Improved energy conversion efficiency by TiO_2 hybrid films with nanoparticles and nanotubes in perovskite solar cells

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Organolead halide perovskite solar cells have recently attracted as their high energy conversion efficiency, low-cost production, simple process such as solution techniques at low temperatures, and flexibility since the first works by Miyasaka in 2009. In highest efficiency, perovskite structure ABX3 has a broad range of absorbed light and corresponds to materials bearing A (e.g., methylammonium or ethylammonium etc.), B (e.g., Pb or Sn etc.), and X (e.g., Cl, Br, or I etc.). To improve the energy conversion efficiency, we studied the metal oxide (e.g., Mg-doped Al2O3, TiO2, or ZnO), halide in perovskite (e.g., chloride, bromide, or iodide), or hole transfer materials (e.g., NiO). Mesoporous TiO2 nanoparticles are used as the electron acceptor and scaffold in perovskite solar cells because of their transmittance, crystallinity, stability, and large band gap. Compared to 0-dimensional structures, the electron transport is much improved wi 2-or 3-dimensional structures. We optimized the perovskite solar cells with TiO2 hybrid films, composed with TiO2 nanoparticles and nanotubes prepared by electrochemical method, for energy conversion efficiency.