Gold–silver@TiO_2 nanocomposite-modified plasmonic photoanodes for higher efficiency dye-sensitized solar cells

ABSTRACT

In the present investigation, gold–silver@titania (Au–Ag@TiO_2) plasmonic nanocomposite materials with different Au and Ag compositions were prepared using a simple one-step chemical reduction method and used as photoanodes in high-efficiency dye-sensitized solar cells (DSSCs). The Au–Ag incorporated TiO_2 photoanode demonstrated an enhanced solar-to-electrical energy conversion efficiency of 7.33%, which is ∼230% higher than the unmodified TiO_2 photoanode (2.22%) under full sunlight illumination (100 mW cm^{-2}, AM 1.5G). This superior solar energy conversion efficiency was mainly due to the synergistic effect between the Au and Ag, and their surface plasmon resonance effect, which improved the optical absorption and interfacial charge transfer by minimizing the charge recombination process. The influence of the Au–Ag composition on the overall energy conversion efficiency was also explored, and the optimized composition with TiO_2 was found to be Au_{75}–Ag_{25}. This was reflected in the femtosecond transient absorption dynamics in which the electron–phonon interaction in the Au nanoparticles was measured to be 6.14 ps in TiO_2/Au_{75}:Ag_{25}, compared to 2.38 ps for free Au and 4.02 ps for TiO_2/Au_{100}:Ag_0. The slower dynamics indicates a more efficient electron–hole separation in TiO_2/Au_{75}:Ag_{25} that is attributed to the formation of a Schottky barrier at the interface between TiO_2 and the noble metal(s) that acts as an electron sink. The significant boost in the solar energy conversion efficiency with the Au–Ag@TiO_2 plasmonic nanocomposite showed its potential as a photoanode for high-efficiency DSSCs.

Keyword: Gold–silver@TiO_2; Gold–silver@titania; Nanocomposite; Plasmonic; Dye-sensitized solar cells