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ELECTRICAL AND PHOTOCONDUCTION STUDIES ON CHEMICAL BATH DEPOSITED CADMIUM SULPHIDE THINFILMS

S. PRABAHAR[a*], N. SURYANARAYANAN [b], D. KATHIRVEL[c]
[a]*Department of Physics, Tamilnadu College of Engineering, Karumatham Patti, Coimbatore-641 659, India*
[b]*Department of Physics, Government College of Technology, Coimbatore-641 013,India*
[c]*Department of Physics Kalaignar Karunanidhi Institute of Technology, Coimbatore-641602, India*

Cadmium sulphide thin films have been deposited on glass substrate by a chemical bath deposition method. An aqueous alkaline bath consisting of cadmium chloride, thiourea, triethanolamine and ammonia. The preparative parameters like ion concentration, temperature, pH and stirring rate have been optimized for getting good quality thin films. The growth of film was found to be ion -by- ion method. Electrical resistivity of CdS thin films have been measured in the temperature range 303- 423 K and voltage range from 2-12 volts. Photoconductivity measurements have been carried out at room temperature as a function of applied voltage and wavelength of light sources.

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1. Introduction

The wide energy gap of cadmium sulphide semiconductors is one of the most important properties leading to the great experimental interest in these materials. The naturally occurring II-IV semiconductors have received increased attention since the early experimental investigation of transistors in 1951, because of their practical use in electronic devices such as photovoltaic cell as window layers, [1,2], multilayer light emitting diodes [3] , photo detectors [4],TFET[5,6] and transparent conducting semiconductors for optoelectronic devices[7]. These materials can be obtained in thin film form by various methods including vacuum evaporation [4, 8- 10], chemical vapour transport [7], spray pyrolysis [11, 12], pulsed laser deposition [13] and chemical bath deposition [2, 14]. The chemical bath deposition method is relatively inexpensive, simple and convenient for the large area of deposition of II-IV compounds. In a previous work we reported the preparation, structural, optical and photoluminescence properties of CdS thin films [15, 16]. In this paper we present the results of our studies on electrical and photoconductivity measurements carried out on CdS thin films.

2. Experimental

Cadmium sulphide thin films were deposited onto cleaned spectroscopic grade glass substrate. Chemical bath used for the deposition of CdS thin films consist of cadmium chloride, thiourea, triethanolamine and ammonia. Thin film deposition is carried out at different temperature from 60 to 90C. Two different molar proportions of cadmium chloride and thiourea namely 5:5

*Corresponding author: prabusr80@gmail.com

and 1:1 are used. The deposition process is performed at various pH values of the bath from 9 to 11. The substrates are placed vertically in the bath for different deposition time varying from 30 to 60min. Electrical resistivity of CdS thin films have been measured in the temperature range 303-423 K and voltage range from 2-12 volts. Photoconductivity measurements have been carried out at room temperature as a function of applied voltage and wavelength of light sources.

3. Results and discussion

3.1 Dependence of resistivity on deposition time

Fig.1 shows the variation of room temperature with deposition of CdS thin films of 9780Å thickness and it has been understood that the resistivity is minimum for the film which has the deposition time of 38 minutes and the resistivity increases as the deposition time increases. Hence the optimum value of the deposition time of CdS thin film has been found as 38 minutes.

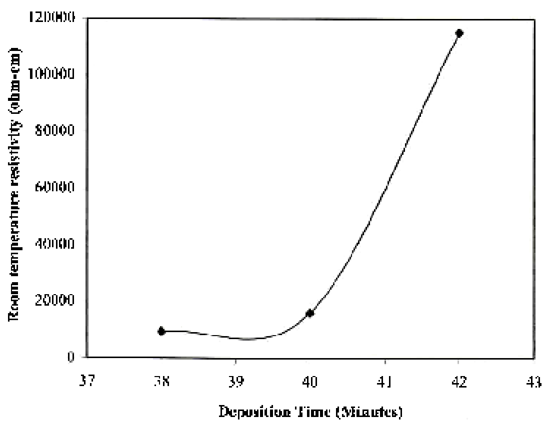

Fig. 1.Variation of resitivity vs. deposition time of CdS thin films of thickness 9780Å

3.2 Temperature dependence of film resistivity

Plot of temperature dependence of resistivity of CdS thin films of two different thicknesses Fig.2 reveals that the film resistivity increases with inverse temperature. Similar behavior has been reported earlier for sprayed CdS thins [17].The evaluated resistivity values of CdS thin films are of the order 10^4-10^5 ohm-cm which agreed well with the earlier reports.

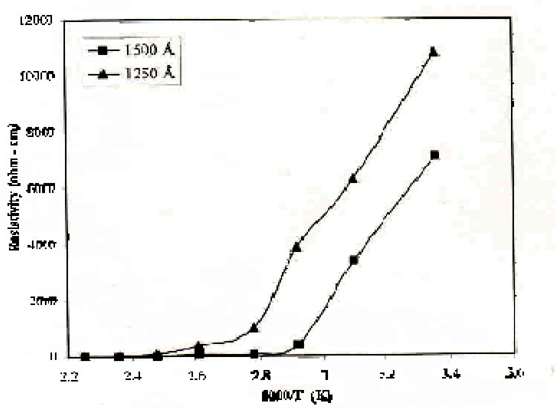

Fig.2. Plot of temperature dependence of resistivity of CdS thin films different temperature

3.3 Room temperature conductivity of CdS thin films

Fig 3 shows the plot of room temperature current density vs. applied voltage of CdS thin films. At lower voltages the slope of curve was approximately equal to 1 whereas the slope increases to approximately 1.5 as the voltage increases to 18 volts. Therefore it can be concluded that at lower voltages ohmic conduction exists and the conduction mechanism tends to change at higher voltages. It can also be expected that at still higher voltages the slope may be approximately 2 which corresponds to space charge limited conduction mechanism. Similar mechanisms have been reported earlier for CdS thin films [8].

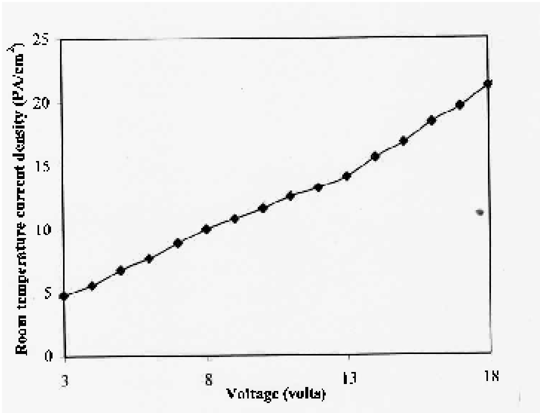

Fig .3.Current density vs voltage characteristics at the room temperature for CdS thin films of thickness 9780Å

3.4 High temperature conductivity of CdS thin films

The temperature dependence of conductivities of CdS thin films of thickness 1250Å and 9780Å has been presented in Fig. 4. From the linear fit of log σ vs.1000/T it is possible to calculate the activation energy for the dominating conduction. The plot shows a unique increase in film conductivity with increase in temperature which indicates the semiconducting nature of the films [18].The linear characteristics of the plot indicate the presence of only one type of conduction mechanism. Since the plot fit to the relation

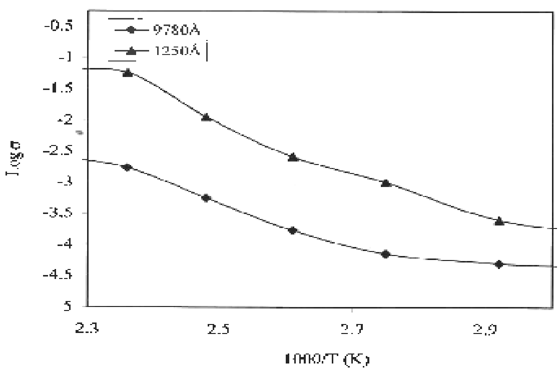

Fig. 4.Temperature dependence of conductivity of CdS thin films of different thicknesses.

$$\sigma = \sigma_0 \exp [E_a/KT] \quad (1)$$

high temperature conductivity is attributed due to the thermal excitation of charge carriers from grain boundaries to the neutral region of the grains. From the plot activation energy of CdS thin films of thickness 9780Å and 1250Å were found to be 0.6eV and 0.4 eV respectively. The decrease in activation energy with film thickness proves the semiconducting nature of the thin films. The decrease in activation energy also suggests that the grain boundary scattering contribution reduces significantly as the thickness increases. Similar characteristics have been reported by other workers [19, 20]

3.5 Photo Conductivity as a function of applied voltage

The variation of photocurrent of CdS thin films with applied voltage is shown in Fig.5. The plot shows that there is a linear dependence of photocurrent (I_{ph}) with applied voltage which supports the deposited CdS films are free from traps as reported earlier [20].The observed relationship of $I_{ph} \infty V_n$ with n≠1 in CdS thin film suggests that recombination mechanism is monomolecular.

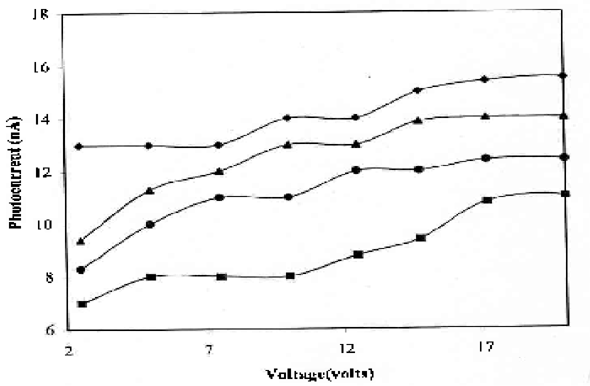

Fig. 5.Plot of photocurrent vs. applied voltage.

3.6 Photo-conductivity as a function of wavelength

The plot of photocurrent vs. wavelength of light is shown in Fig. 6. The photocurrent increases with wavelength and attains a maximum and then decreases. The photoconductive spectrum shows a peak near the absorption edge. The maximum photoconductivity is centered on 600 nm which corresponds to the band gap of CdS thin films.

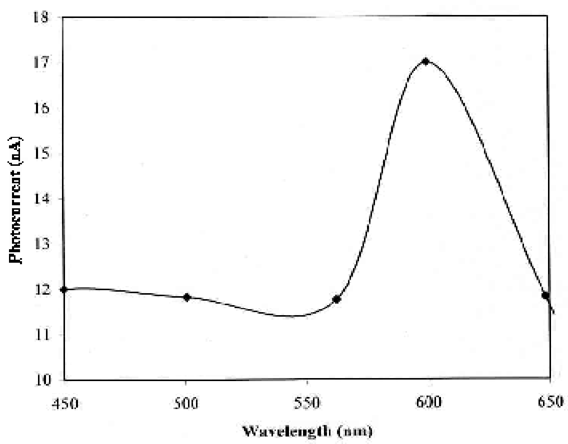

Fig.6. Variation of photocurrent with wavelength of light.

4. Conclusion

The room temperature as well as high temperature conduction mechanisms have been identified from the electrical analysis. Photoconduction studies confirmed that CdS films are free from traps and the recombination mechanisms in the films have been found as monomolecular.

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