Role of poly(ethylenedioxythiophene)/poly(styrene sulphonate) on the performance of nanocrystalline titanium dioxide/poly (3-hexylthiophene) polymer solar cells

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Abstract

Hybrid nanocrystalline titanium dioxide (TiO 2)/polymer solar cells draw intense interest due to the potential advantages of nanocrystalline TiO 2. The poly(styrenesulfonate)-doped poly(ethylenedioxy thiophene) (PEDOT:PSS) layer spin-coated below the top electrode in these solar cells had shown enhanced performance in previous studies, which motivated to explore the dependence of the thickness of the PEDOT:PSS layer on its performance. This study focused on the characterization of solar cells fabricated with poly(3-hexylthiophene) (P3HT) polymer with a silver electrode and different PEDOT:PSS layer thicknesses, in the dark and under AM 1.5 stimulated illumination with the intensity varying from 10 to 100 mW/cm 2. The variations in the photovoltaic parameters, particularly the open-circuit voltage, proved that the PEDOT:PSS layer significantly affects the photovoltaic parameters through the characteristic changes in the morphology as well as the electrical properties. Discussed herein is the possible influence wielded by the thickness of the PEDOT:PSS layer on different factors, such as the series and shunt resistances, the mode of recombination, the reduction of the energy barrier, and the diffusion of silver. The optimum power onversion efficiency was observed for the as-prepared devices with 50-nm-thick PEDOT layers. The optimum power conversion efficiency, however, shifted to that corresponding to the 80 nm thick PEDOT:PSS layer about 30 weeks after the fabrication. A sublinear variation of the short-circuit current density with the intensity was found in the aged cells with relatively lower PEDOT:PSS layer thicknesses, supporting the view of dominant recombination contributed from bimolecular recombination in the cells with lower PEDOT:PSS thicknesses. The significantly increased open-circuit voltage and the more stable current density in the aged devices are the main causes of the improved performance of the cells generally with above 60 nm thick PEDOT:PSS layers. These, along with the long-term stability found in the cells with reasonably thick PEDOT:PSS layers, may be a figure of merit, most probably attributable to the comparatively minimized diffusion of silver nanoparticles.