STUDY ON DIELECTRIC PROPERTIES AND CHARGE CONDUCTION MECHANISM OF ZINC SULPHIDE FILMS BY CHEMICAL BATH DEPOSITION METHOD

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Abstract

ZnS films were prepared by chemical bath deposition (CBD) technique at 80°C for 4h. The composite film was characterized by using LCR meter. Comparative study on dielectric and charge conduction properties of ZnS films (1:1), (2:1) and (3:1) were investigated. Dielectric properties of films significantly obtained and indicated the photovoltaic behavior of fabricated films. Dielectric constant ($\varepsilon_{r,}$),loss tangent (tanδ) and capacitance (C) were measured different at frequency modes. The charge conduction mechanism was identified by $1/C^2$-V characteristics. The dopant concentration for p-type conductivity (N_a), the depletion layer width (W) and barrier height (ϕ) were determined from $1/C^2$-V characteristic.

Keywords: ZnS, PVA, Dielectric, Chemical Bath Deposition(CBD)

Introduction

Zinc Sulphide (ZnS) is II-VI group semiconductor material. ZnS is one of the most attractive semiconductors. ZnS has two types; hexagonal wurtzite and cubic zinc blende depending on synthesis conditions. It has a wide band gap of3.5eV to 3.8 eV.ZnS is an important inorganic material for a variery of applications including photoconductors, solar cells, optical coatings and light-emitting materials [Ben Nasr, T.et al 2006], [Hasanzadeh , J.et al 2013], [Daixun Jiang et al 2009].Typically, the stable structure at room temperature is the zinc blende, with few observances of stable wurtzite ZnS. There have been various studies thin film characteristics of Zn Sincluding optical and electrical properties [Nada M.Saeed 2011].Moveover, Polyvinyl alcohol (PVA) was used with ZnS because it is water soluble that has been well studied [Koski, A.et al 2004].Polyvinyl alcohol has a melting point of 180°C to 190°C. Water solutions of polyvinyl alcohol are also stable and other

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properties such as the transparency over the whole visible spectrum. Moveover, different researchers employed different techniques, such as atomic layer deposition (ALD) [Shin and Sun, 2004], plusedelectrochemical deposition (ECD), chemical vapour deposition (CVD) [Zhenyi et al., 2002], Chemical bath deposition (CBD) [Cheng et al. 2003] and Spray pyrolysis [Afifi et al. 1995]. Among these methods CBD methodis frequently used as it is simple, cheap, and convenient for larger area deposition of the film. Chemical bath deposition (CBD), which is well known as a prevalent low –temperature aqueous technique for depositing large –area thin films of semiconductors, has been recognized as the simplest and most economical one. The present work was described the deposition of ZnS and PVA thin films by CBD method.

Experimental Procedure

ZnS films were prepared by chemical bath deposition. CBD, which is well known as a prevalent low-temperature aqueous technique for depositing large-area thin films of semiconductors, has been recognized as the simplest and most economical one. CBD is a technique in which ZnS and PVA were deposited on glass substrates immersed in distilled water. Firstly, (sample A) was prepared by dissolving 1g PVA and 1g ZnS in 150ml of distilled water. The mixture solution was thoroughly stirred by using a magnetic stirrer (Fig.1) for 5h until the polymer become completely soluble. And then, we used $1cm^2$ glass substrate. It was immersed into the mixture solution. For the growth solutions films was formed by multiple layers deposition at a temperature for 4h at 80°C by using hot plate(Fig.2).These mixture were deposited onto glass substrates. And then, filter paper was used and dried in air. Homogeneous films were obtained after drying at room temperature in order to remove residual distilled water. Continuously, (sample B) and (sample C) were prepared 1g PVA , 2g ZnS and 1g PVA, 3gZnS in 150ml of distilled water, respectively. The flow chart of ZnS films preparation was shown in (Fig.3).

Figure1. Photograph of ZnS and PVA solution with magnetic strirrer

Figure 2. Photograph of ZnS and PVA solution by using hot plate at 80°C

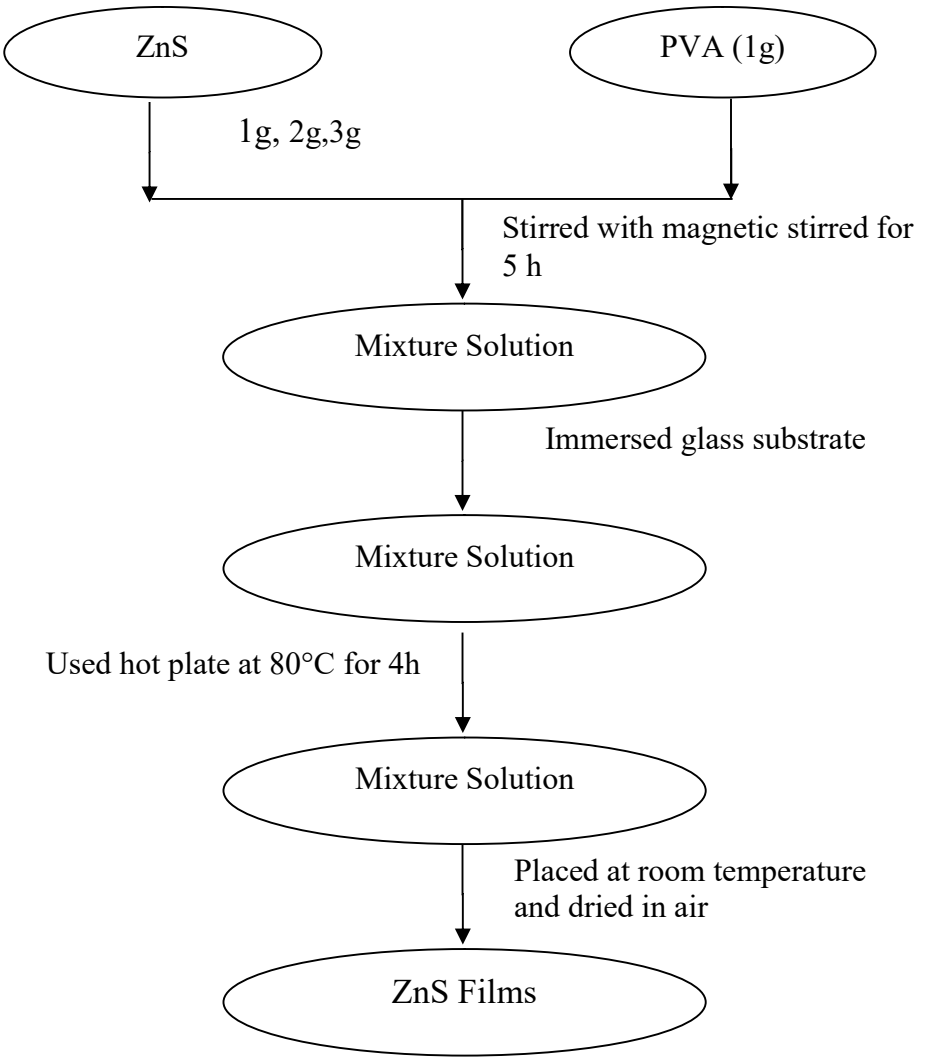

Figure 3. The flow chart of ZnS films

Results and Discussion

Dielectric Characterization

The dielectric properties (ε_γ-f), (C-f) and (tanδ-f) for PVA/ZnS films on glass substrate were examined by LCR meter. The measured values for dielectric properties were listed in Table 1.

Table 1. The Frequency Dependent of Dielectric Properties for PVA/ZnSfilms

PVA/ZnS films	Frequency (kHz)	Capacitance (pF)	Dielectric loss tangent (*tan δ*)	Dielectric constant (ε_γ)
ZnS:PVA (1:1)	1	9.2342	0.1316	0.0642
	10	6.9542	0.0010	0.0481
	20	6.7262	0.0033	0.0464
	50	6.8972	0.0015	0.0481
	100	6.8972	0.0025	0.0481
ZnS:PVA (2:1)	1	13.5810	0.0517	0.1147
	10	10.2276	0.0004	0.0860
	20	9.8923	0.0012	0.0828
	50	10.1438	0.0006	0.0860
	100	10.1438	0.0010	0.0860
ZnS:PVA (3:1)	1	14.9440	0.0412	0.0849
	10	11.2541	0.0003	0.0637
	20	10.8852	0.0010	0.0613
	50	11.1619	0.0004	0.0637
	100	11.1619	0.0008	0.0637

The variation of capacitance (C), dielectric loss tangent (tanδ) and dielectric constant (ε_γ) for the three different ZnS contents were plotted in Fig.4(a), (b) and (c).The realistic characterization of (C-f)variation and (ε_γ-f) variation for PVA/ZnS films were almost the same nature. The highest values of capacitance (C) and dielectric constant (ε_γ) were found at (1 kHz) frequency for ZnS: PVA (3:1). The dielectric loss tangent (tanδ) values varied with applied frequency for the three different ZnS contents were similar.

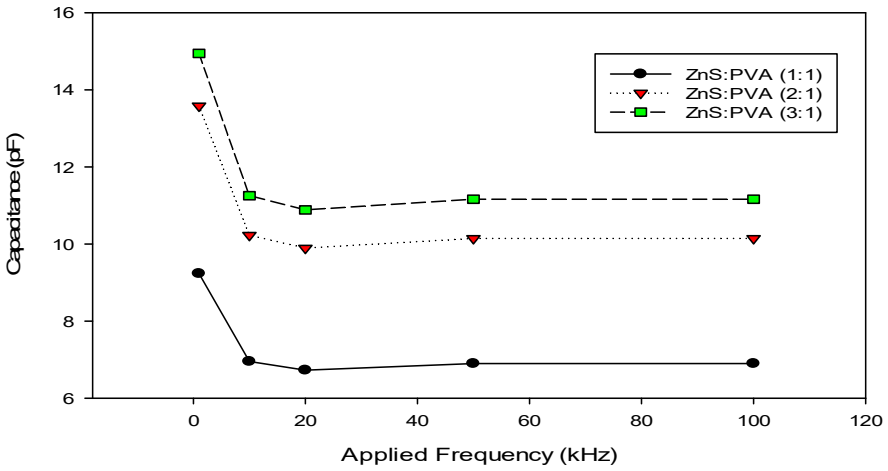

Figure. 4(a) Capacitance and frequency characteristic of ZnS/PVA films

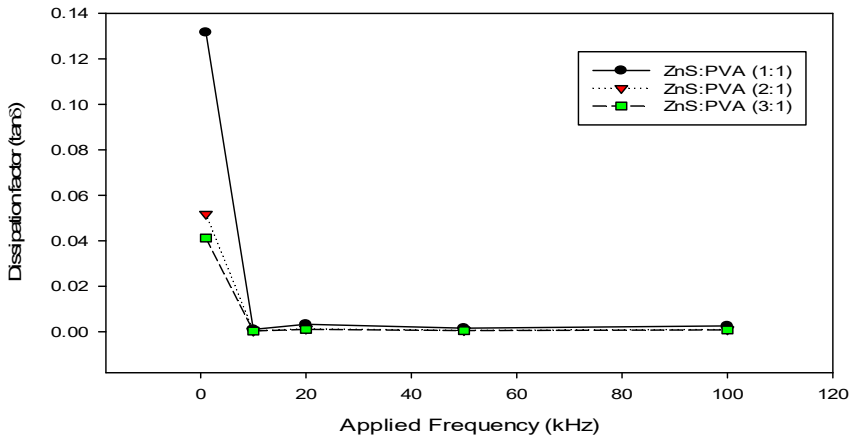

Figure. 4(b) Dissipation factor and frequency characteristic of ZnS /PVA films

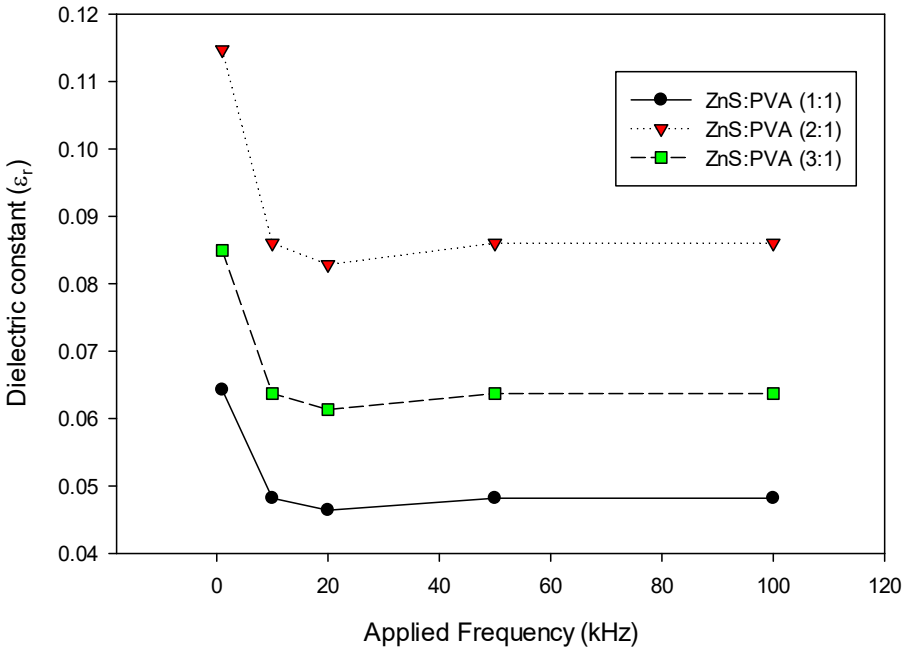

Figure. 4(c) Dielectric constant and frequency characteristic of ZnS /PVA films

Charge Conduction Characterization

The charge conduction mechanism was interpreted by means of $1/C^2$-Vcharacteristics of 100 kHz. Only the reverse voltage was applied and recorded the value of "C" by impedance analyzer. The step voltage was set 0.2V and delay time was 1 min to avoid transient response. The slow rate was 0.2V/min. The $1/C^2$-V graphs were shown in Fig. 5(a, b and c). Linear relations with different orientations were clearly formed on $1/C^2$-V graph. This fact showed the homogeneous and uniform film formation on glass coating substrate. Moreover the ZnS/PVfilms were successfully deposited on this substrate. All build-in-voltage (V_{bi}) was examined to be positive value and less than unity. The change in slope, $(1/C^2)_{max}$ and V_{bi} were collected in Table 2. And the values of N_a, W, and ϕ at different ZnS/PVA films were calculated in Table 3.

Table 2. The slope, $(1/C^2)_{max}$ and $V_{bi}(V)$ at different ZnS/PVA films

ZnS/PVA films	Slope (F^{-2}/V)	Capacitance $(1/C^2)_{max}$ (F^{-2})	Build-in-voltage $V_{bi}(V)$
ZnS:PVA (1:1)	5.41 x e^{18}	7.15 x e^{20}	0.6340
ZnS:PVA (2:1)	5.91 x e^{18}	7.06 x e^{20}	0.2672
ZnS:PVA (3:1)	6.23 x e^{18}	7.14 x e^{20}	0.4672

Table 3. The values of N_a, W and ϕ at different ZnS/PVA films

ZnS/PVA films	Acceptor concentration N_a (cm^{-3})	Depletion layer width W (cm)	Barrier height(ϕ)(eV)
ZnS:PVA (1:1)	2.20 x e^{20}	2.808 x e^{-6}	0.680
ZnS:PVA (2:1)	2.02 x e^{20}	2.790 x e^{-6}	0.316
ZnS:PVA (3:1)	1.91 x e^{20}	2.805 x e^{-6}	0.518

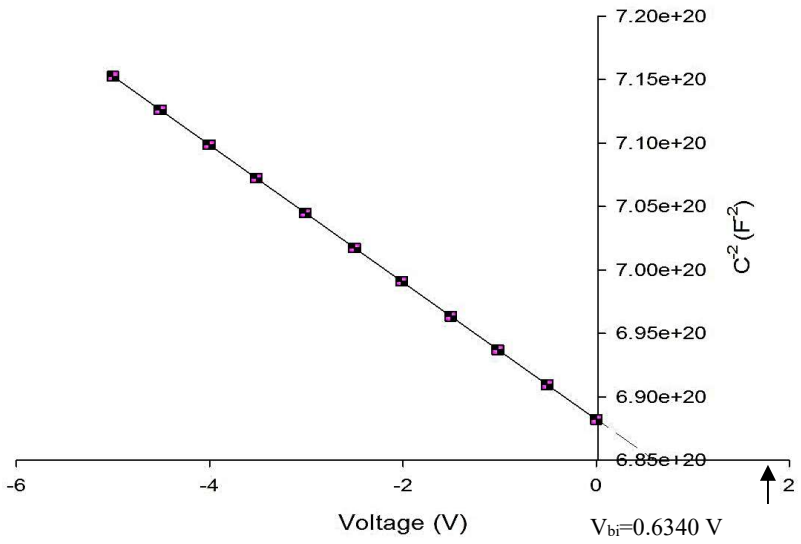

Figure.5 (a) $1/C^2$-V characteristic of fabricated film withZnS:PVA (1:1)

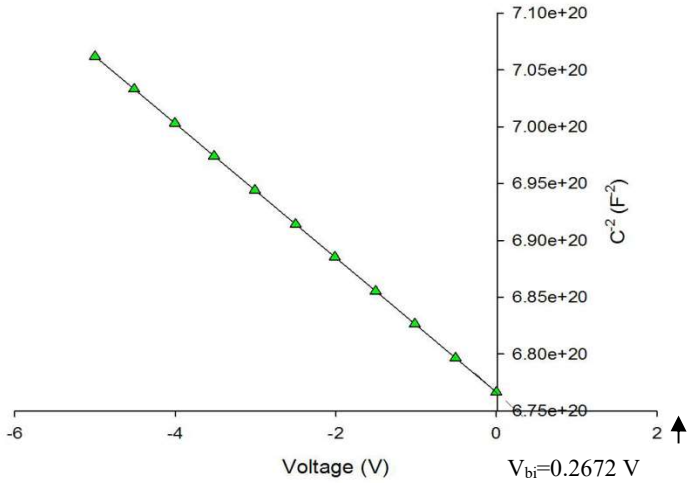

Figure. 5 (b) $1/C^2$-V characteristic of fabricated film with ZnS:PVA (2:1)

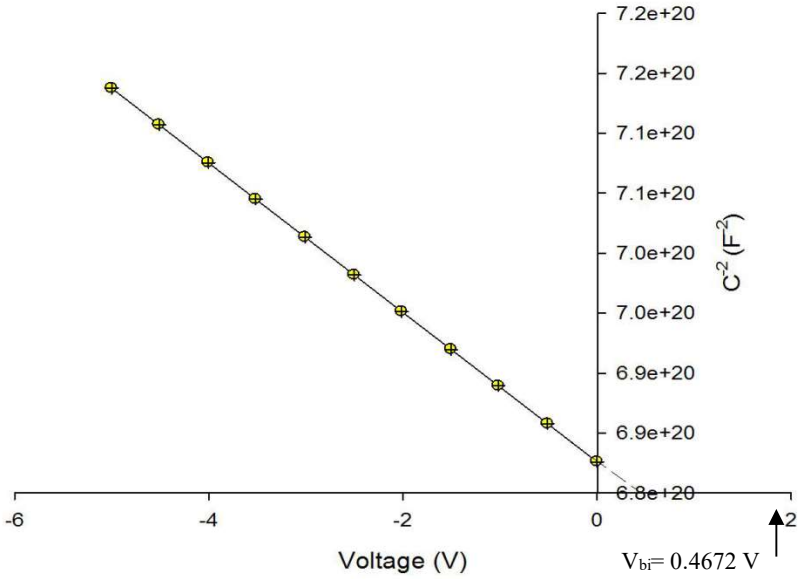

Figure.5 (c) $1/C^2$-V characteristic of fabricated film with ZnS:PVA (3:1)

Conclusion

Comparative study on dielectric and charge conduction properties of ZnS /PVA films has been investigated. The dielectric properties of films significantly obtained and indicated the photovoltaic behavior of fabricated films. According to the $1/C^2$-V characteristics curves, the technique used in this work was quite feasible for thin film growth technology. Therefore, glass coating implied the best film quality. The $1/C^2$-V graph showed the Mott-Schottky relationship. All films were said to be homogeneous because of the linear relationship of $1/ C^2$-Vgraph.

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