Improvement in Dye-Sensitized Solar Cells by Introducing an Interfacial Layer of Mesoporous TiO_2 Thin film

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A randomly microphase-separated graft copolymer was successfully reorganized to show a well-ordered micellar morphology by controlling solvent affinity using a THF-H2O/HCl mixture. Well-organized mesoporous TiO2 films with high porosity and good connectivity were developed via the sol-gel process using an organized PVC-g- POEM amphiphilic graft copolymer. In particular, organized TiO2 thin films with different morphologies were prepared by carefully changing the mole ratio of [TTIP]:[H2O]:[HCl]. A organized TiO2 film with a lower porosity and smaller pore size (orgTiO2-1) was obtained at a lower water content, i.e. [TTIP]:[HCl]:[H2O] ¼ 2 : 1 : 0, whereas the TiO2 film with a higher porosity and bigger pores (orgTiO2-3) was prepared at higher water content, i.e., [TTIP]:[HCl]:[H2O] ¼ 2 : 1 : 1. The organized TiO2 thin films were used as an interfacial layer inDSSCs, and the influence of the material structure on photovoltaic performance was then investigated. The root-meansquare roughness of the FTO substrate was dramatically reduced from 8.4 to 3.2 nm by the deposition of mesoporous TiO2 thin films, indicating an improvement in interfacial adherence between the mesoporous TiO2 layer and TCO, as confirmed by
noncontact 3D surface profiler SEM images. By introducing the organized TiO2 thin films as an interfacial layer in DSSCs, Jsc significantly increased from 8.8 up to 13.7 mA cm_2, thus improving the photovoltaic conversion efficiency from 3.5% up to 5.0%, at 100 mW cm_2 for solid-state DSSCs employing PEGDME/SiO2/MPII/I2 polymer electrolytes. EIS analysis showed that the interfacial resistance of the DSSC with the orgTiO2-3 film was smaller than that with the orgTiO2-1, but the electron recombination lifetime of the former was shorter than the latter. Moreover, the antireflective capability of the orgTiO2-1 thin film was slightly higher than that of the orgTiO2-3 film. As a result, the efficiency of the DSSC fabricated with the orgTiO2-1 thin film as an interfacial layer was higher than that with the orgTiO2-3 film, indicating the importance of the morphology of the organized TiO2 thin film.