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Growth and characterization of spray pyrolysis via deposited Copper oxide thin film

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ABSTRACT: In this work the copper oxide thin films have been coated using Jet nebulizer spray pyrolysis technique. The prepared CuO thin films were characterized by various techniques such as X-ray diffraction (XRD), Scanning Electron Microscope (SEM) and Energy dispersive X-ray spectroscopy (EDX) techniques, in order to study its crystalline nature, particle size and the band gap respectively.
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Keywords: Thin film, CuO, Spray,

1 Introduction

CuO is a p-type semiconductor with a direct band gap of 1.4 eV [1] and has been used as a sensor material for the improvement of gas sensors, which could detect gases of eco-friendly concern, such as NO_2 [2], H_2S [3], ethanol [4], CO [5], and ammonia [6]. It has noted in these studies that the morphology of CuO had marked effect on their gas sensing behavior. In addition, the morphology of the CuO particles has also been the material of concern in other innovative applications such as glucose sensing [7], catalysis [8], etc. Hence, researchers have concentrated on the enlargement of methods and functioning approaches for adjusting particle morphologies of CuO which include polyol, hydrothermal, sol–gel, thermal oxidation [9-11], etc. These determinations led to the manufacture of CuO powders, composed of nanoflowers, nanowires, and nanoribbons.

The aim of the present work is to synthesize the CuO nanostructures by chemical precipitation technique. The chemical composition and the structural of the synthesized materials will be studied using X-ray diffraction (XRD), Scanning Electron Microscope (SEM) and Energy dispersive X-ray spectroscopy (EDX) techniques.

2. Experimental

The substrates are well washed using hydrochloric acid, sodium hydroxide, isopropyl alcohol and then dipped with deionized water. The copper oxide thin film were coated on glass substrates by jet nebulizer spray pyrolysis technique at substrate temperature 400°C The starting solution was prepared by dissolving (0.4 M) cupric acetate in deionized water and was stirred at 30 minutes for room temperature. Then the prepared solution was coated on glass substrates. Compressed air is used as a carrier gas. The prepared CuO films are studied by XRD (X-ray diffractometer), UV-Vis, SEM (scanning electron microscope) and EDS (energy dispersive X-ray spectroscopy).

3. Result and discussion

3.1. XRD study

CuO thin films deposited at substrate temperature 400°C and recorded XRD displayed in

Fig. 1. The XRD diffraction peaks detected in entirely CuO samples match well with those defined for polycrystalline nature with monoclinic phase. The X-RD exposes that all films are having monoclinic phase with XRD peaks matched to (1 1 0), (-1 1 1), (1 1 1), (1 1 2), (0 2 0), (2 0 2), (-1 1 3) and (0 2 2). The diffraction peaks were indexed and the corresponding values of interplanar spacing (d) were determined and matched with JCPDS data (80-1916). The average crystallite size calculated from the XRD data by Scherrer formula (1),

$$D = \frac{0.9\lambda}{\beta \cos\theta} \qquad (1)$$

where λ is the wavelength of X-ray (λ = 1.542Å) (CuKα), (h k l) are the Miller indices, β is the full width at half maximum (FWHM) of the line, and θ is the diffraction angle. The crystallite size of the 84 nm.

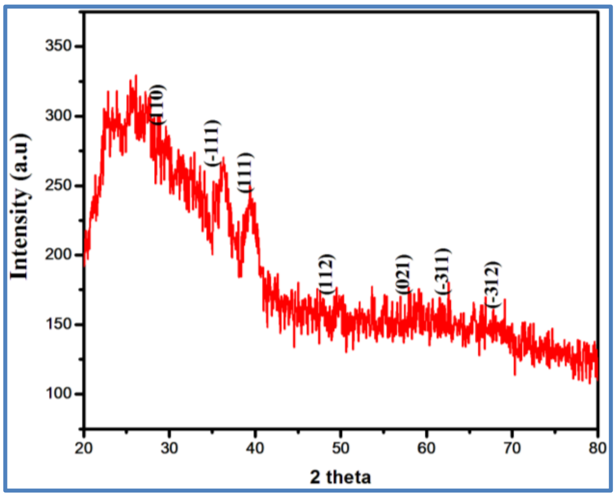

Figure 1. XRD pattern of CuO thin film.

3.2 UV study

The optical transmission spectra recorded in the range 300–900 nm and recorded spectrum shown in Fig 2. The band gap energy is calculated by using the following equation (2),

$$(\alpha h\upsilon)^n = A(h\upsilon - Eg)^2 \qquad (2)$$

where A is a constant, Eg the band gap energy and n = 2 for direct band-gap semiconductors, such as CuO films. A plot of $(\alpha h\upsilon)^2$ versus hυ is a straight line whose intercept on energy axis gives the energy gap 'Eg'. The optical band gap energy values (Eg), were calculated by plotting the value of $(\alpha h\upsilon)^2$ against the photon energy (hυ) and the intercept of this linear region on the energy axis at $(\alpha h\upsilon)^2$ equal to zero gives the band gap. The obtained band gap energy 1.84 eV (Fig.2).

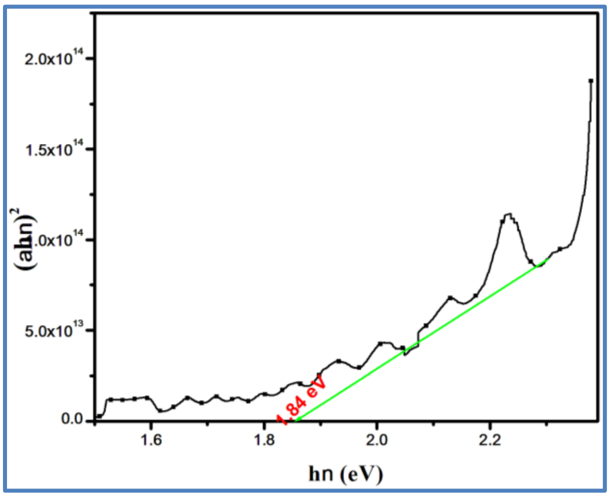

Figure 2. $(\alpha h\upsilon)^2$ versus hυ plot.

3.3 SEM Analysis

Figure 3 revealed the micrograph of the CuO thin film. SEM images of CuO thin film indication the agglomeration of small crystallites and are attributed to uncontrolled coagulation during deposition at 400°C substrate temperature. Small crystallites are close-fitting together to form a large agglomerated spheroidal structure. Substrate temperature help to improves particle size from 10 to 90 nm due to compact of small granules joined together to form agglomeration of large granules as shown in Fig. 3 in good agreement with XRD result.

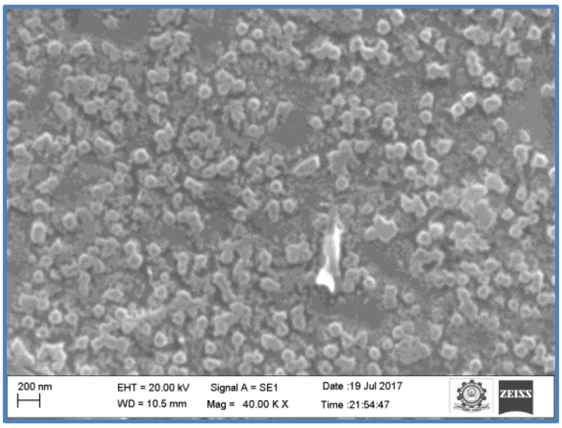

Figure 3 SEM micrograph of CuO thin film.

3.4 EDX spectral analysis

Figure 4 exposed the EDX spectrum of CuO samples. From the EDX spectrum, it can be distinguished that the amount of Cu and O with atomic values 73.71 and 26.29 % respectively. It is good evidence for CuO film formation.

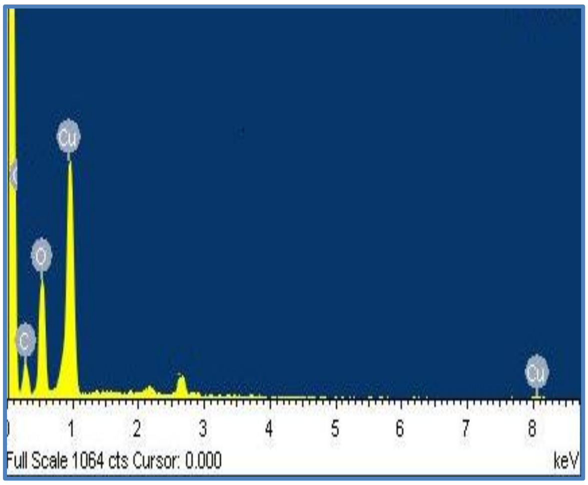

Figure 4 EDX spectra of CuO thin film.

4. Conclusion

CuO films were prepared by jet nebulizer spray pyrolysis (JNSP) technique. The CuO film show monoclinic structure with (-1 1 1) plane orientation. XRD characteristics reveal that the crystallite around 84 nm. SEM images indicate the formation of smooth surface CuO film. EDAX elemental analysis reveals the presence of Cu and O elements. The direct optical band gap energy has 1.84eV. In summary, various results indicate that JNS pyrolysis technique is a low temperature, cheap, and fast method for the producing CuO thin films.

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Conflict of interest

There is no potential conflict of interest in authors regarding publication of this paper.

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