Optimization photoelectrochemical of the cuprous oxide (Cu_2O), by electrodeposition

E. Floric Rakotonarivo[a], C. N. Abouloula[a], A. Narjis[a], L. Nkhaili[a], F. Brouillette[b], A. Oueriagli[a,*]

[a] *Laboratoire des Matériaux de l'Energie et de l'Environnement (LaMEE, ex-LN2E), Faculté des Sciences Semlalia, Université Cadi Ayyad, BP 2390, 40000, Marrakech, Maroc*
[b] *Institut d'Innovations en Écomatériaux, Écoproduits et Écoénergies, à base de biomasse (I2E3), Sciences et Génie des Matériaux Lignocellulosique, 3351 Forges Boulevar, Trois-Rivières (Québec) G8Q 4M3, Canada.*

Fifth International Symposium on Dielectric Materials and Applications ISyDMA'5
Marrakech, Morocco, April 15-17, 2020
ISyDMA'5 : Virtual Edition

ABSTRACT

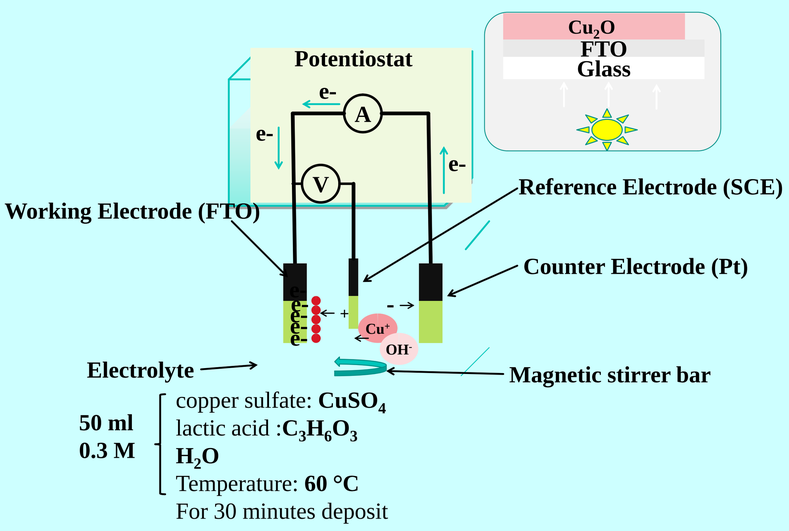
The control of structural properties of the cuprous oxide is an available way to optimize the condition of their deposition for better performance in solar cells and electrodes for PEC hydrogen production. In this study, series of Cu_2O thin films were synthesized using electrodeposition method while varying the *pH* of the electrolyte, the applied potential. The found results reveal that with a *pH* of *12* and a potential of *-0.35 V* lead to obtain the smallest band-gap energy with the best crystallinity. The effect of OH^- ions concentration on the atomic ratio Cu:O and the energy levels in the electronic configuration of cobalt are assumed to be the underlying causes to interpret this optimization.

INTRODUCTION

The research of p-type semiconductors takes priority for several applications. In particular, the cuprous oxide (Cu_2O) thin films have attracted a great deal of attention owing to its uses in solar cells, photoelectrochemical (PEC) hydrogen production, gas sensors, and lithium batteries...
Several techniques were used to prepare Cu_2O thin films, such as thermal oxidation, cathodic sputtering, and electrodeposition method, and other . For the use in a given application, the conditions of deposition have to be optimized to obtain the available properties (structural, morphology, optical and electrical properties). The importance of studying the structural and optical properties of Cu_2O thin films lies in the fact that its band-gap energy is controllable by deposition under various conditions which can be considered as a key property.
Hence, the performances in solar cells and PEC devices can be improved by narrowing E_g to capture a large range of the solar spectrum which is feasible by controlling the structural properties. For catalytic activities, the issue is more complicated as we search for small crystallites to ensure a large effective surface with narrow E_g. This makes the effect of these parameters in competition. Therefore, the performances in term of catalytic activity are strongly sensitive to the conditions of deposition.
In the present study, the Cu_2O thin films were prepared using the method of electrodeposition using copper sulphate ($CuSO_4$) as electrolyte. Hence, the effect of *pH* value, the applied potential were evaluated.

RESULTS

MATERIALS AND METHOD
(Electrodeposition)



50 ml, 0.3 M
- copper sulfate: **$CuSO_4$**
- lactic acid :**$C_3H_6O_3$**
- **H_2O**
- Temperature: **60 °C**
- For 30 minutes deposit

Compared to the SCE, the processes of the deposits evolved, which gave the reduction of Cu^{2+} to Cu^{+} and the Cu^{+} to Cu^0 according to the following reactions, respectively:

$$Cu^{2+} + e^- \longrightarrow Cu^+$$

and

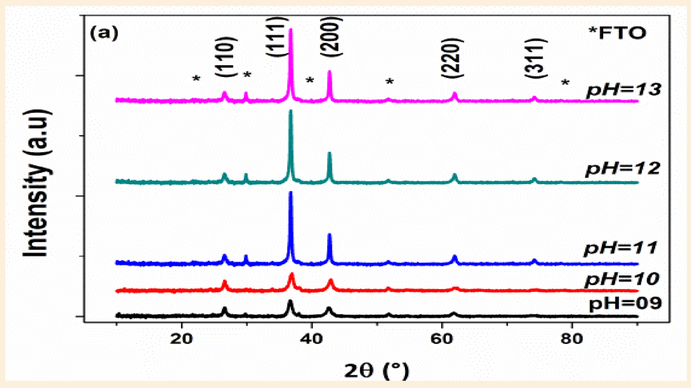
$$Cu^+ + e^- \longrightarrow Cu$$

The reaction of the OH^- ions with the Cu^+ ions in the solution gives Cu_2O

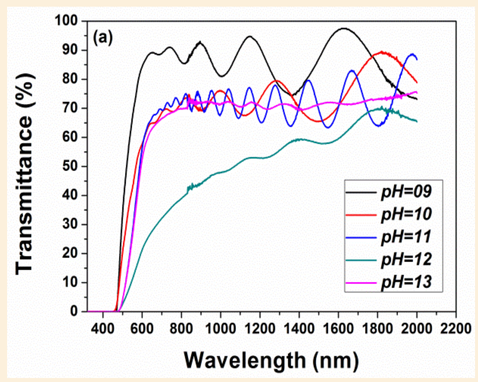
$$2Cu^+ + 2OH^- \longrightarrow Cu_2O + H_2O$$

Effect of *pH* for Cu_2O pure (*E= -0.4V*)

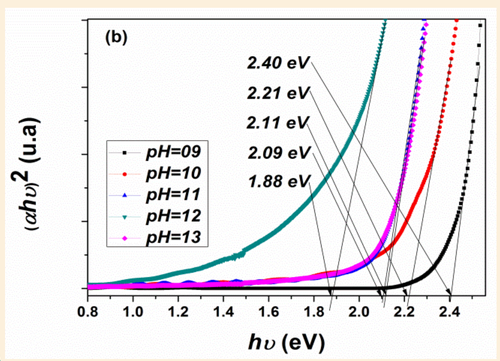
Structural properties:
•DRX analysis (Cubic stricture, and reference of spectra *JCPDS:05–0667*)



- **Optical properties: UV-Vis analysis**

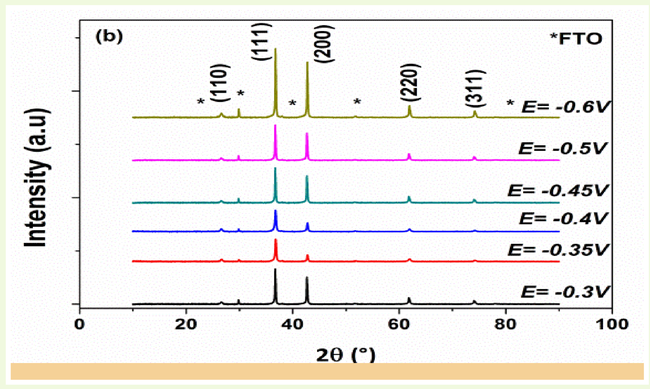


The increase in OH^- ion concentration by increasing of the *pH*, leads to an increase in the amount of Cu (II) than oxygen in the deposited films.

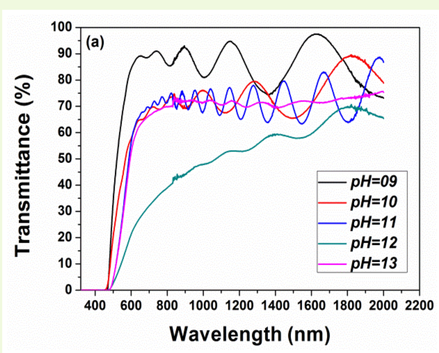


Effect of applied potential for Cu_2O pure (*pH= 12*)

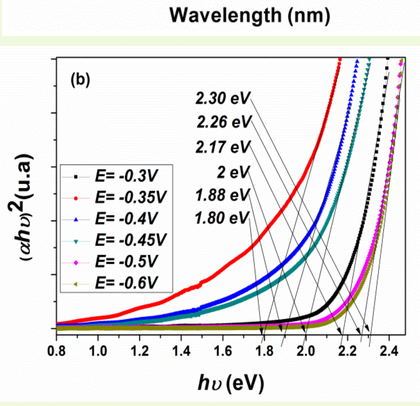
Structural properties:
- **DRX analysis (Cubic stricture, and reference of spectra *JCPDS:05–0667*)**



Optical properties: UV-Vis analysis



Raising the applied potentials, increasing the current density in the electrolyte, accelerating the deposition rate



CONCLUSION

The Cu_2O thin films were successfully synthesized by the method of electroposition. The structural characterizations revealed that the films exhibit a single phase of crystallinity depends on the conditions of deposition. The smallest band-gap energy was obtained using an electrolyte with a *pH=12* and applying a potential of *-0.35 V*.

The crystallinity and the optical properties vary inversely with the rate of deposition. In contrast to those deposited at high speed, the samples deposited at the least cathodic potentials remain the films with higher absorption, smaller band-gap energy and large grain sizes.
. This can be further improved by doping, or other.

References

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