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One-Step Electrodeposition of CuZnSn Metal Alloy Precursor Film Followed by the Synthesis of Cu_2ZnSnS_4 and $Cu_2ZnSnSe_4$ Light Absorber Films and Heterojunction Devices

A.E. Rakhshani[1,*], *A. Bumajdad*[2], *F. Al-Sagheer*[2], *S. Thomas*[1], *P.H. Tharayil*[1]

[1] Department of Physics, Faculty of Science, Kuwait University, Safat 13060, Kuwait
[2] Department of Chemistry, Faculty of Science, Kuwait University, Safat 13060, Kuwait
[*]E-mail : ali.rakhshani@ku.edu.kw; alirakhshani@yahoo.com

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CuZnSn metallic alloy precursor films were electrodeposited on Mo substrate from a Zn-rich bath solution yielding low deposition rates. The precursor films were converted to photovoltaic absorber films of Cu_2ZnSnS_4 and $Cu_2ZnSnSe_4$ by sulfurization and selenization processes. X-ray diffraction, Raman spectroscopy and photocurrent spectroscopy techniques were utilized for the identification of films. The surface morphology, uniformity and compactness of the films were examined by scanning electron microscopy. The precursor and absorber films had a uniform and compact structure. The precursor films were composed from the Cu_3Sn, Cu_6Sn_5 and Cu_5Zn_8 phases and their grain size varied tightly with the cathode potential. The conversion of precursor films to Cu_2ZnSnS_4 and $Cu_2ZnSnSe_4$ were verified from the results of their X-ray diffraction, Raman shifts, and optical transition energies. To assess the device quality of the absorber films, CdS/Cu_2ZnSnS_4 and $CdS/Cu_2ZnSnSe_4$ heterojunction diodes were fabricated and their device parameters were determined. The diodes showed relatively good ideality factor of 1.3-1.9, current rectification factor of ~120, and reverse biased saturation current of ~30-60 $\mu A/cm^2$. Photocurrent spectroscopy was utilized to evaluate the band gap energy and other optical transition energies of the absorber films from the short-circuit photocurrent of the diodes.

Keywords: CZTS; CZTSe; electrodeposition; photocurrent; Raman

FULL TEXT