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Simple Low Cost Cupric Oxide Nanoparticle Synthesis Using Co-Precipitation Method as a Photodetector Application

Zehraa N.Abdul-Ameer

Central environmental lab/College of science/Baghdad university, Baghdad, Iraq.

Address For Correspondence:
Zehraa N.Abdul-Ameer, Central environmental lab/College of science/Baghdad university, Baghdad ,Iraq.
E-mail: Zehraanajim@gmail.com

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ABSTRACT

CuO nanoparticles were synthesized using simple co-precepitation method then deposited on n-type silicon in order to fabricate photodetector. Morphological and optical characteristics were investigated .The photodetector responsivity was found to be (0.68 $*10^2$)(A/W) at wavelength of 500 nm which indicates good performance visible photodtector.

KEYWORDS: CuO, Co-precipitation method, nanostructure.

INTRODUCTION

Copper oxide (CuO) is a multifunctional p-type semiconductor used as for various applications such as: solar cells, photovoltaic's, gas sensing …..etc[1,2]. These applications require novel materials that enhance the development oxide nano materials. CuO synthesized using hydrothermal microwave technique was reported [3].CuO nanoparticles were synthesized via sol gel method [4].

A nanocrystalline CuO particles with a monoclinic structure have been synthesized through a simple, rapid, low-cost and direct solid state reaction method using PEG 400 as a surfactant [5]. The current study deals with CuO synthesis using simple, low cost thin films using co-precipitation method then investigating its optical and structural properties.

Experimental method:

Chemicals:

Copper nitrate Trihydrate ($(CuNO_3)_2.3H_2O$) as a precursor , sodium hydroxide (NaOH), and hexamethylene tetramine (HMT) were used from AnalaR (England).Double dionized water were used throughout experiment.

Synthesis:

5Mm of Copper nitrate Trihydrate ($(CuNO_3)_2.3H_2O$) were dissolved in100 ml of Double distilled water using reflux for 5 min then (1mM) of HMT was added with continues reflux followed by addition of (1 ml) of 10% NaOH for the preparation of the solution .Then the solution was transferred to oven held at 90°C for 2hours. The deposited thin films was heated at 450 °C for 3 hours.

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Characterization:

X-ray diffraction (XRD) patterns were recorded on a shimadzu diffractrometer using Cu-Kα radiations (λ=1.54A) with range in 2θ range from 30° to 70° to determine crystallanity ,structure and crystallite size . Grain size have been calculated using Scherrer's equation [6].

Optical properties:

UV-transmittance and PL Spectrophotometer:

Optical energy gap was investigated using Shimadzue spectrometer with range (200-1000) nm .Photoluminescence (PL) measurement was performed using ELICO company spectrophotometer covering (300-700) nm wavelength at room temperature with 150 W Xenon lamp.

RESULTS AND DISCUSSION

XRD results:

XRD patterns showed various diffraction peas at 2θ=32,4° , 35.12° , 38.52 °, 58.07° ,60.96° ,66.06 °,and 67.76° that corresponds to (110) (002) ,(111) ,(020) ,(202),(022) ,and (113) according to JCPDS Card (No.051-661) [7] with preferred orientation of 2θ=38.52°.The Grain size calculated according to scherrers equation which was found to be (18.75) nm as shown in table(1) . Samples were found to be polycrystalline as in Figure (1).

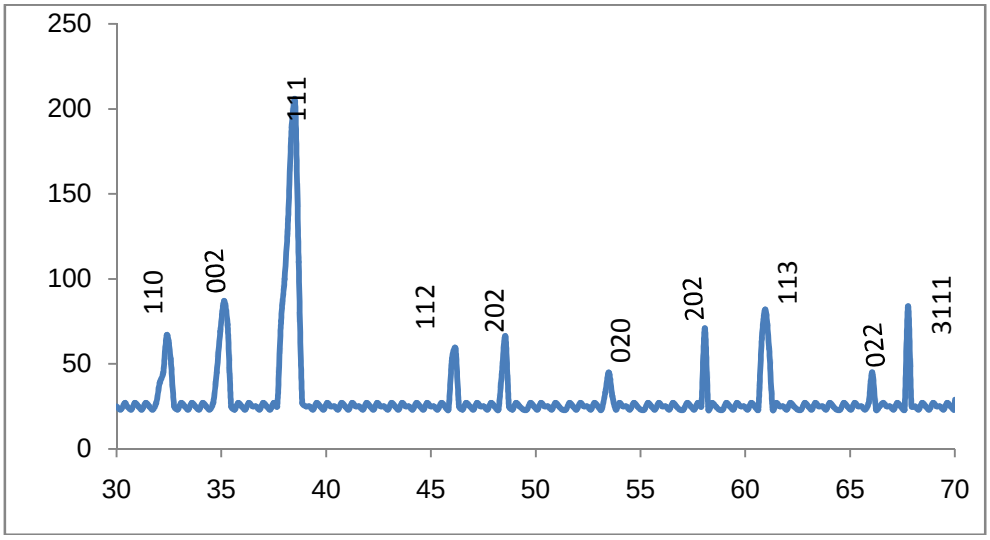

Fig. 1: XRD pattern for the prepared sample.

Table 1: XRD parameters for the prepared samples.

	β (rad)	D (nm)	ε (* 10^{-3} lines $^{-2}$ m^{-4})	hkl
CuO	0.4325	18.75	0.78	110 002 111 020 202 022 113

Optical properties:

UV-visible and Photoluminescence were investigated for CuO samples to calculate the optical energy gap , it was found that E_g equal to (2.6) eV .The transmission region between (390-520) nm due to visible region .The increment in optical energy gap is due to decrease in grain size .Direct energy gap can be calculated using Tauc model and parabolic bands [8].

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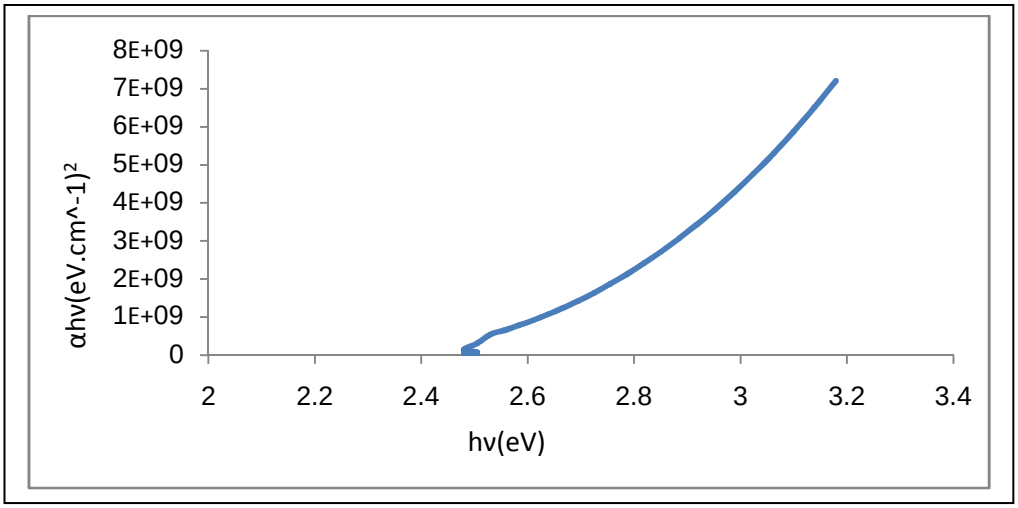

Fig. 2: $(\alpha h\nu)^2$ versus $(h\nu)$ for CuO nanoparticles.

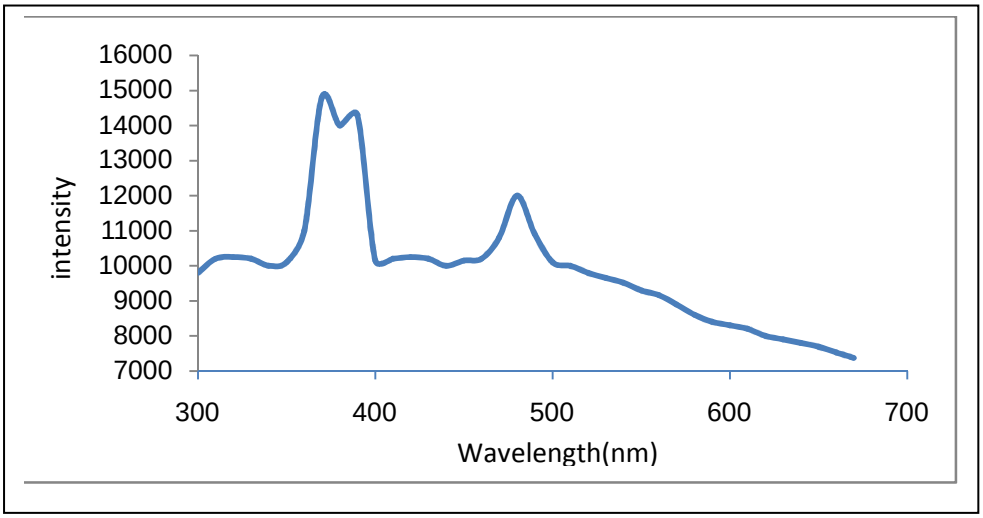

Fig. 3: Photoluminescence versus wavelength of prepared sample.

The energy band gap is calculated using the following equation:

$$E = \frac{1240}{\lambda(nm)} \quad (1)$$

AFM and SEM results:

Three dimentional AFM images show uniform distribution of pore density with average roughness of 0.316 nm and formation of spherical nanoflowers with distribution of nanoclusters here and there with generation of some dislocations and vacancies as shown in Figure (4) and Figure (5).

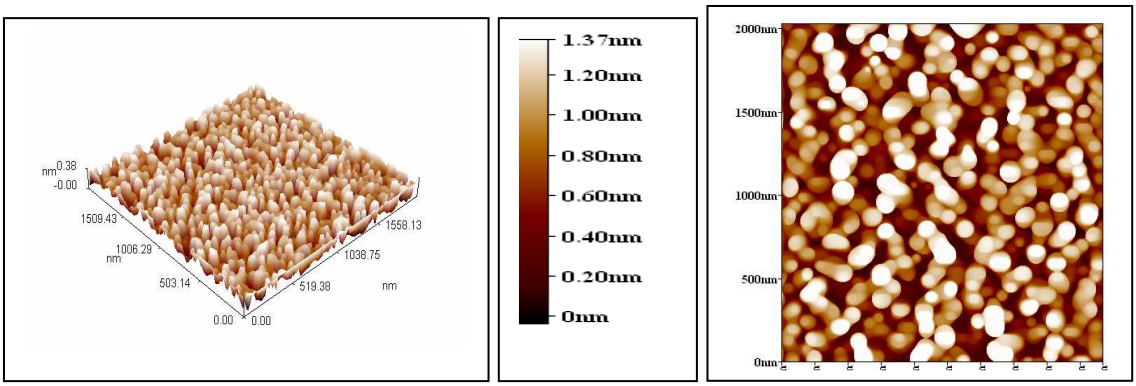

Fig. 4: AFM images of samples.

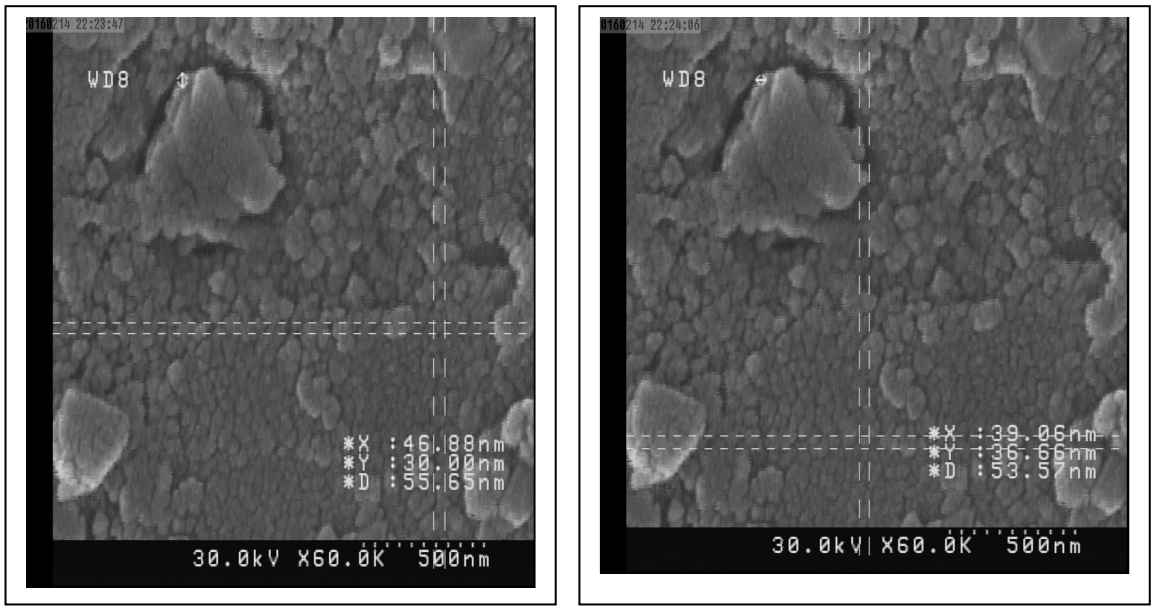

Fig. 5: SEM images of samples.

Spectral Responsivity:

Optoelectronic characteristics were studied for CuO nanoparticles by studying I-V characteristics under dark and illumination.The most important parameters for investigation photodetector properties are responsitivity (R) and gain(G)[9,10]. It is well known that light responsivity is a good indication of efficiency of photodetector, it can be calculated using:

$$R = \frac{Iph\ (A)}{Pinc(W)} \quad (2)$$

Where I_{ph} is photocurrent, P_{inc} is incident optical power on the effective area (A). It was found from results that the photodetector has responsivity about 67 (A/W) in visible region at wavelength 500 nm. The calculation of current gain (G) was using equation

$$G = \frac{\text{Iph}}{Id} \quad (3)$$

Where I_d is dark current, current gain was calculated from (I-V) test in two conditions dark and illumination as in Figure (6). In order to make this study confident we kept light power constant for all the wavelengths used during experiment.

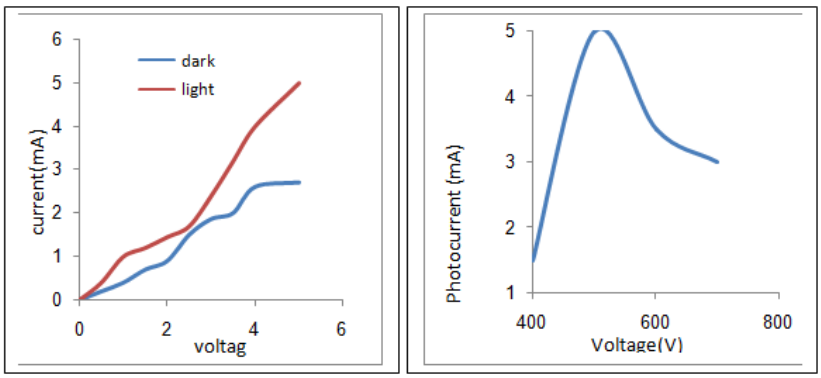

Fig. 6: a-(I-V) characteristic of samples b- photocurrent versus voltage of samples.

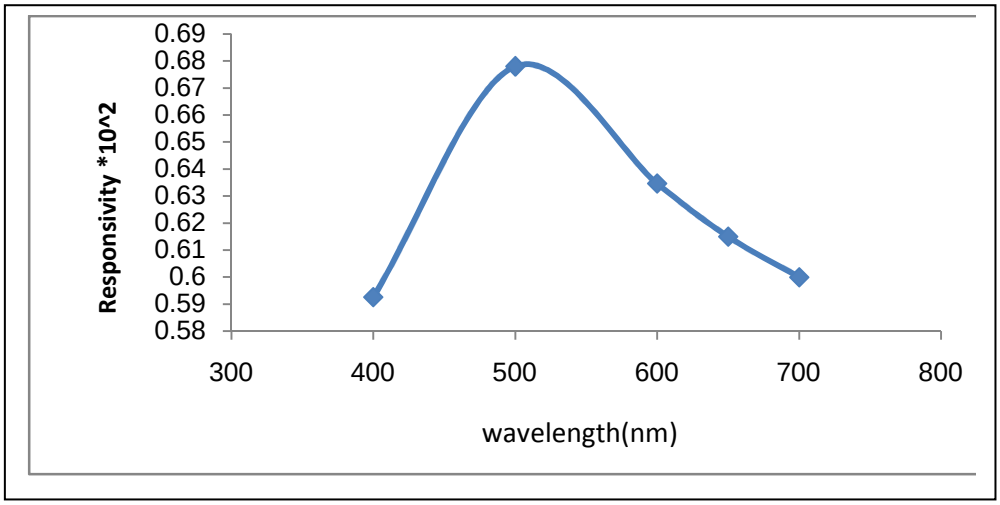

Fig. 7: Rsponsitivity versus wavelength of prepared samples.

Conclusion:

Simple and low cost Co-precipitation method was used to fabricate CuO photodetector**.** XRD results showed polycrystalline structure with preferred orientation 2θ=38.5 ° of (111). AFM and SEM results indicate uniform distribution of pore density with roughness about 0.316 nm [12-15]. While optical energy gap was found to be 2.6 (eV). The spectral resposivity was investigated at visible range with maximum responsivity at 500nm which could be evaluated as promising result for optoelectronic devices synthesis.

Contributions:

The generality of this research comes from the potential for future high performance optoelectronic device using simple low cost method of Coprecipitation method working at visible range which is a valuable result.

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