Potentiostatic deposition of copper (II) oxide thin films

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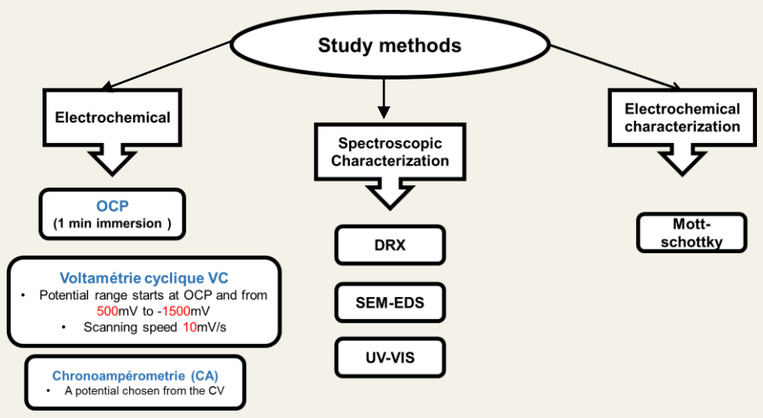
Abstract

Recently, the demand for environmentally friendly electric power generation has increased. The direct conversion of sunlight into electrical energy is a preferred method for producing clean and safe energy in the future. Additionally, the reduction of power generation costs can be achieved with thin film solar cell technologies.

The objective of our work is to electrochemically prepare and characterize semi-conducting nanoparticles precursors to the final manufacture of the photoactive compound used in solar cells.

Keywords: CuO, semiconductor, electrodeposition, cyclic voltammetry, SEM-EDS, XRD, EIS

Experimental methods



- **The deposition solution**

Blank solution

$NaNO_3 + NH_4NO_3$

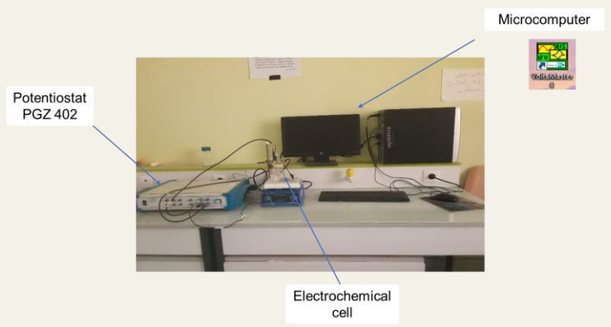
The pH of the solution was adjusted to pH 9.1 by adding NH_4OH

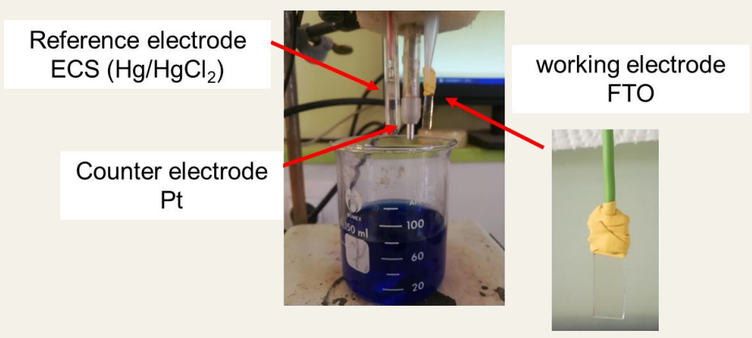
Electrodeposition solution which contains

$Cu(NO_3)_2.nH_2O + NH_4NO_3$

The pH of the solution was adjusted to pH 9.1 by adding NH_4OH

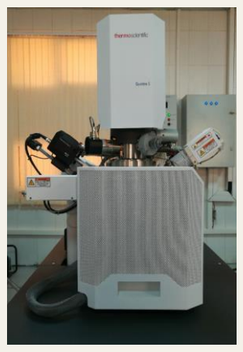
- **Electrochemical equipment**





- **Spectroscopic Equipment**

DRX **Panalytical EMPYREAN MALVERN** (CRAPC-LAGHOUAT)



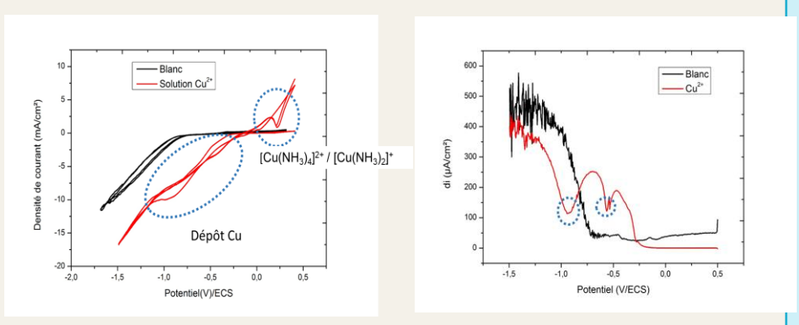
SEM-EDS **THERMO SCIENTIFIC Quattro S** (CRAPC-LAGHOUAT

Spectrophotomètre UV-VIS **JASCO V 750** domaine 200-900 nm

Results and discussion

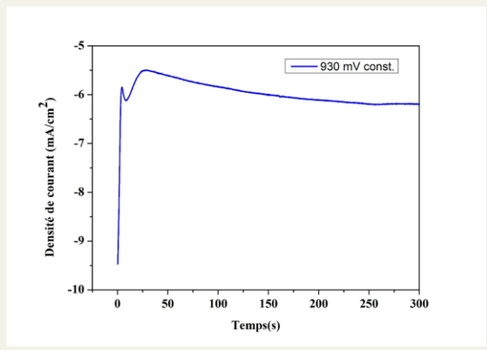
- **Synthesis of copper oxide deposit**

The cathodic current appearing only on the curve obtained with the solution containing copper, it is attributed to the reduction of [Cu(NH3)4]2+ to [Cu(NH3)2]+ The standard redox potential of this reaction is 220 mV relative to ECS, the cathodic reaction may be delayed by the existence of copper film formed on the surface of the FTO electrode during the application of the anodic potential.



Cyclic voltammograms of FTO electrodes in the solution for the formation of copper oxides and the blank solution

Based on the results of cyclic voltammetry, a film was formed by applying constant potential pulse chronoamperometry at -930 mV



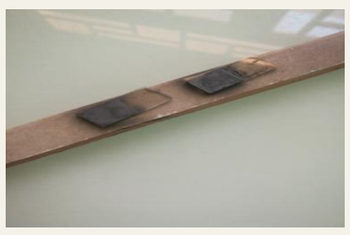
Variation of current density as a function of time during repeated chronoamperometric pulses at constant potential -930 mV

- **Thermal oxidation**

Before treatment

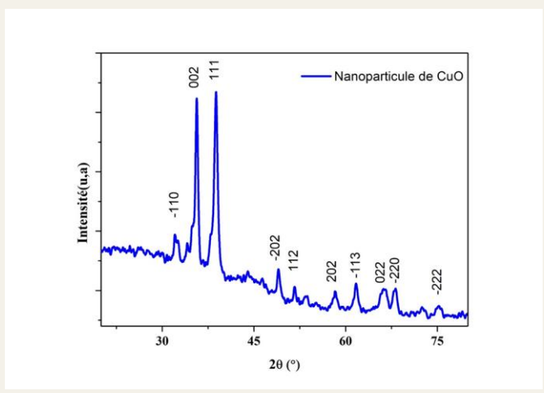
Treatment at 400° C for 4 hours

After treatment



- **Structural characterization of copper oxide deposit**

The XRD analysis reveals that we have a CuO film composed of a monoclinic phase structure, namely the (hkl) planes and the 2 theta values, which are all in good agreement with JCPDS .



XRD diffractogram of CuO

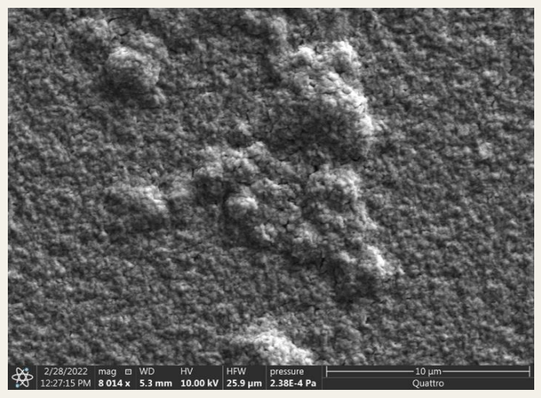
(hkl)	2 théta	size (nm)
-110	32,135	8,8
002	35,635	24,1
111	38,785	53

JCPDS	No. 01-073-6372
Structure	Monoclinic
lattice parameter	a=4.67, b = 3.43, c = 5.12 A ° β = 99.53°

Medium size = 28,6 nm

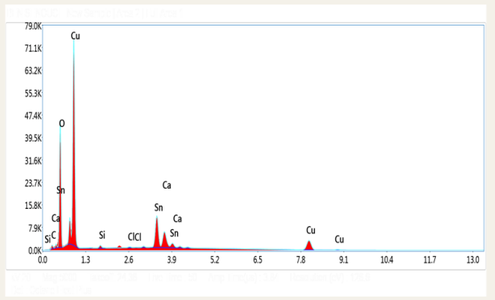
Morphological characterization

The surface morphology of CuO thin film prepared electrochemically This thin film SEM image illustrates a semi-spherical shape of the CuO nanoparticles that distributed more or less evenly on the surface of the FTO substrate



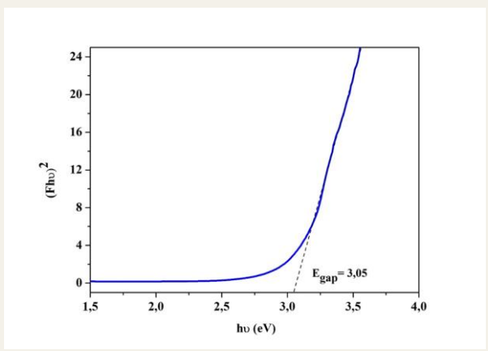
SEM images of CuO thin film on FTO

Semi-quantitative elemental analysis of the prepared film was analyzed by EDS spectrum to determine the exact compositionthis spectrum shows signals for Cu and O. The presence of a strong Cu peak further confirms the deposition of copper nanoparticles for a CuO thin film



EDS spectrum of CuO thin film on FTO

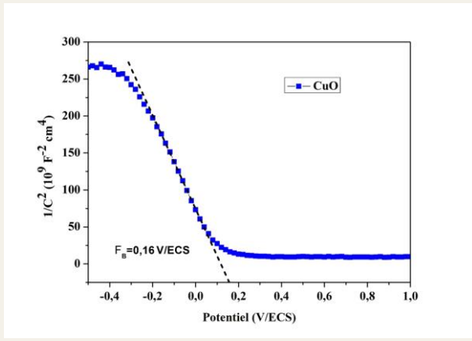
- **UV-VIS optical characterization**



Optical images of CuO thin film on FTO

- **Mott Schottky electrochemical characterization**

This figure shows the Mott-Schottky plots of CuO from which the negative slopes obtained for this material, indicating that it is p-type semiconductorsthe flat band potential (Efb) for CuO is estimated 0.16 v



Mott Schottky diagrams of CuO thin film on FTO

Conclusion

- **Preparation of a semiconducting CuO film by electrodeposition in a basic aqueous solution containing copper nitrate and ammonium nitrate at room temperature on FTO conductive glass**
- **Structural and optical characterizations were carried out by X-ray diffraction, scanning electron microscopy and UV-VIS.**
- **A p-type semiconductor CuO film with a bandgap energy of 3.05 eV.**

Bibliography / References

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[2] Yang, Yang, et al. "Cu 2 O/CuO bilayered composite as a high-efficiency photocathode for photoelectrochemical hydrogen evolution reaction." Scientific reports 6.1 (2016): 1-13.

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