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**NATURAL SCIENCES ABOUT OPTICAL PROPERTIES OF CUO THIN LAYERS  
PRODUCED BY CBD METHOD**

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**ABSTRACT**

Thin layers of Copper oxide have been prepared by chemical bath deposition technique from different deposition times. The layers were grown on glass substrates. The deposition was performed in alkaline media at 80 °C and pH fixed on 7.5 constant values. Optical properties of Nano layers were studied by spectrophotometer analysis in VIS wavelength range. Natural optical properties were obtained by applying Kramers-Kronig relations on reflectivity curves. The optical band gap ( $E_g$ ), was evaluated from VIS absorption spectra and found to have a mean value of 2.7eV. Changing deposition times affect on all optical properties.

**Keywords: Copper oxide; spectrophotometer; thin layer; optical properties.**

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**INTRODUCTION**

Copper oxide is one of those advantageous materials and has been studied for photovoltaic applications [1,2]. These layers have low toxicity and good environmental acceptability, and the constituent elements are cheap and plentiful. Copper oxide thin films have been deposited using many techniques such as reactive sputtering [3],

ultrasonic spray pyrolysis [4], oxidation of copper sheet [5], and electro deposition [6]. Chemical bath deposition (CBD) is one of the chemical techniques and essentially suitable for the solar cell production, because it is capable of depositing a large-area film at a very low cost. In addition, the theoretical energy conversion efficiency of  $\text{Cu}_2\text{O}$ -based

solar cell is about 20% [7]. Optical properties of thin metal films are determined by spectrophotometric, interferometric, and spectro ellipsometric methods. Optical constants determined in such calculations are significantly different in various works and, in addition, differ essentially from the corresponding optical constants of massive metals by their values. In this work we used Kramers-Kronig relations applying on reflectivity curve to calculate natural optical properties of Copper oxide thin layers.

### Experimental details

Copper oxide layers were produced by chemical bath deposited on glass substrates. Prior to deposition, the platelets (50mm x 25mm x 1mm) were ultrasonically cleaned with acetone and then alcohol and dried. The details of the procedure are: amounts of CuSO<sub>4</sub> and Na<sub>2</sub>SO<sub>3</sub> and NH<sub>3</sub> were separately prepared. Formed mixtures are thoroughly

stirring for several minutes in order to dissolve the formed precipitate and solutions to become homogeneous. Then in obtaining solutions were added distilled water. These solutions were mixed in a beaker and stirred well for a few minutes. The deposition bath was continuously stirred and heated at 80°C for 0.5, 1 and 1.5 hour as deposition times. The substrates were immersed into the deposition bath, by vertically suspending them around the stirrer. The substrates were taken out after 1hour as deposition time. Deposition parameters were: [CuSO<sub>4</sub>] = 0.1M, [Na<sub>2</sub>SO<sub>3</sub>]=0.05M; [NH<sub>3</sub>] = 0.01 M; pH = 7.5; All samples were annealed in air, at 250°C for half hour. Table I shows the detail of deposited layers produced in this work. The optical constants of our samples were derived on the basis of standard Kramers–Kronig relations using computer techniques.

Table I: Details of produced CuO layers by CBD method.

Sample name	Deposition time
1	0.5 hour
2	1 hour
3	1.5 hour

## RESULTS AND DISCUSSION

In this work Kramers-Kronig relations were used to calculate the phase angle  $\theta(E)$  [8]:

$$\theta(E) = -\frac{E}{\pi} \int_0^{E_2} \frac{\ln R(E) - \ln R(E_0)}{E^2 - E_0^2} dE + \frac{1}{2\pi} \ln \left[ \frac{R(E)}{R(E_2)} \right] \ln \frac{E_2 + E}{|E_2 - E|} + \frac{1}{\pi} \sum_{n=0}^{\infty} \left[ 4 \left( \frac{E}{E_2} \right)^{2n+1} \right] (2n+1) \quad (1)$$

Where  $E$  denotes the photon energy,  $E_2$  the asymptotic limitation of the free-electron energy, and  $R(E)$  the reflectance. Hence, if  $E_2$  is known, the  $\theta(E)$  can be calculated. Then the real and imaginary parts of the refractive index were calculated, from which other parameters were obtained. Figure 1 show Reflectance curves of Copper oxide thin layers produced in this work. M. Muhibbollah optical curves as a reference are added to all optical curves for comparison. The general trend between our data and M. Muhibbollah data are the same. As it can be seen from figure 1, by increasing the time of deposition, reflectivity curves have increasing trend in general. That is because of configuration more complete layers by increasing deposition time. There is an intersection between optical curves that is because of formation complete layers from one hand and supper saturation property from other hand.

Figure 2 shows the real part of refractive index for layers produced in this work. By increasing time of deposition and formation of complete layers, fraction of voids decreases and denser layers produces,

therefor real part of refractive index increases.

In figure 3 we depict the imaginary part of refractive index ( $k$ ) for the layers produced in this work. Because of formation complete layers by increasing the time of deposition and decreasing the fraction of voids, transmittance increases therefore absorbance decreases, extinction coefficient decreases.

Figures 4 and 5 show the real and imaginary parts of conductivity respectively. By increasing time of deposition, the ratio of copper metallic ions increases on substrate, therefore the real part of conductivity index and the imaginary part of conductivity index increases. The intersection between conductivity curves are discussed before. Also this intersection is a proof of wavelength correlation for optical constants.

We depict the natural optical band gap in figure 6. By increasing time of deposition and increasing the ratio of copper metallic ions increases on substrate, band gap decreases. The value of bang gap calculated 3.65 eV, 3.25 eV and 1.2 eV for 0.5, 1 and 1.5 hours, respectively.

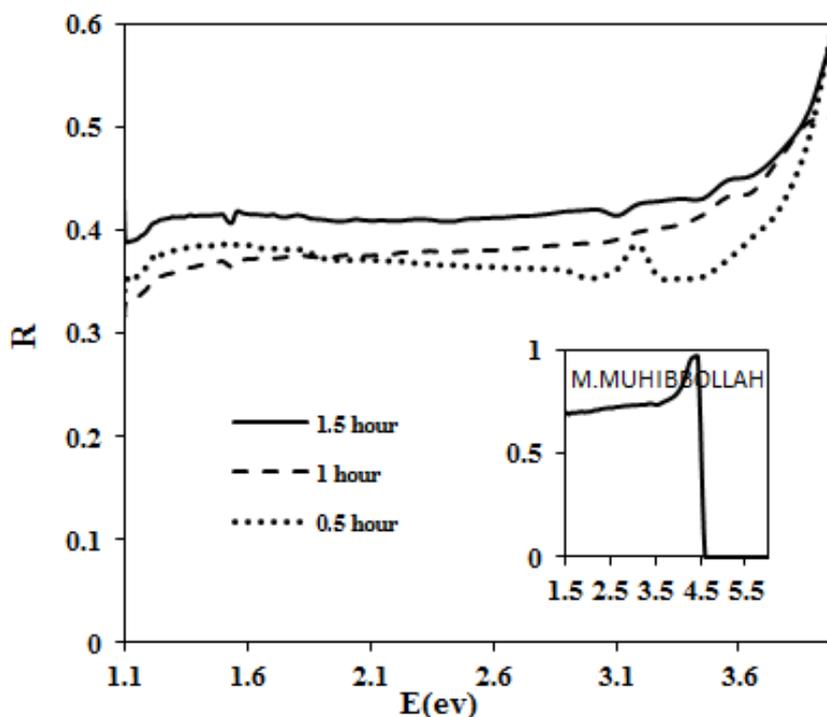


Figure 1: The reflectance of Copper oxide layers produced by CBD method at different deposition times

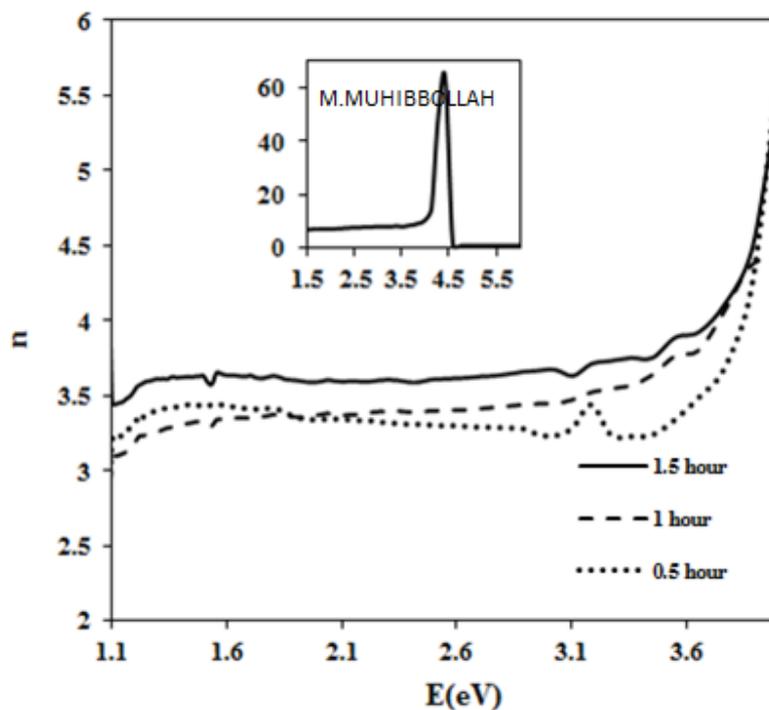


Figure 2: The real part of refractive index of Copper oxide layers produced by CBD method at different deposition times.

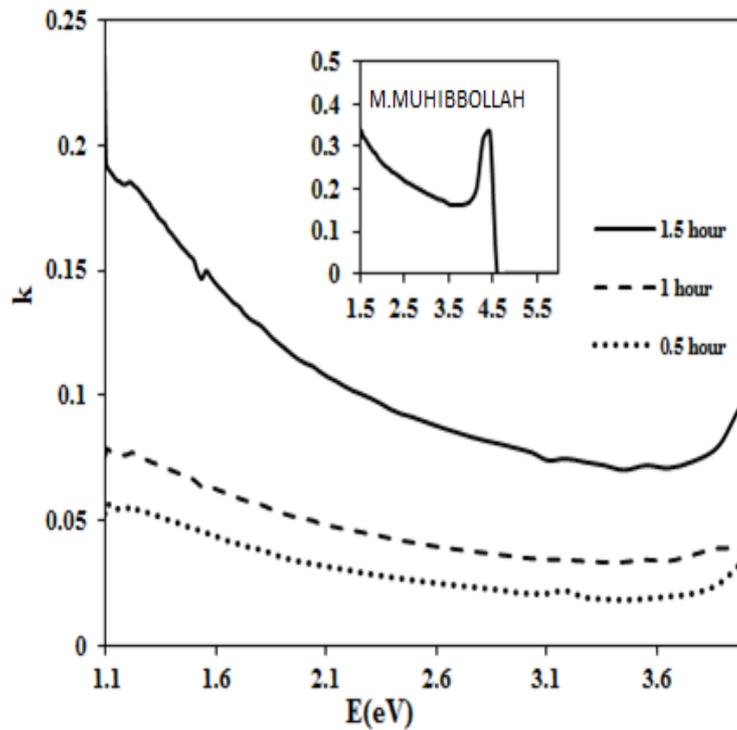


Figure 3: The imaginary part of refractive index of Copper oxide layers produced by CBD method at different deposition times

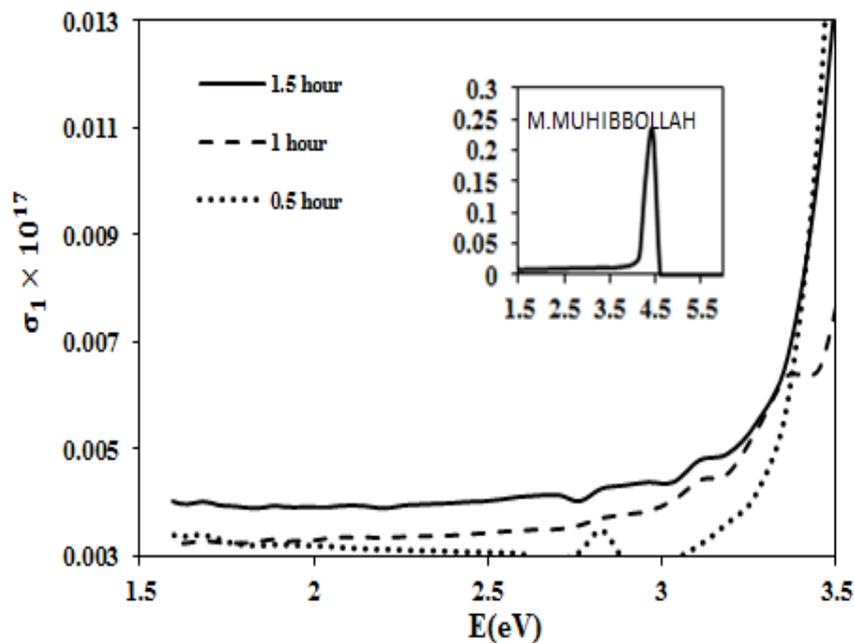


Figure 4: The real part of conductivity index of Copper oxide layers produced by CBD method at different deposition times

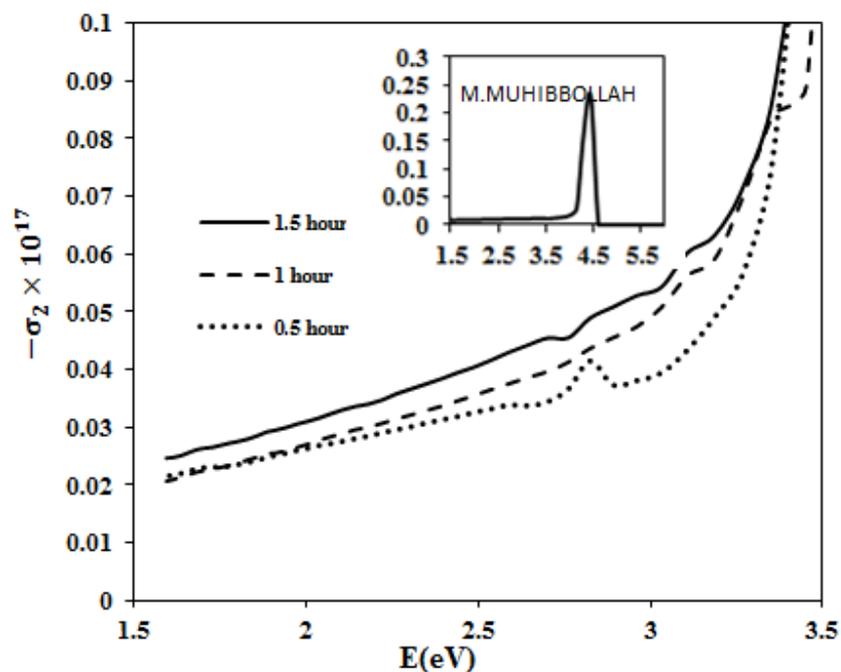


Figure 5: The imaginary part of conductivity index of Copper oxide layers produced by CBD method at different deposition times.

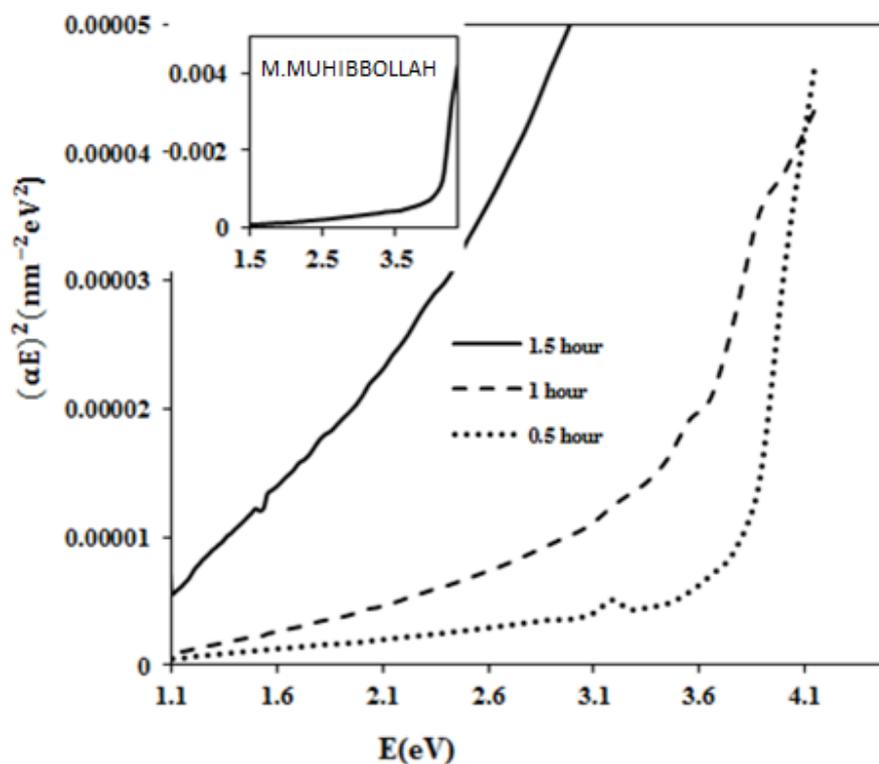


Figure 6: The values of band gap energy of Copper oxide layers produced by CBD method at different deposition times.

## CONCLUSION

Thin layers of Copper oxide have been prepared by chemical bath deposition technique at different deposition times. The layers were grown on glass substrates. The deposition was performed in alkaline media at 80 °C and pH fixed on 7.5 constant value. Optical properties of Nano layers were studied by spectrophotometer analysis in VIS wavelength range. Natural optical properties were obtained by applying Kramers-Kronig relations on reflectivity curves. By increasing time of deposition for copper sulfide, reflectivity, real and imaginary parts of refractive index, real and imaginary parts of conductivity index, increased. The optical band gap ( $E_g$ ), was evaluated from VIS absorption spectra and found to have a mean value of 2.7 eV and by increasing time of deposition because of increasing the ratio of copper metallic ions on layers, band gap decreases. Changing deposition time affect on all optical properties.

## REFERENCES

1. B. P. Rai: Solar Cells 25 (1988) 265.
2. A. E. Rakashani: Solid State Electron. 29 (1986) 7.
3. K. Han and M. Tao: Solar Energy Mat. Solar Cells 93 (2009) 153.
4. M. Hara, T. Kondo, M. Komoda, S. Ikeda, K. Shinohara, A. Tanaka, J. N. Kondo, and K.
5. Domen: Chem. Commun., Issue 3 (1998) 357.
6. N. Ozer and F. Tephani: Solar Energy Mater. Solar Cells 30 (1993) 13.
7. A. Parretta, M. K. Jayaraj, A. Di Nocera, S. Loreti, L. Quercia and A. Agati: Phys. Stat.Sol (a) 155 (1996) 399.
8. Y. Chang, K. Seung, B. Park and Y. W. Kang: Nano Structured Materials, 5 (1995) 777.
9. H. Kangarloo, S. Rafizadeh and B. Salimi, Proc. 3rd WSEAS Int. Conf. on Eng. Mechanics, Structures, and Eng. Geology (EMESEG'10), World Scientific and Engineering Academy and Society (WSEAS), Stevens Point, Wisconsin, USA (Latest Trends on Engineering Mechanics, Structures, Engineering Geology). (2010) 305–309.