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INVESTIGATING THE EFFECT OF IRON DOPANTS CONCENTRATION ON THE OPTICAL PROPERTIES OF SILAR DEPOSITED ZnSFe THIN FILMS

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Abstract

This article investigated the influence of iron dopants concentration on Zinc Sulphide(ZnS) thin films deposited on glass substrates via successive ionic layer adsorption (SILAR) Technique using Zinc acetate, $Zn(CH_3COO)_2$, thioacetamide (S_2H_5NS), Iron (II) Chloride dehydrate($FeCl_2.2H_2O$), ethanol and ammonia in alkaline medium annealed between 283K and 500K were investigated. This article studies the effects of iron dopant concentration (x = 0.05, 0.03 and 0.02) on the optical and solid state properties of Zinc Sulphide(ZnS) thin films. The percentage elemental composition studies were performed by Electron Dispersive Spectroscopy (EDS) Analysis. The Uv-visible studies were done using spectrometer in the Technical University, Ibadan. The direct band gap varied from 4.81eV for 0.01M, 4.50eV for 0.02M and 4.00eV for 0.05M. The indirect band gap varied from 3.80eV for 0.01M, 3.67eV for 0.02M and 3.40eV for 0.05M. The values of the optical properties and solid state values were concentration dependent. The large band gap possessed by ZnSFe thin films suggest that the films can be used for applications where high voltage, frequencies and temperature are required.

Keywords: iron dopant, optical properties, Zinc Sulphide iron thin films,

1.0 INTRODUCTION

The growth of thin films using advanced and expensive method has become an industry in developed countries. Actually, the continuous increase in population and industrialisation in almost every country in the world, has been very responsible for the ever growing or increasing energy demand. It is the energy crisis in the world that gave rise to the thin film growth research as a way to cushion problems associated with it. In Nigeria, less than 40% of the country is connected to the national electric grid and less than 60% of the energy demand by this group is generated and distributed[1-3]. The advantage of energy is facilitation of the provision of those things which are necessary for the welfare of human existence: health, heat, food, light, clothing, shelter and transport, etc. Energy availability improves the standard of living [4]. Solar energy, an energy obtained from the sun, is the world's most abundant and cheapest source of energy available from Nature [5]. It is free and automatically renewable every day. In the world over, emphasis has shifted from the use of hydro and fossil-powered electricity generation to renewable energy(thin film growth). Successive ionic layer adsorption and reaction(SILAR) Technique growth cycle for $ZnS_x Fe_{(1-x)}$ thin films has six.steps . In this research, the optical properties were investigated from spectroscopy measurements of absorbance, etc

2.0 Experimental Procedure

The synthesis and deposition of zinc sulphide thin Films was done with zinc acetate. The number of deposition cycles for ZnS and Fe was adjusted to obtain various compositions of $(Fe)_{1-x}(ZnS)_x$. Fe (2%, 3% and 5%) doped ZnS nanoparticles were prepared by using SILAR method at room temperature. Zinc acetate dihydrate [$Zn(CH_3COO)_2.2H_2O$], ferric nitrate nonahydrate [$Fe_2NO_3.9H_2O$] were dissolved in deionised water to prepare solutions. (cationic precursor). Aqueous solution of sodium sulphide [(Na_2S)] was the anionic precursor. 2grams of ferric nitrate was mixed with ethanol and used after 3 hours. These formed the source of iron ions. The deposition temperature was about 40°C. Actually, one of the most

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important II–VI semiconductors is ZnS nanoparticles with the band gap energy of 3.68 eV. In this case, for the deposited ZnS nanoparticles, several potential and actual applications have been deduced and they agreed with other researchers findings, i.e. in optoelectronic devices, light emitting displays, photocatalysis, solar cells and luminescent materials [6- 25]

3.0 Results and discussion

3-1. **Energy Dispersive spectroscopy Analysis (**EDS) of $(ZnS)_x(Fe)_{(1-x)}$ composite thin films:

The Energy Dispersive spectroscopy Analysis(EDX) showing the percentage elemental composition is shown in Figure 1. The percentage composition of iron was 20.5wt%

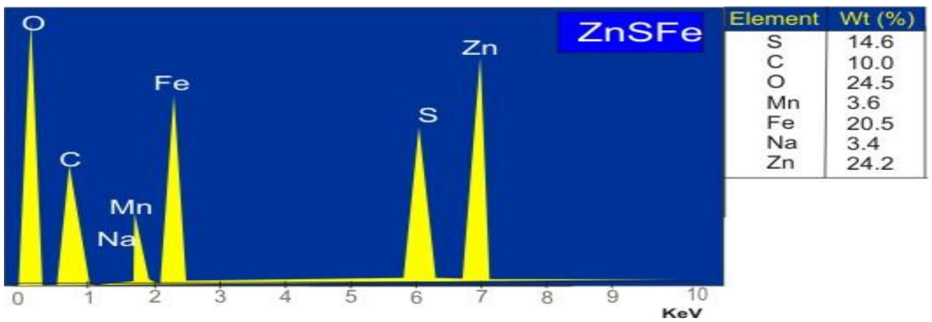

Figure 1: EDS of $(ZnS)_x(Fe)_{(1-x)}$ composite thin films:

3.2 Optical and solid Properties of $(ZnS)_x(Fe)_{(1-x)}$ composite thin films:

The absorbance property of the $(ZnS)_x(Fe)_{(1-x)}$ composite thin films is emphasised. See Figure 2:

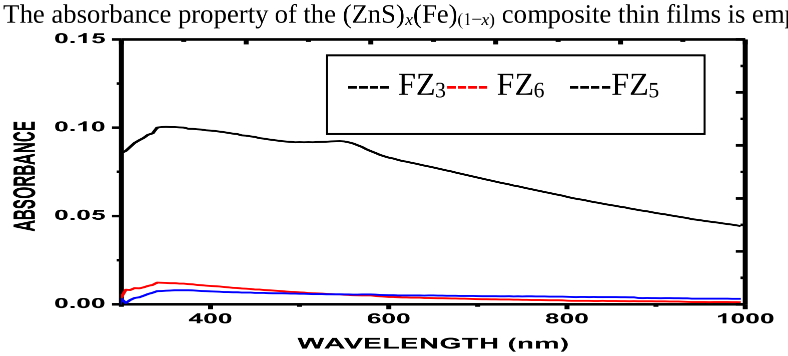

Figure 2: : Plot of absorbance against wavelength for ZnSFe thin films

The absorbance is generally higher in the UV region compared to other regions. From Fig. 2, it is observed that the absorbance of the three samples decreased with increasing wavelength.

The reflectance of the film samples was calculated using the relation :

$R = 1- [T \exp(A)]^{1/2}$ (1),

Where R is the reflectance, T is transmittance and A is the absorbance. The following equation for a direct inter-band transition was applied [26-28].

$\alpha hv = A(hv - E_g)^n$ (2)

where α is the optical absorption coefficient, A is an energy independent constant but depend on the refractive index and the effective masses of the hole and electron respectively. See results in table 1.

Table **1: Thickness and Grain sizes of $(ZnS)_x$ $(Fe)_{(1-x)}$ thin films (From Transmittance)**

S/No	Film composition	Grain Size(nm)	Bandgap
A	$(ZnS)Fe_{(0.1)}$	9	4.81
B	$(ZnS) Fe_{(0.2)}$	8	4.50
C	$(ZnS)Fe_{(0.5)}$	4	4.0

The bandgap was calculated from transmittance values. See results in Figure 3.
The solid state property considered here is the band gap as shown in Figure 3.

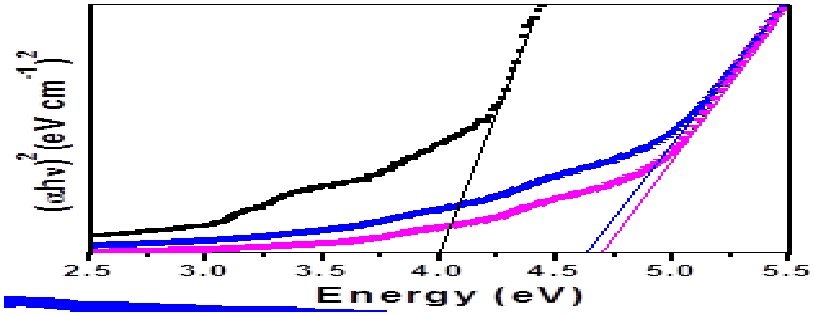

Fig. 3: Plots of $(\alpha h\nu)^2$ as a function of hv of Zinc Sulphide Thin Films

4.0 Discussion

4.0 Discussion and sun

4.1 Optical and Solid Properties of ZnSFe- Absorbance

The graph of absorbance against wavelength for ZnSFe thin films are shown in Figures 2. The absorbance of ZnSFe thin films is maximum with a value of about 2.40 (a.u.) in the visible region in the wavelength range 475-575nm and minimum value of about 1.15 (a.u) in the infrared red region corresponding to 1000nm. The maximum absorbance is above the value of 2.0 (a.u) stipulated by Lambert-Beer's law (http://www.wikilectures.eu/index-php).This may be attributed to the concentration of reagents used in the deposition of ZnSFe thin films. At high concentration, the assumptions of Lambert-Beer law no longer hold (http://www.wikilectures.eu/index-php). Particle attractive forces come into play at high concentration, the particles may not act independently of one another so far as absorbing light. Thus, most of the light is absorbed by the particles thereby reducing the transmission of light as it passes through the sample[17]. The range of absorbance of ZnSFe thin films is in agreement with that of [18-20] for ZnS thin films. The high absorbance displayed by ZnSFe films may be used as spectrally selective coating for solar thermal applications. Solar collectors for heating fluids require increasing the reception area of the solar radiation, and/or to increase the absorbance of the surface coating in order to improve thermal efficiency[21-25]

5.0 Conclusions

A simple, cheap and convenient SILAR method was be employed to deposit good quality ZnSFe composite thin films. The deposited films were uniform and adherent to the substrate. Their structural and morphological properties of those composite thin films were studied. The compositional analysis was done using energy dispersive spectroscopy(EDS). EDS Studies showed that in $(ZnS)_x (Fe)_{1-x}$ thin film, the iron content was 20.5wt%. The XRD and morphological studies revealed that ZnSFe thin films were nanocrystalline in nature depending on film composition. The average crystallite size was found to vary for ZnSFe thin films between 14 and 22 and depending on film composition. The variation in thickness, strain and dislocation densities were also composition dependent. Similar observation has been reported by Wang et al. The samples annealed at different temperatures (383K-500K) never showed any prominent peaks structurally and morphologically as confirmed by studies done by He *et al.*, From literature, considerable changes can be seen for temperatures up to 700 ^{0}K [27-34]. The high absorbance displayed by ZnSFe films may be used as spectrally selective coating for solar thermal applications. Solar collectors for heating fluids require increasing the reception area of the solar radiation, and/or to increase the absorbance of the surface coating in order to improve thermal efficiency. These properties can be well used in solar energy conversion devices and optoelectronics.

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