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Effect of Substrate Temperature on Optical Band Gap and Thickness of $ZnIn_2Se_4$ Thin Films by Spray Pyrolysis

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Abstract: ***Spray Pyrolysis is a simple and inexpensive method to prepare thin films. From the transmission spectra, the absorption coefficient calculated. Thin films of $ZnIn_2Se_4$ grown on the biological glass substrate by varying substrate temperature from 275^0C to 350^0Cin the interval of 25^0C. The optimized temperature is around 325^0C. The band gap energy decrease as increase of temperature of the substrate upto 325^0C then it will increase if temperature increases further. The crystalline material confirms the stability of material with nearly stoichiometry. Thickness of the films increase as temperature increase up to 325^0C, after thickness decrease if temperature increases.$Z_nIn_2Se_4$this films shows Indirect allowed transition.***

Keyword: Thin films $Z_nIn_2Se_4$, optical band gap

1. Introduction

II-III_2-VI_4 ternary groupof semiconductors is important due to their application in semiconductor device technology. The *$ZnIn_2Se_4$* the fabrication of solar cells, Photoconductors and non-linear optics. This group of compounds passes large transparent region non-centro symmetric crystal structure and permits non-linear optical properties and birefringence and is suitable for phase-matched parametric optical mixing. An excellent review of the ternary compound is found in the book by Shay and Wernick [1].

The structure of the ternary chalcopyrites has been investigated by many researchers [2-4]. The technique of capital absorption in thin films has been used by various workers to identify the three basic energy gaps which correspond to the forbidden band gap, the crystal field split and spin-orbit split level respectively. The several authors had prepared *$ZnIn_2Se_4$* single crystal using chemical transport reaction and chemical vapour deposition. So it is impossible to obtain the crystal with extremely high purity by these methods. Many other workers had calculated the optical constants like refractive index and extinction coefficient from the transmittance and reflectance spectra near the absorption edge [5] very few workers works on the *$ZnIn_2Se_4$* thin films and studied optical constant from absorption spectra. We are chosen this material due to energy gap between 1-2 eV due to used to prepared opto-electronic devices. And also used in solar cells

In the present work we studied effect of temperature on thickness and optical band gap energy of*$ZnIn_2Se_4$* thin films. The transmissions were taken on Hatachi-330 Spectrophtometer in the wavelength range 350 nm-2000 nm. Temperature of the substrate were measured by pre-calibrated copper constantan thermocouple.

2. Preparation of Samples

Aqueous solution of zinc chloride, Indium trichloride and Selenium dioxide of 0.02 M of each solution was prepared. Then all the three solutions will mixed in one by 1:2:5.2 by volume. Then insert into the sprayer. Now sprayer, spray the liquid through nozzle of 0.2 mm diameter from the height of 30 cm above from the substrate. The temperatures of the substrate vary from 275^0c to 350^0c in the interval of 25^0c. The thin films show the selenium deficiency [6, 7] if the solution was taken in the ratio 1:2:4 by volume. The sprayer move mechanically to and fro to avoid the formation of the droplets on the substrate. The spray rate was maintained at 3.5 ml /minute at the pressure 12 kg/cm^2.

3. Optical Obsorption Study

Transmission of *$ZnIn_2Se_4$* thin films were carried out on Hitachi – 330 pectrophotometer in the wavelength range 350 nm to 2000 nm at room temperature. The absorption coefficient (α) has been evaluated from the transmission curve of each wavelength using Lamert'law.

$$\alpha = \frac{1}{t}\ln\left(\frac{I_o}{I}\right) \quad (1)$$

Where t-be the thickness of the films, I_o and I are the intensities of incident and transmitted radiation respectively. Plotting the graph between $(\alpha h\nu)^{1/2}$ versus hv for different temperature as shown in fig.1.

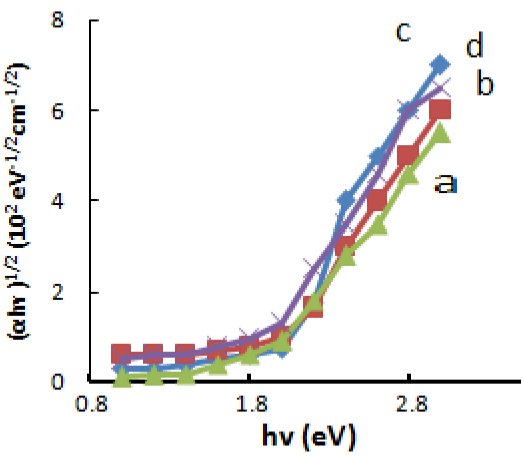

Figure 1: Plot of $(\alpha h\nu)^{1/2}$ vs hv of $ZnIn_2Se_4$ thin films (a) 275^0C, (b) 300^0C, (c) 325^0C and 350^0C

The linear portions of each curve were extrapolated on hv axis yield the band gap energy Eg. The bandgap energy determined for different sample decreases from 1.89eV to 1.75 eV with the increase of the substrate temperature upto 325^{O}C and further increase in the substrate temperature, the band gap energy again increases. The band energy at 325^{0}C of the crystalline materials confirms the stability of the material with nearly stiochiometry. Fig.2, shows the variation of band gap energy with substrate temperature. This result are well agree with the result reported by Sawant et al [8]. Similar results was also reported by Tembhurkar et al [9] for spray pyrolytically deposited $CdIn_2S_4$ thin films.

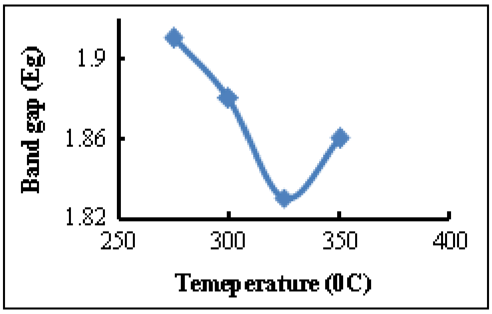

Figure 2: Temperature vs Band gap

4. Determination of Thickness

The thickness of the prepared $ZnIn_2Se_4$ thin films has been determined by Michelson interferometer. The variation of thickness with substrate temperature is shown in fig.3. It was observe that the thickness of the films increase with the increase in temperature and attain maximum value at 325^{0}C. After this increase in temperature there is a decrease in thickness takes place. This is due to higher evaporate the initial a ingredients [10] At lower temperature ($<325^{0}$C) the temperature may not be sufficient to decompose the sprayed droplets on substrate and therefore thickness of the films was estimated. These results are well agreed with the Sawant et al [8] and Tembhurkar et al [9].

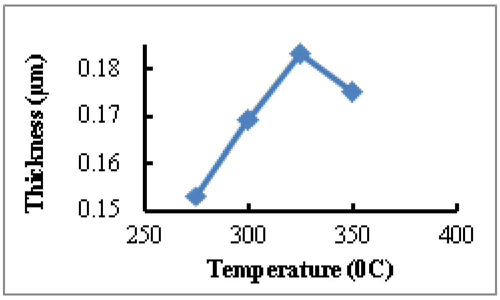

Figure 3: Temperature vs thickness

5. Conclusion

Spray pyrolysis is a simple and inexpensive method to prepared thin films on large substrate area. From the Transmission study it was observed that optical band gap energy decreases as temperature increases and thickness of the films increases if the temperature increases up to optimum temperature (325^{0}C). After this temperature thickness decreases and band gap increases which confirms the stability of material with nearby stoichiometry.

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References

[1] Shey and Wernick, Ternary chalcopyrite semiconductor growth, electronic properties and applications (Pergamon, London) 1975
[2] B. Tell, J. L. Shay and H. M. Kasper., Phys. Rev B (USA) 4 (1971) 2463
[3] M. J. Thwaites, R.D. Tomlinson and M. T. Hamshire, Solid State communication (USA) 23 (1977) 905.
[4] J. L. Sahy, B. Tell, J. M. Kasper and L. M. Schiavome, Phys. Rev. B (USA) 7 (1973) 4485
[5] S. I. Radanstsan, V. F. Zhitar and Ya V. Rilvan, Sav Phys. Semiconductor 9 (1976) 1476
[6] Y.D.Tembhurkar, A.S. Meshram and O.P.Chimankar, International Journal of Scientific Research. Volume 3, 2014, pp .30-32, December 2014, Optical and electrical properties of CdS thin films prepared by spray pyrolysis
[7] Y.D. Tembhurkar and J.P.Hirde, Thin Solid Films 215(1992) 65-70, Structural, optical and electrical properties of spray pyrolytically deposited films of copper indium diselenide
[8] R.R. Sawant, C. H. Bhosale, Ind. J. of Pure And Appli. Phys., 44 (2006) 741
[9] Y. D. Tembhurakar, A. R. Khobragade and S. A. Gaikwad, Proc of National Conference on Synthesis and characterization of Advanced Material organized by Janta M.V. Chandrapur on 8 Oct 2011.

Author Profile

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