ISSN : 0974 - 7524 Volume 10 Issue 2

Physical CHEMISTRY
An Indian Journal

Full Paper

PCAIJ, 10(2), 2015 [041-045]

Effect of annealing temperature on some optical properties of CuO thin film

Khalid Haneen Abass[1]*, Qunoot Mohammed Hadi[1], Shahad Luay Hamdan[1], Muneba Mohammed Alagha[2]

[1]Department of Physics, College of Education for Pure Sciences, University of Babylon, (IRAQ)

[2]Department of Physics, College of Education, Al_Mustansiriyah University, (IRAQ)

ABSTRACT

0.1M of $CuCl_2.2H_2O$ dissolved in double distilled water as a starting solution was used to spray on glass substrate. After preparing CuO thin film, we used UV-Visible spectrophotometer to recording the absorption spectra. From these spectra, it can calculate some of optical constants. The absorption, absorption coefficient, and extinction coefficient increase with increasing annealing temperature. While the skin depth and energy gap decreases with increasing annealing temperature.

KEYWORDS

CuO;
Thin film;
Annealing;
Optical properties;
Energy gap.

INTRODUCTION

Recently, wide band gap oxide semiconductors have attracted much attention for their applications in optoelectronic devices such as UV diodes[1], gas sensors[2], transparent thin film transistors[3], and photovoltaic devices[4]. Cu_2O thin films are prepared by several deposition methods, including anodic oxidation[5], thermal oxidation[6], electro deposition[7], reactive sputtering[8], and chemical bath deposition[9]. The physical and chemical properties of the films are affected by the deposition method and its conditions. In addition, it can also be influenced on the electrical properties, for example, band gap and these large variations can make Cu oxide films suitable for many applications. Cu_2O has a direct band gap of 2 eV[10-11], which lies in the acceptable range of window material for photovoltaic applications. The effect of post-annealing of Cu oxide thin films obtained by thermal oxidation and revealed that the crystallinity and grain size of thin films were dependent on the post-annealing temperature[12].

The aim of this work is to study the effect of annealing temperature on some optical properties of CuO thin films prepared by chemical pyrolysis method.

EXPERIMENTAL PROCEDURES

Thin films of CuO were deposited onto a glass substrate by chemical spray pyrolysis technique

The glass substrate was cleaned by chromic acid for 5 hours, rinse with running water for 15 minutes and subsequently putting in an ultrasonic bath filled with absolute ethanol for 10 minutes. After these operations, the glass was ready to use. 0.1M of $CuCl_2.2H_2O$ supplied from Sigma-Aldrich Chemicals. Dissolved in double distilled water as a starting solution. Many trails have been accomplished in order to meet the requirements of optimization which arrived at the following parameters: Substrate temperature was kept at 350 °C during the spray. The carrier gas was compressed air and was found to be around 10^5 N/m^2.

Deposition rate was 5 ml/min, the spray period was 5 sec lasted by 3 minutes to avoid cracks during the cool substrate exposure by spray time and distance between nozzle and substrates was about 30 cm. The film thickness was recorded using weighing method and was found to be 350 ±30 nm. Utilizing double beam spectrophotometer (Schimadzu 1650Japan) was used to measure the transmittance and absorbance of the films in the wavelength range (460-900) nm. Furnace used for obtaining temperatures for the annealing process, which was restricted to the following temperatures (375, 425, 475) °C.

RESULT AND DISCUSSIONS

The optical absorption spectra of CuO thin film for various annealing temperature was recorded in the wavelength region (460 – 900) nm as in Figure 1. From this figure, it can notice that the absorbance increased with increasing annealing temperature for all prepared thin films.

The absorption coefficient was determined in the Figure 2. From this figure, its clear the increases in absorption coefficient with increasing annealing temperature.

The energy gap was determined from $(\alpha h\upsilon)^2$ versus $h\upsilon$ that represent the allowed direct transition as represented in figs.3-6. From these figures, it is clear that the decreases of energy gap from 2 eV to 1.8 eV with increasing annealing temperature from room temperature to 475 °C.

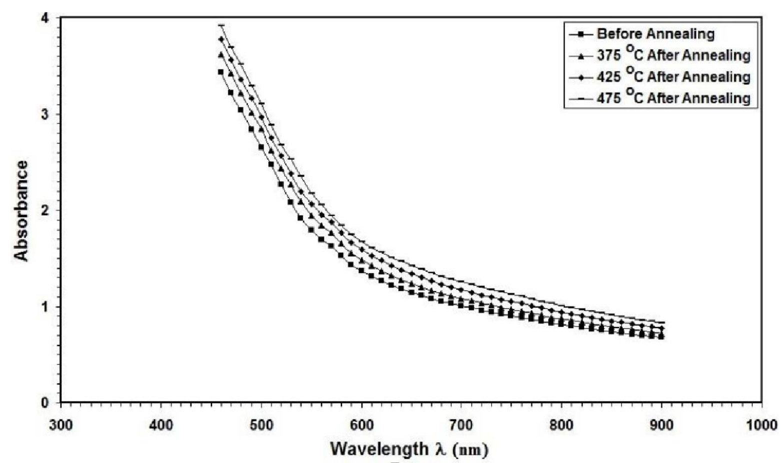

Figure 1 : Optical absorbance spectra of CuO thin films

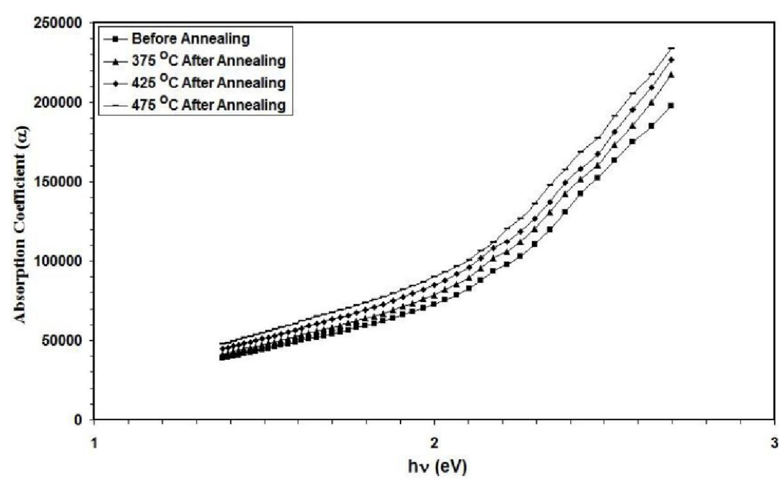

Figure 2 : Absorption coefficient of CuO thin films

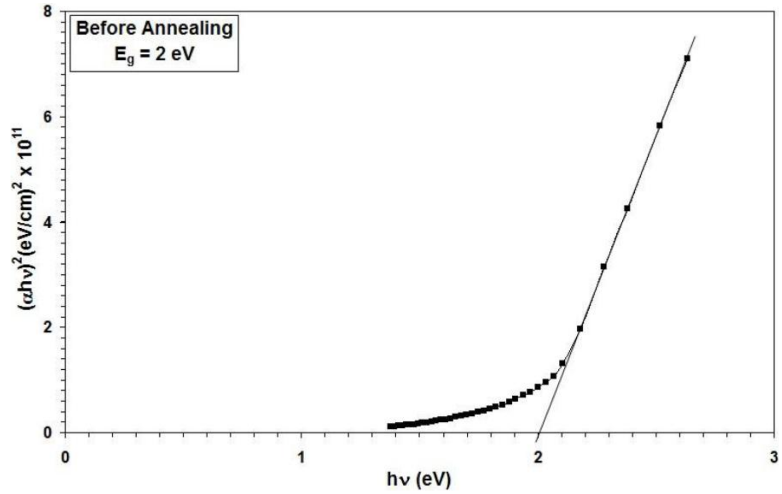

Figure 3 : Plot of $(\alpha h\upsilon)^2$ vs hυ before annealing of CuO thin films

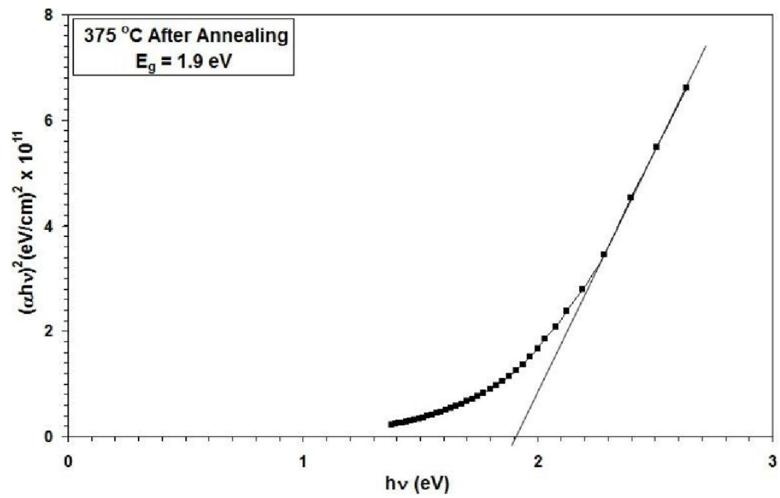

Figure 4 : Plot of $(\alpha h\upsilon)^2$ vs hυ after 375 ºC annealing temperature of CuO thin films

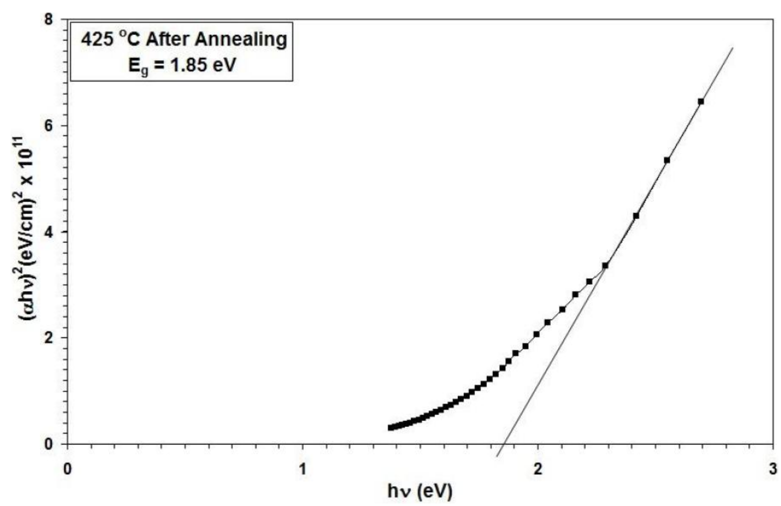

Figure 5 : Plot of $(\alpha h\upsilon)^2$ vs hυ after 425 ºC annealing temperature of CuO thin films

The important optical constant, extinction coefficient (k) has been calculated from the following formula[13]:

$k = \alpha\lambda/4\pi$ (1)

Figure 7 represent the relationship between extinction coefficient and wavelength which shows that

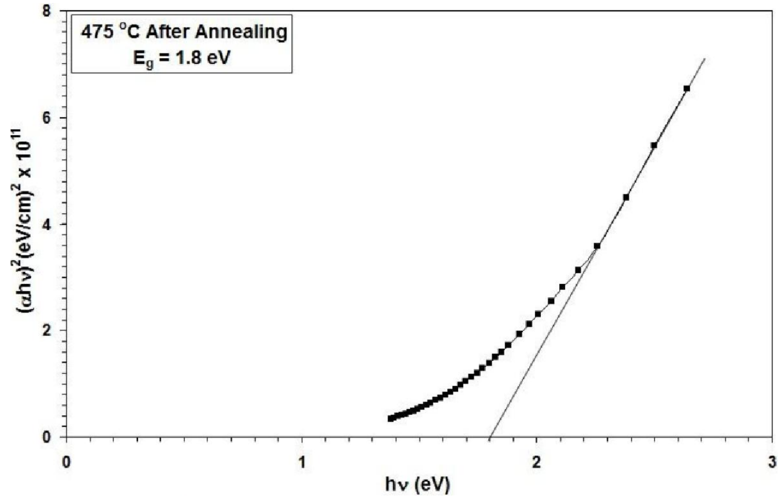

Figure 6 : Plot of $(\alpha h\upsilon)^2$ vs hυ after 475 °C annealing temperature of CuO thin films

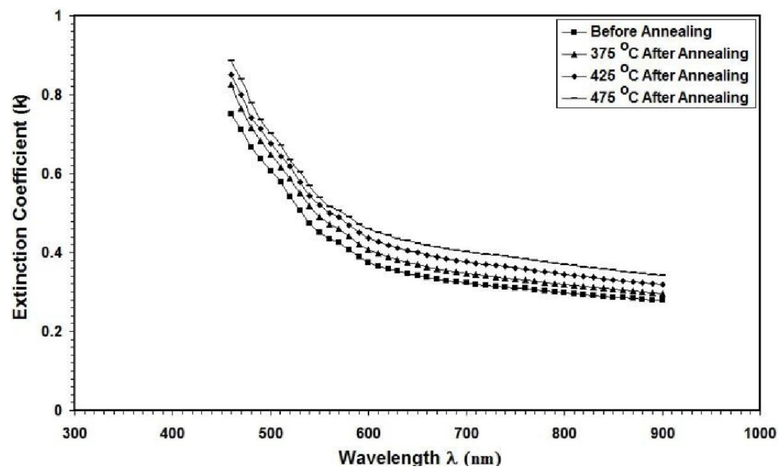

Figure 7 : Extinction coefficient of CuO thin films

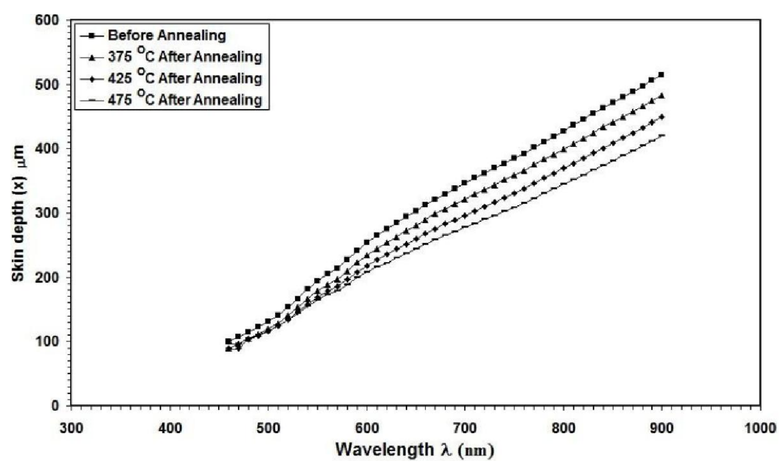

Figure 8 : Skin depth of CuO thin films

k increases with increasing annealing temperature that related directly with absorption coefficient.

Figure 8 shows the decreases of skin depth with increasing annealing temperature for all CuO thin films.

CONCLUSION

0.1M of $CuCl_2.2H_2O$ dissolved in double distilled water as a starting solution was used to spray

CuO thin film. From absorption spectra, it can calculate some of optical constants. The absorption, absorption coefficient, and extinction coefficient increase with increasing annealing temperature. While skin depth decreases with increasing annealing temperature and energy gap decrease from 2 eV before annealing to 1.8 eV after 475 °C annealing temperature.

REFERENCES

[1] H.Hosono, H.Ohta, K.Hayashi, M.Hirano; J.Crystal Growth, **496**, 237-239 (2003).

[2] R.Martins, E.Fortunato, P.Nunes, I.Ferreira, A.Marques M.Bender, N.Katsarakis, V.Cimalla, G.Kiriakidis; J.Appl.Phys., **96**, 1398 **(2004)**.

[3] Y.J.Li, Y.W.Kwon, M.Jones, Y.W.Heo, J.Zhou, S.C.Luo, P.H.Holloway, E.Douglas, D.P.Norton, Z.Park, S.Li, Semicond.Sci.Technol., **20**, 720 **(2005)**.

[4] K.Tonooka, H.Bando, Y.Aiura; Thin Solid Films, **445**, 327 **(2003)**.

[5] A.Roos, B.Karlson; Sol.Energy Mater., **7**, 467 **(1983)**.

[6] K.Santra, P.Chatterjee, S.P.Sen Gupta; Sol.Energy Mater.Sol.Cells, **57**, 345 **(1999)**.

[7] A.K.Mukhopadhyay, A.K.Chakraborty, A.P.Chatterjee, S.K.Lahiri; Thin Solid films, **209**, 92 **(1992)**.

[8] S.B.Ogale, P.G.Bilurkar, N.Mate, S.M.Kanetkar, N.Parikh, B.Patnaik; J.Appl.Phys., **72**, 3765 **(1992)**.

[9] A.Fujinaka, A.A.Berezin; J.Appl.Phys., **54**, 3582 **(1983)**.

[10] A.E.Rakhshani; Preparation, Charaterestics and photovoltaic proporties of cuprus oxide – a review.Soild State Electronics, **29(1)**, 7-17 **(1986)**.

[11] W.Siripala, L.D.R.D.Perera, K.T.L.De Silva, J.K.D.S.Jayanetti, I.M.Dharmadasa; Study of annealing effects of cuprous oxide grown by electrodepositiontechnique, Sol.Energy Mater.Sol.Cells, **44**, 251-260 **(1996)**.

[12] V.Figueiredo, E.Elangovan, G.Gonçalves, P.Barquinha, L.Pereira, N.Franco, E.Alves, R.Martins, E.Fortunato; Appl.Surf.Sci., **254**, 3949 **(2008)**.

[13] D.Gopalakrishna, K.Vijayalakshmi, C.Ravidhas; Effect of annealing on the properties of nanostructured CuO thin films for enhanced ethanol sensitivity, Ceramics International, **39**,7685–7691 **(2013)**.