626/E2

Use of electro-deposition technique for growing n-type and p-type CdS and CdTe thin film semiconductor materials for fabrication of solar cells with improved performances

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Photovoltaic research efforts are currently devoted to production of low cost and high-efficiency solar cells. The aim of this work is to study the electrochemical experimental conditions required to grow CdS and CdTe thin film semiconductors for the purpose of fabricating solar cells with higher performances at a relatively low cost. n-type CdS and p-type CdTe thin films were electrodeposited on fluorine doped tin oxide (FTO) / indium tin oxide (ITO) substrates using a three electrode system. In the three electrode system, high purity graphite rods were used as counter electrodes and an Ag/AgCl electrode was used as the reference electrode.

The electro-deposition conditions used for growth of CdS with ammonium thiosulfate as S precursor were; $[CdCl_2]$ = 0.0015 mol dm^{-3}, $[(NH_4)_2S_2O_3]$ = 0.0015 mol dm^{-3}, voltage = -1100 mV, temperature = (28 – 30) ^{0}C deposition time = 2 h. pH of the solution = 1.5. The conditions for electro-deposition of CdS with thiourea as S precursor were; $[CdCl_2]$ = 0.003 mol dm^{-3}, $[CS(NH_2)_2]$ = 0.004 mol dm^{-3}, voltage = -700 mV, temperature = 60 ºC, deposition time = 2 h pH was in the range of 1 to 4 . All CdS films were annealed at 400 ºC for 10 minutes. The conditions for CdTe electro-deposition were; $[CdSO_4]$ = 1.00 mol dm^{-3}, $[CdCl_2]$ = 1000 ppm, 3 drops of TeO_2, pH = 1.6, voltage = -700 mV, temperature = (28 – 30) ^{0}C, deposition time = 3 h . All CdTe films were annealed at 400 ºC for 10 minutes.

Photo-electrochemical (PEC) cell measurements were carried out to determine the photovoltaic-activity and electric conductivity type (n/p) of both as deposited and heat treated materials. Upon heat treatment, the material layers show enhanced PEC signal indicating improved optical properties. Band gap measurements were obtained using UV/Visible spectrophotometry and the observed value for CdS was 2.40 eV, which is similar to the characteristic band gap of CdS. XRD analysis revealed that the electrodeposited CdS had hexagonal crystal structure. Thickness measurements carried out by both profilometer and atomic force microscopy revealed that the thickness of CdS and CdTe thin films were ~ 250 nm and 430 nm respectively. The scanning electron microscopic (SEM) images showed that the grain size and the thickness of the electrodeposited polycrystalline CdTe were not satisfactory as the depositions were conducted over (28-30) ^{0}C. A higher deposition temperature around 85° C needs to be used in order to increase the grain size of CdTe.
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