Gold-silver@TiO₂ nanocomposite-modified plasmonic photoanodes for higher efficiency dye-sensitized solar cells

ABSTRACT

In the present investigation, gold-silver@titania (Au-Ag@TiO₂) 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 TiO₂ photoanode demonstrated an enhanced solarto-electrical energy conversion efficiency of 7.33%, which is ~230% higher than the unmodified TiO₂ 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 TiO₂ was found to be Au₇₅-Ag₂₅. This was reflected in the femtosecond transient absorption dynamics in which the electronphonon 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 TiO2/Au100:Ag0. The slower dynamics indicates a more efficient electron-hole separation in TiO₂/Au₇₅:Ag₂₅ that is attributed to the formation of a Schottky barrier at the interface between TiO₂ and the noble metal(s) that acts as an electron sink. The significant boost in the solar energy conversion efficiency with the Au-Ag@TiO₂ plasmonic nanocomposite showed its potential as a photoanode for highefficiency DSSCs.

Keyword: Gold–silver@TiO_{2;} Gold–silver@titania; Nanocomposite; Plasmonic; Dyesensitized solar cells