

SLOW RESPONSE PHOTOCONDUCTIVITY OF  
 $\text{Cd}_{1-x}\text{Hg}_x\text{S}$  THIN FILMS

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**ABSTRACT:**  $\text{Cd}_{1-x}\text{Hg}_x\text{S}$  thin films are prepared by chemical deposition. The films prepared by this method exhibit pronounced slow response photoconductivity. The fall of the conductivity with time was subject to examination and non-exponential decay was found. The spectral sensitivity of the photoconductivity was found to be maximal for the wave length which corresponds to the energy gap and moves to the longer wave lengths with increase of Hg concentration.

**INTRODUCTION:** Semiconductor thin films can be prepared by variety of methods, but among them, the chemical deposition method /1,2/ is the simplest and most economic. The solid solution or alloy of semiconductors in a thin film form are of particular interest due to the possibility of changing their properties with the composition. The energy gap of alloyed semiconductor films can be tailored with respect to their application. The variation of the chemical deposition method /1/ has been found effective for  $\text{Cd}_{1-x}\text{Zn}_x\text{S}$  preparation /3/ and also it was applied for  $\text{Cd}_{1-x}\text{Hg}_x\text{S}$  thin films preparation with  $x = 0,0 - 0,30$ .

**EXPERIMENTAL PROCEDURE:** A substrate microscopic glass is dipped subsequently in two solutions for 1-2 s: The first solution was made of 0,1M  $\text{CdCl}_2$  and  $\text{HgJ}_2$  complex solutions in a ratio  $(1-x): x$ , where  $x$  was changed from 0,0 to 0,30 and it was kept at room temperature. The second solution was made of 0,1M thiourea and 5-10 ml 2M NaOH, heated to temperature from  $80^\circ$  to  $90^\circ$  C. After each fifth dipping in one of the solutions the film was rinsed with water in order to remove the deposited powder from the surface. The film quality (plan parallelity) was checked by colour of the interference curves of equal thickness.

**RESULTS AND DISCUSSION:** The dynamics of the slow response photoconductivity of  $\text{Cd}_{1-x}\text{Hg}_x\text{S}$  thin films was studied by observing the time dependence of

resistance of the films during the illumination and after the illumination has ceased, followed by the resistance variation in time during the illumination and darkening of the films. The films were illuminated by white light with intensity  $25 \text{ mW/cm}^2$  and the resistance was measured by universal instrument VK7-9. The time dependence of the photoconductivity for  $\text{Cd}_{0,85} \text{Hg}_{0,15} \text{S}$  is presented in Fig.1, where it can be seen that the films exhibit pronounced slow response photoconductivity. It was found that the

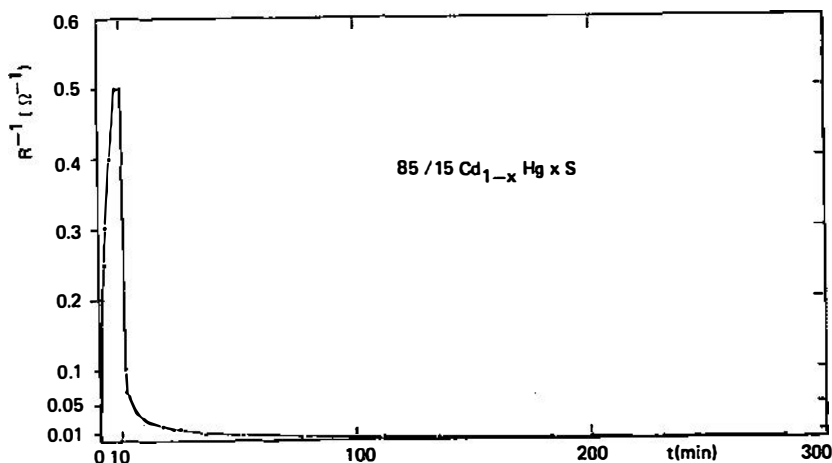


Fig. 1

conductivity falls slower after darkening as Hg concentration is increased. The decrease of photoconductivity after darkening of the films does not follow the simple law of the linear or square recombination. For linear recombination the conductivity should follow the relation  $y = j_0 e^{-at}$  and for square recombination it should follow the relation  $y = \frac{y_0}{1 + bt}$ , i.e.  $\ln y$  vs.  $t$  and  $\frac{1}{y}$  vs.  $t$  should be straight lines for the first and the second case respectively. In our case neither  $\ln y$  nor  $\frac{1}{y}$  vs.  $t$  gave straight lines and so neither linear nor square recombination is involved in the mechanism of slow response photoconductivity.

The investigations showed that the mechanism in these films is more complicated and the decrease of the photoconductivity with time can be described by an extended exponential function

$$Y = Y_0 \exp(-at^n)$$

where the values of  $n$  are slightly higher than  $1/4$ . This is evident from the graphycal presentation of  $\ln \ln \frac{Y_0}{Y}$  vs.  $\ln t$ , Fig.2, which gives a straight line with a slope of  $n \approx 0,25$  for all the films which were subject of the investigation.

Special sensitivity of the slow response photoconductivity of the pure CdS thin film was investigated and some of the alloyed films

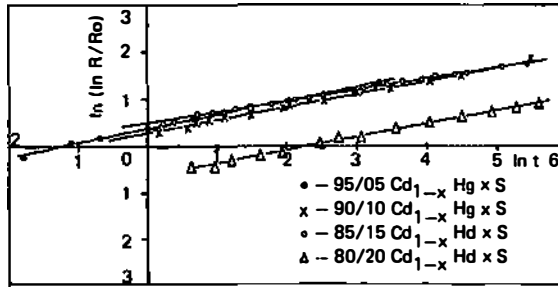


Fig. 2

( $Cd_{0.90}Hg_{0.10}S$  and  $Cd_{0.80}Hg_{0.20}S$ ). The resistance was measured with the same instrument, and as a monochromator was used the spectrophotometer SPG - 300 PYE UNICAM. Two Ag-paste electrodes were painted on the film at 2 mm distance. The films were left 2-3 days in the dark chamber of the spectrophotometer in order to eliminate the residual conductivity. Then the film was illuminated by monochromatic light during 3 hours and after that the increase of the resistance was measured as a function of time. This procedure was repeated for every 10 nm in the range from 400-650 nm. The results presented in Fig.3 show that the spectral sensitivity of the slow response photoconductivity reaches maximum at the wavelength  $\lambda_c$ . This maximum coincides with the wave length  $\lambda_0$  which corresponds to the energy gap determined by optical absorption spectrum /4/. The maximum moves towards the longer wavelength as the concentration of Hg in the film increases, as shown in Table 1.

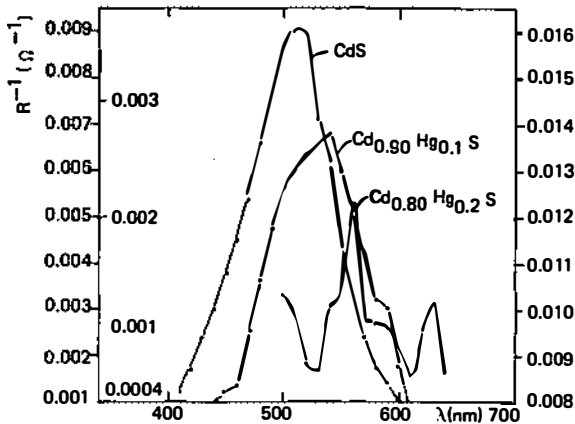


Fig. 3

Table 1.

$1-x/x$	$\lambda_0$ (nm)	$\lambda_c$ (nm)	
1/0	506	515	$\lambda_c$ was not determined for
0,95/0,05	508	-	films $Cd_{0,95} Hg_{0,05} S$ and
0,90/0,10	520	540	$Cd_{0,85} Hg_{0,15} S$ because of
0,85/0,15	526	-	the very long relaxation time
0,80/0,20	537	560	for this composition.

The dependence of the spectral sensitivity of the slow response photoconductivity for the  $Cd_{0,80} Hg_{0,20} S$  film presented in Fig.3 shows clear maximum at  $\lambda = 560$  nm, which, probably corresponds to  $\lambda_0$  for energy gap at  $Cd_{0,80} Hg_{0,20} S$ . In Fig.3 there are two more maxima, one left and one right, which, probably, correspond to the energy gap of CdS and HgS, whose energies are 2,42eV and 1,8 eV, respectively /57. This shows that the film is not of uniform composition.

**CONCLUSION:** The results in this paper show that chemical deposition method with variable composition is simple and economic and it can be used successfully for preparation of  $Cd_{1-x} Hg_x S$  thin films. These films exhibit a dominant slow response photocinductivity. It was shown that the mechanism is more complex because it does not follow neither linear nor square recombination. It can be described with an extended exponential function. Maximal spectral sensitivity of the slow response photoconductivity appeared at a wavelength which corresponds to the energy gap and moves towards the longer wavelength by increasing the Hg concentration in the films.

#### REFERENCES

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