

Optical Studies of ZnS-Al₂O₃ Composite Thin Films by Spray Pyrolysis



Physics

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ABSTRACT

Spray pyrolysis is a very cheap and inexpensive method of depositing thin films of large area. We have deposited ZnS-Al₂O₃ composite thin films on glass substrates at 300°C by this method, using aqueous solutions of Zinc chloride, thiourea and aluminum chloride (Al₂Cl₃) of 0.1 M of each. Our results show that as Al₂Cl₃ concentration increases in ZnCl₂ solution, the optical band gap decreases. This indicates that there are three composite mixtures ZnAl₂, ZnS-Al₂S₃ and ZnS-Al₂O₃ also formed.

Introduction

The polycrystalline ZnS has been receiving considerable attention for a long time for their low cost production and various useful applications in thin films devices [1-3]. In order to fulfill the growing needs, the human efforts has always been to explore new avenues to obtain energy from other possible sources, the man ceaseless effort have revealed one such possible source of energy, that is solar energy. The solar heat has a tremendous power which can be utilized for various energy needs. The direct conversion of solar energy into electrical energy is highly desirable. This photovoltaic conversion is brought about by devices known as solar cells [4,5,6]. Thin films have played an important role in a variety of satellite programmes and appear to be increasing importance of this area. The importance of the thin films in optical properties was considerable. The interest in optical properties was largely confined to be use of reflecting films in interferometry. Thus thin films are put to various uses. To prepare thin films of desired properties, usually composite films are prepared.

Bodh Raj et al [7] and others workers have reported the optical properties of CdS-Al₂O₃ composite films, for solar cells CdS films are of use. In their study they found that energy gap of composite CdS-Al₂O₃ films does not change with concentration of Al₂O₃. Hence we thought it worthwhile to study the optical properties of ZnS-Al₂O₃ and find out whether the energy gap changes with composition or not.

Preparation of sample

Aqueous solution of Zinc chloride, thiourea and aluminum chloride (Al₂Cl₃) were used for spraying the films. The molarity of each solution was 0.1 M. Chemical were used as AR-grade. The temperature of the substrate was maintained at 300°C, which was the most suitable temperature for the production of composite ZnS: Al₂O₃ thin films. The temperature was measured by pre-calibrated copper-constantan thermocouple. The sprayer was mechanically moved to and fro to avoid the formation of droplets on hot glass substrate and to ensure instant evaporation. The solution was sprayed at a pressure of 12 kg/cm². The rate of flow was maintained at 3.5 ml/min. The thickness of the films so obtained was of the order of 0.183 μm. The thin films of ZnS had faint yellow colour while when addition of Al₂Cl₃ was done, colour becomes white.

Transmission study

The transmittance of the all thin films was measured for various wavelengths ranging from 350 nm to 700 nm using UV-1800 Shimadzu spectrophotometer. Fig. 1 shows the transmittance vs wavelength for varying concentration of Al₂Cl₃. From curves I to III, concentration of Al₂Cl₃ increases from 20 % (While ZnCl₂ concentration decreases from 100 % to 80 %) which shows steep rise in transmittance as wavelength increases. Curves IV to IX, concentration of

Al₂Cl₃ increases from 30 % to 80% (while ZnCl₂ concentration decreases from 80 to 30 %) which shows less steep rise in transmittance as wavelength increases. The graph I) 0 % of Al₂Cl₃ in ZnCl₂, II) 10 % Al₂Cl₃ in ZnCl₂, III) 20 % Al₂Cl₃ in ZnCl₂, IV) 30 % Al₂Cl₃ in ZnCl₂, V) 40 % Al₂Cl₃ in ZnCl₂, VI) 50 % Al₂Cl₃ in ZnCl₂, VII) 60 % Al₂Cl₃ in ZnCl₂, VIII) 70 % Al₂Cl₃ in ZnCl₂ and IX) 80 % Al₂Cl₃ in ZnCl₂. The graph 1, 2, 3 showing steep rise in transmittance as wavelength increases. The graph 4, 5, 6 shows as concentration of Al₂Cl₃ increases less steep in transmittance as wavelength increases.

From the fig.1, the absorption coefficient (α) was determined at various wavelengths for all films by using the following relation,

$$\alpha = \frac{1}{t} \log\left(\frac{I_0}{I}\right) \quad (1)$$

Where, t-is the thickness of the films, I₀ and I are the intensities of incidents and transmitted radiation respectively.

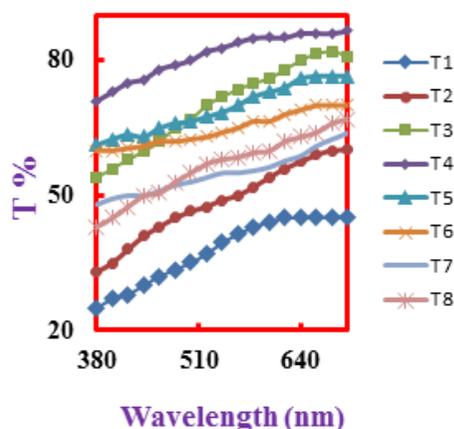


Fig. 1 shows the transmittance vs wavelength for varying concentration of Al₂Cl₃ in ZnCl₂

To calculate the exact value of optical band gap plotting graph $(\alpha h\nu)^2$ against $h\nu$ for all films, for the region near and above the fundamental absorption edge. The linearity of graph indicated that directly allowed transition described by the relation,

$$\alpha = \frac{A}{h\nu} (h\nu - E_g)^{1/2} \quad (2)$$

is probably responsible for the absorption process. The band gap E_g determined from extrapolated intercepts on $h\nu$ axis for all films was listed in table 1. This result well agree with the result reported by Bodh et al [7]

Fig. 2 shows the variation of optical band gap against % of concentration of Al_2Cl_3 in ZnCl_2 solution

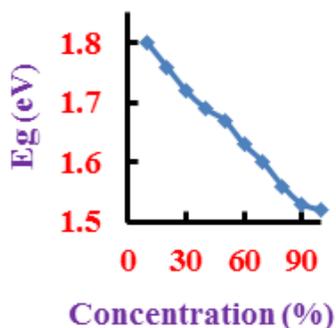


Table. 1 % of Al_2Cl_3 Solution in ZnCl_2 Solution with band gap (eV)

% of Al_2Cl_3 solution in ZnCl_2 solution	Band Gap (eV)
10	1.80
20	1.75
30	1.70
40	1.69
50	1.68
60	1.68
70	1.60
80	1.60
90	1.54
100	1.53

From fig. 2 we conclude that optical band gap is continuously decreasing as concentration of Al_2Cl_3 increases.

Results and Discussion

Bodh et al has developed the films of composites $\text{CdS}-\text{Al}_2\text{O}_3$ by similar methods. Their results indicate no change in optical transmittance of composites CdS films. Also they observed that presence of Al_2O_3 does not interfere with structure of CdS and concluded that CdS and Al_2O_3 crystallites are separately developed. Initially before conducting the experiments we had also expected no change in band gap of ZnS derived from optical results. However our results show that as Al_2Cl_3 concentration increases, the optical band gap decreases. This proves that there is sort of interference of Al atoms in ZnS Structure [9].

It is also possible that oxygen from carrier gas (air) combines with Al^{3+} ions and Al_2O_3 is formed separately [10]. Thus three composite mixtures ZnAl_x , $\text{ZnS}-\text{Al}_2\text{S}_3$ and $\text{ZnS}-\text{Al}_2\text{O}_3$ can be formed while spraying or mixtures of all above three composite is also possible.

Thus spray pyrolysis is a successful method for depositing $\text{ZnS}-\text{Al}_2\text{O}_3$ composites thin films.

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References

- 1] W. D. Gill and R. H. Bube, J. Appl. Phys. 41 (1970) 3731.
- 2] S. Banerjee and H. sah, Ind. J. Pure and Appl. pHys., 26 (1988) 561.
- 3] H. Sehil, H. Lhermite, F. Raoult and Y. Colin, Solid State Electron, 37 (1994) 159.
- 4] Y. D. Tembhurkar, Bull.meter.sci., Vol 20 No. 7 October (1997) 1011.
- 5] Y. D. Tembhurkar and J. P. Hirde, Bull.Meter.Sci., Vol 16, No. 3 June (1993) 177.

- 6] Y. D. Tembhurkar and A. S. Meshram, Inter. J. Scienti. Res., Vol 7 (9) September (2015)23.
- 7] Bodh Raj, D. K. Chapra, National Solar Energy Conversion, I. I. T. New Delhi (1989)
- 8] Y.D. Tembhurkar and J.P.Hirde, Thin Solid Films 215 (1992) 65-70
- 9] J. M. Pawli Kowski, Thin Solid Films 127 (1985) 29.
- 10] O.S. Heavens, Optical properties of thin films, Butterworths Scientific Publications, London (1955)