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Effect of Bath Temperature on the Optic Properties of Aluminium Sulphide Thin Films

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ABSTRACT

Al_2S_3 thin films on glass substrate have been deposited by chemical bath deposition technique at temperatures 300K and 373K. Aqueous solution of 50ml containing $AlCl_3$, Thiourea and EDTA, where AlS_3 and thiourea were the sources of Al^+ and S^- and EDTA was used as a complexing agent. Al_2S_3 films were prepared at various bath temperatures while the deposition period was kept fixed at 2 hours. The effect of the resulting film properties was studied by UV-VIS spectrophotometer. The optical absorption spectra of Al_2S_3 films showed that the optical absorption increases with the bath temperature while the transmittance decreases with increase in the bath temperature. The optical band gap was found to decrease from 1.80eV to 1.35eV, as the deposition temperature was increased from 300K to 373K.

Keywords: *Metal chalcogenide, thin films, Aluminiun Sulphide, chemical synthesis, optical properties.*

1. INTRODUCTION

The metal chalcogenides are used for the solar energy conversion through photo electrochemical cells. Recently, extensive research has been devoted to study the fabrication and characterization of chalcogenide compounds in the form of thin film. Among the metal chalcogenides, aluminium sulfide thin film is one of the most interesting metal chalcogenide. Thin films of aluminum sulphide were grown using solution growth technique (SGT). The chemical bath deposition technique (Wang *et al,* 1999) has been found to be an inexpensive and simple low temperature method that could be used to produce good quality film for device applications. It is well studied and produces films that have comparable structural and opto-electronic properties to those produced using other sophisticated thin film deposition technique. The grown film was characterized using optical UV-VIS spectrophotometer and four point probe which determined the optical and electrical properties of the grown film.

2. MATERIALS AND METHODS

Prior to the deposition, the substrates were degreased by dipping them in concentrated HNO_3. They were brought out after 24hrs, washed with detergent, rinsed in distilled water and dried in air. The degreased and cleaned surface has the advantage of providing nucleation centers for the growth of the films, hence, yielding highly adhesive and uniformly deposited films.

The reaction bath constitute a mixture of 5mls of 0.1M aluminum chloride solution, 3.5mls of 0.1M EDTA solution, 3.5mls of 0.1 thiourea, 5mls of ammonia solution, 35mls of distilled water. The mixture was stirred with stirrer. During the deposition, Ethylenediaminetetra acetate was used as the complexing agent to prevent spontaneous precipitation and ensure film deposition for the growth of Al_2S_3 while ammonia solution was used to provide the alkaline medium. The deposition was done at two different bath temperatures 300K and 373K for two hours each. The substrates were immersed vertically into the reaction baths with the help of the synthetic foam. The substrates were allowed to stay in the bath for different dip times. After each deposition, the films were washed in distilled water and dried in air. The chemical reaction processes involved are:

$$AlCl_3 + EDTA \rightleftharpoons [Al(EDTA)] + 3Cl^-$$

$$[Al (EDTA)] \rightleftharpoons Al^{3+} + EDTA$$

$$(NH_2)_2CS + OH^- \rightleftharpoons (NH_2)_2CO + HS^-$$

$$HS^- + OH \rightleftharpoons H_2O + S^{2-}$$

$$Al^{3+} + S^{2-} \rightleftharpoons Al_2S_3$$

The deposited films were characterized for optical and electrical properties.

3. RESULTS AND DISCUSSIONS

UV-visible absorption studies of Al_2S_3 film.

The optical properties of Al_2S_3 films have been studied using UV-VIS spectrophotometer in the wavelength ranging from 300-1000nm. The absorption spectra of Al_2S_3 films recorded at temperatures 300K and 373K as function of wavelength is shown in fig. 1.

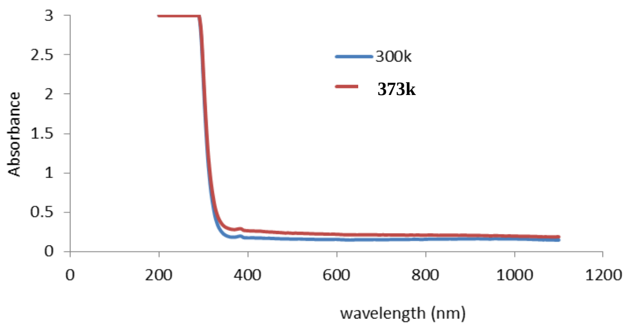

Fig.1 Plot of absorbance versus wavelength at temperatures 300K and 373K

The films prepared at temperatures 300K and 373K show a gradually decreasing absorbance throughout the visible region. The film prepared at higher temperature 373K has higher absorption. This is because of the most homogeneity at higher temperatures. The grown films (Al_2S_3) show high absorbance in UV region and low absorbance in VIS-NIR region.

The optical absorption in figure 1 increases with the deposition temperature. This may be attributed to the decrease in defects.

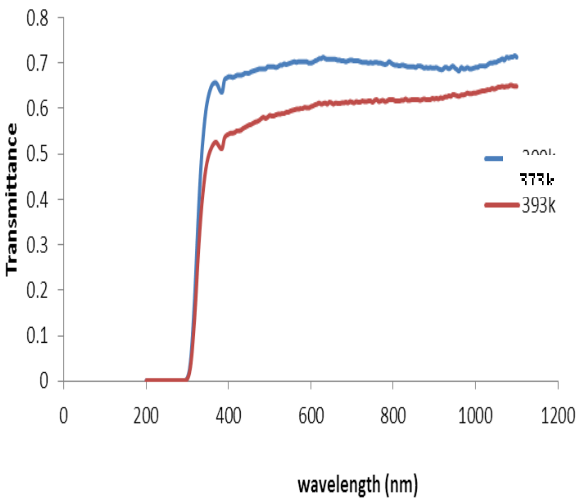

Fig. 2 Plot of transmittance versus wavelength at temperatures 300K and 373K

The optical transmission spectra of the Al_2S_3 thin films with different temperatures are shown in Figure 2. It is evident from the figure that the transmittance of the Al_2S_3 thin film decreases with increase in the bath temperature. The spectral absorbance and transmittance of the Al_2S_3 for the two temperatures varies with wavelength in the same manner. There is no transmittance in the UV region but increases sharply to about 0.6 in the VIS-NIR regions for film deposited at 373K and 0.7 for film deposition at 300K. The properties of high transmittance in VIS-NIR regions make the film good materials for thermal control window coatings for cold climates and also antireflection coating

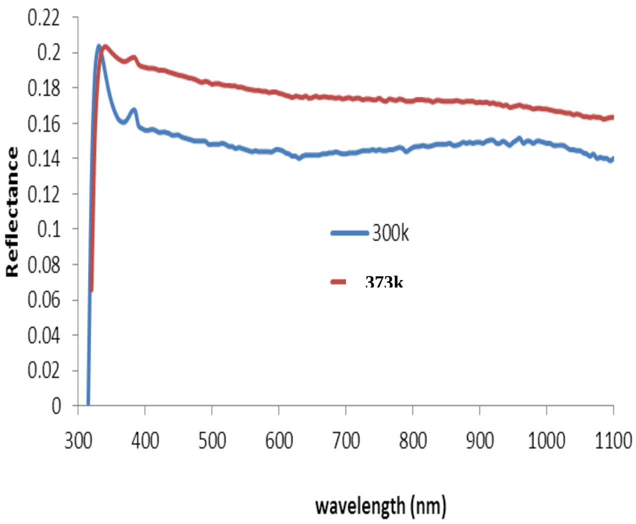

Fig. 3 Plot of reflectance versus wavelength at temperatures 300K and 373K

Reflectance increases sharply to 0.2 at 340nm and gradually drops to about 0.15 in the UV-NIR regions for film deposited at 300K and 0.18 for film deposited at 373K. Reflectance was almost zero in the UV region and low in the VIS-NIR regions. As a result of this property, the UV radiation is screened off and the infrared and visible radiation is admitted. This makes the films good materials for the construction of poultry roofs and walls for the protection of young chicks from the sun's burning due to UV radiation while the admittance of infrared radiation helps to warm the inside of the poultry house which is needed for young chicks. The films are also suitable for eye glass coating for the protection of the skin around the eye from UV radiation.

The absorption coefficient square versus photon energy plots of Al_2S_3 thin films are linear over a wide range of photon energies, as shown in figure 4. This indicates the presence of a direct the band gap in the deposited Al_2S_3 thin films (Joshi *et al*, 2003). The absorption coefficient square α^2 as observed in the figure increases gradually from near zero to about 0.4 x 10^{12} at 3.4eV and then increases sharply.

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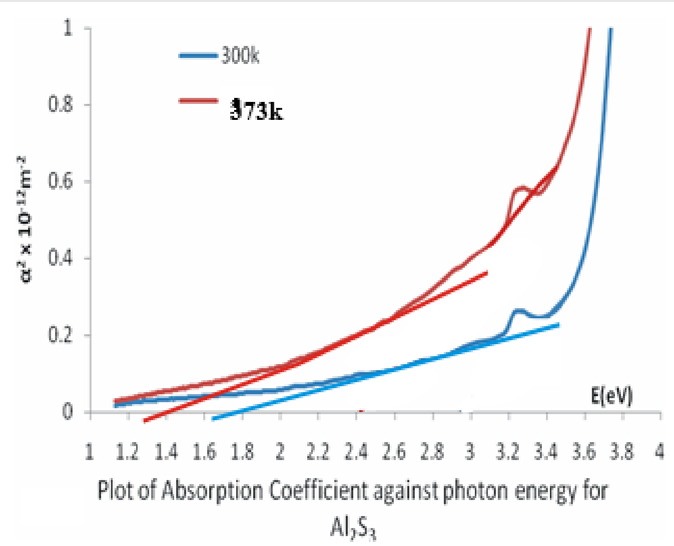

Fig.4.4 Plot of absorption coefficient square versus photon energy at temperatures 300K and 373K

The two graphs increase gradually in a similar manner from near zero at 1.15eV to values of 0.3 and 0.6 at 3.4eV for films deposited at 300K and 373K respectively. The graphs then rise sharply at 3.6eV. The optical band gap of these films was obtained by extrapolating the linear portion of the curve to the energy axis. The band gap values for the films are 1.80eV and 1.35eV for Al_2S_3 films deposited at 300K and 373K respectively. The band gap was observed to decrease from 1.80eV to 1.35eV, as the bath temperature was increased from 300K and 373K which shows its capability to be used as an absorber layer in photovoltaic application. There is no record for Al_2S_3 thin film in the literature to compare the band gap of the deposited Al_2S_3. The decrease in the band gap with increasing temperature can be viewed as increasing the energy of the electrons in the materials. Lower energy is therefore needed to break the bond. Reduction in the bond energy also reduces the band gap. These values make the films suitable for solar fabrication.

4. CONCLUSION

Aluminum sulphide film was successfully grown at different temperatures (300K and 373K) below and above room temperature (303K) using solution growth technique (SGT). The Al_2S_3 show high absorbance in UV region and low absorbance in VIS-NIR regions while there is no transmittance in the UV region but s hows high transmission in the VIS-NIR regions. The reflectance of the grown film was almost zero in the UV region and low in the VIS-NIR regions. The optical band gap for aluminum sulphide films was found to decrease from 1.80eV to 1.35eV as the deposition temperature was increased from 300K to 373K. It was observed that the films have the property of screening off UV portion of the electromagnetic radiation by absorbing and the admittance of the visible and infrared radiation by transmission. These properties confirm the films good materials for coating poultry buildings, eye glasses coating, solar and thermal conversion, solar control, anti-reflection coating and solar cells fabrication.

REFERENCES

Joshi R.K, kanjila a and sehgal h.k. (2003) Nanotechnology **14**, 809-812.l

Wang, C., X.F. Qian, W.X. Zhang, X.M. Zhang, Y. Xie and Y.T. Qian, (1999). Mater. Res. Bull., **34**: 1637-1641 (1999).

D. Karashanova, K. Starbova, N. Starbor (2003) Journal of Optoelectronic and Advanced Materials, 5, No. 4, Dec. 903 – 906.

F.I. Ezema, P.U. Asogwa, A.B. C Ekwealor, P.E. Ugwuoke, R.U. Osuji (2007), Journal of the University of Chemical Technology and Metallurgy, 42, 2, 2007, 217 – 222.

Granqvist, C.E. and Erikson T.S. (1991), Materials for Radiative Cooling to Low Temperature Material Science for Solar Energy Conversion System, C.G. Granqvist (ed), Pergamon Oxford, 97 – 114.

Hallahan, J.K. and R.S. Roster (1978), Thin Film Processes, J.L. Vossen and W. Kern (eds), Academic Press Inc. New York, 335 – 340.

Heavens, O.S. (1970), Thin Film Physics, Methuen and Co. Ltd. London.

Lampert, C.M. (1985), Workshop on Non-Conventional Energy Sources and Material Science for Energy I.C.T.P. Trieste. 2 – 20th September, 143 - 144

O.A. Osore, (2000) Journal of Engineering Technology and Industrial Applications 1, 72 -78.

Pankove, J.I. (1971), Optical Processes in Semiconductors, Prentice-Hall, New York.

Pentia, E., V. Draghici, G. Sarua, B. Mereu, L. Pintilie, F. Sava and M. Popescu (2004),Structural Electrical and Photoelectrical properties of CdxPbi-xS thin film prepared by Chemical bath deposition, J. Electrochem. Soc. 151(11) 729 – 733.

International Journal of Science and Technology

http://www.ejournalofsciences.org

Prabhune V. B., N.S. Shinde and V.J. Fulari: Applied Surface Science, 255 (208),1819 -1822.

Quijada, M., J. Ceme, J.R. Simpson, H.D. Drew, K.H Ahn, A.J. Millis, R. Shreekala, R.Ramesh, M. Rayeswari and T. Venkatesan (1998), Optical Conductivity of Manganites Crossover from Jahn-Teller Small Polaron to the Ferromagnetic State, Physical Review B.Vol. 58(24) 99 – 102.

Reather, H. (1976), Structure Determination of Thin Films in Physics of Non-Metallic thin films C.H.S. Dupuy and A. Cachard (eds), Plenum, New York 123 125.

Robert West (1976 – 1977) Handbook of Chemistry and Physics, Ohio, CRC Press.