CHAPTER V

SPECTRAL STUDIES OF FILMS
5.1 Introduction

Spectral studies provide quite useful informations. The excitation spectra in which plot of photocurrent is considered against wavelength or frequency of the exciting light, gives information about the nature of the light near the absorption edge or different from the absorption edge. Presence of impurities are also resolved in many cases. If the proportion of light scattered is small then it is essential to consider only the light absorbed and transmitted (Parker 1968). Particularly in thin films such studies are very important as it is possible to determine the optical constants conveniently Chopra (1969). Thus study of transmission/absorption spectra becomes very useful tool in such cases. In view of importance associated with such studies, excitation and transmission spectra were studied for the samples under present study and corresponding results are discussed in the present chapter.

5.2 Results and discussions

5.2.1 Excitation spectra

Figure 5.1 shows the excitation spectra for undoped and Nd doped CdS films. Normalization has
Fig. 5.1: Excitation spectra of different photoconductive films: (a) Undoped CdS, (b) CdS:NaCl (7.5 ml), (c) CdS:Nd (5.0 ml), (d) CdS:NaCl (7.5 ml), Nd (10.0 ml), (e) CdS:NaF (5.0 ml), (f) CdS:NaF (5.0 ml), Nd (5.0 ml)
been done using the highest photocurrent out of all the studies. A strong peak in all cases is observed in the range 500-510 nm which corresponds closely to the band gap of CdS and thus indicates the formation of CdS. A decrease in the response at shorter wavelengths may be due to an enhanced energy absorption in the thin film surface layer where the rate of recombination through the traps is much higher than in the bulk of the material (Sharupich and Tugov 1987). In the case of undoped CdS some smaller peaks are also observed at 620 and 640 nm which may be due to presence of impurities in the original chemicals utilized in the preparation of CdS. In CdS : NaF another smaller peak at 670 nm is observed whose intensity increases in presence of Nd. In fact, the intensities of all the peaks are improved very much in presence of Nd. The corresponding curves for Pr doped materials are shown in fig 5.2. Here also a similar situation is observed but with little change in the positions of the peaks. Thus, the role of impurities may be considered as enhancing the intensities of the peaks as well as creating some new peaks.
Fig. 5.2: Excitation spectra of different photoconductive films (a) Undoped CdS, (b) CdS:NaCl (7.5 ml), (c) CdS:Pr (7.5 ml), (d) CdS:NaCl (7.5 ml), Pr (1 ml), (e) CdS:NaF (5.0 ml), (f) CdS:NaF (5.0 ml), Pr (7.5 ml)
5.2.2 Transmission spectra

The transmission spectra of undoped CdS films at different times of deposition are shown in fig 5.3. Increasing deposition time reduces the transmission along with increase in growth thickness. Thus, the major effect of crystalline growth is in the film transmittance. The results of CdS : NaF at different concentrations of NaF are shown in fig 5.4. In this case a better fall in transmission is observed at around 520-540 nm. Bhushan and Sharma (1980) reported that in presence of NaF the crystalline nature of CdS is improved. This may be probable cause for this effect. Due to annealing almost a similar behaviour is observed as can be seen from fig 5.5 in which results of annealed and unannealed CdS and CdS : NaF are plotted. However, the percentage transmission in the annealed film is reduced.

Figures 5.6 and 5.7 represent the transmission spectral curves for CdS : NaF, Nd and CdS : NaF, Pr films at different concentrations of Nd and Pr respectively. In this case also almost a similar nature is observed. Further with increasing concentration of the impurities (Nd and Pr) the transmission is found to reduce. The effect of annealing was also studied in Pr doped samples and the corresponding results are shown in
Fig. 5.3: Transmission spectra of undoped CdS films at different deposition time: (a) 2 hrs., (b) 4 hrs., (c) 6 hrs., (d) 8 hrs., (e) 10 hrs.
Fig. 5.4: Transmission spectra of CdS:NaF films with different concentration of NaF: (a) 2.5 ml, (b) 5.0 ml, (c) 7.5 ml.
Fig. 5.5: Transmission spectra of different films: (a) Undoped CdS unannealed, (b) Undoped CdS annealed (at 400°C for 3 min.), (c) CdS:NaF (5.0 ml) unannealed, (d) CdS:NaF (5.0 ml) annealed (at 400°C for 3 min.).
Fig. 5.6: Transmission spectra of different Nd doped films with fixed concentration of NaF (5.0 ml): (a) CdS:NaF,Nd (2.5 ml), (b) CdS:NaF,Nd (5.0 ml), (c) CdS:NaF:Nd (7.5 ml).
Fig. 5.7: Transmission spectra of different Pr doped films with fixed concentration of NaF (5.0 ml): (a) CdS:NaF, Pr (5 ml), (b) CdS:NaF, Pr (7.5 ml), (c) CdS:NaF, Pr (10 ml).
fig 5.8. Here also it is found that annealing reduces the transmission. Jaychandran et al (1989) observed in electrodeposited CdS films on transparent conducting SnO$_2$ substrates that annealing enhances the absorbance. Thus the present results also favour such observation. The transmission spectra of films prepared in presence of NaCl were also studied and the corresponding results are shown in fig 5.9. Here also it is observed that the nature of transmission spectra in presence of NaCl alone is well defined similar to those observed in presence of NaF. However the presence of impurities does not show sharp fall of the transmission curves.

The absorption coefficient can be defined as

$$\alpha = \frac{4\pi Kg}{\lambda} \tag{5.1}$$

where $K_g$ is the absorption index defined by

$$K_g = 2.303 \times 4\pi d \log \left(\frac{1/T_0}{\lambda}\right) \tag{5.2}$$

where $T_0$ is the percentage transmission corresponding to wavelength $\lambda$ and $d$ is the thickness of the film. From
Fig. 5.8: Transmission spectra of different Pr doped films: (a) CdS:Pr (7.5 ml) unannealed, (b) CdS:Pr (7.5 ml) annealed (at 400°C for 3 min.), (c) CdS:NaF (5.0 ml), Pr (7.5 ml) unannealed (d) CdS:NaF (5.0 ml), Pr (7.5 ml) annealed (at 400°C for 3 min.).
Fig. 5.9: Transmission spectra of different doped films: (a) CdS:NaCl (7.5 ml), (b) CdS:NaCl (7.5 ml), Nd (10 ml), (c) CdS:NaCl (7.5 ml), Pr (10 ml).
the results of transmission spectra for undoped CdS films prepared at 8 hrs. $\chi^2$ was calculated and then plotted against the incident photon-energy ($hv$) in fig 5.10. This gives a direct optical band gap of 2.40 eV which agrees closely with the generally accepted value of band gap of CdS as 2.42 eV.
Fig. 5.10: Variation of absorption coefficient against incident photon-energy for undoped CdS film (deposition time 6 hrs.).