EFFECT OF PRECURSORS ON OPTICAL AND ELECTRICAL PROPERTIES OF MAGNESIUMSULPHIDE (MGS) THIN FILM GROWN BY CHEMICAL BATH DEPOSITION METHOD FOR SOLAR CELL APPLICATION.

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Abstract

This study investigated the effect of variation of magnesium concentration information of MgS thin film on optical and electrical properties of MgS deposited by chemical bath deposition method onto glass substrates, the transmittance of the film was obtained from AVANTEX UV spectrophotometer in the wavelength range from 239.534 nm to 999.495 nm. Also, the electrical characteristics of the thin films were investigated using KEITHLEY four-point probe techniques. The films exhibit low reflectance, low absorbance and high transmittance between 69 % to 80% in the visible region, the bandgap energy of all the films is 4.10 eV .The film deposited at 1.50 M concentration of Mg Source exhibits low resistivity and high conductivity while the film deposited at 2.50 M concentration exhibits high resistivity and low conductivity.

Keywords : MgS, transmittance, band gap , resisistivity, conductivity

Introduction

A non-renewable resource is also known as a finite resource. It is a resource that doesn't renew itself at a sufficient rate for sustainabl economic extraction in meaningful human time-frame(Netravati, U. M. & Patil, 2015). Most of non renewable energy source are obtained from fossil fuel which affects our eco system in term of pollutions(Rajapakse, 2007). In order to have sustainable and environmental friendly energy supply , renewable energy especially solar energy must be considered (Hosseini et al., 2011; Painuly, 2001) Solar energy is generated from sun and this energy is being converted into electrical energy by a device called solar cell or photovoltaic (Mohammad Bagher, 2015; Sharma et al., 2015) .Solar cell made with silicon material is called first generation solar cell, this cell has good efficiency but the major problems of the cell include relative expensive (S. Sharma et al., 2015). However, the thin film solar cell is very economical and required a very thin p-type absorber layer(Acevedo-Luna et al., 2017).The absorber layer absorbs solar radiation from the and converts the radiation into electricity. Among the absorber layer are cadmium telluride CdTe (Deivanayaki et al., 2010), copper indium sulphide (CIS)(Acevedo-Luna et al., 2017; Nguyen et al., 2011), copper indium gallium suphide (CIGS) (Firoozi & Imanieh, 2018; Wang et al., 2019) ,copper zinc thin sellenide (CZTSe) (Cui et al., 2017; De Wild et al., 2018; Kumar et al., 2016). However, in the fabrication of thin film solar cell another layer is also required call window layer, the main function of window layer is to enhance transmission of radiation into the absorber and forms a contact called p-n junction (Bin Rafiq et al., 2020). Cadmium sulphide (CdS) is mostly used for window layer(Corral-Guerrero et al., 2018) but CdS contains a toxic element (Cd) this has led researchers to look for a substitute to CdS and still perform the same function. This replacement for CdS includes ZnS (Babatunde et al., 2019; Boutebakh et al., 2017), ZnSe (Ayeshamariam et al., 2014; Okereke & Ekpunobi, 2011; J. Sharma et al., 2014), ZnO (Chavan et al., 2015; Singh et al., 2015; Taunk et al., 2015), MgS (Akinyemi et al., 2016; Ezenwaka, I et al., 2015; Taleatu et al., 2015). Many authors have worked on MgS thin film used different techniques to study various parameters , these include (Ezenwaka, I et al., 2015) they fabricated MgS thin film on FTO substrates by electrodeposition method, the optical and structural properties of the films were studied, Also,(Akinyemi et al., 2016) deposited MgS thin-film ferritic stainless steel using CBD method and effect of polishing treatment on the substrates was carried out. Among several methods of synthesis compound semiconductor,chemical bath deposition method is very common because simplicity, economical and large surface area of substrate can be covered this justified the method for this study.

Materials and Method

Magnesium sulphide thin films were deposited on glass substrates which were previously labelled as Mi, Mii, Mii and Miv .They were cleaned by soaking them in HCl acid for 24 hours after which they were washed with detergent and rinsed with distilled water. The substrates were allowed to dry and weighed with an analytical balance to determine their mass before deposition. Four different baths were prepared by putting different concentration of magnesium chloride ($MgCl_2.7H_2O$) at 1.0M, 1.5M, 2.0M and 2.5M into four different beakers labeled Mi , Mii, Miii and Miv. Then sequential addition to each of the beakers were 20ml of 1.0M thiourea ($SC(NH_2)_2$) solution as a source of sulphur ,20ml of 1.0M Ethylene Diamine Tetraacetate (DETA) as a complexing agent . The resulting solution was stirred vigorously for several minutes with a magnetic stirrer; initially the solution was milky and later turns to colorless. Each of the mixtures was then poured into a four different 100 ml chromatography tanks labeled Mi,Mii, Miii and Miv and a pre cleaned substrates Mi, Mii Miii and MiV was inserted vertically into the tanks Mi, Mii, Miii and Miv respectively .The tanks were placed in a water bath which has been previously set to 65° C and stayed there for 1 hour. At the end of the deposition times, the substrates were took out and rinsed with distilled water and allow to dry naturally. After the deposition, one side of each of the substrates was cleaned using cotton wool with hydrochloric acid (HCl) and later with distilled water and weighed again for a change in mass before and after deposition, then annealed in an oven at 300^0 C for 1 hour. The thickness of the films was obtained by double weigh method using the equation below

$$t = \frac{m2-m1}{A*\rho} * 10^4 \mu m \quad (1)$$

where

m_1 is the mass of the substrate before deposition

m_2 is the mass of the s substrate after deposition

A is the area of the glass substrate covered by the film

ρ is the theoretical density of MgS.

The transmittance of the thin films was measured using Avantex UV Spectrophotometer in the wavelength range from 239.534 nm to 999.495nm. The film-coated glass substrate was placed across the sample radiation pathway while the uncoated glass substrate was used as a indication casing. The transmittance data was got directly from the spectrophotometer and other parameters such as absorbance, reflectance, photon energy and optical band gap energy were calculated using the relevant known equations.

$$E = hf \quad (2)$$

Where h is Planks constant with the numerical value of $6.63x10^{-34}$Js

$$f = \frac{c}{\lambda} \quad (3)$$

where f is the frequency of radiation, c is the speed of light with numerical value 3 $x10^8$ ms^{-1} while λ is the measured wavelength

$$E = \frac{hc}{\lambda} \quad (4)$$

By substituting all the constants and convert the energy to eV, the energy then becomes

$$E = \frac{1243}{\lambda} \quad (5)$$

The absorbance of the films was obtained from the relation below

$$A = \log\left(\frac{1}{T}\right) \quad (8)$$

The reflectance (R), was calculated using the relation below.

$$R = 1 - (A + T) \quad (9)$$

The absorption coefficient (α) was calculated using

$$\alpha = -ln\frac{T}{t} \quad (10)$$

Where T is the transmittance and t is the film thickness

The bandgap energy of the film is extrapolated from the plot of $(\alpha hv)^2$ against the photon energy in eV according to the equation below

$$(\alpha hv)^2 = A(hv - Eg)_2 \quad (11)$$

The electrical characteristics of the as-deposited as well as annealed MgS thin films were examined using a KEITHLEY four-point probe technique. The connection was made in such a way that the voltage across the transverse distance of the films and the corresponding values of the current was measured. The sheet resistivities ρ of the films at room temperature were calculated using the expression below.

$$\rho = (\pi t \, ln2)\frac{V}{I} = 4.53Rt \quad (12)$$

where V is the potential difference (voltage) across the transverse distance of the film. I is the current and t is the thickness of the film deposited

The conductivities were calculated using

$$\sigma = \frac{1}{\rho}(\Omega m)^{-1} \quad (13)$$

Results and Discussion

Optical properties

The transmittance, reflectance, absorbance and bang gap energy of MgS thin film were depicted figure 1 , figure 2, figure 3 and figure 4 respectively. The transmittance spectral illustrates that the MgS thin films have high transmittance of 80 %, 76 %, 70 % and 69 % in the visible region, for the film deposited at 1.0 M, 1.5 M,2.0 M and 2.5 M respectively. This shows that the transmittance decreases as concentration of Mg source increases , the decreased in transmittance may caused by the thickness of the films because as the concentration increases the film thickness deposited increases Such high transmittance in visible region have recorded by (Okoli, 2015) The transmittance is constant in the infrared region of the electromagnetic spectrum. The reflectance spectral is shown in figure 2, the spectral shows that the same percentages of films transmitted were reflected in the opposite direction. This shows the films have very little reflectance even lower than the reflected reported by (Ezenwa et al., 2015). The absorbance spectral in figure 3 shows that the film deposited from 2.5 M of Mg source has maximum absorbance of 10 % while the other films have negligible absorbance . The optical band gap energies were extrapolated from figure 4a, 4b, 4c and 4d. The same value of 4.1eV was obtained from the four concentration of Mg source and this result is closed to the reported value (Taleatu et al., 2015)

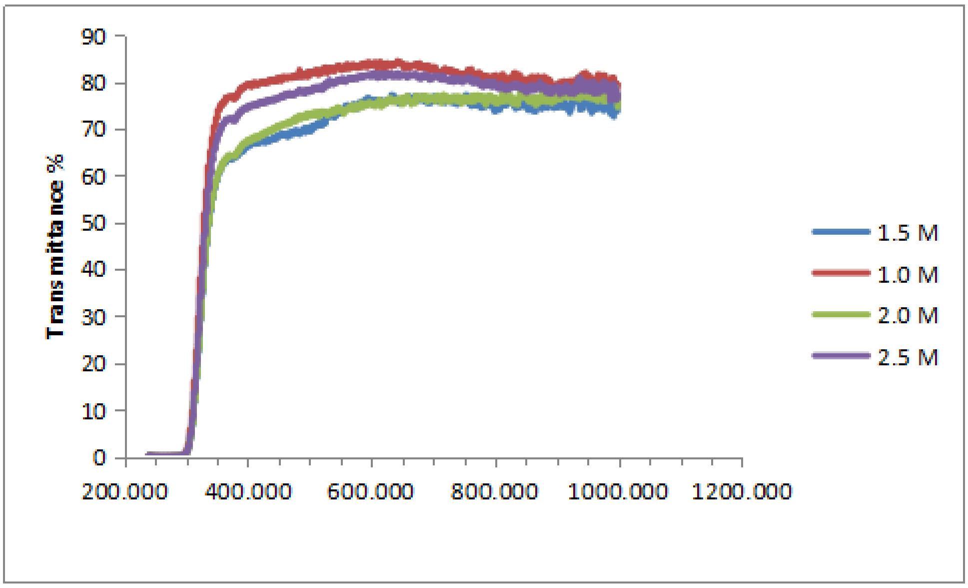

Figure 1 :Transmittance spectral of MgS thin films

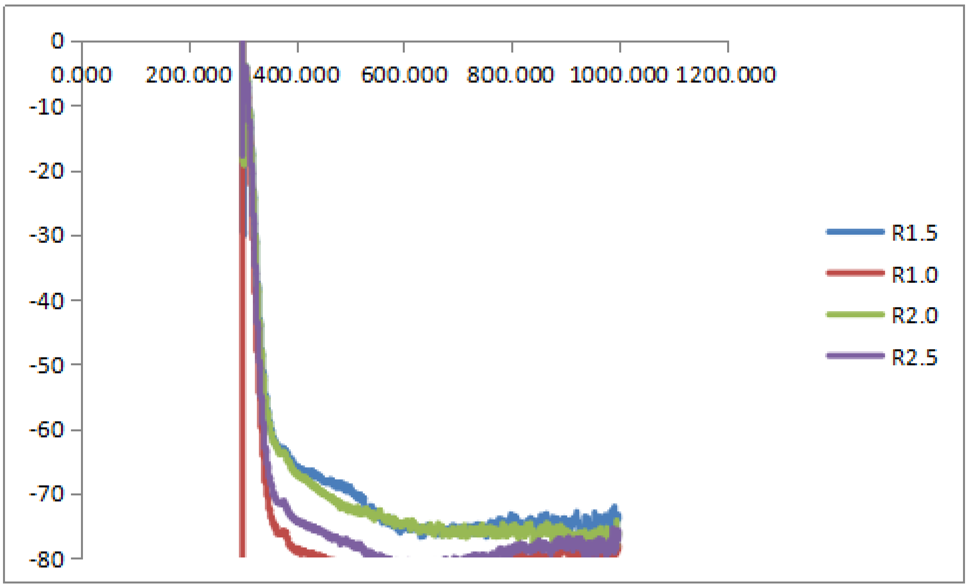

Figure 2: The reflectance spectral of MgS thin Films

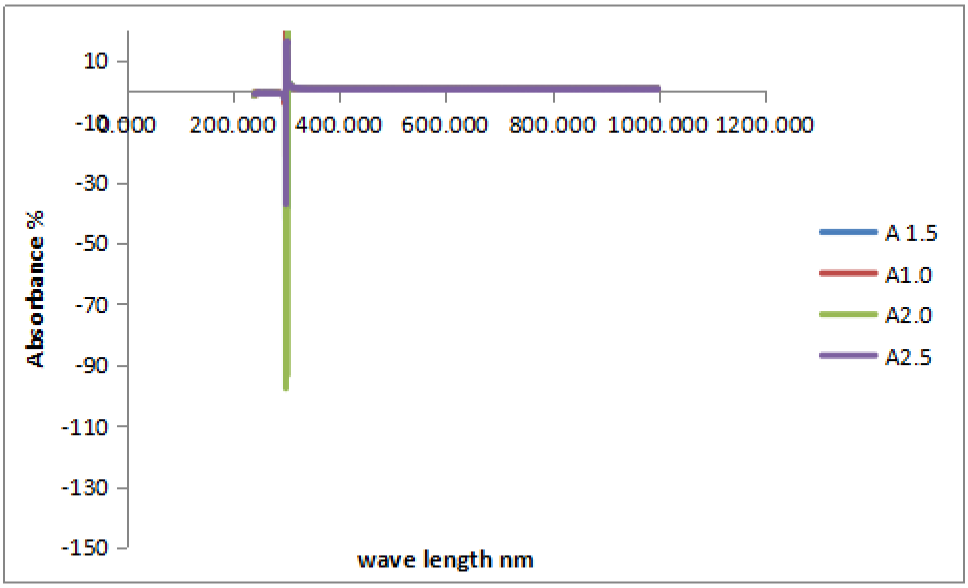

Figure3: The Absorbance Spectral of the MgS thin films

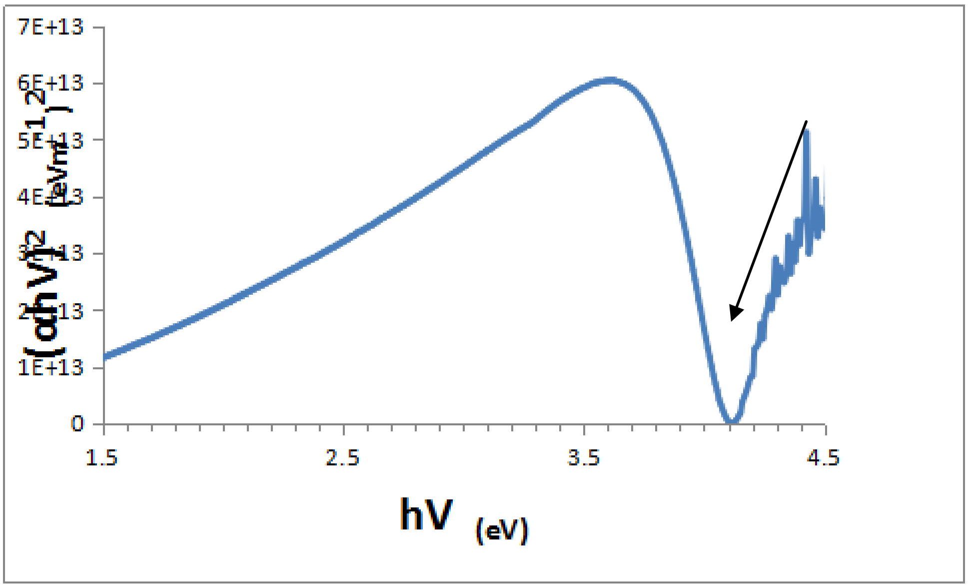

Figure 4a: Graph of $(\alpha hv)^2$ in against hV in at 1.0 M of Mg Source

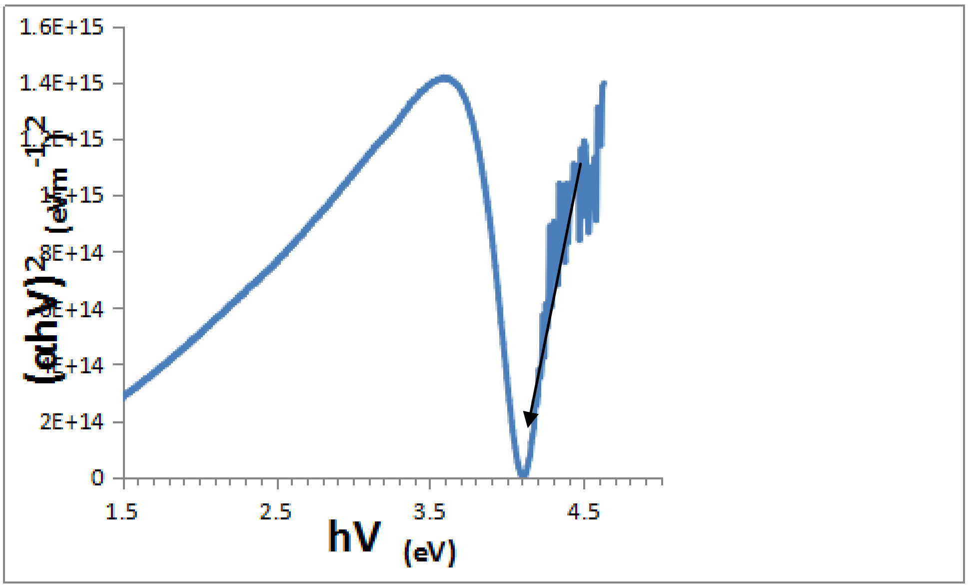

Figure 4b: Graph of $(\alpha hv)^2$ in against hV in at 1.5 M of Mg Source

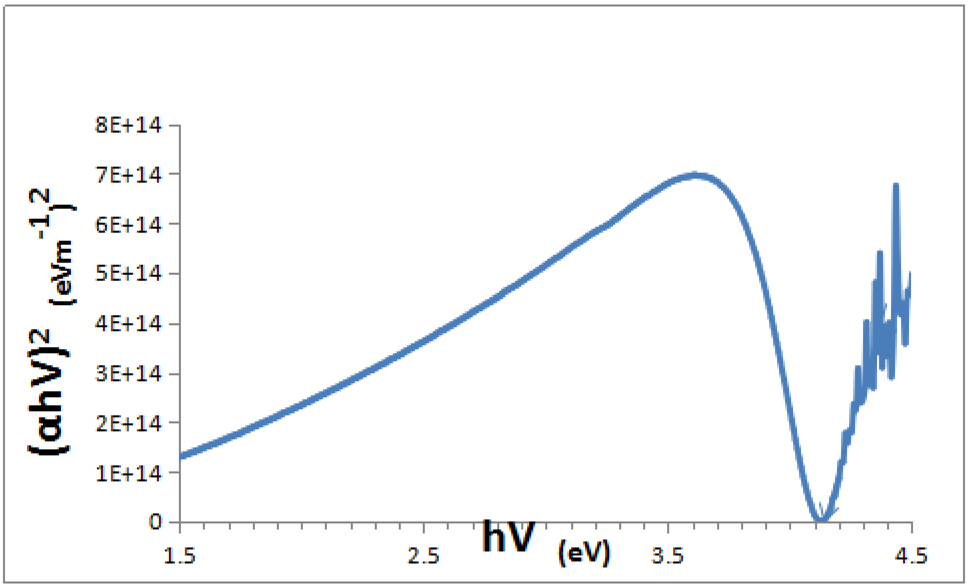

Figure 4c: Graph of $(\alpha hv)^2$ in against hV in at 2.0 M of Mg Source

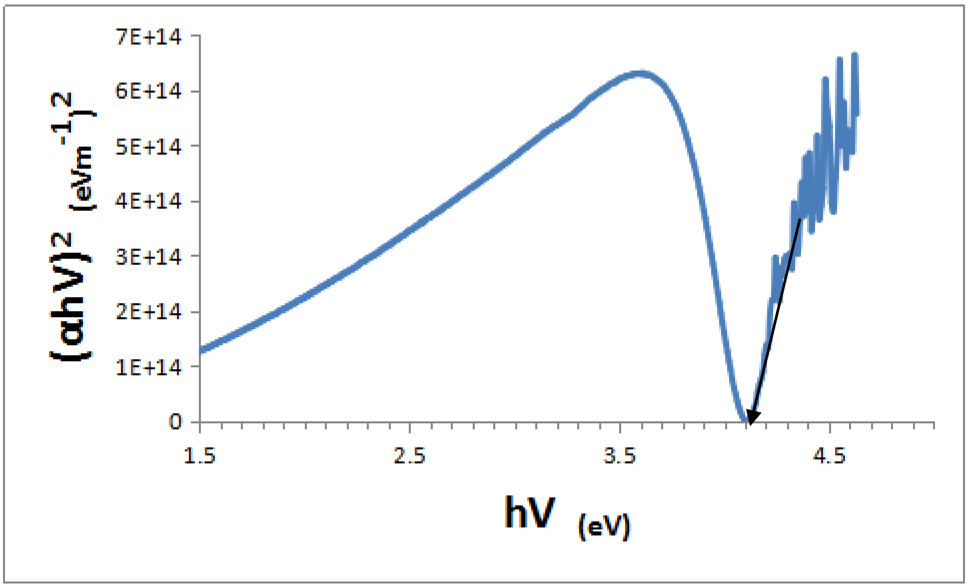

Figure 4d: Graph of $(\alpha hv)^2$ in against hV in at 2.5 M of Mg Source

The Electrical properties

The resistivity's and conductivities of the films according to the concentrations of Mg source are presented in Table 1. The resistivity of the film deposited at 1.50 shows the least resistivity and maximum conductivity while the resistivity of the film from 2.5 M of Mg source showed highest resistivity and lowest conductivity.

Table 1: The Electrical Properties

Sample	Current I/A	Voltage V/V	Sheet Resistance R/Ω	Film thickness t/μm	Resistivity ρ/Ωm	Conductivity σ/ $(\Omega m)^{-1}$
1.0 M	14.50 E-9	60.00E-3	0.241E6	1.9279	211 $\times10^{-2}$	0.4739
1.5 M	15.0E-9	65.00E-3	0.231E6	3.8543	203 $\times10^{-2}$	0.4926
2.0 M	22.5 E-9	50.00E-3	0.450E6	5.2034	1060 $\times10^{-2}$	0.0943
2.5M	19.0E-9	25.0 E-3	0.760E6	5.7865	1990 $\times10^{-2}$	0.0503

Conclusion

MgS thin films were successfully deposited on the glass substrate using a chemical bath deposition method. The effects of magnesium concentration on optical and electrical characteristics of the films were investigated. The optical result shows the films have high transmittance, low reflectance in the visible region and also high optical band gap energy of 4.1 eV. The resistivity of films ranged between 203 $X10^{-2}$ and 1990 $X10^{-2}$ Ωm. The films can be used as a replacement for toxic CdS in fabrication of thin film solar cell

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