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ORIGINAL CONTRIBUTION

RF magnetron sputtered Cu_2O thin films for solar conversion

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ABSTRACT

Thin films of Cu_2O were deposited by RF-magnetron sputtering and were characterized by techniques including XRD, AFM, and photocurrent. The structure, morphology and optical characteristics of the films were found to depend on the radio frequency magnetron deposition parameters. The corning glass is used as substrate. The RF magnetron sputtered Cu_2O films used for photovoltaic solar cell applications.

KEY WORDS: Cuprous oxide, RF-magnetron sputtering, Solar Cell

1. INTRODUCTION

Non-toxicity is an important feature of the elements of Cu_2O, which finds suitability in photovoltaic, photo-electrochemical, photo-thermal, and gas sensing devices [1–4]. RF-magnetron sputtering [5] is one of the most appealing techniques for synthesis of thin film, because this technique is simple and it is most suitable technique for large area film synthesis. Cu_2O is generally prepared by oxidation of Cu at high temperature, however much attention has been given recently for low temperature synthesis of Cu_2O [6]. Cu_2O is a very promising material for photovoltaic applications because its optical band gap is ~ 2 eV. This material is quite stable and abundantly available and also there a number of inexpensive techniques for fabrication of devices based on Cu_2O. Thin films of Cu_2O prepared on glass substrates show interesting properties that find huge applications in photovoltaic and photocurrent-based devices. The present paper discusses on fabrication of p-Cu_2O thin films on glass substrate, the structure, morphology, and optical behavior of the RF magnetron sputtered Cu_2O films and then used as photovoltaic solar cell with n-ZnO.

2. EXPERIMENTAL

Glass substrates were cleaning by some mechanical and chemical technique. Polycrystalline thin films of p-Cu_2O/n-ZnO heterostructure was prepared on properly cleaned corning 7059 glass substrate by radio frequency magnetron sputtering technique. For this purpose, 99.99% pure copper target and ZnO targets were used. Inert gas Ar was used for preparation of plasma during deposition of the films. Oxygen was used as reactive gas and it was introduced in the deposition chamber in a controlled manner during synthesis of Cu_2O by means of a nozzle with its end placed close to the substrate holder. For Cu_2O, oxygen flow rate is 140ml/m, and substrate temperature is 400^0C. At the juncture of n-ZnO and p-Cu_2O, an insulating layer of ZnO (i-ZnO) was introduced. The insulating layer i-ZnO and the n-ZnO of the heterostructure were synthesized using undoped and 1wt% Al_2O_3 doped ZnO targets, respectively. The ohmic contacts of diameter 0.3 mm, needed for measurements were made on Cu_2O layer by thermally evaporating 99.99% pure gold target. A schematic of the manufactured heterostructure is shown in Fig.1.

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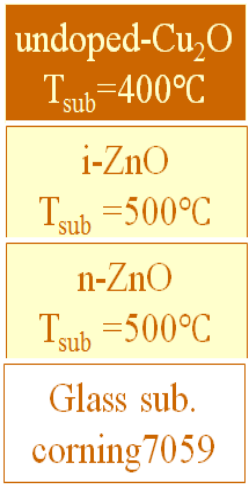


Fig. 1: Schematic of the manufactured heterostructure

The p-Cu_2O films were characterised by X-ray diffraction (XRD) study, atomic force microscopy (AFM) and also photocurrent measurements. An extensive study of the current - voltage (I–V) characteristics of n-ZnO/i-ZnO/p-Cu_2O heterostructures was performed.

3. RESULTS AND DISCUSSION

The structural characteristics of the samples were analysed by recording X-ray diffraction (XRD) data in the θ-2θ mode. For this purpose, Cu-K_α radiation was used. Fig. 2 depicts the X-ray diffractograms of the RF magnetron sputtered Cu_2O thin films prepared on glass substrate. The XRD peaks representing the (111) and (200) planes of Cu_2O were identified by comparing the results with standard JCPDS file for Cu_2O. This observation confirms synthesis of Cu_2O in the heterostructures.

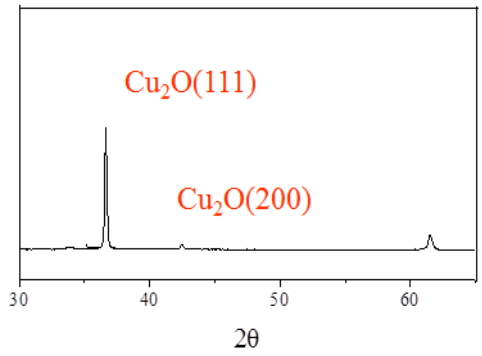


Fig. 2: X-ray diffractograms of the RF magnetron sputtered Cu_2O thin films prepared on glass substrate

Surface morphology of the films were studied using atomic force microscopy (AFM) and the same for a representative Cu_2O film prepared on glass substrate is shown in Figure 3. The figure clearly reveals polycrystalline morphology of the samples with sharply defined grain boundaries. The grains appear to be more or less uniform and densely packed. Average size of the crystallites was estimated to be ~ 130 nm.

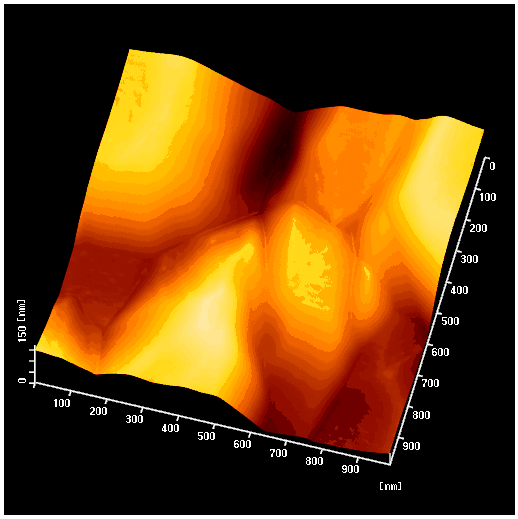


Fig. 3: Polycrystalline morphology of the samples with sharply defined grain boundaries

The results of spectral response as a function of wavelength in relation to the photocurrent measurement for Cu_2O has been shown in Fig. 4. The figure shows that photocurrent response is maximum around 450 nm and is drops drastically at higher wavelength. This drops in

photocurrent at higher wavelength is because of the following fact. When light with photon energy exceeding the band-gap energy is absorbed by the semiconductor, the photocarriers get excited through the metal - semiconductor junction resulting in a change of the electrical conductivity. Thus, it corresponds to the band absorption of Cu_2O.

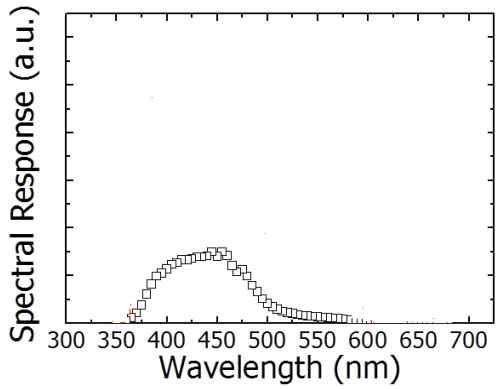


Fig. 4: Photocurrent response is maximum around 450 nm

The current–voltage (I–V) characteristics of n-ZnO/i-ZnO/p-Cu_2O heterostructures is depicted in Fig.5. The n-ZnO layer in the heterostructure is used as the window layer as well as n-electrode. Gold (Au) has been used as the electrode for p-side. In this context it must be mentioned that, the results could not be reproduced very well and the inverse current density was relatively high. The solar cells properties as obtained are the following: the open circuit voltage (Voc), short circuit current (Jsc) and fill factor (FF) were estimated to be 0.12 V, 0.6 mA/cm^2 and 0.38, respectively, under the condition of AM1.5. The conversion efficiency was found to be 0.04%. It appears from the results that the value of Voc is somewhat smaller than that expected and this may be due to presence of interface defects.

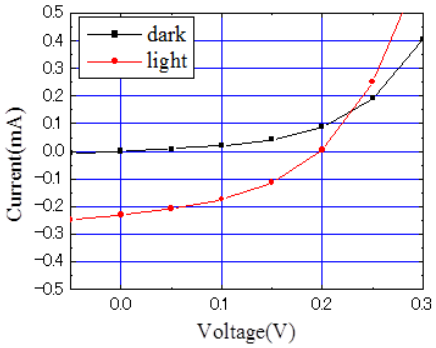


Fig. 5: n-ZnO layer in the heterostructure is used as the window layer as well as n-electrode

4. CONCLUSION

Cu_2O in thin film form were synthesized by the reactive rf magnetron sputtering technique on properly cleaned glass substrates. The XRD peaks indicate orientation of the crystallites of the films. The average size of the grains was found to be ~ 130 nm with efficient photo response around 450 nm. The rf magnetron sputtered Cu_2O films can used for solar cell application.

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