

Growth of spray pyrolysis deposited copper oxide thin film

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Abstract

Copper oxide thin film is deposited on the glass slide using aqueous solution of copper chloride and hydrogen peroxide by using spray pyrolysis deposition technique. The deposited CuO thin film is adherence and homogeneity with high transparency in visible region. Investigation of CuO thin film for physical properties is done. By using UV –Visible Spectrophotometer optical properties like absorption, transmission, energy band gap, Absorption coefficient and extinction coefficient in the visible region (380 – 1000 nm) are studied. The X-ray diffraction of CuO thin film is polycrystalline in nature with monoclinic crystal structure. The resistivity of CuO thin film is studied using four probe methods.

Keywords: CuO Thin Film; XRD; Electrical Properties; Absorption Coefficient and Extinction Coefficient.

1. Introduction

Copper oxide belongs to I –VI compound of semiconductor material [1]. CuO is a p-type semiconductor material with band gap of 1.21–1.51 eV having monoclinic crystal structure [2]. Cu₂O thin film exhibited good electrical and optical [3]. Copper oxide thin films are used in solar cell application [4], thin film batteries [5], gas sensing [6] etc. various method are used to deposition copper oxide thin film like sol-gel [7], magnetron sputtering [8], successive ionic layer adsorption and reaction [1], spray pyrolysis [9-10], Spin coating [11] etc.

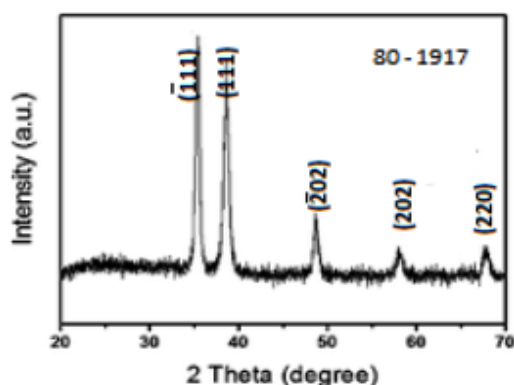


Fig. 1: XRD Pattern.

In the present work copper oxide thin film is deposited using spray pyrolysis method. Optical, Structural and electrical properties of deposited CuO thin film are studied by using UV- VIS spectrometer, X- ray diffraction pattern and electrical resistivity by four probe method. Absorption spectrum of CuO thin film is carried out in optical range (380 – 1000nm). The energy band gap of thin film is observed at 1.5 e V.

2. Experimental detail

Glass slide used deposition of CuO thin film is cleaned in conc. Nitrate acid, alcohol, double distilled water and ultrasonic cleaner for several times to remove the impurities on the surface. To calculate the thickness of deposited CuO thin film the glass slide is weighed before and after deposition using electron unipan microbalance of accuracy 10⁻⁴ gm. Copper chloride of 0.1N is prepared in double distilled water and Conc. hydrogen peroxide of 3.5 cc was mixed to form an aqueous and clear solution of copper oxide precursor in spray. Cleaned glass slide was arranged on metal plate with heating coil at 350°C. After deposition glass slide was allowed to cool down at room temperature.

Deposited CuO thin film is used to study structural, optical, and electrical properties [12-16]. Structural study of CuO thin film was carried out on X- ray diffractometer using Cu- α radiation. Optical absorption & percentage transmission were measured by UV – VIS Spectrophotometer Elco (SL- 159) in the wavelength range 380 – 1000 nm.

3. Result and discussion

3.1. Structural observation of the CuO thin film

Fig. 1 shows X- ray diffraction pattern to find the structural information of CuO thin film. The nature of CuO thin film is polycrystalline with monoclinic crystal structure. The 2 θ angle peaks are shown at 35.504°, 38.735°, 48.660°, 58.372°, 68.057° with oriented (-111) (111) (-202) (202) (220) direction and agreement with Card Number 80 – 1917

3.2. Optical properties of CuO thin film

Optical absorption spectra of thin film were studied on ELCO – SL159 Spectrophotometer in optical range of 380 – 1000nm. Absorbance (A) and % transmission variation with wavelength are shown in Fig. 2 and Fig. 3. The band gap of the CuO thin film is calculated by equation no.1 of stern [11-14].

$$(\alpha \cdot hv)^2 = K(hv - E_g)^n \quad (1)$$

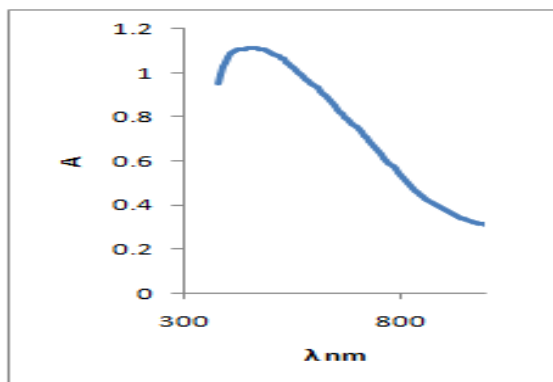


Fig. 2: Absorption Spectra.

Where ν = the frequency of radiation, h = Planck's constant, K = constant, $n=1$ for direct band gap material. Fig 6 shows the variation of absorption coefficient with linear function of frequency. Band gap energy of grown CuO film is studied and observed. The thickness of thin film is calculated by using weight different density method which is most convenient method to calculate the thickness of thin film [16]. The absorption coefficient (α), extinction coefficient (K) of CdS thin films are studied and shown in Fig. 4, 5.

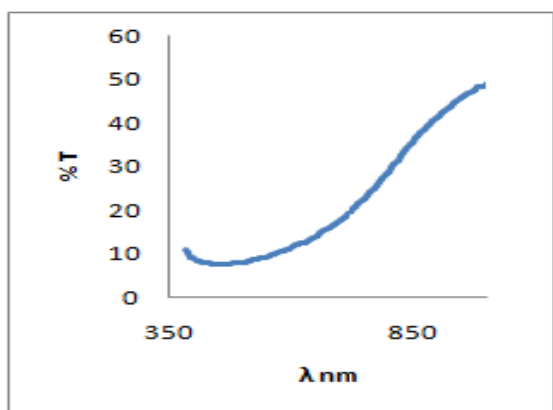


Fig. 3: Transmission Spectra.

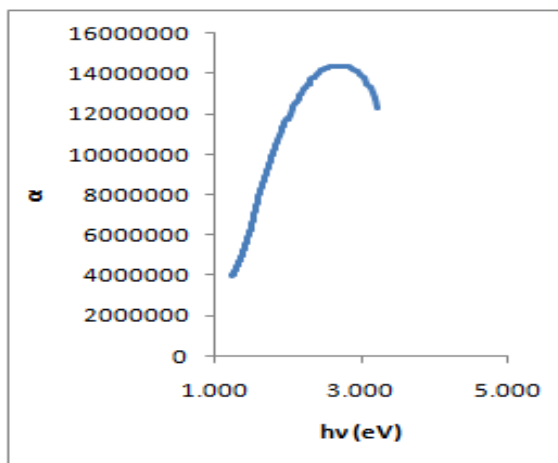


Fig. 4: Absorption Coefficient.

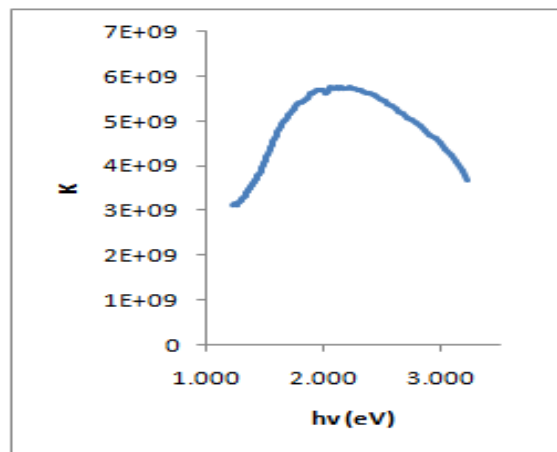


Fig. 5: Extinction Coefficient.

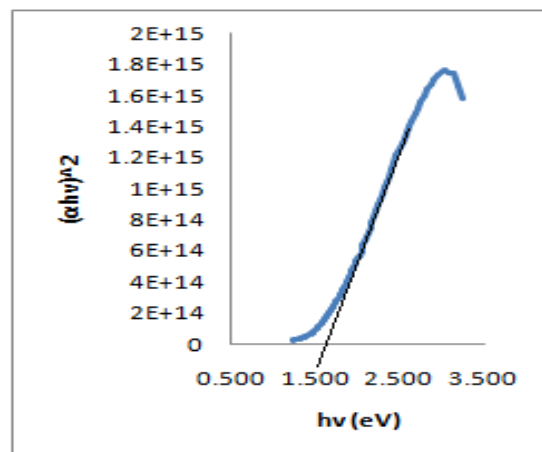


Fig. 6: Optical Energy Gap.

3.3. Electrical studied

Electrical studied of CuO thin film are carried out using four probe methods. Due to the combination of current and voltage probe correction factor is applied to determine resistivity of the thin film. Fig. 7 and Fig. 8 show the resistivity and conductivity as a function of temperature. Electrical conductivity as a function of inverse of temperature for thin films is shown in Fig. 9. Resistivity of the thin film decreases with the increase in temperature and conductivity is increased with increase in temperature.

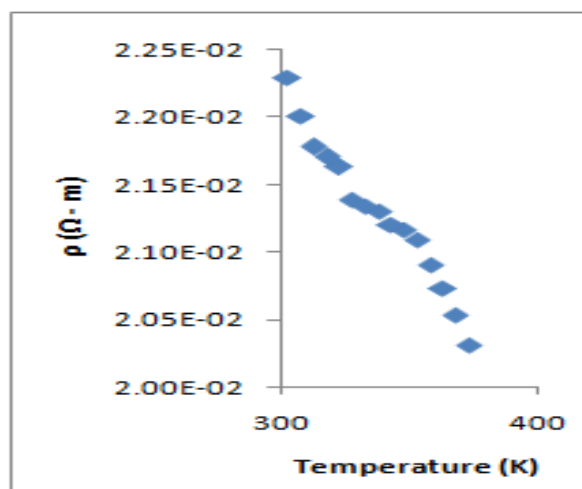


Fig. 7: Electrical Resistivity.

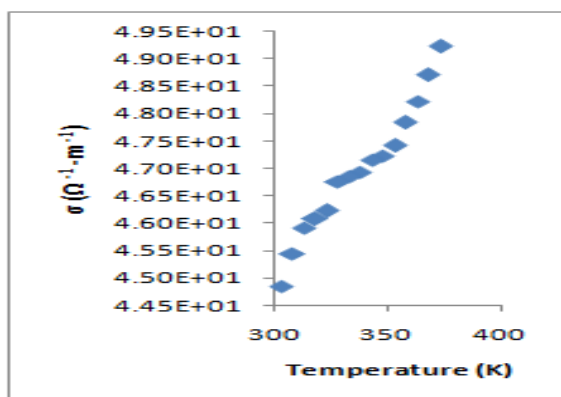


Fig. 8: Electrical Conductivity.

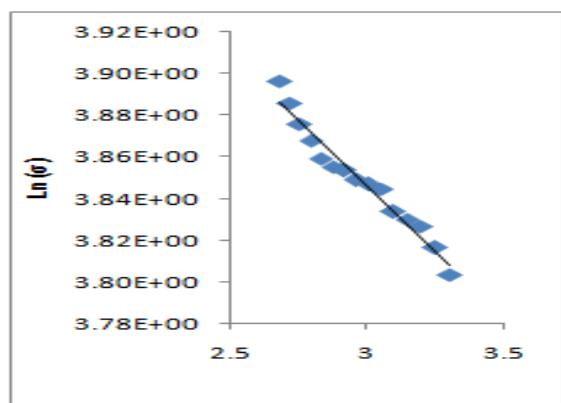


Fig. 9: Ln (σ) Vs. 1000/T (K⁻¹).

4. Conclusion

By using spray pyrolysis technique CuO thin film are successfully deposited at 350°C. The structural properties were studied by XRD pattern which examine thin film is polycrystalline in nature. Optical studied of CuO thin film are carried out by using UV – Visible Spectrophotometer in the visible region (380 – 1000 nm). Different variation of optical properties shows that CuO thin film is suitable for application of solar devices. Absorption coefficient (α), extinction coefficient (K) of thin films is studied. The direct band gap of thin films is obtained at $E_g = (1.5 \text{ eV})$. Variation of resistivity, conductivity shows that deposited material is semiconducting and charge carrying material

References

- [1] H.M.Pathan, C.D.Lokande Deposition of metal chalcogenide thin films by successive ionic layer absorption and reaction (SILAR) method Bull. Mater. Sci. 27, P 85 -111, 2004. <https://doi.org/10.1007/BF02708491>.
- [2] Balamurunga B and Mehta B R 2001 Thin Solid Films 396 90. [https://doi.org/10.1016/S0040-6090\(01\)01216-0](https://doi.org/10.1016/S0040-6090(01)01216-0).
- [3] G Papadimitropoulos, N Vourdas, V Em Vamvakas, D Davazoglou; J. Phys.: Conference Series 10 (2005) 182–185] <https://doi.org/10.1088/1742-6596/10/1/045>.
- [4] K, Borgohain, S, Mahamuni. J Mater. Res 17 1219.
- [5] E.A. Souza, R. Landers, L.P. Cardoso, Tersio G.S. Cruz, M.H. Tabacniks, A. Gorenstein; J. Power Sources 155 (2006) 358-363 <https://doi.org/10.1016/j.jpowsour.2005.04.014>.
- [6] Liu J, Huang X, Gang Ye, Liu W, Jiao Z, Chao W, Zhou Z and Yu Z. Sensors (2003) 2 110. <https://doi.org/10.3390/s30500110>.
- [7] Armelao L, Barreca D, Beriapelle M, Borro G, Sada C and Tondello E, mater. Res. Soc, Symp. Pro. (2003) 737
- [8] A.A. Ogwu, T.H. Darma, E. Bouquerel; J. Achievements Materi. Manufact. Engg. 24 (2007) 172-177
- [9] V. Saravanakannan, T. Radhakrishnan, Structural, Electrical and Optical Characterization of CuO Thin Films Prepared by Spray Pyrolysis Technique International Journal of ChemTech Research, Vol.6, pp 306-310, Jan-March 2014.
- [10] Vignesh Saravanan, Prabakaran Shankar, Ganesh Kumar Mani, John Bosco Balaguru Rayappan, Growth and characterization of spray pyrolysis deposited copper oxide thin films: Influence of substrate and annealing temperatures Journal of Analytical and Applied Pyrolysis 111 (2015) 272–277 <https://doi.org/10.1016/j.jaap.2014.08.008>.
- [11] Aykut Nalbant, Özlem Ertek, and Ibrahim Okur, Producing CuO and ZnO composite thin films using the spin coating method on microscope glasses, Mater. Sci. Eng. B, 2013, 178, 368– 374. <https://doi.org/10.1016/j.mseb.2013.01.010>.
- [12] Mustafa Amer Hassan, Studying the Effect of Doping in Some Physical Properties of Copper Oxide Thin Film, Engg. And tech. Journal, vol 30,2012
- [13] Sachin H. Dhawankar, Avish K. Patil and B.M.Suryavanshi, Optical characterization of CdO thin films on dielectric substrate, International Journal of Innovative and Applied Research (2014), Volume 2, Issue (8): 67- 71
- [14] Sachin H. Dhawankar, Avish K. Patil, B.M.Suryavanshi Optical Properties of ZnO Thin Film Deposited by Spray Pyrolysis applied physics letter, Vol_1, Issue_2, 2014
- [15] Saturi Baco, Abdullah Chik, Fouziah Md. Yassin, study on optical properties of tin oxide thin film at different annealing temperature, journal of science and technology, 61-72
- [16] F.Stern Elementary theory of the optical properties of solids, solid state physics, 15, P299 – 408, 1963.
- [17] K.C.Lalithambika, K.Shanthakumari and S.Sriram, optical properties of CdO thin film deposited by chemical bath method, International Journal of ChemTech Research, Vol.6, No.5, pp 3071-3077, aug – Sept 2014.