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Electrodeposition of n-type Cuprous Oxide Thin Films

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Cuprous oxide (Cu_2O) is an attractive material for solar energy applications because it is low cost, non toxic and has a direct band gap of 2 eV. It has been well established that Cu_2O is generally a p-type semiconductor material due to the Cu ion vacancies exist in the crystal lattice [1-3]. Among the various methods available for growing Cu_2O films, electrodeposition is attractive because it provides a low cost method for growing thin films for solar energy applications [4-8]. Moreover, electrodeposition of Cu_2O provides the possibility of depositing cuprous oxide thin films on conducting substrates resulting n-type photoresponse in solar cell devices [4,9,10]. Indeed, electrodeposition of Cu_2O in high pH aqueous depositing baths produces p-type conducting films. However, by maintaining the pH values in the range of 5.5 to 7.5 of the depositing bath, Cu_2O thin films can be potentiostatically electrodeposited in a potential domain of about 300mV, as shown in Fig. 1. Single phase Cu_2O polycrystalline films can be obtained in this potential domain and at more negative depositing potentials co-deposition of Cu is resulted. Photoresponse of a Cu_2O film electrode in a photoelectrochemical cell is shown in Fig. 2, where the photocurrent signal is n-type. This n-type behavior and the quality of the Cu_2O films produced by this technique will be presented using CV, SEM, XRD, EDX, XPS and XRF data. Further, the evidence of the existence of oxygen vacancies in the electrodeposited n-type Cu_2O films is presented. Possibility of using these n-type films in low cost solar cell devices is demonstrated by establishing the n-Cu_2O/p-Cu_xS junction by sulphiding Cu_2O thin films[11] and the spectral response of the ITO/n-Cu_2O/p-Cu_xS/Al structure is shown in Fig. 3. Implications of the results presented for low cost solar cell devices will be discussed.

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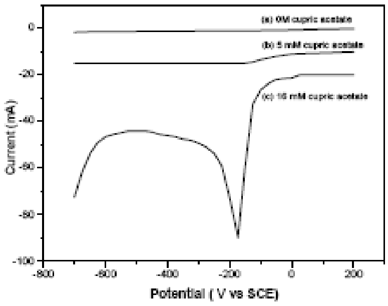

Fig.1 Current–voltage characteristics of a platinum electrode in a three electrode electrochemical cell containing 0.1 M sodium acetate and cupric acetate concentrations of (a) zero (b) 0.5 mM and (c) 16 mM.

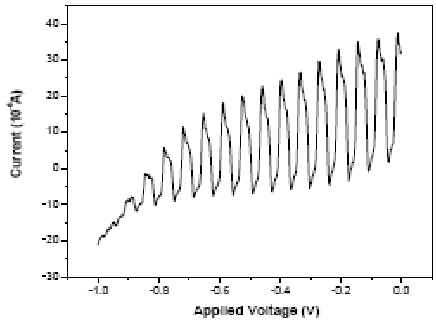

Fig. 2 Current voltage characteristics of a Cu_2O thin film electrode in a PEC cell containing 0.1 M sodium acetate solution, under chopped light illumination.

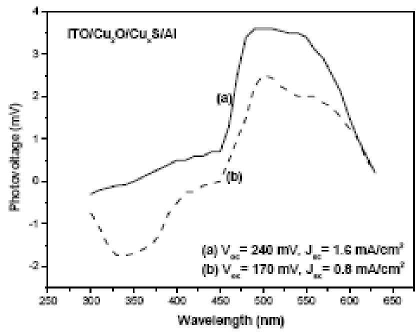

Fig.3 Spectral responses of ITO/Cu_2O/Cu_xS/Al solar cell structures producing different solar cell outputs (a) V_{oc} =240 mV, J_{sc}= 1.6 mA/cm^2 and (b) V_{oc}=170 mV, J_{sc} = 0.8 mA/cm^2.