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Fabrication And Characterization Of P-Cuo/N-Si Heterojunction For Solar Cell Applications

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***Abstract*—This studies p- CuO / n - Si heterojunction was deposited by high vacuum thermal evaporation of Copper subjected to thermal oxidation at 300 °C on silicon. Surface morphology properties of The optical properties concerning the transmission spectra were studies for prepared thin films. this structure have been studied. XRD anaylsis discover that the peak at (111⁻) and (111) plane are take over for the crystal quality of the CuO films. The band gap of CuO films is found to be 1.54 eV. The average grain size of is measured from AFM analysis is around 14.70 nm. The responsivity photodetector after deposited CuO appear increasing in response.**

Keywords—CuO, structure properties, AFM, optical properties, solar cell .

1. Introduction

Solar cell technology for future energy resources has been progressed recently. Silicon is used as the semiconductor material for conventional solar cells, and the cost reduction of the solar cells is one of the most important issues. having a relatively low band gap (1.21-1.51) eV Cu oxides such as CuO and Cu2O are one of the candidate materials [1]. The features of copper oxide semiconductors are high optical absorption and nontoxic and low cost fabrication Copper oxide thin films have attracted much interest due to their potential applications for solar cells and gas sensor [2–3] It has been widely used for diverse applications such as heterogeneous catalysts [4-5], lithium ion electrode materials [6], high Tc superconductors [7] and field emission(FE)emitters [8–9]. It is also a promising material for fabricating solar cell, due to its photo- conductive and photo chemical properties [10-11]. this work, we investigated the effect of thickness on the properties of copper oxide thin film prepared by oxidation of thermal vacuum evaporated Cu thin films. The films were characterized using Atomic Force Microscope (AFM), X-ray diffraction (XRD), UV-Vis spectro-photometer .

2. Experimental

The n-Si layers were fabricated by anodic etching where a n-type silicon n-Si (1- 10) Ω .cm , (1×1) cm dimensions, 0.785 cm^2 etched area substrate was placed in the Teflon etching cell using an admixture of aqueous hydrogen fluoride (purity 47%) and ethanol (purity 99.99%), by volume. The sample was anodized at a current density of 10mA/cm^2 and at 15min etching time. No further chemical or thermal treatment was carried after etching. High purity (99.99%) Cu thin film was deposited on the n-Si substrates by thermal evaporation system type (Edwards) was used. The pressure deposition 3.4×10^{-5} mbar and the thickness of the films 300 nm, then Cu thin film was thermal oxidation A thin layer of CuO is formed on a chemically deposited Cu thin film through reaction with atmospheric oxygen during heating by (VECTOREEN model) thermal oven for one hour at 300 °C. During the

heating process, the color of the Cu films changed from silver-grey at room temperature to a black-brown color at a temperature of oxidation. The bottom of Si and above of CuO electrodes is coated with a thick aluminum layer to measure the electrical properties. It is obtained under vacuum of Al wire of high purity (99.99%).The evaporation process is started at a pressure of 5×10^{-6}mbar. at the following operation condition-:Source Cu Kα radiation of wavelength (λ=1.5405 Ȧ), -Current =20mA, Voltage =4kV, -Scanning speed = 5 cm/min, We can get information about the crystal structure such as phase crystalline, polycrystalline, amorphous, grain size, and lattice parameter. Optical transmission measurements were performed with (UV/Visible 1800 spectrophotometer). The band gap (Eg) and optical constants of the transparent films were determined from the optical transmission spectra (300-1100nm). The shape and size of CUO were investigated by using SEM and AFM (AA 3000 Scanning Probe Microscope .The spectral responsively of the photodiode was measured in the spectral range (400-1100) nm using a calibrated monochromator**.**

3. Results and discussion

XRD pattern for CuO thin films synthesized are shown in Figure (1) is contain two main peaks at diffraction angle of 35.54, 38.70° corresponds to $(11\bar{1})$, (111) and respectively of Copper oxides is observed and compared with the Joint Committee on Powder Diffraction Standards the film was polycrystalline in nature. The monoclinic structure was matched with the standards peaks (ASTM - Card file No. 00-005-0661). film [12].

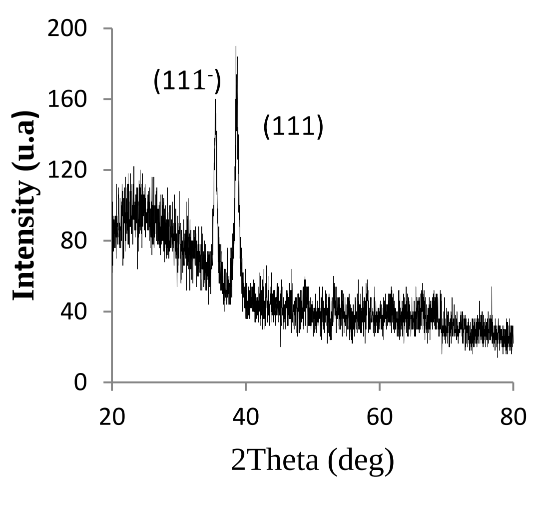

Fig.1 XRD pattern for CuO thin film.

The crystallite size was calculated by using Debye-Scherrer's relation [13]:

$$G_s = \frac{0.9\,\lambda}{\beta\cos\theta} \quad (1)$$

Where G_S is the crystallite size, β the full width at half maxima, θ is the angle of diffraction, and λ is the wave- length of X-ray.

The strain value η and the dislocation density δ value can be evaluated by using the relations in equation 2 and 3 [14].

$$\eta = \frac{\beta\cos\theta}{4} \quad (2)$$

$$\delta = \frac{1}{{G_s}^2} \quad (3)$$

The optical energy gap of the CuO film was calculated from the transmission Figure (2) displays the transmission as a function of wavelength. It is observed that maximum transmittance at 350 nm thickness for wavelength 850 nm show transmission spectra of CuO thin films is which prepared by thermal evaporation techniques and deposited on glass substrate , The date is corrected for glass in UV-regain ,the transmission is sharply decreases because of the wide of absorbed particle size .

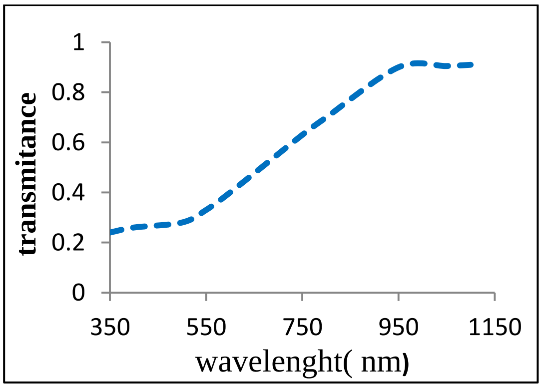

Fig .2: Transmission spectra for CuO thin film.

Figure (3) shows the band gap of CuO measured from the plot of the square of $(\alpha h\upsilon)^2$ versus photon energy $h\upsilon$ where α is the absorption coefficient) by extrapolating the linear part of the curve toward the photon energy axis is found to be 1.54 eV. which is due to the energy band structure and the variation of density of state with the energy level.

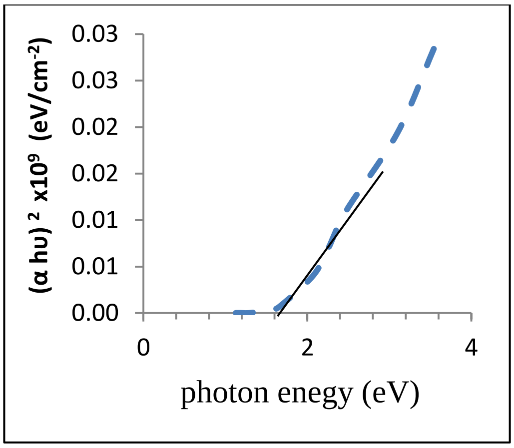

Fig. 3:$(\alpha hv)^2$ versus optical energy gap of CuO thin films.

Figure (4) reveals the (3-D) AFM images and the chart distribution of CuO film. AFM image proves that the grains are uniformly distributed within the scanning area (2000×2000nm) with individual columnar grains extending upwards.

The average grain size of pore is measured from AFM analysis using software and is found to be around 14.70 nm depending on preparation

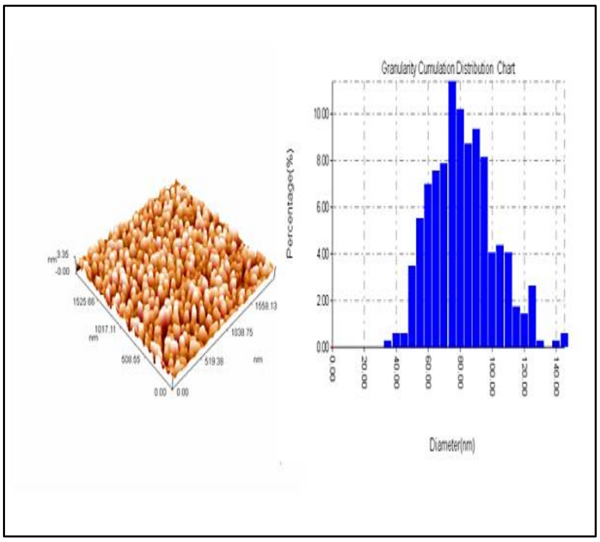

Fig.4 AFM images of CuO thin films

Shows Figure a (5) the I-V characteristics for p-CuO /n-Si and Shows Figure b(5) The measured short-circuit current, open-circuit voltage, fill factor and Efficiency are 1.4 mA, 1 mV, 40 and 4.9% respectively .All the results relieve that the sandwich structure p-CuO/n-Si could be used as a solar cell.[15] The conversion efficiency of the solar cells depends on morphology of interfaces in solar cells. A schematic microstructure of the present solar cells fabricated by thermal deposition.

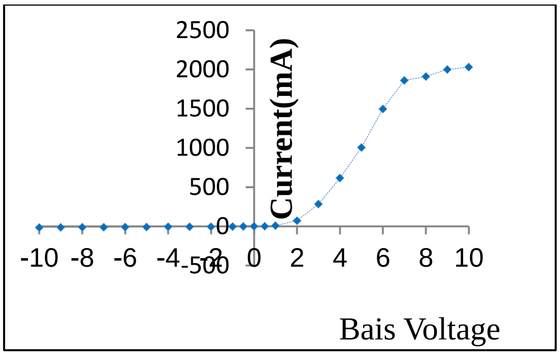

Fig. 5a: I-V of CuO thin films

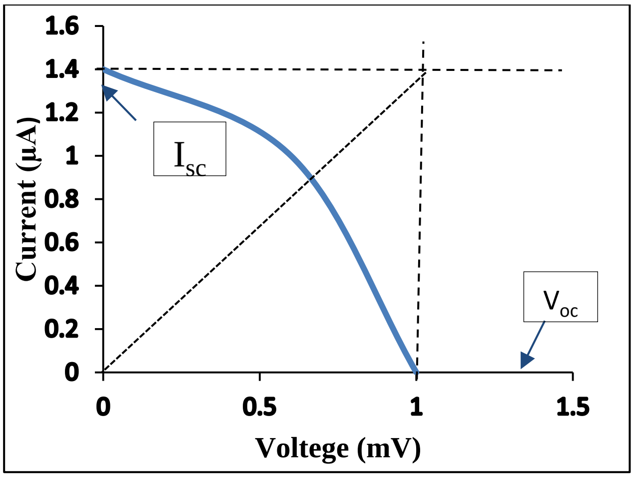

Fig.5b: open-circuit voltage of CuO thin films

4. Conclusions

p-CuO/n-Si heterojunction was successfully fabricated by using thermal evaporation etching of silicon and deposition Cu thin films by thermal evaporation and rapid oxidation the films at 300ºC. CuO show a good transparency in the spectral range (350- 850) nm and the The porosity of Si improves the performance the solar cell p-CuO/n-Si heterojunction **.** To increase power conversion efficiency structures of the solar cells should be optimized.

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