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Effect of thermal annealing of CBD-CdS on the electrical properties of CBD-CdS/ED-CdTe solar cell

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Thermal annealing is one of the key steps to enhance the optoelectronic properties of the CdS/CdTe solar cells. In this study, the effects of annealing temperature and annealing time of chemical bath deposited (CBD) CdS on the electrical properties of CBD-CdS/electrodeposited (ED) CdTe solar cells were investigated. CBD-CdS layers were prepared using pre-optimized deposition conditions (90 ℃, 55 min) on fluorine doped tin oxide (FTO) glass substrates utilizing a bath consisted of 0.033 mol/L $Cd(CH_3COO)_2$, 0.667 mol/L $CS(NH_2)_2$ as cadmium and sulfur precursors, respectively and therein, 1 mol/L $CH_3CO_2NH_4$ and 0.735 mol/L NH_4OH were used for pH adjustment. Thereafter, a set of CBD-CdS samples prepared was annealed at different temperatures (350, 375 and 400 ℃) by varying the annealing time (10, 20, 30, and 40 min). Consequently, CdTe thin films were electrodeposited on annealed CBD-CdS substrates using an ED-bath consisted of 1.0 mol/L $CdSO_4$ and 1.0 mmol/L TeO_2 at pH of 2.3, temperature of 65 ℃, and potential of -650 mV against a saturated calomel electrode. The prepared glass/FTO/CBD-CdS/ED-CdTe samples were air annealed (400 ℃, 20 min) and Cu/Au back contacts were deposited using thermal evaporation technique.

The electrical properties of the CBD-CdS samples were investigated by photo-electrochemical cell (PEC) study at the CBD-CdS/electrolyte junction. As per the PEC analysis, CBD-CdS sample annealed at 375 ℃, 30 min has shown the highest short circuit current density (J_{sc}) of 21.5 μA/cm^2, while the sample annealed at 400 ℃, 10 min shown the highest open circuit voltage (V_{oc}) of 499 mV. The electrical properties of the CBD-CdS/ED-CdTe/Cu/Au devices were investigated under AM 1.5 light source and therein, CBD-CdS sample annealed at 375 ℃, 30 min scored the highest J_{sc} (14.12 mA/cm^2) and the one annealed at 400 ℃, 10 min displayed the highest V_{oc} (616 mV). Also, the device annealed at 375 ℃, 30 min showed the lowest series resistance (205 Ω) while the one annealed at 400 ℃, 10 min demonstrated the highest shunt resistance (1401 Ω). Accordingly, the 375 ℃, 30 min and 400 ℃, 10 min were found to be the effective conditions for annealing CBD-CdS that can result in materials with better electrical properties for CBD-CdS/ED-CdTe/Cu/Au device fabrication.

Keywords: Chemical bath deposition, Electrodeposition, Thermal annealing, CdS/CdTe solar cell

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