Growth and Characterisation of $CuInS_2$ Thin Films

R P Wijesundara[1], W Siripala[1], K D Jayasuriya[1], S R D Kalingamudali[1], K T L De Silva[2], J K D S Jayanetti[2], A P Samantilleke[3] and I M Dharmadasa[3].

[1] Department of Physics, University of Kelaniya, Kelaniya, Sri Lanka.
[2] Department of Physics, University of Colombo, Colombo, Sri Lanka.
[3] Applied Physics Division, City Campus, Sheffield Hallam University, Sheffield S1 1WB, UK.

Abstract

Copper Indium Disulphide thin films were grown by electrodeposition of Cu-In alloy followed by sulphurisation in H_2S gas. It was observed that the ionic concentration of Cu^{2+}/In^{3+} in the electrodepositing bath determines the composition of the materials formed after the sulphurisation. $CuInS_2$ thin films having the chalcopyrite crystal structure can be produced using this technique and the films are n-type semiconductors.

Introduction

Copper Indium Disulphide ($CuInS_2$) is a very attractive semiconductor material for application in thin film solar cells because of its direct band gap value of about 1.5 eV (1,2). The highest energy conversion efficiency reported up to now for devices fabricated using this material is 12.5 % (3). Further improvements in the efficiency are expected through improvements in the electronic properties of this material by optimising the preparation conditions. Several methods for the preparation of this material have been reported (4-6). Among them electrodeposition is eminently suitable for large-scale preparations and commercial applications. Moreover, thin $CuInS_2$ films have been prepared by heat treatment of Cu-In alloy in H_2S or S gas atmosphere where the Cu-In alloy was prepared by sputtering (6), molecular beam deposition (7), electrodeposition (8) and electroless deposition (9). The film quality was very subjective to the Cu-In alloy preparation conditions and methodology being adapted.

In this investigation Cu-In precusers were electrodeposited on Ti substrates using various aqueous bath solutions having a wide range of Cu^{2+}/In^{3+} ionic ratios in the electrolyte. Subsequently the films were heated in saturated hydrogen sulphide (H_2S) gas for the sulphurisation and the formation of $CuInS_2$ thin films. As prepared and heat treated films were investigated using X-ray diffraction (XRD), X-ray fluorescence (XRF) spectroscopy, Scanning electron microscopy (SEM), Energy dispersive X-ray analysis (EDX) and photoresponse measurements in a photoelectrochemical cell. We report in this communication the dependence and the sensitivity of the Cu/In atomic ratio in the Cu-In alloy to the growth and to the optical, structural, morphological properties of the $CuInS_2$ thin films.