Photoconductivity, XRD and SEM studies of $Gd(NO_3)_3$ doped and undoped (Cd-Pb)S Films of different concentrations

Research Paper—Physics

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1. Introduction:-The increase in electrical conductivity due to photons is known as photoconductivity. Photoconductivity studies are important because of applications in image intensifiers, xerography, thin film electronics etc. The films deposited by chemical deposition method are quite important for photoconductivity studies, chemical deposition method reported by Nair et al (*1-3*) and Bhushan et al (*4-6*) are very important, while the former group found improvement in the opto- electronic characteristics of solar assisted chemically deposited films, the latter group reported improvement of CdS and (Cd-Zn)S (mixed base) films. Only recently CdS thin films were grown by chemical deposition method by O.V. Galan et al.(7). In the present case, the same technique was used for depositing (Cd-Pb)S films of different concentrations. In this paper, the results obtained from different studies of (Cd-Pb)S films of concentrations of 98%-2%, 95%-5%, 90%-10% and 50%-50% are reported.

2. Experimental:-The films are prepared on 24x75 mm commercial glass slides as reported earlier (8-*11*) by chemical bath deposition method at a constant temperature of 60 degree C. For the deposition of the films the glass substrates were washed with acetone and finally with distilled water and finally dipped in a beaker containing a mixture of acetates of lead and cadmium, thiourea, triethanolamine, 30% aqueous ammonia etc. (8-*11*). XRD studies were carried out, using a Philips diffractrometer. Further SEM studies were performed using LEO (430) SEM.

3. Results and Discussions:-3.1 Rise and decay studies- In the present work, photoconductivity rise and decay in films of rare earth doped (Cd-Pb)S were studied. Table-1 summarizes the dark current I_{dc} and the ratio I_{pc}/ I_{dc} for a number of films. The graphs for CdS, $(Cd_{.98}\text{-}Pb_{.02})S$,$(Cd_{.95}\text{-}Pb_{.05})S$ and $(Cd_{.90}\text{-}Pb_{.10})S$ films are shown in fig.-1. The general nature of the graph is similar for all the films. This is characterized by a fast rise in the beginning followed by saturation. The latter sets in when the recombination becomes predominant. Earlier workers considered the component of the photocurrent in (Cd-Zn) S films is due to enhanced mobility (*5-6*). In case of Pb mixed samples, the photoconductivity gain (I_{pc}/ I_{dc}) gives the highest value for a particular sample i.e. $(Cd_{.95}\text{-}Pb_{.05})S$ sample. From the analysis of the photoconductivity decay curves, the values of instantaneous lifetime (τ) and mobility (μ) and trap depth values are evaluated. The calculations are described in earlier publication (*11*). The values of τ, μ and E_1, E_2 obtained for different concentrations of (Cd-Pb)S systems are summarized in Table – 2.

3.2 XRD and SEM Studies:-The XRD studies were performed. Fig.-2 shows the X-ray diffractogram of $(Cd_{0.95}\text{-}Pb_{0.05})S$ film. Different lines are assigned by comparing with ASTM data. Lattice constants were calculated from the standard values. The observed and reported d-values, intensities, h,k,l values, observed and calculated lattice constants are summarized in Table- 3 for different films. Considering table- 3(A) lines (111)c, (200)c, (220)c ,(311)c and (222)c lines of cubic phase,(203)h line of hexagonal phase of CdS, along with (200)c line of PbS has been found in $(Cd_{0.98}\text{-}Pb_{0.02})S$ sample. The XRD pattern in $(Cd_{0.95}\text{-}Pb_{0.05})S$ film Table-3(B), lines (111)c, (200)c, (220)c and (311)c correspond with the cubic phase of CdS along with (200)c line of PbS. In the next Table-3(C),only (511)c line of cubic phase of PbS has been found in $(Cd_{0.50}\text{-}Pb_{0.50})S$ sample. It is observed from the results of the XRD that by increasing the percentage of PbS, the lines of CdS disappear. The calculated and reported values of lattice constants tally with each other and are mentioned in the Table- 3.

3.3 **SEM Studies:-**SEM micrographs of different films were also investigated. For representative samples SEM micrographs of CdS and $(Cd_{0.95}\text{-}Pb_{0.05})S$ films at a magnification of 10K are shown in fig. – 3. Both show cabbage type structure. Such structures indicate layered growth of the material. These layers under continued growth condition formed cabbage like structure.

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Table- 1, Values of dark current (I_{dc}) photo current (I_{pc}) and the ratio (I_{pc}/I_{dc}) for different films (Temp. of deposition=60^{0}C, time of deposition =1 hr., voltage =15volts.)

Systems	I_{dc} (nA)	I_{pc} (μA)	I_{pc} / I_{dc}
1. CdS	0.1	32	3.2 x 10^5
2. ($Cd_{0.98}$-$Pb_{0.02}$)S	0.1	21	2.1 x 10^5
3. ($Cd_{0.95}$-$Pb_{0.05}$)S	0.05	30	6 x 10^5
4. ($Cd_{0.90}$-$Pb_{0.10}$)S	0.1	13	1.3 x 10^5
5. ($Cd_{0.95}$-$Pb_{0.05}$)S:$CdCl_2$	0.1	315	3.15 x 10^6
6. 5. ($Cd_{0.95}$-$Pb_{0.05}$)S:$CdCl_2$.$Gd(NO_3)_3$	0.1	522	5.22 x 10^6

Table- 2, Values of instantaneous lifetime (τ) , mobility (μ) and trap depths (E_1 and E_2) for different (Cd-Pb)S films. (Temp. of deposition =60^{0}C, time of deposition =1 hr., voltage =15volts.)

Table – 3, XRD data for different films

d-values (^{0} A) Obs.	Rep.	Relative intensities Obs.	Rep.	hkl	Lattice const. (^{o}A) Obs.	Rep.
(A)(Cd-Pb)S		98% -02%				
3.3434	3.36	100	100	(111)c - CdS	a=5.723	a=5.833
3.0269	2.969	55.2	80	(200)c - PbS	a=6.0538	a=5.936
2.7814	2.90	36.0	40	(200) c- CdS	a=5.5628	a=5.833
2.0474	2.058	23.6	80	(220) c -CdS	a=5.799	a=5.833
1.7687	1.76	47	90	(311)c- CdS	a=5.866	a=5.833
1.7492	1.680	22.2	10	(222)c- CdS	a=5.81	a=5.833
1.3918	1.398	6.6	15	(203)h- CdS	a=4.102 c=6.6868	a=4.1354 c=6.712
(B)(Cd-Pb)S		95% -5%				
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
(C)(Cd-Pb)S		50% -50%				
1.1192	1.1424	40	6	(511)c– PbS	a=5.8155	a=5.936

pths

$_2$= 0.712

$_2$= 0.538

$_2$=0.567

$_2$= 0.773

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