 10 V a. c.

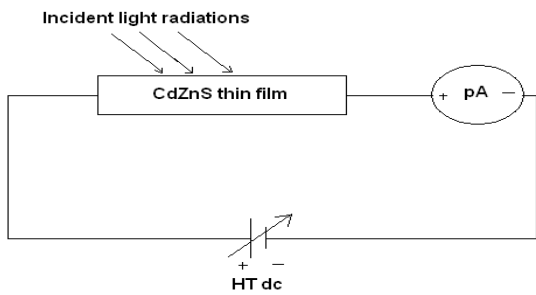


Figure 3. Experimental setup for photosensitivity measurement

Figure 3 depicts the experimental setup of measurement of photosensitivity. Light radiations were allowed to incident on CdS_xSe_{1-x} thin films giving the photosensitivity of the materials. One can customized the Photosensing performance of the thin films by arranging the unimolecular layers of nanostructured materials on the substrates.

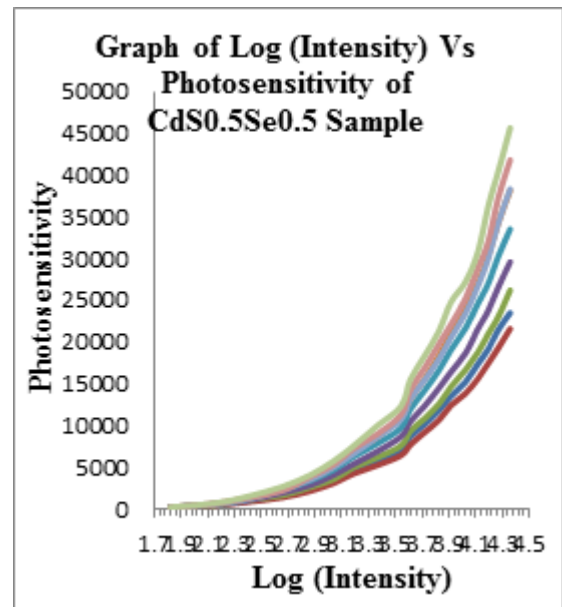


Figure 4 (c). Photoresponse of film T3

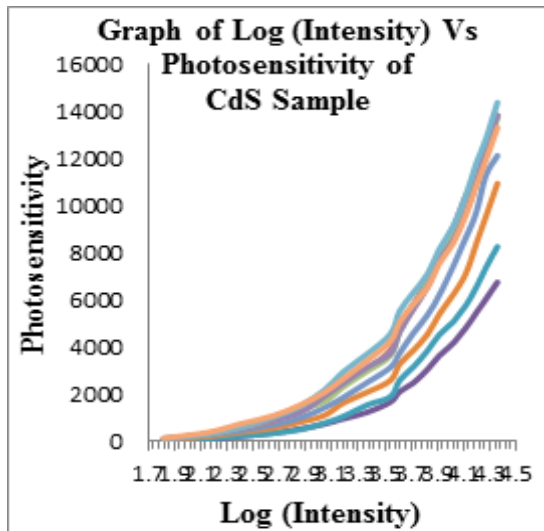


Figure 4 (a). Photoresponse of film T1

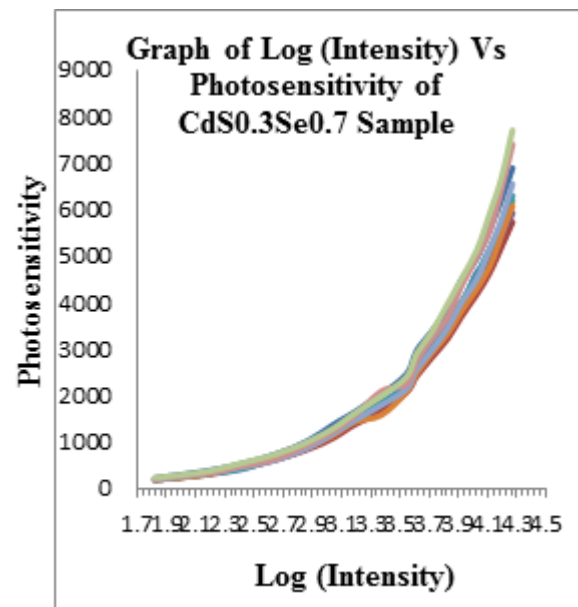


Figure 4 (d). Photosensing performance of film T4

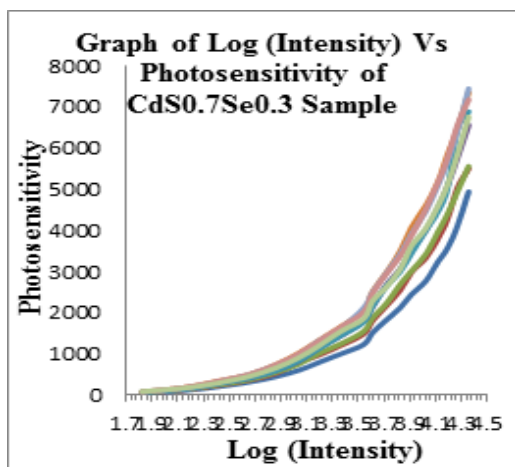


Figure 4 (b). Photosensing performance of film T2

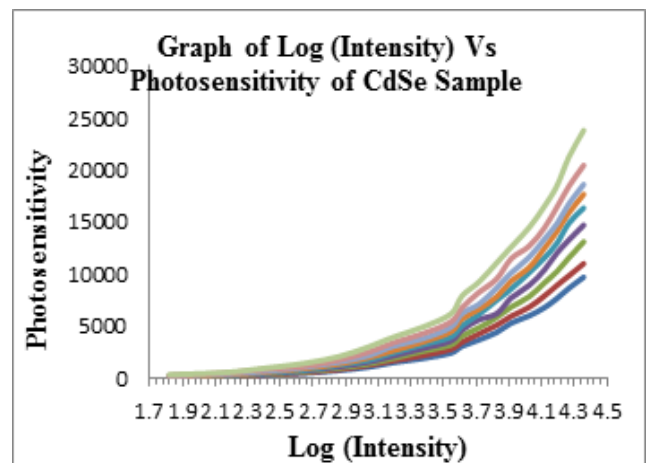


Figure 4 (e). Photosensing performance of film T5

Group II-VI compounds are important class of materials for photoconductivity. From this group, the two most sensitive semiconductors known today are CdS and CdSe[10,11]. It is reported that, CdS and CdSe are isovalent and have similar electronic structures, identical point groups in the form of II-VI solid solutions and ionicities, in conjunction with a small value of atomic size mismatch [7]. Due to these features, when we synthesize the mixed CdSSe material, it automatically creates the lattice mismatch and creates the trapping, recombination and acceptor centers in the energy gap. Out of these two materials, CdSe has double acceptor level. Due to mixing of these systems these levels gets mixed and form intermediate levels. Optical absorption in semiconductors results in excitation of free electrons and holes from one band to another of the same type, and these excited charge carriers cross the gap from valance band to conduction band (12, 13, 14). This transition gives rise directly to photoconductivity. It is also reported that, in semiconductor, the effect of radiation can be considered as a small perturbation on a large dark carrier density resulting in photoconductivity [15]. In undoped CdS both majority and minority carrier life times are same. However, when it is illuminated by radiation source, majority carrier lifetime increases while minority carrier lifetime decreases. Due to this time difference in majority and minority carrier life times, the recombination and capturing is disturbed which leads to increase in concentration of free charge carriers resulting in photoconductivity.

IV. REFERENCES

[1]. P. Raji. C. Sanjiviraja, K. Ramchandran. Bull. Mater. Sci 28,(2005) p.p.233-238.
 [2]. M. Roy and P. Chattopadhaya , Indian J. Pure Appl. Phy., 35 (1997) 349-354.
 [3]. A. Ashour, N. El. Kadry and S. A .Mohmoud. Thin Solid Film 269(1995) 117.
 [4]. S. A .Mohmoud, A. A. Ibrahim, A. S. Riad, Thin Solid Film 372(2000)144.
 [5]. Al Oliva, O Solis Conto, R. Castro-Radrigurz and P. Quiotuna ,Thin Solid Films 391(2005) 28.
 [6]. Ph Hoffmann. K. Horn, A.M. Bradshaw, R. L. Johnson, D. Fuchs and M. Cardona ,Phys Rev.B.47(1993)1639.

[7]. A. S. Abdul Ghafor, N. A. Awad, and N. S. Othman, Indian Journal of Pure and Applied Physics Vol 31, (1993), pp.123-125.
 [8]. S. H. Pawar, C. H. Bhosale, A. J. Pawar, Indian Journal of Pure and Applied Physics 26, (1988), pp.323-325.
 [9]. S. H. Pawar, C. H. Bhosale, A. J. Pawar, J. Pure Appl. Phy., 26 (1988) 323-325
 [10]. L. A. Patil, P. A. Wani, S. R. Sainkar, A. Mitra, G. J. Phatak. D. P. Amalnerkar . Materials Chem. Phys,(1998)55,79-83
 [11]. L. A. Patil, A. M. Patil, M. S. Wagh. Trends in Applied Sciences Research 1(4), 362-367. 2006
 [12]. R. H. Bube, Photoconductivity of solids, John Willey and Sons, Inc., N. Y. (1960) pp.129-136.
 [13]. F. Herman, Proc IRE 43,1703,(1955).
 [14]. D. P. Amalnerkar., N. R. Pavaskar, S. K. Date ,and A. P. B Sinha ,Indian Journal of Pure and Applied Physics(1985)23,539-547.
 [15]. J. A. Jakimavicious, Alisauskas and A. Sirvaitis, Chem. Abstr (1972), 76, 38400
 [16]. R. S. Feigalson , A. N. Diaye, Yin S-Y, R. H. Bube, J. Apple Phy, 48 (1977) 3162.