Research Inspiration
An International Multidisciplinary e-Journal
(Peer Reviewed & Opened Access Indexed)
www.researchinspiration.com
Email: researchinspiration.com@gmail.com, publish1257@gmail.com
ISSN: 2455-443X
Vol. 1, Issue-III
June 2016
Impact Factor : 4.012 (IIJIF)

BAND GAP MEASUREMENT OF CdTe, ZnTe AND CdZnTe II-VI SEMICONDUCTING SINTERED FILMS: A REVIEW

Dr. SEEMA TEOTIA
Professor and Head,
Department of Physics, Govt. Raza P.G. College, Rampur,
M.J.P.R University, Bareilly UP, (India)

Abstract

The sintered films configurations of ternary alloy of Cd, Zn and Te are emerging as an important class of material for optoelectronics applications due to their flexible electrical and optical properties. CdTe, ZnTe and CdZnTe are some of the very important II-VI semiconductor compounds. Ternary compounds are one option to vary the band gap of semiconductors almost continuously over a wide energy range. This method is highly dependent on the materials as well as the growth techniques. Especially materials with very different lattice constants or different crystal phases (wurtzite or zincblende in this case) are difficult to combine. Tensions and impurities due to low crystal quality result in low optoelectronic properties. Basically, it is possible to gain any band gap between those of the two materials. Consequently, it is possible to choose very specifically the wavelength of photons emitted by laser diodes or light emitting diodes.

Keywords: Absorption spectra, Direct and indirect band gap, Refection spectra Semiconductor, Screen printing, Sintering.

INTRODUCTION

II-VI semiconductors crystallize either in the zincblende lattice structure or the wurtzite crystal structure [1]. These semiconductors show usually big band gaps. That's why they are popular for short wavelength applications in optoelectronics. Especially wide band gap II-VI semiconductor compounds are expected to be very good candidates for high performance applications such as light emitting diodes and laser diodes for the blue and ultraviolet applications [2].

Cadmium telluride has been the subject of intensive research because of its intermediate band gap, reasonable conversion efficiency, stability and low cost [3]. From the analysis of absorption spectra of evaporated CdTe film, the CdTe films have direct band gap 1.50 eV and indirect band gap 1.82 eV [4].

Zinc telluride (ZnTe) thin films are widely used in modern technologies of solid-state devices (light-emitting diodes, solar cells, photo detectors etc.) because of its excellent characteristics, namely large energy band gap, low resistivity, high transparency in visible spectral domain, [5 – 8] etc. For this compound, there is a very sensitive and complex dependence of film microstructure on preparation method and deposition conditions [9–12]. In this connection, many studies have recently been reported to establish the deposition conditions in order to obtain ZnTe films having a particular crystalline structure, desired optical properties and also the morphology [6 – 10, 13].

CdZnTe or CZT, is a compound of cadmium, zinc and tellurium or, more strictly speaking, an alloy of cadmium telluride and zinc telluride [14]. An alloy is a combination, either in solution or compound, of two or more elements. An alloy with two components is called a binary alloy; one with three is a ternary alloy; one with four is a quaternary alloy and so on. The resulting alloy substance generally has properties significantly different from those of its components [15].

Many methods have been extensively applied to grow high-quality films and bulk single crystals from the vapor and liquid phases. In this study We Prepare the sample by Screen printing method. The promise of sintered films of compounds Cd, Zn, and Te as variable energy band gap and fast response optoelectronic material has recently been established sintered films as the recent class of materials for the fabrication of optoelectronic devices. The sintered films have advantages like; ease of processing, cost effectiveness and no sophisticated technology is required for device fabrication. Although many devices have been developed to date from sintered materials but the search is still on for newer configuration and compositions and bring down the physical size of the device to the micro miniature level in the form of sintered films. The sintered films offer two main advantages, flexibility in fabrication of films of good quality, which makes them suitable for optoelectronic devices, and that their optical energy band gap can be varied through processing. These devices have recently become the focus of intensive fundamental and applied studies. The main advantages of sintered films are: low-cost technology reducing conventional thin film deposition method, case of modification and adjustment of optical properties like energy band gap and absorption characteristics, a varied substrate choice, relatively low temperature processing and possibility of coating on hybrid circuits, interfacing with electrical or optical device [16-17].

EXPERIMENTAL DETAIL

PREPARATION OF CdTe SAMPLE

To prepare sintered CdTe films we make the composition as

Wt. of CdTe = 240 mg

Wt. of $CdCl_{2}.2.1/2H_{2}O$ = 10% Wt. of CdTe mg = 24mg

And a few drops of ethylene glycol were added to make the paste properly. We may take any amount of CdTe and $CdCl_{2}.2.1/2H_{2}O$ keeping the same proportion as above. The paste thus prepared was screen printed on a glass substrate which has been cleaned by HCl embry powder soap solution/ detergent and finally with distilled water. The sample thus prepared was dried at 120° C for 4 hours in an open air. The reason for drying the sample at lower temperature was to avoid cracks in the sample. The removal of organic material takes place at 400° C so sintering temperature cannot be less than 400° C. The melting point of cadmium chloride, which is used as an adhesive is 568° C however the evaporation of cadmium chloride starts above 400° C. Cadmium chloride is hygroscopic so to get a stable sintered film, cadmium chloride and organic material should not remain in the sample, So after drying, the sample was sintered at 500° C for 10 min, to remove the organic materials left which have been used as a binder in the formation of paste.

PREPARATION OF ZnTe SAMPLE

To prepare sintered ZnTe films, a calculated amount of ZnTe powder, 10% of ZnTe, $ZnCl_2$ and few drops of ethylene glycol were thoroughly mixed. The paste thus prepared was screen printed on ultra clean glass substrate to get the film of ZnTe. The sample thus prepared was dried at 120° C for 4 hours in nitrogen atmosphere in a tube furnace. The reason for drying the sample at lower temperature was to avoid cracks in the sample. The melting point of zinc chloride, which is used as an adhesive, is 283° C however the evaporation of cadmium chloride starts at lower temperature. Zinc chloride is hygroscopic so to get a stable sintered film, zinc chloride and organic material should not remain in the sample, so after drying, the sample was sintered at 500° C for 10 min in tube furnace, to remove the organic materials left which have been used as a binder in the formation of paste. For drying and sintering nitrogen atmosphere is used instead of open atmosphere because in open atmosphere ZnTe reacts with atmospheric oxygen and the formation of zinc oxide (ZnO) occurs. But in nitrogen atmosphere this problem does not exist.

PREPARATION OF CdZnTe SAMPLE

For the preparation of sintered films of $Cd_{1-x}Zn_xTe$ (X = 0, 0.8, 0.6, 0.4, 0.2, 1), an appropriate amount of CdTe, ZnTe powder, $ZnCl_2.H_2O$ as an adhesive and ethylene glycol as a binder were thoroughly mixed. The composition of materials was taken as

Wt. of CdTe = (1-X) x 240 = 240(1-X) mg

Wt. of ZnTe = X x 192.97 = 192.97Xmg

Wt.of$ZnCl_2.H_2O$ = 10% of Wt. [CdTe + ZnTe]mg

Since the weights are large, we can reduce the weights in the same proportion. All the three were mixed properly along with the weight of ethylene glycol. The paste thus prepared was screen printed on a glass substrate which has been cleaned properly. The samples thus prepared were dried at 120° C for 4 hours and then sintered at 500° C for 10 min in nitrogen atmosphere in a tube furnace to remove the organic materials left. For drying and sintering nitrogen atmosphere is used instead of open atmosphere because in open atmosphere ZnTe reacts with atmospheric oxygen and formation of zinc oxide (ZnO) occurs. But in nitrogen atmosphere this problem does not exist. To minimize the problem of diffusion, the sample was covered with a glass plate of substrate size. The thickness of these prepared films is of the order of a micron.

BAND GAP MEASUREMENT

Reflection spectra/absorption spectra of these films were taken at room temperature with the help of Hitachi spectrophotometer model U-3400.In this model all the prism/grating double monochromatic system is used. In this model all the lenses used in conventional monochromatic system have been replaced with mirrors. So, the image deviation due to chromatic aberration is eliminated. Its wavelength range is 187nm to 2600nm. The lead sulphide (PbS) detector is used for the detection of infrared rays. The visible wavelength light source is long life WL lamp. The band gap of these films was calculated with the help of reflection spectra/absorption spectra. To measure the energy band gap from reflection spectra/absorption spectra Tauc relation [18] is used.

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

Where

hv= Photon energy

α=Absorption Coeffcient

E_g= Bandgap

A= Constant

n = ½ for direct band gap

n = 2 for indirect band gap

To measure the energy band gap from reflection spectra/absorption spectra a graph $[\alpha hv]^n$ versushv was plotted .

RESULT AND DISCUSSION

From the analysis of reflection spectra data the band gap of CdTe sintered film at 500° C was found to be 1.47eV[19] and at 550° C it was found to be 1.48 eV [20]. From the analysis of the absorption spectra of screen printed sintered CdTe films, the CdTe film has a direct band gap 1.45 eV and indirect band gap 1.66 eV in the same sample [21].

From the analysis of reflection spectra data, the band gap of ZnTe sintered film at 500° C was found to be 2.21eV [22]. From the analysis of reflection spectra data and absorption spectra data the band gap of ZnTe sintered film at 600° C were found to be 2.22eV and 2.19eV respectively [23].

$Cd_{1-x}Zn_xTe$ is one of the II-VI ternary semiconductor materials whose band gap can be tailored to any value between 1.48 eV to 2.26 eV as x varies from 0 to 1 [24]. From the analysis of absorption spectra and reflection spectra data the band gap of $Cd_{0.4}Zn_{0.6}Te$ sintered film at 500° C was found to be 1.70 eV and 1.88 eV respectively [24, 16]. From the analysis of reflection spectra data, the band gap of $Cd_{0.8}Zn_{0.2}Te$, $Cd_{0.5}Zn_{0.5}Te$ and $Cd_{0.2}Zn_{0.8}Te$sintered film at 500° C were found to be 1.58eV, 1.78 eV, and 1.98 eV respectively [25, 26].

Above results show that with increase in sintering temperature band gap increases and this increase is due to increase in average grain size and crystallinity [27]. There is difference in band gap measured from reflection and absorption spectra data. The band gap energy measured through absorption spectra is less than reflection spectra. This may be attributed to the difference in reflection from the reference and the sample. Band gap measurement from reflection spectra data is more accurate easier and faster method than absorption spectra data in case of sintered films with thickness of the order of micron [23].

REFERENCES

[1] C. F. Klingshirn, B. K. Meyer, A. Waag, A. Hoffmann, J.Geurts: Zinc oxide From Fundamental Properties Towards Novel Applications Springer Series in Materials Science Vol. 120, Springer, Heidelberg u. a. 2010, ISBN: 978-3-642-10576-0(Print) 978-3-642-10577-7 (Online).

[2] D.W. Palmer, “Properties of the II-VI compound Semiconductor”, www.semiconductors.co.uk. 2008.03 (Retrieved 11 September 2015).

[3] M.S. Shaalan, J. Muller, Solar cells 28(1990) 185-.192.

[4] G K M Thutupalli and S G Tomlin J. Phys., D:Appl. Phys. 9 (1976), 1639-1646.

[5] M. Jain, (Ed). II-VI Semiconductor Compounds, World Scientific, 1993.

[6] R. Bhargava, (Ed). Properties of Wide Band gap II-VI Semiconductors. Inspec, 1997.

[7] A. Rohatgi,, S.A. Ringel, R. Sudharsanan, P.V. Meyers, C.H. Liu, V. Ramanathan, Solar Cells 27 1989: 219 – 230.

[8] P.K. Kalita, B,K. Sarma, H.L. Das, Indian Journal of Pure and Applied Physics 37 1999: pp. 885 – 890.

[9] A.K.S. Aqili,Z. Ali, A. Mazsood, Applied Surface Science 167 2000: pp. 1 – 11. http://dx.doi.org/10.1016/S0169-4332(00)00498-0111.

[10] M.R.H. Khan, Interface, Journal Physics, D:Applied Physics 27 1994: 2190 – 2193. http://dx.doi.org/10.1088/0022-3727/27/10/031

[11] W.I. Tao, M. Jurkovic, I.N. Wang, Applied Physics Letter 64 1994: 1848 – 1849.

[12] G.I. Rusu, P. Prepelita, N. Apetroaei, G, Popa J. of Optoelectronics and Advanced Material 7 (2) 2005: 829 – 835.

[13] T. Mahalingam, V.S. John, S. Rajendran, G. Ravi, P.J. Sebastian, Surface Coatings Technology 155 2002: 45 – 249.

[14] S.Teotia, Research Ambition - An International Multidisciplinary e-Journal, ISSN : 2456-0146,(2016)207-211.

[15] S. Adachi, Properties of Semiconductor Alloys: Group-IV, III–V and II–VI Semiconductors Gunma University, Gunma, Japan.

[16] S. Teotia, T.P. Sharma, S.C.K. Mishra, SPIE, 1999, Vol. 3903, 298-304.

[17] S.Teotia, J. of Scientific and Applied Research, ISSN :0975 – 9743,(Jan 2015) 21-22.

[18] J. Tauc Ed., Amorphous and Liquid Semiconductors, Plenum,New York, 1974, 159.

[19] S.K. Sharma, V. Kumar, S. Sirohi, T.P. Sharma, C.S.I.O. 4(3), (1996), 189-191.
[20] S. Sirohi, V. Kumar, T.P. Sharma, J. of Optical Material, 12(1999),121-125.
[21] S Sirohi, T.P Sharma, J. of Optical Material, 13(1999), 267-269.
[22] S. Sirohi, V. Kumar, V. Kumar, T.P. Sharma, Semiconductor materials, R.K. Bedi (Ed.) 1998, 91-94.
[23] S. Sirohi, V.K. Sharma, T.P. Sharma, C.S.I.O. 6(2), (1998). 95-99.
[24] S. Sirohi, V. Kumar, T.P. Sharma, ICOL-98, Optics and Optoelectronics, Narosa Publication, 1361-1363.
[25] S. Sirohi, T.P. Sharma, ICAM-2000, SM-43.
[26] S. Sirohi, T.P. Sharma, CONIAPS – VIII, December 2005, PH- 63.
[27] S. Sirohi, T.P. Sharma, ISOAP – 2006 February,6.

****