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A Study on Development and Characterization of AZS ternary Thin Films for the Applications of Device

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Abstract

At bath temperatures of 298 K and 333 K, ternary aluminium zinc sulphide (Al_2ZnS_4) thin films were effectively formed on glass substrates utilising the solution growth approach. A GBC enhanced mini-material analyzer x-ray diffractometer with a wavelength of 1.5418 A was used to evaluate the films for structural characteristics. The films were found to have a polycrystalline structure after structural analysis. A UV-VIS-NIR Spectrophotometer was used to perform the optical characterization. For films formed at bath temperatures of 298 K and 333 K, respectively, transmittance ranged from 32-90 percent and 42-95 percent, with an optical band gap of 3.40-3.85 eV. Because of the films' excellent transmittance in the visible range and broad band gap energy, they might be employed as window layers in heterojunction solar cells and optoelectronic applications.

Keywords: *Ternary thin films, Aluminium zinc sulphide, Solar cells, Band gap*

INTRODUCTION

The hexagonal structure of new ternary thin films of aluminium zinc sulphide belongs to group II-VI compounds. Recent years have seen an upsurge in the characteristics and uses of ternary thin films in light-emitting diodes, solar cells, and non-linear optical devices. Some ternary compounds have been investigated for specialised uses in super ionic conducting materials, and ternary thin films have been proposed as excellent materials for window layer solar cells. Both basic and complex deposition

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processes have been used to create ternary thin films. Simple deposition techniques like chemical bath deposition, spray pyrolysis, and complex approaches like sputtering have been published. However, due of their complexity and the poverty of third-world nations, these sophisticated techniques have not been widely used in these countries. As a result, there is an increasing interest in creating simple and inexpensive thin film deposition processes. Chemical bath deposition is the easiest, cheapest, most cost-effective, and most inexpensive way of depositing thin films of various types. The characterisation of chemically deposited aluminium zinc sulphide (Al_2ZnS_4) ternary thin films is presented in this paper.

MATERIALS AND PROCEDURES

The substrates (slides) were degreased for 24 hours before deposition in a flask filled with pure HNO_3. Following that, the depleted substrates were removed from the flask, washed with detergent, rinsed with de-ionized water, and air-dried. Degreasing was done to generate nucleation sites for the film's development, resulting in highly sticky and evenly deposited layers. In a 100ml beaker, 16mls of 0.1-0.5M A1CI_3, 16mls of 0.1-0.5M $ZnSO_4$, l0mls of 0.1M $CS(NH_2)_2$, and l0mls of concentrated aqueous ammonia (NH3) solution make up the reaction bath. The mixture was agitated using a magnetic stirrer to ensure that the solution was homogenous. To inhibit spontaneous precipitation and assure film deposition for Al_2ZnS_4 growth, the complexing agents ethylene diamine tetraacetic and ammonia were utilised. The deposition was carried out for 24 hours and 2 hours at two distinct bath temperatures of 298 K and 333 K, respectively. The perforated synthetic foam was used to dip the substrates vertically into the reaction baths. The substrates were left in the bath for varying amounts of time. After each deposition, the films were rinsed with distilled water and dried in the open air. For each of the multiple temperatures utilised, the process was repeated. After deposition, the crystal structure of the thin films was characterised using a GBC enhanced mini-material analyzer (EMMA) X-ray diffractometer with a Cuka radiation of wavelength, while the optical characterization was done using a UV-VIS-NIR spectrophotometer to determine the transmittance (T) versus wavelength measurements spanning 300 nm-1000 nm.

DISCUSSION AND RESULTS

Figure 1 depicts the x-ray diffraction profiles of aluminium zinc sulphide ternary thin films grown at different bath

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temperatures 298 K and 333K at a concentration of 0.1 M, while Figures 2 and 3 depict the x-ray diffraction profiles of aluminium zinc sulphide ternary thin films grown at concentrations of 0.3 M and 0.5M at different bath temperatures. The existence of several x-ray diffraction peaks, as illustrated in Figures 1-3, indicated that the films were polycrystalline. For AlZnS films deposited at 298 K, the XRD pattern is characterised by several peaks with preferred orientation at (2 = 32.172^o and 37.441^o) corresponding to diffraction lines produced by (104) and (105) planes respectively, while the XRD pattern for AlZnS films deposited at 333K is characterised by several peaks with preferred orientation at (2 = 32.172^o and 37.441^o) corresponding to diffraction lines produced by According to fig.2, films grown at 298 K have a preferred orientation of 2 = 14.59^o and 22.038^o, which correspond to the (002) and (003) planes, respectively, whereas films grown at 333 K have a preferred orientation of 2 = 28.401o and 36.085o, which correspond to the (100) and (103) planes, respectively. With JCPDS: 00-040-1074, Figure 3 indicates that films produced at 298 K have notable peaks at (2= 7.180°) which corresponds to (001) plane and (2 = 14.581°) which corresponds to (002) plane.

It is possible to examine the influence of concentration and bath temperature on the structural characteristics of the films. The strength of diffraction peaks increased when concentration and bath temperature were varied parametrically. This indicates that the crystallinity of the deposited films increased when the growth conditions were raised. Equations (1), (2), and (3) were used to compute the lattice parameter, crystallite sizes, and micro strain, respectively [11]. Tables 1 and 2 summarise the structural characteristics for AlZnS thin films deposited at 298K and 333K, respectively.

$$d_{hkl} = \frac{a_o}{\sqrt{h^2 + k^2 + l^2}} \quad (1)$$

Where d_{hkl} is the interplanar spacing, a_o is the lattice parameter while hkl are miller indices.

$$D = \frac{k\lambda}{\beta cos\theta} \quad (2)$$

Where λ is the wavelength of the x-ray radiation, β is the full width half maximum of the diffraction peaks of preferred orientation, k is the scherrer constant which accounts for the shape of the particle with the value of 0.9 and θ is the diffraction Bragg's angle.

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$$\mu = \frac{\beta \cos\theta}{4} \quad (3)$$

μ is the micro strain while other parameters retain their usual meaning.

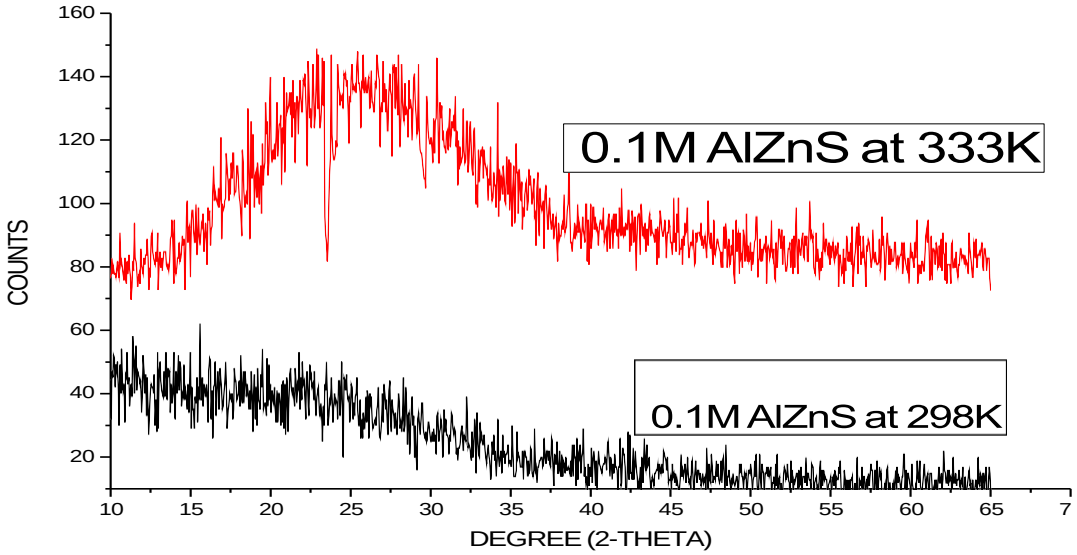


Fig.1: X-ray diffraction profiles of AlZnS thin films for 0.1M at different bath temperatures

Table 1: Structural parameters of AlZnS thin films at varied concentrations for 300K

Conc (M)	Lattice constant (a_o)	Crystallite size (D)	Micro strain (μ) x10^{-2}
0.1	9.353	12.491	2.776
0.3	12.115	11.710	2.961
0.5	7.615	11.845	2.927

Table 2: Structural parameters of AlZnS thin films at varied concentrations for 333K

Conc (M)	Lattice constant (a_o)	Crystallite size (D)	Micro strain (μ) x10^{-2}
0.1	6.904	12.113	2.862
0.3	5.503	12.035	2.880
0.5	12.220	11.845	2.985

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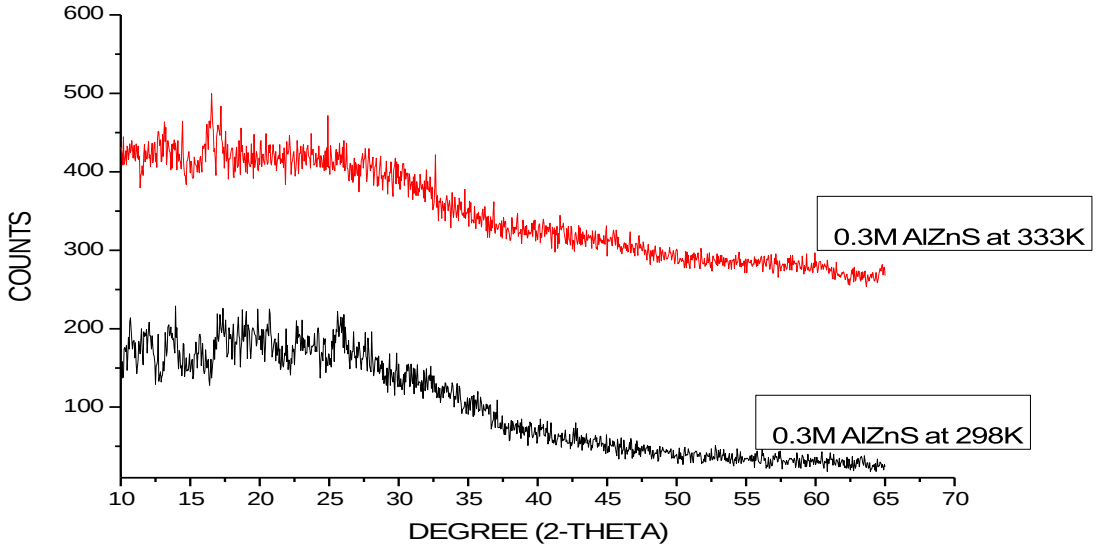


Fig.2: X-ray diffraction profiles of AlZnS thin films for 0.3M at different bath temperatures

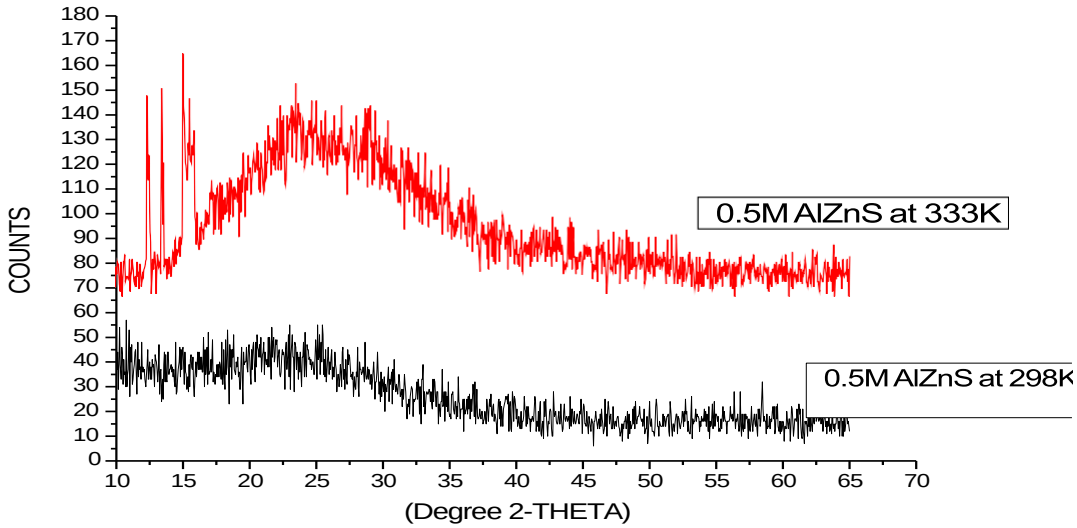


Fig.3: X-ray diffraction profiles of AlZnS thin films for 0.5M at different bath temperatures

Figures 4 and 5 exhibit transmittance versus wavelength charts for various concentrations of Al_2ZnS_4 thin films deposited at 298K and 333K, respectively. The transmittance spectra for films formed at 298K show that the transmittance rises with concentration, with the 0.5M layer having the highest transmittance. For 0.1M, 0.3M, and 0.5M, the transmittance ranges from 32-75 percent, 55-85 percent,

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and 84-90 percent, respectively. According to fig.5, the transmittance of the 0.1M and 0.3M layers varies with wavelength, but the transmittance of the 0.5M layer rises with wavelength. The effect of the bath temperature on the film transmittance may be seen. The films' transmittance climbed to around 90% for the 0.5M layer while the bath temperature was kept at 298K (fig.4), but fell to 84.5 percent when the bath temperature was raised to 333K (fig.5) (Fig.5). The transmittance of the other layers (0.1M and 0.3M) varied similarly with bath temperatures. When the bath temperature is 298K, the transmittance increases with concentration, however when the bath temperature is 333K, the transmittance decreases with concentration. Except for the 0.1M layer (fig.4) and the 0.5M layer (fig.5), the average transmittance of AlZnS thin films is greater than 50%. (fig.5). The human eye is only sensitive to wavelengths between 400 and 700 nm, with a peak at 500 nm. This is a critical element in window coatings, and these films meet it. As a result, the AlZnS thin films formed in this study are appropriate for window coating. The transmittance of the films formed in this study is generally quite high, with maximum values of 90 percent and 96 percent for films deposited at 298K and 333K, respectively. The high transmittance of thin films in the infrared range is sufficient for covering the roofs and walls of chicken buildings. This will supply the necessary heat for the warming of young chicks while also potentially lowering the expense of energy consumption connected with the use of electric lamps, stoves, and lambs to give the necessary heat for the warmth of young birds. These findings are consistent with the findings of other researchers. Deposition factors have a significant impact on thin film transmittance. The impact of growth factors on the transmittance of thin films has been described in the literature, including concentration, annealing temperature, deposition duration, and P^H.

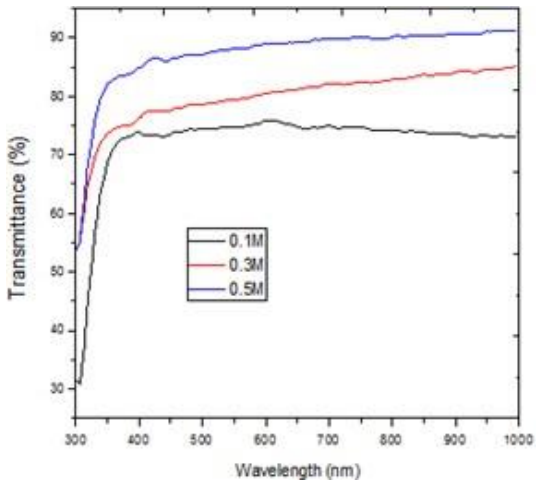


Fig.4: Plot of T against λ at different concentrations for 300K

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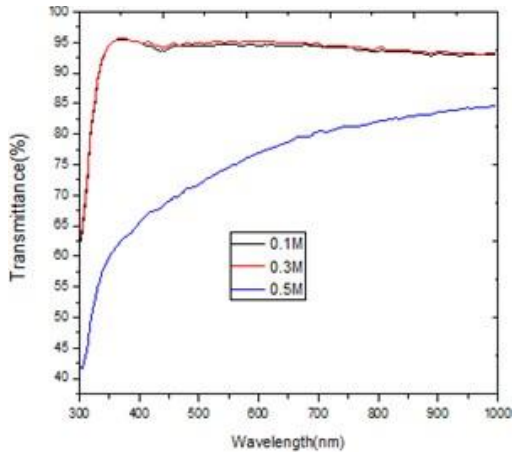


Fig.5: Plot of T against λ at different concentrations for 333K

Fig. 6 shows plots of absorption coefficient vs photon energy for AlZnS thin films deposited at 298K, and Fig. 7 shows plots of absorption coefficient versus photon energy for AlZnS thin films deposited at 333K. Figure 6 shows that the absorption coefficient rose with concentration, peaking at 0.5M layer. AlZnS thin films deposited at 333K showed a similar pattern. Our results are on the same order of magnitude as those reported elsewhere.

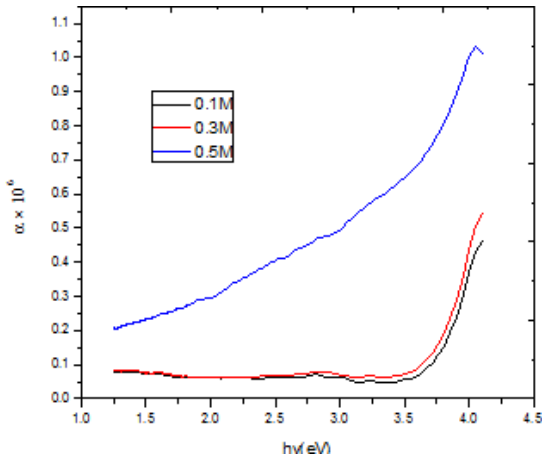


Fig.6: Plot of α against hν at different concentrations for 300K

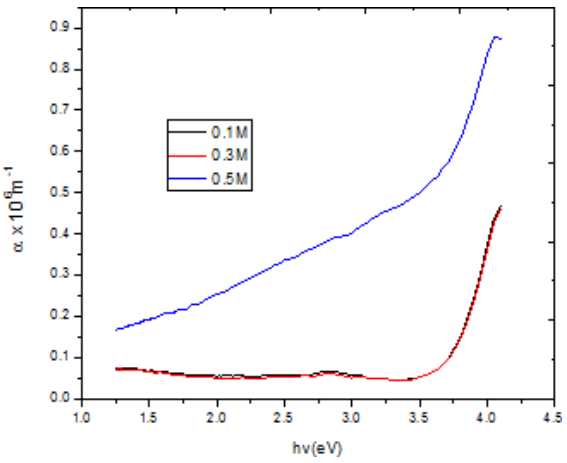


Fig.7: Plot of α against hν at different concentrations for 333K

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CONCLUSION

Using the solution growth approach, new ternary thin films of Aluminum Zinc Sulphide have been successfully formed on glass substrate (SGT). GBC enhanced mini material analysed (EMMA) X–ray diffractometer was used for structural characterization, while UV-VIS –NIR Spectrophotometer was used for optical characterization. Both XRD and optical parameter data revealed significant change with growth factors. AlZnS thin films formed at varied bath temperatures and concentrations are excellent for photovoltaic and optoelectronic applications due to their high transparency in the visible range and large energy band gap.

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