Substrate effect on photocurrent enhancement of electrodeposited n-type Cu_2O thin films

KMDC Jayathilaka[1], V Kapaklis[2], W Siripala[3], JKDS Jayanetti[1]

[1]*Department of Physics, Faculty of Science, University of Colombo*

[2]*Department of Physics and Astronomy, Upsala University, Sweden*

[3]*Department of Physics, Faculty of Science, University of Kelaniya*

Introduction

Cuprous oxide (Cu_2O) is a metal-oxide semiconductor with a band gap of about 2 eV, which has attracted interest because of its potential applications in solar energy conversion, catalysis and gas sensors. Such applications and emerging applications of Cu_2O thin films in other areas make it worthwhile to study the electro-optical characteristics of Cu_2O thin films extensively (Olsen *et al.*, 1982). Fabrication of Cu_2O thin films using electrodeposition is advantageous over the other techniques as this process includes low temperature, economy, simplicity and possibility of making large area thin films. Also, adjusting the deposition parameters during electrodeposition allows the conductivity type and the film morphology to be controlled as required (Lee *et al.*, 2006; Rai 1988).

The currently reported photovoltaic conversion efficiencies of good Cu_2O based solar cells have remained in the range of 1-2 % which is far below the theoretical value. Barrier height measurements in various Schottky barrier solar cells have shown that values are always in the range 0.7-0.9 eV regardless of the substrate which forms the back contact of the cell. This is believed to be the principal cause of the low performance of the Cu_2O Schottky barrier solar cells (Abdu, 2009). Therefore, the selection of a better substrate (metal or condcutive coating) for the junction formation is considered to be the most important factor. Metals with high work functions such as Ni and Pt, are considered to be such candidates for the n-Cu_2O Schottky junction solar cells. Cost-wise Ni can be considered a better material as opposed to Pt which is highly expensive.

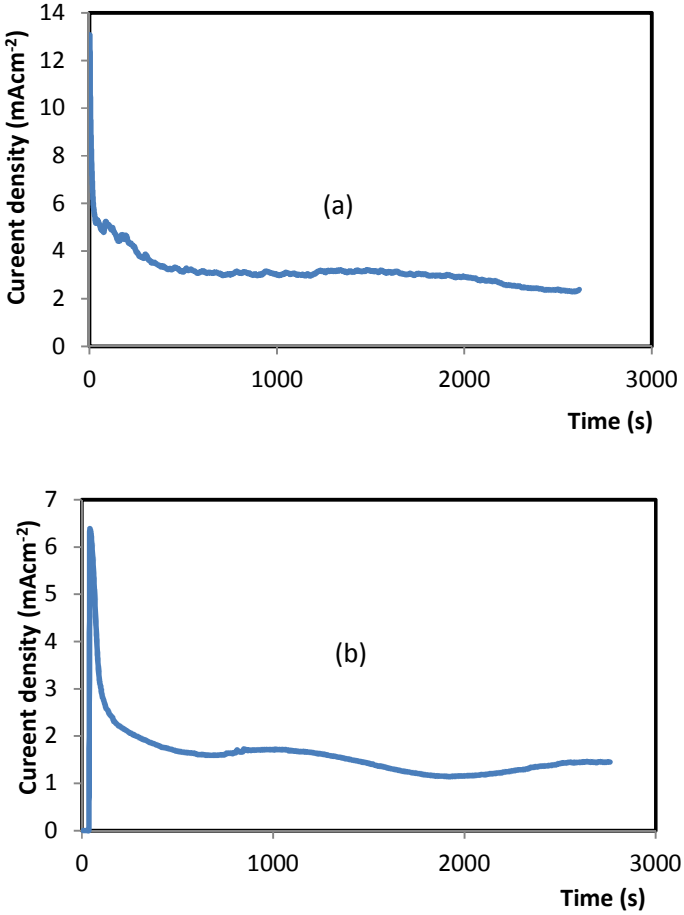
Experimental

Electrodeposition of Cu_2O thin films on Ti, ITO and Ni substrates was accomplished in a three-electrode electrochemical cell containing aqueous solutions of 0.1M sodium acetate and 0.01 M cupric acetate Deposition method has been discussed in detail elsewhere (Siripala and Jayakody,1986). Prior to the deposition, Ti and ITO substrates were cleaned with detergent, diluted HNO_3 and finally with distilled water. Ni substrates cleaned with acetone and distilled water. The film deposition was carried out at 60 ^{0}C under potentiostatic conditions of -200 mV vs. SCE. Deposition times on different substrates of Ti, ITO glass and Ni were 40 minutes, 1 hour and 4 hours respectively. The deposition times were determined by estimating the current-time values in order to obtain films of similar thicknesses. Current-time characterization was performed using a multimeter (Mastech MS 8218)

For spectral response measurements Cu_2O films were investigated in a photoelectrochemical cell containing a 0.1M sodium acetate solution. The contact area of the film with the electrolyte was ~4 mm^2. The counter electrode was a platinum plate and the reference electrode was a saturated calomel electrode (SCE). Measurements were made using a phase sensitive detection method to monitor the photocurrent signal produced by a chopped monochromatic light beam at a chopping frequency was 63 Hz. A monochromator (Sciencetech - 9010), a potentiostat (HukotoDonko HAB-151), a lock-in amplifier (Stanford Research- SR 830 DSP), and a chopper (Stanford-SR 540) were used for the measurements. Morphological and structural characterization of the films were made using a scanning electron microscope (Philips XL40), an atomic force microscope (Burleigh, Vista-100) and a SHIMADZU (XD-D1) X-ray diffractometer.

Results and Discussion

Structural and morphological studies of the films made with SEM, AFM and XRD were consistent with small grain Cu_2O thin films. Figure 1 shows the deposition current vs. time curves for Cu_2O films deposited on three different substrates, ITO glass, Ti and Ni justifying the need of different deposition times to obtain similar thicknesses.



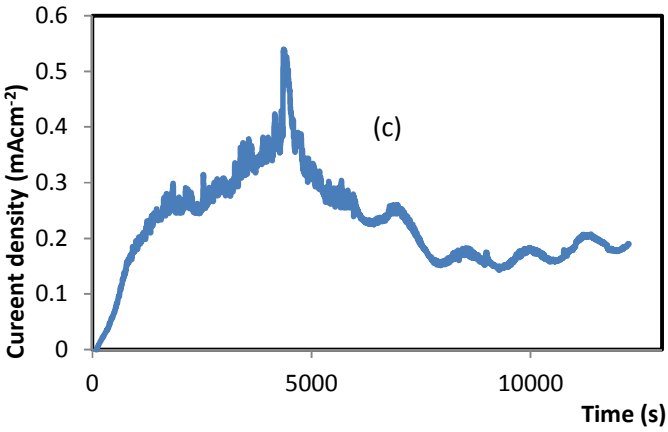


Fig.1: Deposition Current vs. time curves for electrodeposition of Cu_2O thin film on (a) Ti electrode (b) ITO electrode (c) Ni electrode

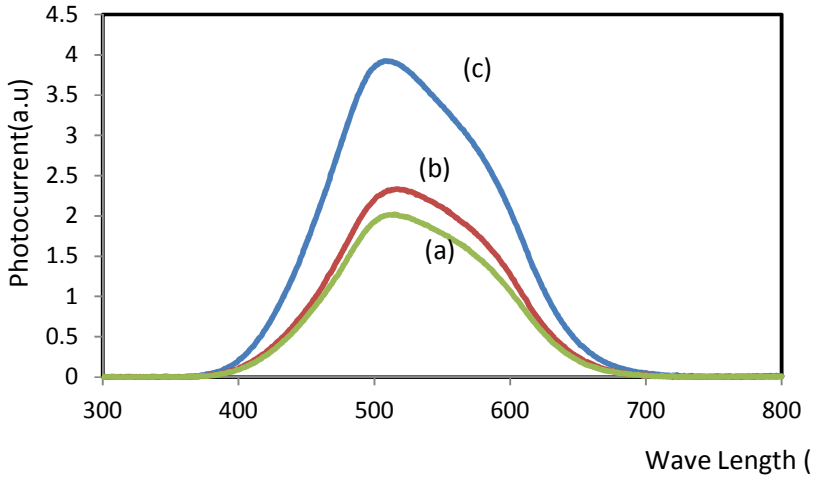


Figure.2: The spectral responses of the Cu_2O film in PEC cell (a) ITO substrate (b) Ti substrate (c) Ni substrate

Figure 2 shows the spectral responses of Cu_2O films grown on Ti, ITO glass and Ni substrate. It can be clearly seen that there is remarkable improvement in photocurrent of the Cu_2O films grown on Ni substrates. This is attributed to the ohmic contact formed between Ni and the Cu_2O layer as opposed to the rectifying contact that is formed when ITO glass and Ti are used as substrates. This enhanced photo-current will lead to solar cells of improved performance in which the efficiencies will better the current value of 1%.

Conclusions

It can be seen from this study that the n-type Cu_2O thin films electrodeposited on Ni substrates have enhanced spectral responses compared to ITO glass and Ti substrates as a result of better film-substrate contact. Therefore, Ni/Cu_2O system can be used as a highly useful junction for solar cells application.

References

Abdu Y. and Musa, A.O Bayero Journal of Pure and Applied Sciences, 2(2) (2009) 8 – 12

Lee J.H., Tang B.X., Tao L.M.,Xie Y.X, Zang M.B.,*J.Org Chem.* 71 (2006) 7488.

Olsen L.C., Addis F.W., Miller W, *Solar cells 7* (1982) 247.

Rai B.P, *Solar Cells* 25 (1988) 265.

Siripala W, Jayakody J.R.P, Solar Energy Materials 14 (1986) 23.

HETC project is gratefully acknowledged for the financial assistance through the research grant KLN/O-Sci/N4.