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Photoluminescence, XRD and SEM Studies of Chemically Deposited Undoped and Doped (Cd – Pb) S Films by Chemical Bath Deposition Method

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Abstract— *The present paper reports results of photoluminescence emission spectra, photoluminescence decay and temperature dependence of photoluminescence brightness of chemically deposited (Cd-Pb)S undoped and doped films. From the emission spectra peak positions were determined. From the decay curves the trap depths were calculated. Along with these, results of X-ray diffraction and SEM studies have also been presented and discussed.*

Keywords— *Photoluminescence, chemically deposited, doped, undoped, temperature dependence.*

1. INTRODUCTION

Films are prepared by chemical bath deposition method on glass and aluminium substrates of size 24 mm x 75mm. Chemical bath deposition method is one of the cheapest and simplest methods and its potentiality has been shown by Nair et al [1, 2] and Bhushan et al [3,4,5]. The present paper reports results of photoluminescence emission spectra; photoluminescence decay and temperature dependence of photoluminescence brightness for lanthanum and praseodymium nitrate doped (Cd-Pb)S films. For better discussions, results of XRD and SEM studies are also presented.

1.1 Materials and Methods

Films were deposited on by cleaned, commercial quality microscopic glass slides and aluminium substrates of same size by dipping vertically in a mixture of 1M cadmium acetate, 1M thiourea, triethanolamine and 30% aqueous ammonia (all analytical reagent grade). For mixed base (Cd-Pb)S films lead acetate was also used. The pH value of this mixture was approximately 11. For the addition of impurities, calculated proportions of 0.01M solutions of NaF and nitrates of La and Pr (lanthanides) was mixed in the original mixture and then the depositions were made. All the depositions were made in a water bath by maintaining a temperature of 60 ^{0}C for 1 hour. The film preparation and experimental arrangements are described in details in earlier publications [6-10].

The photoluminescence excitation was done by 365nm line of high-pressure mercury vapour lamp filtered by Carl Zeiss interference filter. For the photoluminescence decay studies the signals from photo multiplier tube were fed to a storage CRO (HM 205-2, Scientific MES-TECHNIK Pvt. Ltd., Indore) through a resistor of 1MΩ. XRD studies were done using a computerized Philips diffractometer with CuK_α radiation. Further, SEM studies were performed using LEO (430) SEM.

1.1.1 Results and Discussions

Photoluminescence studies— Fig.-1 shows the photoluminescence emission spectra of CdS, (Cd-Pb) S, (Cd-Pb) S: NaF, (Cd-Pb) S: NaF,La and (Cd-Pb) S: NaF, Pr films prepared on glass and aluminium substrates. The peaks found are at 550nm, 560nm, 550nm, 520nm and 530nm for glass substrates.

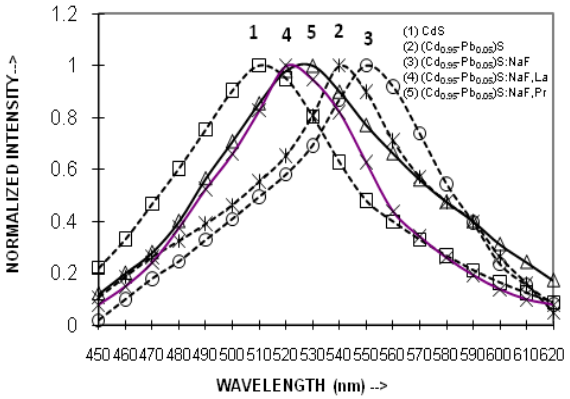

Fig. 1: Emission spectra of different films on glass substrate

Figure-2 shows that for those prepared on aluminium substrates. The peak positions are found at 530nm, 550nm, 560nm, 580nm and 550nm for films prepared on aluminium substrates. The reason for the change in peak positions by changing the substrate is probably that aluminium reacts with the alkaline solution. In CdS these peaks may be associated to acceptor levels formed by Cd^{++} vacancy.

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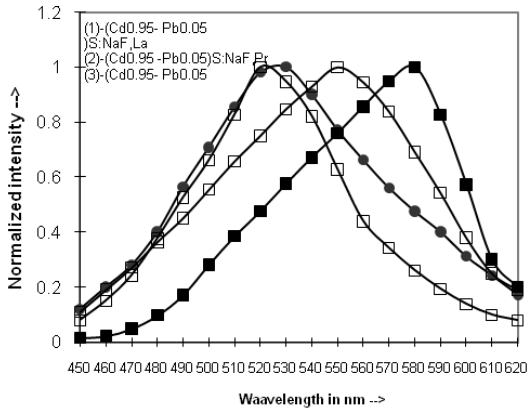

Fig. 2: Emission spectra of different films on glass and aluminium substrate

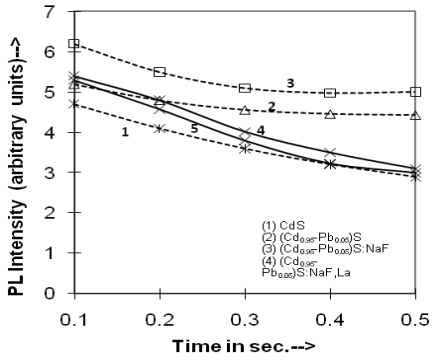

Fig. 3: PL Decay curves for different films on glass substrate

The photoluminescence decay of these samples is shown in fig.-3 (on glass substrates).

The peak positions of different films deposited on glass and aluminium substrates are given in table-1. The log It vs t plots are shown in fig. – 4

Table 1: Peak positions of PL emission spectra in different (Cd-Pb) S films

Systems	*(Glass Substrate) Peak Positions (nm)*	*(Aluminium Substrate) Peak Positions (nm)*
CdS	550	530
$(Cd_{0.95}$-$Pb_{0.05})S$	560	550
$(Cd_{0.95}$-$Pb_{0.05})S$:NaF	550	560
$(Cd_{0.95}$-$Pb_{0.05})S$:NaF,Pr	520	580
$(Cd_{0.95}$-$Pb_{0.05})S$:NaF,La	530	550

The values of trap depths were determined [11] from the relations $I_t = I_o \exp(-pt)$ and $p = s \exp(-E/kT)$ with I_t and I_o being the photoluminescence intensity at time t and 0 respectively, p represents probability of escape of electrons from traps per second and E is the trap depth. The values of the trap depths were found to vary from 0.6eV to 0.78 eV.The calculated values of trap depths are shown in table -2.

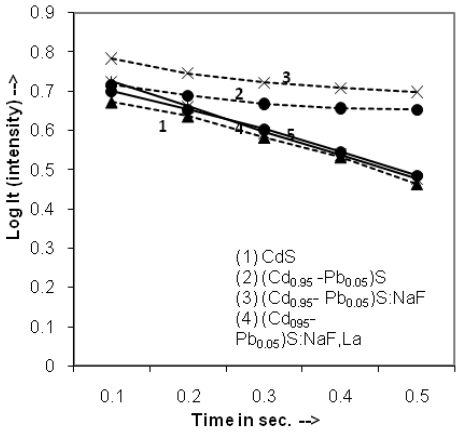

Fig. 4: Log l_t (intensity) vs time plots for films

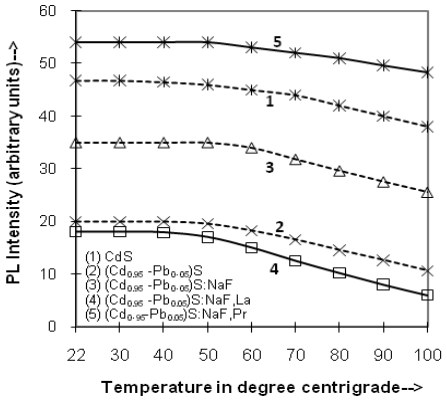

Fig. 5: Temperature dependence of PL brightness for different films prepared on glass substrate temperature the brightness is found to decrease The temperature dependence of photoluminescence brightness is shown in fig.- 5 for samples prepared on glass substrates.

Table 2: The values of trap depths calculated for different samples from PL studies

Systems E_1 (eV) E_2(eV)
1. CdS 0.639 0.621
2. $(Cd_{0.95}$-$Pb_{0.05})S$ 0.661 0.626
3.$(Cd_{0.95}$-$Pb_{0.05})S$:NaF 0.681 0.735
4.$(Cd_{0.95}$-$Pb_{0.05})S$:NaF,La 0.649 0.602
5.$(Cd_{0.95}$-$Pb_{0.05})S$:NaF,Pr 0.643 0.642

With continuously which is due to temperature quenching effect.

1.1.1.1 XRD Studies

The different peaks are assigned by making comparison with ASTM data. Lattice constants were also evaluated and compared with the standard values. In (Cd – Pb) S film (111)c, (200)c, (220)c and (311)c lines correspond with the cubic phase of CdS along with (200)c line of PbS. These values are presented in table-3.

Table 3: X-ray diffraction data for ($Cd_{0.95}$-$Pb_{0.05}$)S

d-values (^{0}A) Obs. Rep. (A)CdS annealed		*Relative intensities Obs. Rep.*		*hkl*	*Lattice const. (^{o}A) Obs. Rep.*	
3.3086	3.36	100	100	(111)c - CdS	a=5.7306	a=5.833
3.0451	2.969	81.0	100	(200)c - PbS	a=6.0902	a=5.936
2.8426	2.90	56.2	40	(200)c - CdS	a=5.6856	a=5.833
2.0432	2.058	60.1	80	(220)c- CdS	a=5.778	a=5.833
1.7703	1.76	68.1	90	(311)c- CdS	a=5.871	a=5.833

Table 4: XRD table for ($Cd_{0.95}Pb_{0.05}$)S :NaF

d-values (^{0}A) Obs. Rep.		*Relative intensities Obs. Rep.*		*hkl*	*Lattice const.^{o}A Obs. Rep.*	
3.3551	3.36	93.2	100	(111)c-CdS	a=5.811	a=5.833
3.033	2.969	62.9	100	(200)c-PbS	a=6.066	a=5.936
2.8537	2.90	62.9	40	(200)c-CdS	a=5.7074	a=5.833
2.0472	2.058	21.7	80	(220)c-CdS	a=5.790	a=5.833
1.7751	1.76	42.9	90	(311)c-CdS	a=5.8873	a=5.833
1.2389	1.212	100	10	(422)c-PbS	a=6.0693	a=5.936

Table 5: XRD table for ($Cd_{0.95}$-$Pb_{0.05}$)S:NaF,La (NO_3)$_3$

d-values (^{0}A) Obs. Rep.		*Relative intensities Obs. Rep.*		*hkl*	*Lattice constant ^{o}A Obs. Rep.*	
3.3256	3.36	100	100	(111) c-CdS	a=5.7599	a=5.833
3.3256	3.36	100	60	La(NO3)3		

In case of NaF doped samples lines (111)c, (200)c, (220)c and (311)c correspond with the cubic phase of CdS while (200)c and (422)c coincide with those of PbS. It has also been found that by the addition of NaF the number of lines increases. Earlier workers[13] found that in presence of NaF crystallinity improves. Probably this may be the cause of getting more lines in this case. Table-4 gives the values for NaF doped sample. In ($Cd_{0.95}$-$Pb_{0.05}$)S: NaF, La(NO_3)$_3$ sample [table-5], one line corresponding with (111)c line of CdS has been found. The lattice constants calculated are compared with the standard values and are tabulated in table-5. In case of Pr doped sample, i.e. ($Cd_{0.95}$-$Pb_{0.05}$)S: NaF, Pr(NO_3)$_3$ film different lines of CdS observed are (110)h, (111)c and (311)c along with (220)c line of PbS. The diffraction lines at d =3.3366 ⊕ and d = 2.0565^0 A may be due to Pr(NO_3)$_3$.

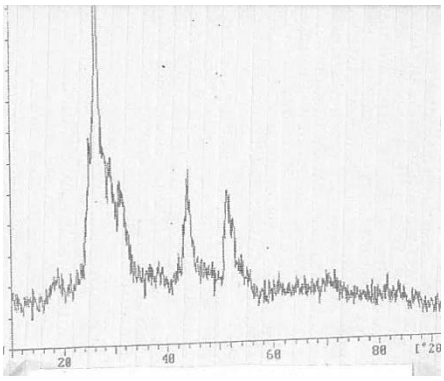

Fig. 6: X-ray diffractrogram of (Cd-Pb)S:NaF, Pr(NO_3)$_3$ film.

Similarly the lines at d =1.6480^0 A and d = 1.0305^0 A may be associated with NaF.The observed and reported d-values and the assigned (hkl) values are also summarized in the same table - 6. The calculated lattice constants are found to resemble with the standard values. The X – ray diffractograms of (Cd – Pb) S and (Cd – Pb) S: NaF, Pr(NO_3)$_3$ are shown in fig.-6.

1.1.1.1 SEM Studies

Fig.-7, shows the SEM micrograph of ($Cd_{0.95}$-$Pb_{0.05}$) S:NaF, Pr(NO_3)$_3$ sample. The SEM micrographs consist of leafy or cabbage structures. The leafy structures indicate layered type of growth of the film.

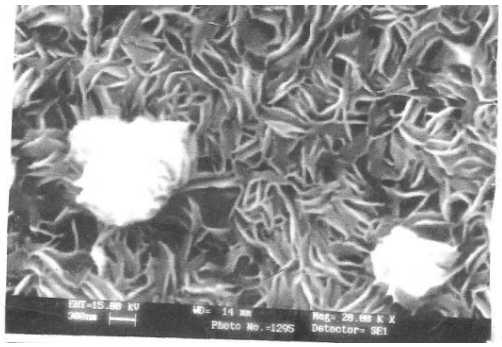

Fig. 7: SEM micrograph of (Cd-Pb)S:NaF,Pr(NO_3)$_3$ film at magnification 20k

Under continued deposition these structures sometimes converge and thus results in the formation of cabbage like structures.

Table 6: XRD table for ($Cd_{0.95}$-$Pb_{0.05}$)S:NaF, $Pr(NO_3)_3$

d-values (^{0}A) Obs. Rep.		*Relative intensities Obs. Rep.*		*hkl*	*Lattice const.^{o}A Obs. Rep.*	
3.5392	3.583	38.7	22	(100)h-CdS	a=4.0755, c=6.7	4.1354, 6.712
3.3366	3.36	100	100	(111)c-CdS	a=5.7791	5.689
	3.33	100	40	→ Pr		
2.0565	2.099	40.2	57	(220)c-PbS	a=5.8166	5.936
	2.090	40.2	5	→ Pr		
1.7746	1.761	34.3	45	(311)c-CdS	a=5.8856	5.833
1.6480	1.6390	2.9	60	→ NaF		
1.0305	1.0364	11.7	12	→ NaF		

2. CONCLUSIONS

Photoluminescence of undoped and La and Pr doped (Cd-Pb)S films show emission peak in the green yellow region under 365 nm excitation. Temperature dependence of photoluminescence brightness is decreasing in nature. XRD studies show crystalline nature and SEM studies show growth of layered structure.

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