

PHYSICAL properties of CuO Deposited by Ultrasonic Spray by Flow Rates 5ml/h and 10 ml/h for Application in Renewable Energy

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ABSTRACT

The copper oxide is a semi-conductor type P, the present work is an investigation of flow rate influence deposition on the structural, optical and electrical properties of our samples, we used a solution of chloride copper CuCl_2 with molarity 0.1 M, substrates of glass were kept at temperature of 350 °C, We used two flows 5ml/h and 10ml/h with a time spray of 15 minutes. Composition and structure of films were characterized by X-ray diffraction and Raman scattering, optical and electrical properties were studied by UV spectroscopy visible and technique of four points. The results obtained indicate that the flow rate is an important factor in the physical properties of CuO film, these films are formed of single phase CuO, crystallite size and energy gap is improving with the increase in flow.

I. Introduction

Thin film of copper oxide CuO is a metal with optical gap [1.3-2.5] eV [1], have been studied for a long time. Given that they present a conductivity of type p, the present studies are increasingly devoted to their use as absorbent layer in the solar cells. Therefore, the physical properties of copper oxides, including optical band gap, optical absorption coefficient, defect, mobility, carrier concentration and diffusion length minority, have a strong influence on the performance of the cells. Others applications of the copper oxide are: photovoltaic materials [2], catalytic applications [3], and gas sensors [4]. The oxide films of copper can be obtained by using various methods of deposition such as: thermal evaporation [5], electro deposition [6], laser ablation [7], thermal oxidation [8] and spray ultrasonic pyrolysis [9-11]. Among these techniques, spray ultrasonic which is a simple method, economic and compatible with production of thin materials homogeneous.

In this work the copper oxide CuO is deposited on glass substrates with method of ultrasonic spray, seeking the effect of the flow rate deposition on the structural properties, electrical and optical films obtained.

II. Research Method

The oxide films of copper have been obtained by the dissolution of the chloride of copper $\text{CuCl}_2 \cdot 2\text{H}_2\text{O}$ precursor in distilled water with a molarity of 0.1 M. Our substrates of glass have been heated to a temperature of 350°C . The total solution was sprayed during 15 min by ultrasonic system for two flows deposition 5ml/h and 10 ml/h. The thickness of films obtained is measured with profilometer, structural properties are determined by using a diffractometer PhilipsX'Pert system with Cu K α radiation ($\lambda_{\text{Cu}} = 1.54056 \text{ \AA}$), the 2θ varied in the range 20° – 70° , and Raman spectrometer. Optical properties citing energy gap and absorption coefficient will be calculated from spectrum transmissions obtained by spectrophotometer Shimadzu in UV visible with wavelength range between 400 and 1000 nm. Electrical resistivity was measured with the four points.

III. Results and discussion

III.1. X-Ray diffraction

The XRD spectra recorded for different flow rate is shown in figure 1 and 2, Our films have polycrystalline structure, in comparison data with references in PDF card 45-0937, confirms tetragonal structure of CuO (monoclinic cell), two preferential orientations are observed in (002) and (111), and film thickness increases from 851 nm to 1364 nm.

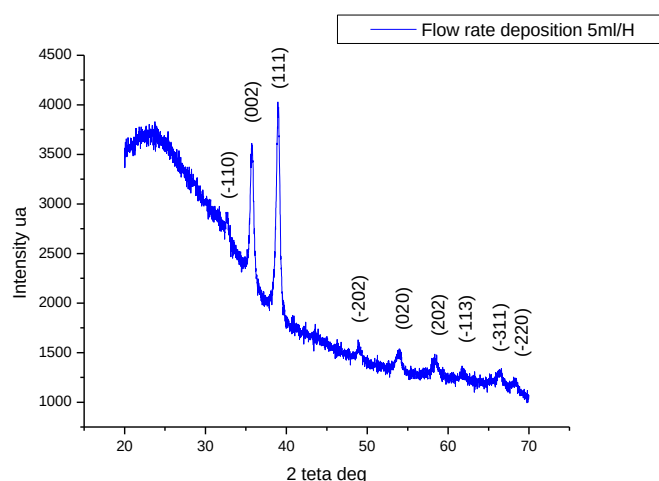


Figure 1. XRD diffraction pattern of CuO thin films prepared with flow rate deposition 5ml/h.

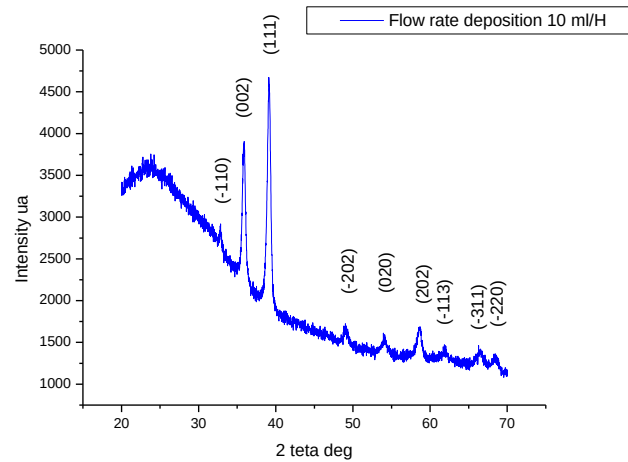


Figure 2. XRD diffraction pattern of CuO thin films prepared with flow rate deposition 10ml/h.

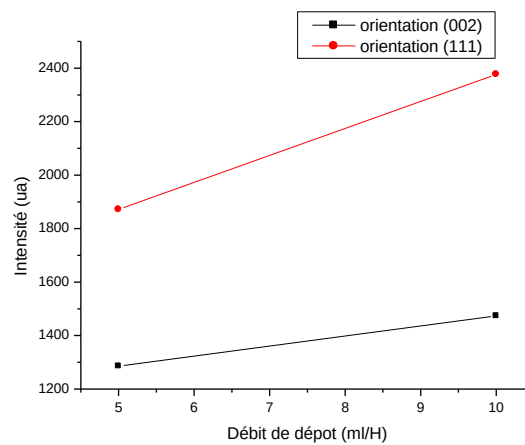


Figure 3: Variation of intensity in (111) and (002) orientation as a function of flow deposition

In order to study the structural properties, we have estimated the average crystallite size using Scherrer's formula [12]:

$$D = \frac{0.9\lambda}{w \cdot \cos\theta} \quad (1)$$

The micro-strain ε was also estimated using the following formula [13]:

$$\varepsilon = \frac{w \cdot \cos\theta}{4} \quad (2)$$

Where λ is the wavelength of the X-ray beam incident, w is the width at half height of diffraction line, and θ is the Bragg angle. The size crystallite and micro strain variations are reported in figure 4, the size crystallite growth increases from 20.07 nm for 5 ml/h, to 21.08 nm for 10 ml/h. The growth in the size grains is due to decrease in internal constraints which will let these grains to occupy more space and makes our material more crystalline.

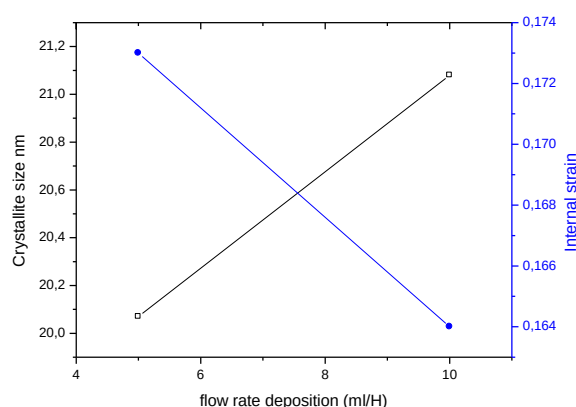


Figure 4: Crystallite size and micro-strain variations as a function of flow rate deposition

III.2. Transmission by UV-Visible

Figure 5 shows the spectra transmittance of UV-visible from films of CuO. The films deposited at low flow rate have a high transparency, in the visible region of light. We can see that when the flow rate increases, transmittance decreases up to 10 %. All films present a strong absorbance in the visible region. The copper oxide is recommended to be a good candidate for application of solar cells.

The energy of gap will be calculated from the relationship [14, 15]:

$$(\alpha h\nu)^2 = A(h\nu - E_g) \quad (3)$$

Where: α is a absorption coefficient, A is a constant, h is Planck constant, E_g is the energy band gap.

The film prepared with a flow rate of 5ml/h has an energy gap higher than prepared with a flow of 10ml/h which is 1.54 eV (figure 6). This returns that the film to be more crystallite material with increase in flow deposition (figure 7). M. Zeggar and al [15], have found an energy of gap of 1.61 eV with substrate kept at temperature of 300 °C and a flow rate of 10 ml/h, however the increase in the temperature of the substrate such as our case of 350 °C and flow rate in our case 10 ml/h, has allows our grain to find a sufficient location for form a material more organized which is well required for solar cells.

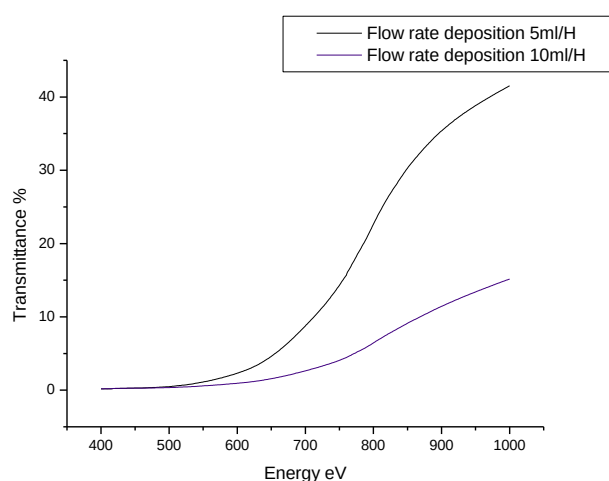


Figure 5: UV-visible transmittance spectrum of CuO thin films deposited two different flow rates

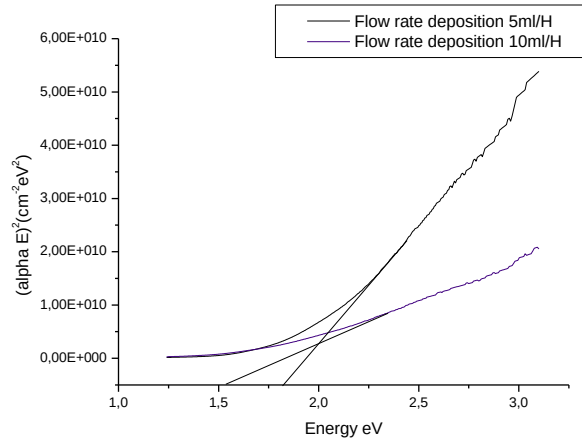


Figure 6: Variation of $(\alpha h\nu)^2$ as a function of photon energy, for different two different flow rates used for the determination of the optical gap

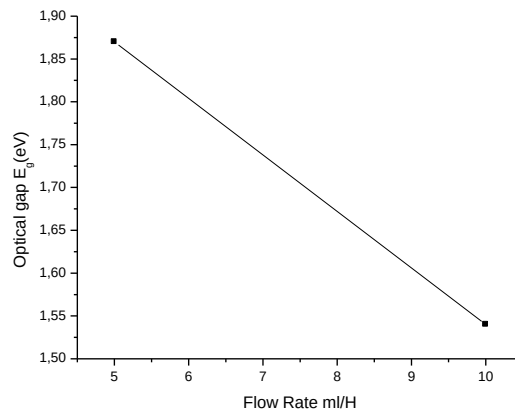


Figure 7: Variation of optical gap as a function of different flow rates

III.3. Electrical resistivity

The resistance of our films has been measured with the four points; this last is related to the electrical resistivity ρ by the expression [16]:

$$\rho = \frac{\Delta V}{I} \frac{\pi d}{\ln 2} = R_s \cdot d \quad (4)$$

Where: d : Thickness film of the material, R_s : The surface resistance.

We note that the resistivity decreases of 128.5 $\text{k}\Omega\cdot\text{cm}$ with a flow rate of 5ml/h at 107 $\text{k}\Omega\cdot\text{cm}$ for the flow of 10ml/h (figure 8), this devaluation is explained by the decrease of optical energy that reflects as films of CuO became more conductive and also by the increase in the average crystallite size which also explains that our film is become more a polycrystal (figure 7).

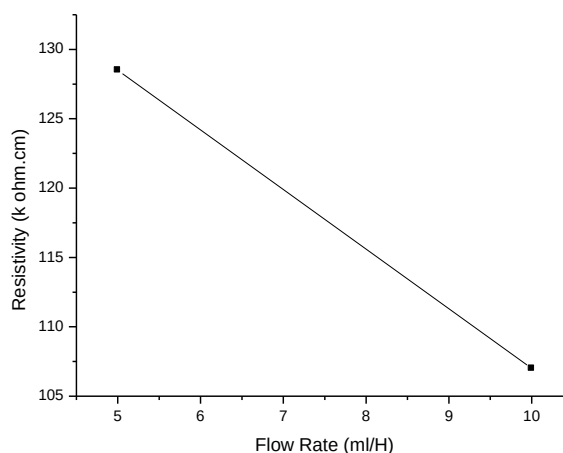


Figure 8: Variation of resistivity as a function of different flow rates

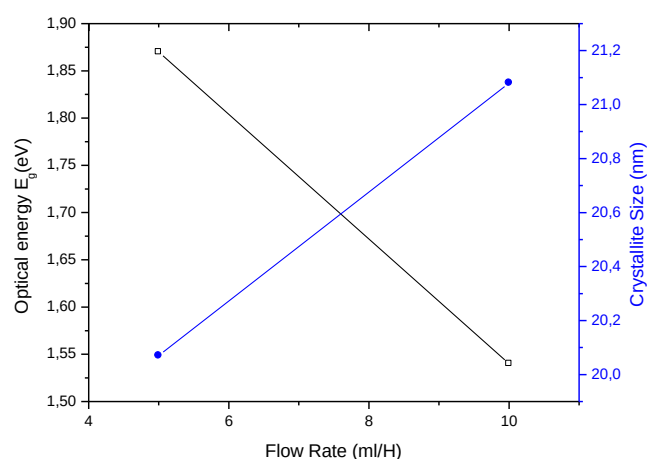


Figure 9: Typical variation of optical gap and crystallite size as a function of different flow rates

III.4. Spectroscopy Raman

Figure 10 shows the Raman spectra of CuO of our films for different time of spray and for a flow rate of 5 ml/h and 10 ml/h with a temperature of 350 °C of our substrates. The Raman spectra are composed of three main modes Ag and 2 Bg located at 286.7 cm^{-1} , 339 cm^{-1} and 592.25 cm^{-1} . These peaks are reported in the literature [17-20], are the confirmation of the presence a single phase CuO for all films deposited and total absence of secondary phase of Cu₂O.

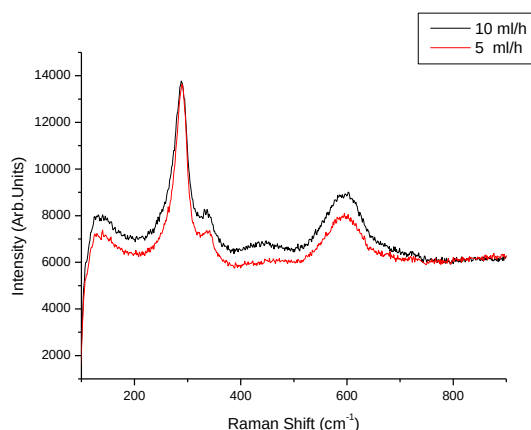


Figure 10: Raman spectra of deposited films as a function of different flow rates

IV. Conclusion

In our work the copper oxide is obtained using the chloride copper and deposited on the glass substrate kept at a temperature of 350 °C with ultrasonic spray for 15 minutes and by varying the flow rate of the solution of 5ml/h and 10 ml/H. The results indicate that the physical properties of CuO are sensitive to flow. The Raman spectroscopy reveals that our films are composed of a single phase monoclinic of CuO, and structural analysis indicate that our films is polycrystalline which improves with increase in flow. Our films present a strong absorption in the visible with an optical energy varies between 1.87 eV and 1.54 eV for a flow rate of 10 ml/h which is suitable for the manufacture of solar cells.

Acknowledgements

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