Volume : 5 | Issue : 9 | September 2016 • ISSN No 2277 - 8179 | IF : 3.508 | IC Value : 69.48

Original Research Paper

Annealing Effect on Structural and Electrical Properties of Cuinte2 Thin Films

Physics

KEYWORDS : Ternary Semiconductor, structural and electrical properties.

Y. D. Tembhurkar | Department of Physics, S. K. Porwal College Kamptee, Nagpur (M.S) India-441002

ABSTRACT

CuInTe2 thin films of thickness 0.186 nm were prepared by spray pyrolysis using aqueous solution of Cupric chloride, Indium tri-chloride and Tellurium tetra-chloride of 0.02M. XRD pattern shows the films is polycrystalline with preferred orientation along 112 direction. Annealing effect shows the atom are arrange regularly. As the films are not doped intentionally defect observed in intrinsic nature operative to be produced by tellurium interstitials. Grain size has been studied by Scanning Electron Microscope.

Introduction:-

There has been growing interest in the application of I-III-VI_2 ternary compound semiconductors in various electronic devices. $CuInTe_2$ is a ternary compounds for the use in thin film solar cells because of its optimum direct band gap energy [1] 0.98 eV and its controllable conduction type. In the recent years the ternary group compounds have high conversion efficiency that exceeds 15 to 19 %. This means that CIS/Se/Te-based solar cells are able to complete with poly si-based solar cells even though their cost of production is high. Thin films of ternary compound have been prepared by several methods such as r. f. sputtering [2], co-evaporation [3], chemical bath deposition [4], electrodeposition [5] and spray pyrolysis [6-13].

We choosen spray pyrolysis method because the films can be made at temperature 300 to 350^0C with large area and low processing cost and that is require only very pure starting materials. This paper is focused on the effect of annealing in air atmosphere on the structural, Morphological and electrical properties of $CuInTe_2$ thin films.

Preparation of Sample

The aqueous solution of Cupric chloride, Indium tri-chloride and Tellurium tetra-chloride were prepared of 0.02 M. Chemical used as AR grade. Solution of Cu:In:Te were mixed together in the ratio 1:1:3.2 by volume. Excess Tellurium required to reduce the deficiency of tellurium [7, 8 and 13]. If ratio of Cu:In:Te used in the ratio 1:1:2, shows the tellurium deficiency. Temperature of the substrate was maintained at 300^0C and it was measured by pre-calibrated copper constantan thermocouple. Thicknesses of the films were calculated by Michelson-interferometer. Electrical resistivity calculated by Four-probe technique. X-ray diffraction was taken on Philips X-ray diffractometers by CuK_α -radiation of wavelength 1.542 Å. The details experimental set-up was discussed elsewhere [6-13].

X-ray study

Fig.1 (a .& b) shows the X-ray diffraction pattern of as deposited and annealed at one hour of $CuInTe_2$ thin films. The observed diffraction peaks of $CuInTe_2$ thin film were found at 2θ values of angles 25.113^0, 28.888^0, 33.292^0, 39.281^0, 44.64^0, 49.90^0, 59.88^0, 72.23^0, 76.53^0 corresponding to the lattice planes [112], [200/400], [211], [301], [116/312], [231/107], [235/413] and [420/404] respectively. Each diffraction peak of annealed films shows sharp. XRD studies revealed that the films of $CuInTe_2$ are polycrystalline in nature with cubic structure with lattice constant a = 6.1798 Å and C= 12.3596 Å. The different peaks in the diffractogram were indexed by usual method. The corresponding values of interplanar spacing'd' were calculated and compared with standard JCPDS data [13]. It was observed that films to be well crystallined with preferential orientation along (112) direction. Our calculated values of lattice parameter well agree with results reported by other workers [5, 13 and 15].

Electrical properties

Thin films as checked by hot probe method showed p-type conductivity. The resistivity is determined for two different ranges of temperature range (a) from 300 K to 473 K and range (b) is from 77 K to 273 K. The resistivity for range (a) is measured at atmospheric pressure. The resistivity for range (b) is measured at 10^{-2} torr pressure for which a four-probe arrangement together with sample film was enclosed in a specially prepared stainless steel container, which was immersed in a liquid nitrogen bath. Fig. 2 (a and b) shows the Arrhenius plot of conductivity versus inverse temperature of as deposited and annealed for one hour respectively. The annealed films showed that the atoms are arranged in more regular form than as deposited films. It was observed from fig 2 that three distinct regions of conductivity are seen. The activation energy (E_a) in p-type film can be calculated using the relation, $\sigma \alpha \exp(Ea/kT)$

Activation energies calculated using above equation for these three regions (From fig 2.a) are 86 meV, 38 meV and 3 meV for the temperature range 300 K-473K, 160 K- 250 K and 90 K- 125 K respectively and from fig.2 (b), the activation energies are 96 meV, 60 meV and 8.2meV for the above temperature ranges.

The Arrhenius plot can yield the different levels which are responsible for different donor or acceptor mechanisms. The change in the carrier mechanism is indicated by the change in slope of the curve [12]. Films are not doped intentionally and therefore the defect observed in intrinsic nature. As the conductivity is p-type, acceptors like levels are expected to be present [12].

The activation energy of 86 meV obtained in our investigation is agreed well with 88 meV calculated by hydrogenic approximation [14] which may be due to the acceptor like levels produced by tellurium interstitials at high temperature regions above 250 K. our value 86 meV are smaller than Sridevi and Reddy [15] who was reported activation energy 100 meV for the temperature range 250 K to 300K for flash evaporated $CuInTe_2$ thin films. After annealing the films at 1 hr the activation energy increases and it was found to be 110 meV, 60 meV and 15 meV which indicates the increase in annealing temperature the activation energies also increases [13]. Dawar et al [14] studied the similar works on vacuum deposited $CuInTe_2$ thin films in the temperature range 77 K to 300K. They stated that the films would have a large deficiency in copper than indium which consistent with higher carrier concentration. Since the films are polycrystalline, the activation energy compounds to the potential barrier of the grain boundary.

Volume : 5 | Issue : 9 | September 2016 • ISSN No 2277 - 8179 | IF : 3.508 | IC Value : 69.48

Fig.3 (a,b)shows a SEM of $CuInTe_2$ thin films of as deposited and annealed for 1 hour respectively.. After annealing for 1 hour the grain size of the films increases and it is seen clearly from fig. b. The grain size of the films of the order of 268 nm. This result is similar to other worker [7, 12].

Conclusion

The $CuInTe_2$ thin films have been successfully prepared by a simple and inexpensive spray pyrolysis deposition method. The XRD spectra of the sample showed tetragonal structure with preferred orientation along 112 directions. The good crystallinity was found for annealed sample. The conductivity of the films of p-type was obtained. The films are not doped intentionally hence the defect observed in intrinsic nature. The acceptor like levels are appears to be produced by tellurium interstitials. The SEM images of the $CuInTe_2$ thin films shows good compound formation.

Acknowledgements

Author would like to express his thanks to the university Grants Commission New Delhi for financial support in the form of Major research Project and is indebted to Department of Physics, RTM Nagpur University Nagpur and Principal, S. K. Porwal College Kamptee for providing research facilitates in the respective laboratories.

Figures

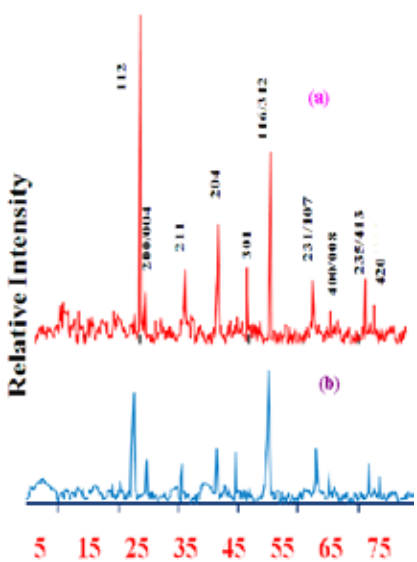


Fig.1 X- Ray diffraction of (a) as deposited and (b) for annealed 1 hour of $CuInTe_2$ thin films

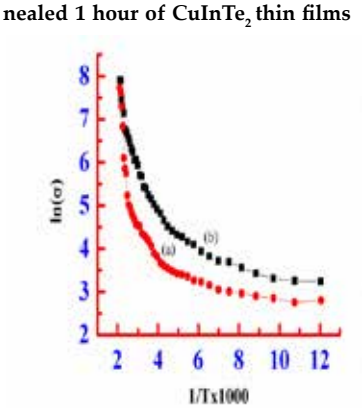


Fig. 2 Arrhenius plot of $CuInTe_2$ thin film (a) as deposited and (b) annealed for 1 hour

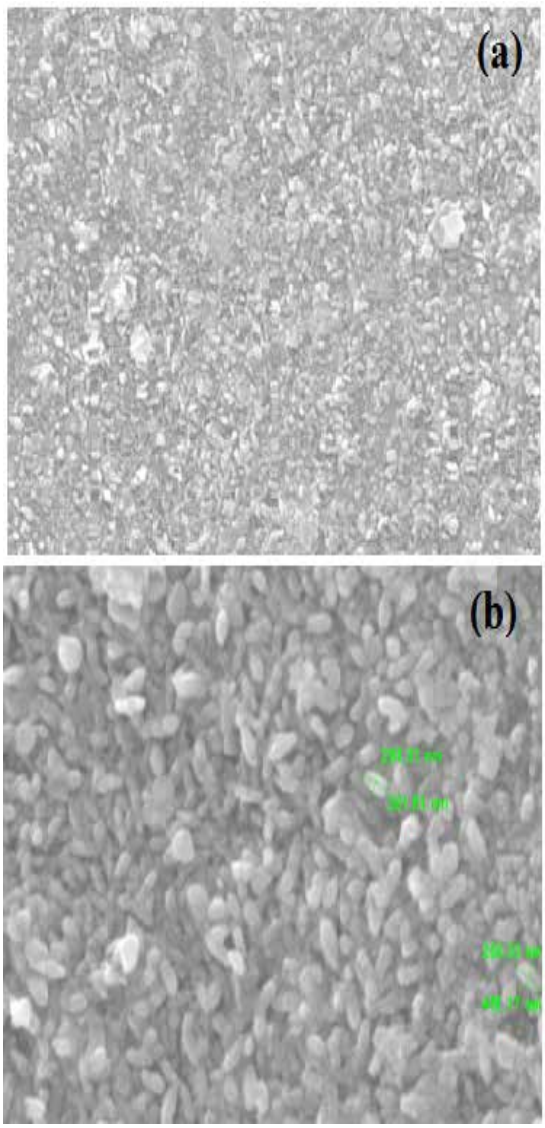


Fig.3 SEM micrograph of $CuInTe_2$ thin film for (a) as deposited and (b) annealed for 1 hour

References:

1] D. Sridevi and K. V. Reddy, Electrical conductivity and optical absorption in flash evaporated $CuInTe_2$ thin films, Thin Solid Films 141 (1986) 157-164.

2] A. Parreta, M.L. Addonizia, A. Agati, M. Pellegrino, L. Quercia, F. Cardellini, J. Kessler, H. W. Schock, Influence of morphology and $CuInSe_2$ for thin films solar cells, Jpn. J. Appl. Phys. 32 (1993) 80-83.

3] A.H. Moharriam, M. M. Hafiz, A. Salem, Electrical properties and structural changes of thermally co-evaporated $CuInSe_2$ films, Appl. Surf. Sci. 172 (2001) 61-67.

4] M. Dhanam, R. Balasundaraprabhu, S. Jaykumar, P. Gapalakrishnam, M. D. Kannam, Preparation and study of structural and optical properties of chemical bath deposited copper indium diselinide thin films, Phys. Status solidi (a) 191 (2002) 149-160.

5] S.N. Sahu, R. D. L. Kristensen, D. Haneman, Electrodeposition of $CuInSe_2$ thin films from aqueous solution, Solar Energy Mater., 18 (1989) 285-397.

6] Y.D. Tembhurkar and A.S. Meshram, Spray pyrolytically deposited CdSe thin films for Photoelectrochemical solar cells, Inter. J. Scienti. Res., September (2015) 331-332.

7] Y.D.Tembhurkar, A.S. Meshram, A. R. Khobragade, R. S. Shriwas and O. P. Chimankar, Some physical properties of CuInSeTe thin films prepared by spray pyrolysis, Inter. J. Sci. Res., (2013) 543-545.

8] Y.D. Tembhurkar and J.P.Hirde, Band gap variation and structural param-

eter variation of $CuInSe_{2(1-x)}S_{2x}$ solid-solution in the form of thin films, Bull. Meter Sci.Vol. 15 No. 2 April (1992)pp 143-148.

9] Y.D. Tembhurkar and A.S. Meshram and O.P. Chimankar, Optical and electrical properties of CdS thin films prepared by spray pyrolysis, Inter. J. Scienti. Res., December (2014) 1-3

10] Y.D. Tembhurkar, Electrical properties CdO thin films prepared by Spray pyrolysis, International Journal of Researches in Bioscience, Agriculture and Technology, 2 (1) January (2014) 1064-1066.

11] Y.D. Tembhurkar, Study of spray pyrolytically deposited CuInSTe thin films, international Journal of Application or Innovation in Engineering of Management, (2013) xx-xx

12] S.A. Gaikwad, Y.D. Tembhurkar and A. S. Meshram, Some physical properties of spray pyrolytically deposited CuInSeS thin films, International Journal of Researches in Bioscience, Agriculture and Technology, 2 (1) January (2014)

13] Y.D. Tembhurkar and J. P. Hirde, Structural, optical and electrical properties of spray pyrolytically deposited thin films of $CuInS_2$, Bull. Mater.Sci. 16 (3) June (1993) 177-186.

14] JCPDS File No. 34-1498

15] K.M.A. Hussain, J. Podder, D. K. Saha and M. Ichimura, Structural, electrical and optical characterization of $CuInS_2$ thin films deposited by spray pyrolysis, Ind.J. Pure and Appl. Phys., 50 Feb (2012) 117-122.

16] S.M. Wasim, G. Marcono and G.S. Porez, Transport properties of ternary compounds, Jpn. J. Appl. Phys.Supp. 19(3) (1980) 133.

17] D. Sridevi and K. V. Reddy, Electrical and optical properties of flash evaporated $CuInSe_2$ thin films, Ind. J. Pure and Pure Phys. 24 (1986) 392-396.

18] Y.D. Tembhurkar and J. P. Hirde, Annealing effect on conductivity and grain size of spray pyrolytically deposited $CuInSe_2$ thin films, Proc. 80th Ind. Sci. Cong. Part III (Advance Abstracts) 1993.

19] A.L. Dawar , A. Kumar, R. P. Mall and P.C. Mathur, Growth and Electrical transport properties of $CuInTe_2$ thin films, Thin Solid Films 112 (1984) 107.

20] Major Research Project File No. UGC F. No. 42-808/2013(SR).