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Transparent oxide CuxO thin layers produced by the Glancing angle deposition technique (GLAD). Application to the development of solar cells with CuxO as absorber

Jawher Gannouni(1,2)*, Ferid Chaffar Akkari(2), Olivier Durand(1).

(1) Univ Rennes, INSA Rennes, CNRS, Institut FOTON - UMR 6082, F-35000 Rennes, France;

(2) Faculty of sciences of Tunis, Univ of Tunis El-Manar, Campus Universitaire Farhat Hached,Tunis B.P.n°94-Rommana 1068, Tunisia;

**Corresponding author Email: Jawher.Gannouni@insa-rennes.fr*

This study explores ways to improve the efficiency of solar cells based on copper oxide materials by optimizing their absorber layers [1-4]. To this end, a systematic comparison was carried out between thin films of cuprous oxide (Cu_2O) and cupric oxide (CuO), and a mixing of both oxides, focusing on their structural and optical characteristics. Both types of films were fabricated through thermal vacuum evaporation, employing the Glancing Angle Deposition (GLAD) method. The deposition angles were varied (0°, 60°, 75°, and 85°) to assess how angle-induced microstructural changes affect the properties relevant to solar energy harvesting.

Optical properties were investigated using UV-Vis-NIR spectroscopy, on oxides deposited on glass substrates, from which transmission, reflection, and absorption spectra were derived. Band gap values were determined using Tauc analysis: Cu_2O was found to have a direct band gap of around **2.2 eV**, whereas CuO displayed rather an direct gap behavior closer to **1.6 eV**. Moreover, absorption coefficients as large as 5.10^4 cm^{-1} are measured.

Crystallographic assessment using X-ray diffraction (XRD) confirmed the formation of the Cu_2O or CuO oxide phases, or a mixing of both, depending on the deposition angle and the time of deposition, with well-defined crystalline structures. Surface morphology was evaluated using Atomic Force Microscopy (AFM), revealing nanoscale features with root mean square (Rq) roughness values ranging from **5 to 10 nm**. Energy Dispersive X-ray Spectroscopy (EDX) validated the chemical composition and stoichiometric accuracy of the deposited films. The thickness increases from approximatively 260 nm to 530 nm, by decreasing the deposition angle from 85° to 0°. These findings demonstrate the complementary nature of Cu_2O and CuO in terms of band alignment and absorption capabilities. This synergy suggests the potential of combining both materials in a tandem or multilayer photovoltaic configuration to harness a broader portion of the solar spectrum. The approach leverages earth-abundant, environmentally friendly, and cost-effective materials, aligning with current goals in sustainable solar energy technology development.

Keywords:
Copper oxide, Cu_2O, CuO, GLAD, thin film, solar cell, thermal evaporation.

References:

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