Acta Ciencia Indica, Vol. XL P, No. 2, 57 (2014)

OPTICAL AND STRUCTURAL PROPERTIES OF $CdInS_2$ THIN FILMS DEPOSITED BY SPRAY PYROLYSIS METHOD

RAMESH M. THOMBRE

Deptt. of Physics. M.G. Arts, Science & Late N.P. Commerce College, Armori Dist Gadchiroli -441208 (MS) India

RECEIVED : 28 December, 2013

Stoichiometric ternary chalcogenide $CdInS_2$ were prepared in the film form by pyrolytic spray deposition technique using air/ nitrogen as the carrier gas. The precursor solution comprised of $CdCl_2$, $InCl_3$ and $NH_2Cs\ NH_2$ (Thiourea). The deposition were carried out under optimum conditions of experimental parameters viz. came gas (air/nitrogen) flow rate, concentration of precursor constituents, nozzle, substrate distance and temperature of glass substrate. The deposited thin films were later annealed at 240°C for 120 min.

The structural, compositional and optical properties of the annealed thin films were studied. X-ray diffraction studies of the thin films taken with Cu-Kα radiation. The optical study was carried out by optical absorption in the wavelength range 380-1000nm by using Elico SL 159 UV-VIS spectrophotometer. The optical band gap energy, refractive index and % transmission revels that $CdInS_2$ thin films in Indirect band gap material with band gap 2.24 eV match with single crystal value. The band gap energy of the crystalline material confirms the stability of the material nearly stoichiometric.

KEYWORDS: Spray pyrolysis, $CdInS_2$ thin films, XRD, optical study.

INTRODUCTION

Chemical Spray Pyrolysis (CSP) technique offers an extraordinary easy way to prepared thin films. It is most convenient, cheap inexpensive and simple method for depositing semiconducting thin films on to glass substrate. The deposition rate and thickness of the film can easily be controlled for a wide range. The versatile nature of this technique lies in the way various parameters that include effect of precursors, dopant substrate temperature, annealing treatments, solution concentrations and so on can easily be controlled. Various type of metal oxide binary and ternary chalcogenides and superconducting oxides can be prepared [1, 2, 3].

Ternary chalcogenides $CdInS_2$ thin films is semiconducting material of the type $A^{II}\ B^{III}\ X^{IV}$ where A = Cd, Zn; B = In, Ga; and X = S, Se, Te;. the interest in the ternary chalcogenides $CdInS_2$ thin films exhibits many excellent physical and chemical properties such as high absorption coefficient in the visible spectral range, high chemical stability [4, 5] and their potential application in science and technology [6, 7]. In contrast to other ternary semiconducting materials, $CdInS_2$ is nontoxic, low cost and easy to fabricate by various thin films deposition techniques [8, 9]. $CdInS_2$ transparent conducting thin films are n-type semiconductor with energy band gap 2.24 eV. The structure of $CdInS_2$ in its crystalline form polycrystalline body centred cubic with a lattice constant (311) at $2\theta = 41°$. In this paper, we report on structural and optical properties of $CdInS_2$ thin films as function of substrate temperature and annealing effect.

Experimental

The spray pyrolysis technique is a simple technology in which an ionic solution containing the constituent elements of a compound in the form of soluble salts is sprayed on to overheated substrates using a stream of clean, dry air/nitrogen gas. The $CdInS_2$ thin films were prepared by spraying an aqueous solution of $CdCl_2$, In_2Cl_3 and thiourea [NH_2CSNH_2] on glass substrate kept at 350°C to 400°C.

The atomization of the chemical solution in to a spray of fine droplets is effected by the spray nozzle. With the help of compressed air as carrier gas. The spray rate was about 10 cm^3/min through the nozzle which ensures a uniform film thickness. The apparatus used to carry out the chemical spray process consists basically of a device use to atomize the spray solution and some sort of substrate heater. Our setup consists of a reaction chamber foreseen to its lower part with a plate heated by electrical resistance standard commercial glass slides ($25 \times 25 \times 1$ mm^3) were used as substrates, which were previously cleaned well using detergent, water, tolune and dried, prior to weight with numbers to the film deposition process.. The substrate temperature is measured with a thermo couple which is precalibrated. Above the substate at variable distances (5 to 25 cm) the glass spraying nozzle is fixed. The solution is sprayed (from a reservoir) by means of a carrier gas, incidently to the substrate. The air/nitrogen flow rate was 13 ml/min. The spraying time varied between 10 and 20 S for one layer and layer numbers between 1 to 5. The heater was a cylindrical stainless steel block furnace electrically controlled to an accuracy of $\pm$ 2°C. The substrate temperature was varied while other spray parameter were kept constant. The thickness of the film was 400nm and established by micro weighting or spectra photometrical [11, 12]. The X-ray diffraction (XRD) patterns of the films were recorded with Philips 60 PA. X-ray diffractometer operating with a 0.15418 nm monochromatized Cu-Kα radiation at 40 KV and 30 mA. Transmission and absorption spectra of the prepared sample were measured by normal incidence of light using double beam Elico SL 159 scanning spectrophotometer in the wavelength range 380-1000nm using a blank substrate as the reference position.

Result and discussion

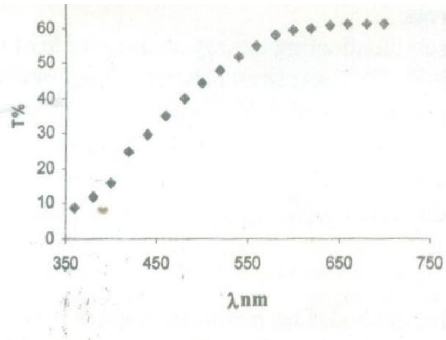
The optical absorption studies of $CdInS_2$ thin films prepared at 400°C temperature carried out in the wavelength range 350-1000 nm at room temperature.

The absorption coefficient (α) at various wavelengths for the samples thickness (t) is given by relation

$$11\alpha = 1/t \log (I_0/I) \quad \dots (1)$$

where I_0 and I are the intensities of incident and transmitted radiation respectively.

The absorption coefficient (α) at various wavelength was calculated from the transmission curve (fig. 1) using the relation (1) to calculate the exact value of the band gap, a graph $(\alpha h\upsilon)^2$ verses ($h\upsilon$) was plotted for region near and above the fundamental absorption edge fig. 2 the graph had some linear portion above the fundamental absorption edge the extra polluted interest on $h\upsilon$ axis gave the value of band gap and was found out to be 2.24 eV.



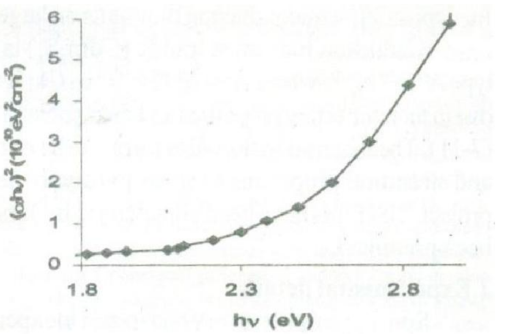


Fig. 1. Transmission spectra of CdIns₂ **Fig. 2. Band gap $\alpha h\upsilon$ verses $h\upsilon$**

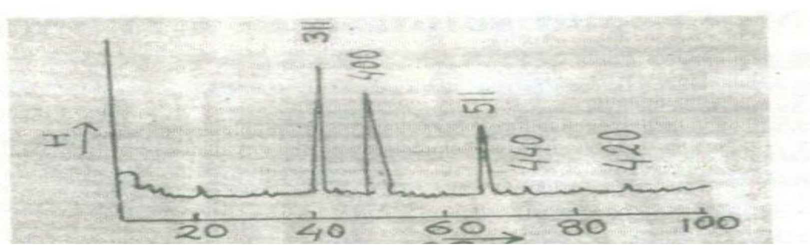
The linearity of the graph indicated that the directly allowed transmission described by the relation

$$\alpha = (A/h\upsilon)\,(h\upsilon - E_g)^{1/2} \quad \ldots (2)$$

Was probably responsible for absorption process. The band gap energy of the crystallinc material at 400°C canters the stability of the material with nearly stoichiometery this band gap is in good agreement with that of the Sawant and Bosale [13] and this value also matching with single crystal value.

The crystal structure of the film was analyzed by XRD. X-ray diffraction spectra were taken with Cu-Kα radiation in high resolution geometry shows in fig 3 which revels deposited material in polycrystalline. To index the X-ray pattern firstly the intensity of each line is determined, from the experimental values of 20 the inter spacing (d_{hkl}) were calculated using Bragg's relation.

$$2d_{(hkl)} \sin\theta = n\lambda \quad \ldots (3)$$



→ 2θ

Fig. 3. XRD pattern of $CdInS_2$

The comparison of the intensities of the line with JCPDS diffraction data. The maximum intensity of reflection from (311) plane indicates the preferred orientation along the direction (311) is paralleled to the substrate surface. All other lines in XRD pattern for $CdInS_2$ are compared with JCPDS diffraction data and are properly index. This confirms the dominantly cubic (spin) structure of the film [14].

Conclusion

In this work we give a brief review of the structural and optical properties of $CdInS_2$ thin films deposited by spray pyrolysis technique which is nearly stoichiometric. The film deposited at substrate temperature of 400°C and concentration of 0.01M. The optical band gap of $CdInS_2$ thin films was 2.22 eV. Obtained from the transmission curve data. The compounds having such band gap are helpful for the preparation of solar cells.

XRD pattern shows that $CdInS_2$ thin films is polycrystalline with cubic (spin) structure. Hence spray pyrolysis is best and reprolyable method for developing solar cell and for studying their properties.

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