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Selenization of electrochemically synthesized Copper-Indium layers from non-aqueous solution for solar cell application

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Abstract

A simple two-step, electrodeposition of copper-indium (Cu-In) intermetallic alloy thin films followed by selenization process was employed for the synthesis and development of $CuInSe_2$ (CIS) thin film solar cells (TFSC). The co-deposition of Cu and In in ethylene glycol at 130˚C was studied using the cyclic voltammetry (CV) to obtain a stable Cu-In phase. A wide window of deposition potentials from -0.7 V to -1.5 V versus Ag/AgCl reference electrode was optimized. Three different potentials, -0.7 V, -1.0 V and -1.3 V are chosen to deposit the Cu-In intermetallic alloy thin films, which were further selenized in controlled selenium ambient at 400 ˚C. The selenization effect is studied extensively on structural, morphological, optical and compositional properties of selenized Cu-In (CIS) thin films. Polycrystalline CIS layers with tetragonal crystal structure are obtained upon selenization of Cu-In thin films. Three prominent reflections of CIS, (112), (204/220) and (312/116) are exhibited in all selenized Cu-In layers. Additional secondary phases of Cu_xSe_{1-x} are attributed for the layers grown at -0.7 and -1.0 V. Compact and void-free surface morphology with particle size ~1 to 2 µm was observed for all selenized samples. The selenized Cu-In layer sample deposited at -1.3 V measure ~ 1.06 eV energy band gap with polycrystalline tetragonal chalcopyrite ctrystal structure of CIS. The photoelectrochemical measurement confirms the growth of p-type material. A selenized Cu-In layer deposited at -1.3 V with CdS window layer measured power conversion efficiency 5.44 %.

Keywords: Electrodeposition, nucleation, selenization, $CuInSe_2$, thin film solar cells,