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Tuning ordered mesoporous titania films via introducing germanium nanocrystals for high-efficient photoanodes

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With an aim of obtaining high-efficient titania photoanodes, we introduce germanium nanocrystals (GeNCs) into a diblock-copolymer polystyrene-block-polyethylene oxide (PS-b-PEO) template-assisted sol-gel synthesis. The surface and inner morphologies of the TiO2/GeNC films with different GeNC content after thermal annealing are investigated via scanning electron microscopy and grazing incidence small-angle X-ray scattering (GISAXS). GISAXS provides important insights into the influence of GeNC addition on the structure evolution. We probe the crystal phase, chemical state and optical properties of the nanocomposite films via X-ray diffraction, transmission electron microscopy, X-ray photoelectron spectroscopy and ultraviolet-visible spectroscopy. These measurements show that even with GeNC addition, the nanocomposite films still have good crystallinity and high transparency. We further study the charge-carrier dynamics of the nanocomposite films. Compared to pristine titania photoanodes, the GeNC addition enhances the electron transfer, resulting in an overall improvement in the short-circuit current density (Jsc) of the exemplary perovskite solar cells and thereby an enhanced solar cell efficiency. The findings reveal that an optimal morphology is obtained by adding 2.5 wt% GeNCs, showing the largest pore sizes inside films. The optimized structures obtained in 2.5 wt% GeNCs yields, correspondingly, the best device performance.

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