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Enhancement of the fill factor of cuprous oxide homojunction solar cells

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Cuprous oxide is a non-toxic low-cost photovoltaic material, which has the potential to replace expensive Si based solar cells. With the direct band gap of 2 eV, theoretical energy conversion efficiency of Cu_2O is 20%. Even if the short circuit current density (J_{sc}) of Cu_2O homojunction solar cells have been developed to the theoretical limit, open circuit voltage (V_{oc}) and the fill factor is yet to be improved. This low fill factor followed by low V_{oc} is due to the existence of p-type conductivity in n-type Cu_2O trap states and low transmittance of the window layer. In this investigation, we were able to increase the fill factor of Cu_2O homojunction device. n-Cu_2O films were electrodeposited on Ti substrates in baths containing 0.1 M sodium acetate, 0.01 M cupric acetate at -200 mV potential with respect to Ag/AgCl electrode. A Pt plate was used as counter electrode. Bath pH was adjusted to 6.1 and the temperature was maintained at 55 ^oC. After 60 minutes of deposition, samples were annealed at 100 ^oC for 24 hours and 175 ^oC for 30 minutes, respectively. Expectation of annealing was to eliminate the p-type conductivity in n-Cu_2O. Electrodeposition of p-Cu_2O was carried out in a bath containing 4 M NaOH, 3 M lactic acid and 0.4 M $CuSO_4$. Bath pH was adjusted to 13.0 and the temperature was maintained at 60 ^oC. Thicknesses of the n-Cu_2O and p-Cu_2O films were calculated to be 2.2 µm and 0.1 µm, respectively. After the deposition, bi-layers were exposed to ammonium sulphide vapor to form a thin CuS layer to remove the surface states so that it would make an ohmic contact with Au front contacts which is grown by sputtering. Final devices were characterized by obtaining I-V measurements and it was observed that p-type response of the device has disappeared and the fill factor is improved from 25% to 36%. Photoactive performance of the device improved from J_{sc} of 9.25 mA cm^{-2}, V_{oc} of 449 mV, and efficiency of 1.04 to J_{sc} of 10.11 mA cm^{-2}, V_{oc} of 425 mV, and efficiency of 1.55 under AM 1.5 illumination without and with improvement of the fill factor, respectively.

Keywords: Cu_2O Electrodeposition, Cu_2O Homojunction, fill factor

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