The role of n–p junction electrodes in minimizing the charge recombination and enhancement of photocurrent and photovoltage in dye sensitized solar cells

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Abstract

The composite electrode comprising n-type TiO_2 and p-type NiO oxides when sensitized with Ru-dye showed short-circuit photocurrent (I_{sc}) of 17 mA/cm^2 and open-circuit photovoltage (V_{oc}) of 730 mV compared to I_{sc} of 12 mA/cm^2 and 700 mV for TiO_2 electrodes. Formation of a n–p junction between TiO_2 and NiO oxide layers contributes to the enhanced photocurrent, photovoltage, fill factor and efficiency. In addition to the junction effect, NiO acts as a barrier for charge recombination leading to higher cell performance. The efficiency of the NiO coated TiO_2 solar cell is 30% more than that of bare TiO_2. The negative shift of the flat-band potential of the NiO coated TiO_2 electrode compared to TiO_2 also could be one of the reasons for higher photovoltage observed for TiO_2/NiO electrode. The highest cell efficiencies were obtained immersing TiO_2 thin films in Ni^{2+} solution and converting them to NiO by firing and the optimum NiO coating thickness was found to be only a few angstroms. The energy levels of the excited dye and the band positions of TiO_2 and NiO suggest that the electron transfer from the excited dye to the underlying n-type oxide layer occurs by tunneling through the p-type NiO layer.

Keywords: n–p Junction; TiO_2; NiO; Dye sensitization; Charge transfer