Structural and Optical Properties of ZnS Thin Films Deposited by Spray Pyrolysis Technique

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ABSTRACT

The II-VI group semiconductors are of great importance due to their applications in various opto electronic devices. Among these semiconductor. Zinc sulphide is the most suitable for its utility in opto electronic devices. Zinc Sulphide has been prepared on glass substrate by using Spray Pyrolysis method. The optical properties of these films have been studied in the wavelength range 380-1000-nm using UV-VIS spectro-photometer. The ZnS films has a direct band gap of 3.47eV-3.54eV. The thickness of these films were determined by weighing method and in the range of 0.2120µm - 0.2543.µm The structure of the prepared films was studied from X-ray diffraction pattern, the results shows that the film was polycrystalline with hexagonal structure.

KEYWORDS

ZnS thin films, XRD, SEM

INTRODUCTION

Zinc sulphide belongs to II-VI group compound material with large direct band gap between 3.4-3.70eV depending upon composition. It is potentially important material to be used as an antireflecting coating for heterojunction solar cells [1], for light emitting diode [2,3], and other optoelectronic devices such as blue light emitting diode [4], electro luminescence devices and photovoltaic cells which enable wide application in the filed of displays [5,6], sensor and Laser [7], In recent years ZnS attracted much attention because the properties in nano form differ significantly from those of their bulk counter parts. Therefore much effort has been made to control the size, morphology and crystalline of ZnS thin films. There has been growing interest in developing techniques for preparing semi conductor nano particles and films.

ZnS thin films can be obtained a variety of techniques RF sputtering [8] ,Chemical vapor deposition[9],Spray Pyrolysis [10], atomic layer deposition [11] and chemical bath depositions. [12-15].

In present investigation ZnS thin films have been deposited using Chemical Spray Pyrolysis techniques. The optical and structural properties of the as deposited ZnS thin films were studied.

MATERIALS AND METHODS

Thin films of ZnS are prepared by Spray Pyrolysis technique. Spray Pyrolysis is basically a Chemical deposition technique in which fine droplets of the desired material solution was sprayed onto a heated substrate. The experimental Setup used for the preparation of pyrolytically spray deposited films is described here. The initial solution was prepared with one part of 0.1M ZnCl2 and one part 0.1 M SC(NH2)2 [thiourea] in deionzed water. The substrate temperature was 3000 c. The Structural Study was carried out using X-ray diffractometer with CuKα radiation (λ=1.5405A0). The optical transmittance was recorded using UV-VIS Spectrophotometer in the wavelength range 380-1000 nm.

RESULTS AND DISCUSSION

Structural properties:

The X-ray diffraction pattern of ZnS films is also reported in the present work with the help of a Philip X-ray diffractometer by using CuKα radiation (λ = 1.54045A)

The average grain size was calculated from the Scherrer formula, which involve the width of the X-ray diffraction line [16]

$$G = \frac{0.9\lambda}{D\cos\theta} \text{ ------------------ } (1)$$

Where θ is the diffraction angle, λ is the wavelength of the X-ray source and D is measured in radians as full-width at half maximum of the diffraction line. The grain size of ZnS thin films were found to be about 242 nm and 253 nm

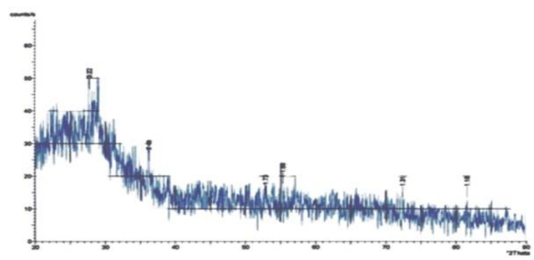

Fig. 1 X-ray diffraction pattern of sprayed ZnS film at substrate temperature, 300°C

Fig.2 Scanning Electron microscopy as deposited ZnS on glass substrate at 300oC sprayed

OPTICAL PROPERTIES:

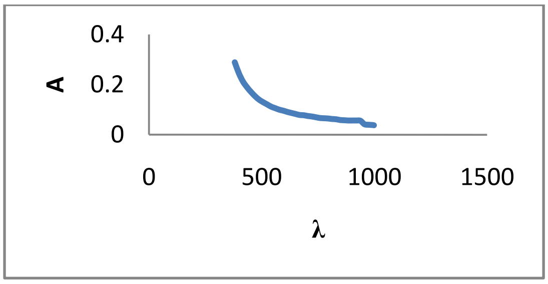

Fig: 3a The absorption spectra of ZnS thin Film as a function to wavelength,thikness ,t=0.2120 µm

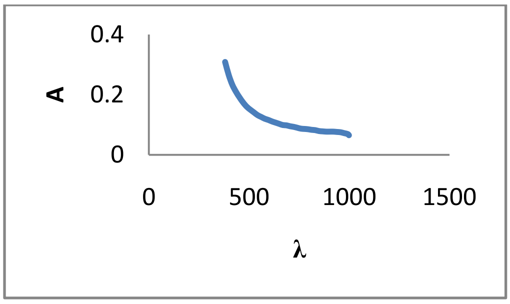

Fig: 3b The absorption spectra of ZnS thin Film as a function to wavelength,thikness, t=0.2359 µm

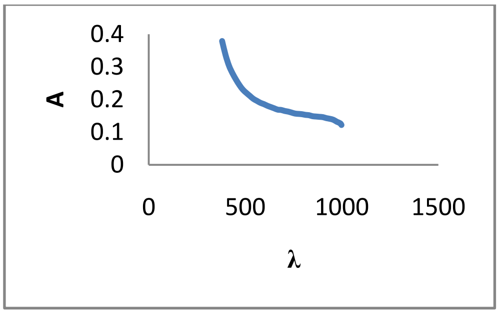

Fig: 3c The absorption spectra of ZnS thin Film as a function to wavelength,thikness , t=0.2543 µm

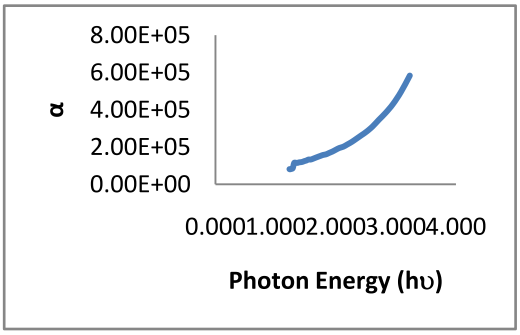

Fig: 4a The absorption Coefficient of ZnS thin Film as a function to photon energy, thikness , t=0.2120 µm

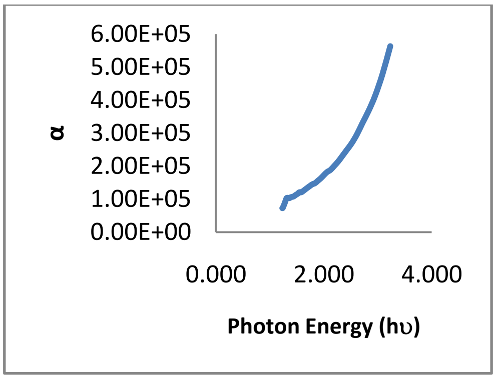

Fig: 4b The absorption Coefficient of ZnS thin Film as a function to photon energy,thikness , t=0.2359 µm

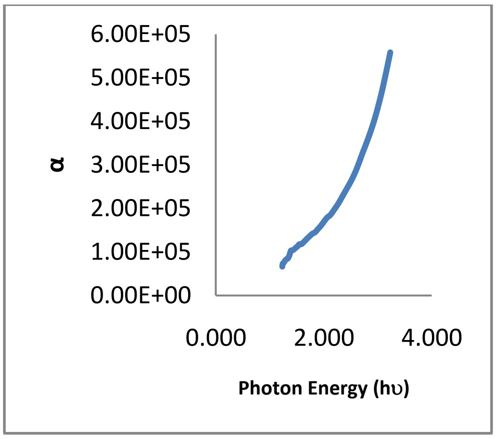

Fig: 4c The absorption Coefficient of ZnS thin Film as a function to pthoton enegry,thikness , t=0.2543 µm

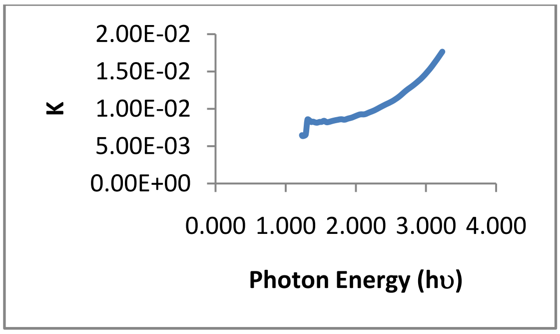

Fig: 5a The extinction Coefficient of ZnS thin Film as a function to the Photon energy ,thikness , t=0.2120 µm

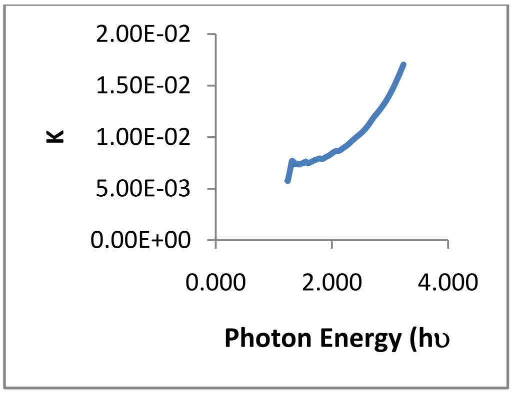

Fig: 5b The extinction Coefficient of ZnS thin Film as a function to the Photon energy ,thikness, t=0.2359 μm

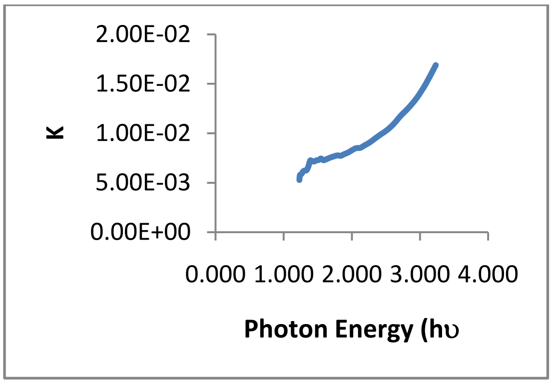

Fig: 5c The extinction Coefficient of ZnS thin Film as a function to the Photon energy ,thikness, t=0.2543 μm

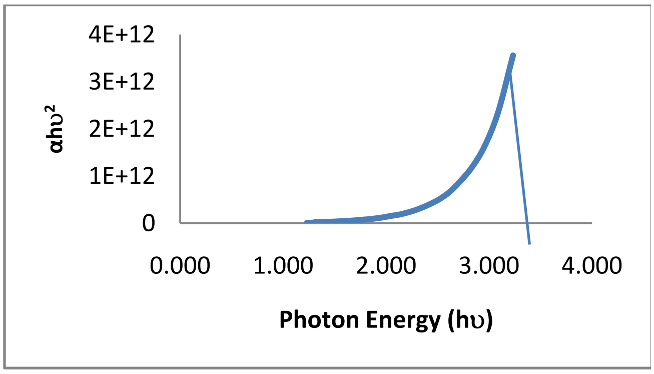

Fig: 6a The optical energy gap for the direct allow transition of ZnS thin Film,thikness, t=0.2120 μm

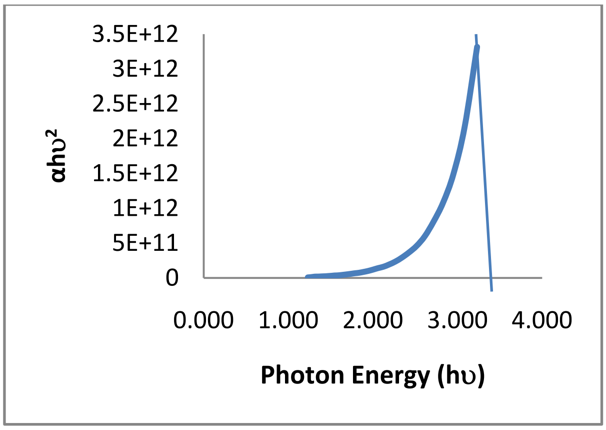

Fig: 6b The optical energy gap for the direct allow transition of ZnS thin Film t=0.2359 μm

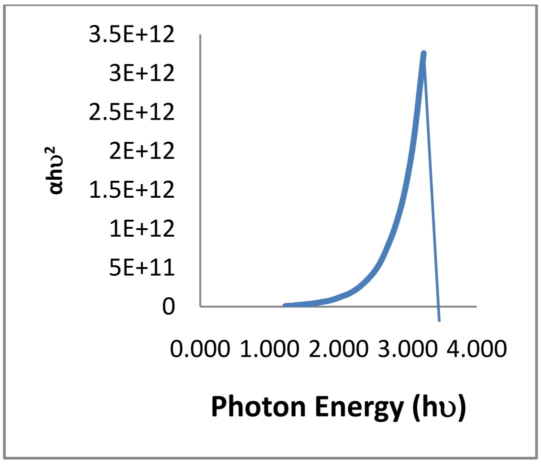

Fig: 6c The optical energy gap for the direct allow transition of ZnS thin Film,thikness , t=0.2543 μm

1. Absorption Coefficient:-

The absorption coefficient (α) of ZnS thin films was determined from the absorbance measurements,was calculated using the following equation:

$$\alpha = 2.303 \times A / t$$

Where A is the absorbanc, t is the thickness of the films. The absorption coefficient of ZnS films was calculated to be 4.05X104 cm-1 at 3.54.eV Photon energy. Fig. 4a,4b and 4c shows the absorption coefficient is function of the Photon energy, decrease in the low photon energy because the probability of the electrical transfer between valence band and the conduction band is very rare and it will increase in the edge of the absorbance toward the high energy .

2. Extinction coefficient

The extinction coefficient K can be determined from the transmittance spectrum as a function of the photon energy at the wavelength within the range 380-1000 nm, it can be determined from the relation:

$$K = \frac{\alpha \times \lambda}{4\pi}$$

Extinction coefficient K verses wavelength spectra is shown in Fig 5a,5b and 5c

3. The Optical Energy Gap

The optical energy gap for the direct allowed transition between valance bands and conduction bands of ZnS thin film was calculated from equation

$$\alpha h\upsilon = A(h\upsilon - Eg)^n$$

using the values of the band gap of ZnS thin film for the direct transition can be determined by extrapolating the straight line portion of the verses as shown in the fig 6a,6b and 6c

Direct band gap energy of ZnS thin films was estimated to be 3.47eV, 3.51eVand 3.54eVthe value of the optical energy gap for direct allowed transition of ZnS thin films prepared at substrate temperature 3000C is in good agreement with previously reported value [14-17]. The wide direct band gap makes these films good material for potential applications in optoelectronic devices such as multilayer dielectric filters, and solar cell due to decreases the window absorption loses and that will improves the short circuit current of the cell.

CONCLUSION:

We have successfully deposited ZnS thin films onto glass substrate, from a chemical Spray Pyrolysis at the temperature of 3000C. In our experiment, based on the optical transmission measurements, the band gap energies are calculated to be between 3.47eV-3.54eV for the ZnS films with different thickness. The result promises a potential application of Spray pyrolysis deposited ZnS thin films for the solar cells. Optical properties of the ZnS films were characterized using UV-VIS spectrophotometer.

REFERENCES

[1] W.H. Bloss, F. Plisterer, H.W. Schock "Advances in Solar energy, and Annual review of research & development", 1988, Vol. 4, P-275

[2] H. Katayama, S. Oda, H. Kukimoto, Appl. Phys. Lett., 1975, 27, 657

[3] A. Antony, K.V. Mirali, R. Manoj, M.K. Jayaraj, Mater. Chem. Phys., 2005, 90, 106.

[4] S. Coe, W.K. Woo, M.G. Bawendi, V. Bulovic, Nature, 2002, 420, 800

[5] M. C. Beard, G.M. Turner, C.A. Schmuttenmaer, Nano Lett., 2002, 2, 983

[6] R.P. Raffaelle, S. L. Castro, A.F. Hepp, S.G. Bailey, Prog. Photovoltaic, 2002, 10, 433

[7] V.I. Klimov, A.A. Mikhailovsky, S. Xu, A. Malko, J.A. Hollingsworth, C.A. Leatherdale, H.J. Eisler, M.G. Bavendi, Science, 2000, 290, 314

[8] O.L. Arenas, M.T.S. Nair, P.K. Nair, Semicond. Sci. Technol. 12, 1323 (1997)

[9] J.M. Blacmore, A.G. Cullis, Thin, Solid Films 199, 321 (1991)

[10] J.W. Li, Y.K. Su, M. Yokoyama, Jpn. J. Appl. Phys. 33, 4723 (1994)

[11] N. Tohge, S. Tamaki, K. Okuyama, Jpn. J. Appl. Phys. 34, L 207 (1995)

[12] J.M. Dona, J. Herrero, Thin Solid Films 268, 5 (1995)

[13] J. Vidal, O. de Melo, O. Vigil, N. Lopez, G. Contreras-Puente, O. Zelaya-Angel., Thin Solid Films 419, 188 (2002)

[14] A. Antony, K.V. Mirali, R. Manoj, M.K. Jayaraj, Meter. Chem. And Phys. 90, 106 (2005)

[15] Q. Liu, M. Guobing, A. Jianping, Appl. Surf. Sci. 254, 5711 (2008)

[16] Uplane M.D.,and pawar S.H. Solid State Communi 46 (1983) 847

[17] M.A. Al-Sabayleh, Umm Al-Qura Univ. J.Sci.Med. Eng. Vol. 20 No. 1, 2008, pp. 17-30