Plasmonic Effect on Photocurrent in PbS/CdS Quantum Dot-Sensitized Solar Cells with TiO_2 Nanofiber/Nanoparticle Photoanode

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Abstract

Semiconductor quantum dots have gained more attention due to their unique optoelectronic properties applicable in many important research fields such as fabrication of light emitting devices, photon detecting devices, medical equipment, spectrometers and photovoltaic cells. Quantum dot – sensitized solar cells (QDSSCs) are photovoltaic devices with low fabrication cost and high efficiency due to the ability of multiple exciton generation and tunable energy gab by quantum confinement effect. Ag plasmonic colloidal nanoparticles were synthesized using reduction method. PbS/CdS quantum dots were loaded on the TiO_2 electrode by successive ionic layer adsorption and reaction (SILAR) technique. Plasmonic Ag nanoparticle incorporated TiO_2 double layer (nanofiber/nanoparticle) nanostructured photoanodes have been prepared for solar cells sensitized with PbS/CdS core-shell structure quantum dots. Ag plasmonic PbS/CdS QDSSC shows a better power conversion efficiency of 4.09% with short-circuit density of 14.85 mA cm^{-2} and open-circuit voltage of 627.70 mV under the simulated light of 100 $mWcm^{-2}$ with Air Mass (AM) 1.5 spectral filter. The efficiency of the similar QDSSCs made without Ag nanoparticles under the same condition was 3.55%. The overall performance and short-circuit current density of the QDSSC are enhanced by 15% and 23% respectively. The enhanced performance of the QDSSC is clearly due to the enhanced optical absorption by localized surface plasmon resonance effect by the Ag nanoparticles in the TiO_2 photoanode and the resulting increase in the short-circuit photocurrent.