Optical Properties of CdZnS Thin Film by CBD Method

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***Abstract*—** *Using chemical bath deposition (CBD) technique, (Cd-Zn)S:$CdCl_2$ thin films were prepared on glass substrates. Room temperature photoluminescence analysis in the 400-700 nm emission wavelength ranges for the excitation energies 365nm show the 'well known' green emission band related to exciton-donor complexes formed in presence of S / excess Cd are observed in the PL emission spectra of various rare earth doped (Cd-Zn)S:$CdCl_2$ films. In doped films, characteristic emissions of lanthanide such as Ce are observed. Some properties related to nanocrystalline effects are also found. The influence of variation of ratio of cadmium and sulphur was studied on the PL emission intensity of (Cd-Zn)S:$CdCl_2$ thin films. In a selected ratio of cadmium and sulphur for which emission intensity was highest, the effect of impurity $_{concentration}$ on PL emission intensity was studied.*

***Keywords*— Photoluminescence, Chemical Bath Deposition, Thin Films, CdS.**

I. INTRODUCTION

Cadmium sulphide is a suitable window layer for solar cells [1-3] and also finds applications as optical filters and multilayer light emitting diodes [2], photo detectors [3], thin film field effect transistors [3-5], gas sensors [6], and transparent conducting semiconductor for optoelectronic devices [7]. Among the various known methods to synthesis CdS thin films; the reliable, simple and cost effective route is one using the chemical bath deposition (CBD) technique.

The wide technological applications of CdS type materials make the PL and PC studies important. Some of the important applications of PL are lamp phosphors and display devices and those of PC are xerography and IR detectors etc. PL edge emission was extensively studied in

CdS by several workers [8-10] and was related to excitonic transitions involving donor/acceptor-exciton complexes [4]. Similarly PC of CdS and CdSe were extensively studied by Bube and co-workers [11, 12]. The effect of alloying of CdS, CdSe and other II-VI group compounds on the PL and PC properties has attracted the interest of research workers in recent years. The rare earth ions are well known to form efficient luminescent centers as they show distinct absorption and emission transitions within the 4fN shell configuration [13,14]. Mixed base (Cd-Zn)S has a wider band gap than CdS, which makes it suitable for Phospho-Luminescent screen pigment manufacture etc.[15]. Thus in the present paper (Cd-Zn)S is used as base material. Further rare earth material cerium has been used as impurity as they form prospective luminescent material. CdCl2 has been used as flux which facilitates the incorporation of the rare earth ions into the lattice and also helps in recrystallisation of (Cd-Zn)S [16]. The present work concerns with PL studies of (Cd-Zn)S:CdCl2,Ce films prepared at different preparative condition

II. EXPERIMENTAL DETAILS

The films were prepared by dipping microscopic glass slides of dimension 24 x 75 mm in a mixture of 1 M solution of cadmium acetate, thiourea, tri-ethanolamine, 0.01 M solutions of cadmium chloride, .01M solution of cerium oxide in appropriate proportions in presence of 30% aqueous ammonia. Being insoluble in water, solution of cerium oxide was prepared in sulphuric acid; solutions of all other chemicals were prepared in double distilled water. The pH value of the mixture was ~ 9. After deposition the films were sprayed with distilled water to wash out the uneven overgrowth of grains at the surface and dried in open atmosphere at room temperature (RT). The (Cd-Zn)S:CdCl2,Ce thin films were prepared on glass substrates in the chemical bath at 60°C. The (Cd-Zn)S:CdCl2,Ce thin films are yellowish and have a good adherence to the glass substrate.

III. RESULTS AND DISCUSSION

3.1 PL Emission Spectra

The chemically deposited (Cd-Zn)S:CdCl2 thin films were uniform and consisted of small nanocrystalline grains. The preparation of CdS thin films by CBD is governed by the chemical reaction within the solution of reactants. It was reported that at lower temperatures the surface of the CdS thin films is rough, but as the temperature remains constant (at 60°C), the film surface becomes more uniform [13]. In the present paper (Cd-Zn)S:CdCl2 films has prepared at different time duration and found that maximum PL emission intensity occurs at 1:25 hours. The photoluminescence (PL) emission spectra of the different (Cd-Zn)S:CdCl2 films under the excitation energy of 365 nm wavelength have studied. The effect of time on PL emission intensity has shown in fig.-1. The maximum PL emission intensity occurs at 520nm.

In present paper effect of concentration of Zn content on PL emission intensity has also studied. Samples have been prepared at 60°C for 1.25 hour for different combination of Cd and Zn solutions and found that the PL emission peak obtained at 500nm for (Cd.8-Zn.2)S. It is also observed that there is a blue shift occurs in emission peak for increasing concentration of Zn content. Because for ZnS the band gap is 3.7 eV and for CdS the band gap is 2.4 eV so for (Cd-Zn)S a blue shift in PL emission intensity occurs for increasing band gap **(Fig.2)**.

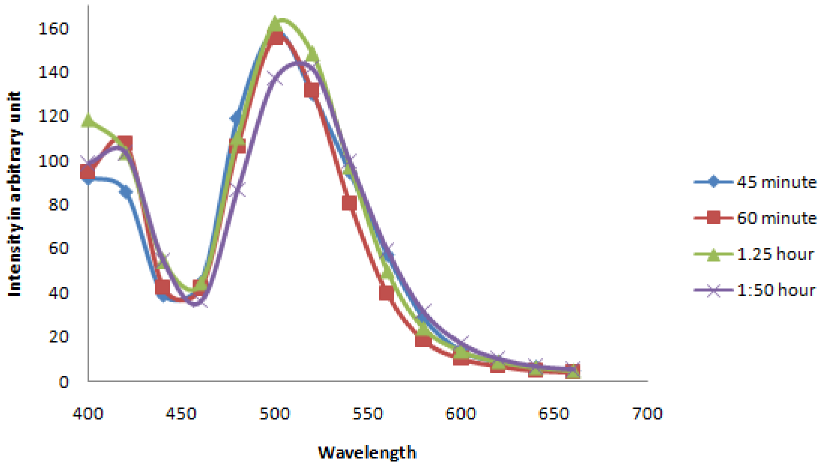

FIG.1-EFFECT OF TIME ON PL EMISSION INTENSITY

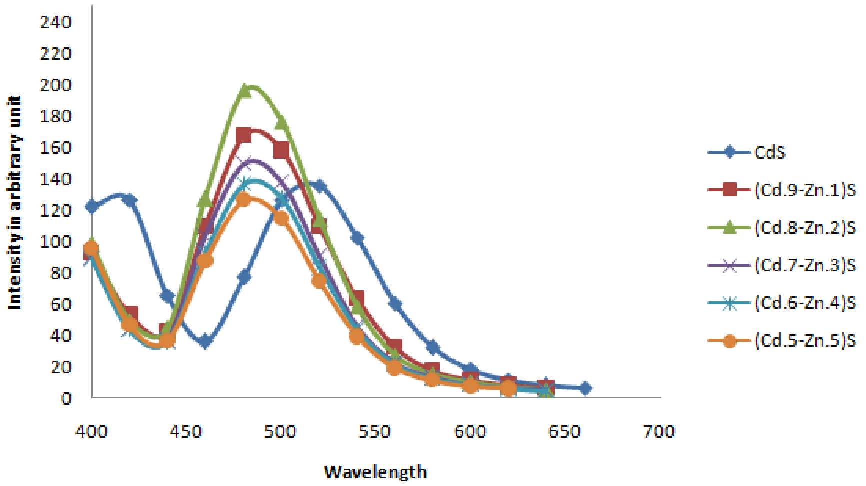

FIG.2-EFFECT OF VARIATION OF CONCENTRATION OF ZN

The photoluminescence (PL) emission spectra of the different CdS films (for various combinations of Cd and S) prepared at 60°C for 1.25 hour under the excitation energy of 365 nm wavelength is presented in fig.-3. The principle of PL measurements is to create carriers by optical excitation with photon energy above the band gap of the films (2.4eV). Electrons and holes relax to their respective ground states in the conduction and valence band. They can then recombine radiatively as most free carrier or excitations. When light energy input is applied to the film there is an electronic transition between two energy levels, E1 & E2 (E2 > E1), with the emission of wavelength λ, where $\frac{hc}{\lambda} = E_2 - E_1$

Invariably E1 and E2 are part of two groups of energy levels so that instead of a single emission wavelength a band of wavelength is observed [13].

The highest emission appears at (Cd_1-$S_{0.9}$) concentration and with increase in concentration of sulphur, the intensity of emission spectra is found to decrease. Therefore this concentration was used for the (Cd.8-Zn.2)S films doped with $CdCl_2$. This result has shown in Fig.3

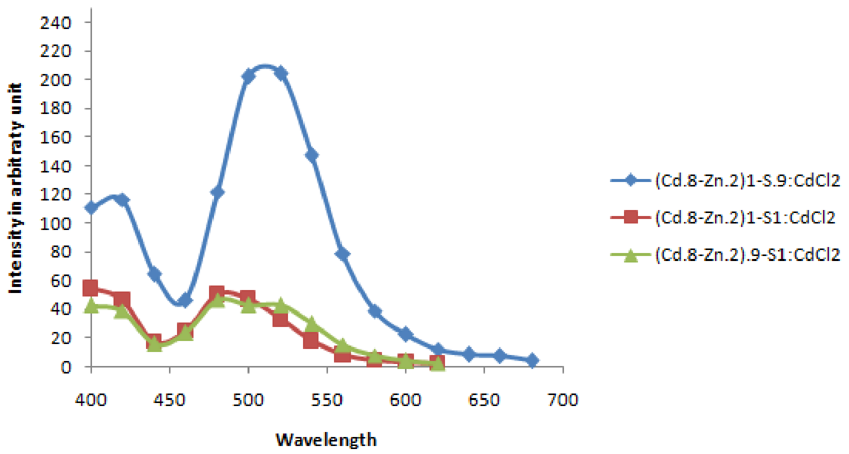

FIG.3-PL EMISSION SPECTRA FOR VARYING CONCENTRATION OF CADMIUM AND SULPHUR

In fig.4 we studied the effect of impurity concentration on the (Cd-Zn)S:CdCl2 film for the selective proportion of contents and preparative conditions. Varying concentration of rare earth impurity cerium has used and found that a wavelength shift occurs for mixing impurity in crystal lattice. Wavelength shift occurs in higher wavelength side is observed in comparison to that obtained in the case of base material which suggests the substitution of impurity in lattice. It also shows the nanocrystalline effect of (Cd-Zn)S:CdCl2,Ce material. The PL emission peak has observed at 540nm for 6ml impurity solution.

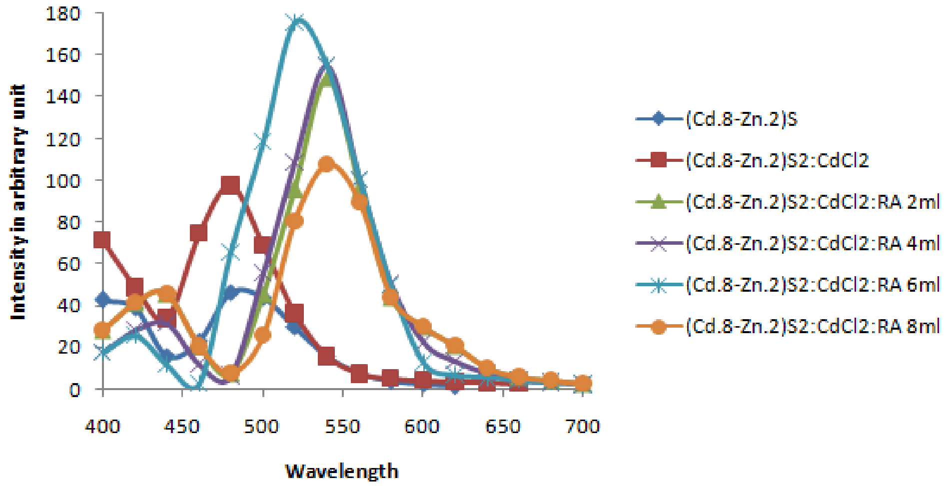

FIG.4-EFFECT OF VARIATION OF IMPURITY CONCENTRATION ON PL EMISSION SPECTRA

IV. CONCLUSION

An intense PL emission spectra obtained for the nanocrystalline structured (Cd-Zn)S:$CdCl_2$,Ce films. Films were prepared at different concentration of contents and preparative conditions and it has observed that the PL intensity peak observed for the sample ($Cd_{.8}$-$Zn_{.2}$)$_1$$S_{.9}$:CdCl2,Ce prepared at 60°C for 1.25 hour for 6ml rare earth impurity. Shift in wavelength for emission peak also observed indicating the substitution of impurity in the crystal lattice.

REFERENCES

[1] J. Herrero, M. T. Gutierrez, C. Guillen, J. M. Dona, M. A. Martinez, A. M. Chaparro, R. Bayon, Thin Solid Films 361 28 (2000).

[2] M. E. Calixto, P. J. Sebastian, Solar Energy Materials and Solar Cells 59 65 (1999).

[3] U. Pal, R.Silva-Gonzalez, G. Martinez-Montes, M.Gracia-Jimenez, M.A.Vidal, Sh.Torres, Thin Solid Films 305 345 (1997).

[4] J. H. Schon, O. Schenker, B. Batlogg, Thin Solid Films 385 271 (2001).

[5] J. Levinson, F.R.Shepherd, P.J.Scanlon, W.D.Westwood, G.Este, M.Rider, Journal of Applied Physics 53 1193 (1982).
[6] Toshiya Hayashi, Takehiro Nishikura, Tatsuro Suzuki, Yoshinori Ema, Journal of Applied Physics, 64 3542 (1988).
[7] T. L. Chu, S. S. Chu, C.Ferekides, C. Q. Wu, J. Britt, C. Wang, Journal of Applied Physics 707608 (1991).
[8] R. E. Halsted, M. Aven, Phys. Rev. Lett. 14, Y533(2-1) (1965).
[9] S. Iida, M. Toyama, J. Phys. Soc. (Japan) 31, 190 (1971).
[10] Y. Kokubun, T. Kaeriyama, J. Appl. Phys. (Japan) 14, 1403 (1975).
[11] S. M. Thomsen, R. H. Bube, Rev. Sci. Instrum., 26, 664 (1955).
[12] R. H. Bube, Phys. Rev. 99, 1105 (1955).
[13] G. Wakefield, H.A. Keron, P.J. Dobson and J.L.Hutchinson, J. Phys. Chem. Solids, 60(1999)503.
[14] R. Reisfield, T.Saradairov, E.Ziganski, M.Gaft, S. Lis, M.Pietraszkiewiez, J. Lumin.102-103 (2003) 243.
[15] J.D.G.Duran, M.C. Guindo, A.V. Delgado, J. Collide, Interface Sci. 193 (1997) 223.
[16] R.H. Bube, Photoconductivity in solids, Wiley, New York, (1960)P. 161.