Electrodeposited Cuprous Oxide for Solar Cell Applications

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Abstract

Work performed to electrodeposit Cuprous Oxide thin films for the fabrication of a solar cell is presented. A review of solar cells, with emphasis on Cu_2O solar cells is also made. The experimental study deals with the potentiostatic electrodeposition of Cu_2O, characterization of electrodeposited Cu_2O thin films, investigation of effects of annealing Cu_2O and the fabrication and characterization of a thin film Cu_2O solar cell. Electrolysis of an aqueous solution containing Cu^{2+} ions was investigated by current-potential scans to establish the deposition parameters for potentiostatic electrodeposition of Cu_2O. A potential domain of ~200 mV where Cu_2O can be electrodeposited was identified. Cu_2O films of ~1μm thickness were potentiostatically electrodeposited on glass/ITO substrates. X-ray diffraction, X-ray fluorescence, scanning electron microscopy, optical absorption measurements and photoresponse of Cu_2O/electrolyte junctions were used to study the deposit's crystallographic, compositional, morphological, optical and electrical properties. The deposited material is high purity polycrystalline Cu_2O with grain size of ~1μm, and had a direct band gap of 2.0 eV. As-deposited Cu_2O was found to be n-type in conductivity. A band structure is proposed to describe the spectral response of the ITO/Cu_2O/electrolyte system. Annealing at temperatures below 200°C enhanced the n-type photocurrents of ITO/Cu_2O electrodes in PEC, and annealing at 300°C resulted in conductivity type conversion of Cu_2O. Metal/semiconductor type solar cells were fabricated by vacuum evaporating metal contacts. A glass/ITO/n-Cu_2O/p-Cu_xS/Al heterojunction solar cell was fabricated by partial sulphidation of Cu_2O. Current-Voltage characteristics and the spectral response of the devices were studied. The spectral response of the cell was observed to be limited to shorter wavelengths. The observed anomalous behaviour of the I-V characteristics of the cell is interpreted in terms of the proposed band structure of the device. The best Cu_2O/Cu_xS cell exhibited an open circuit voltage of 240mV and a short circuit current density of 1.6mA/cm^2 and a Fill Factor of 0.34 under 100 mW/cm^2 illumination. Further work to enhance the efficiency of Cu_2O solar cells is suggested. The study reveals the potential application of electrodeposited Cu_2O thin films in low-cost thin film solar cells.