Fabrication of Perovskite Solar Cell with Thickness-defendant TiO_2 Photoelectrode

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【Introduction】Perovskite solar cells (PeSCs) have made great attention in the last 5 years. The efficiencies of PeSCs have been improved from 3.8% to over 20% [1]. The TiO_2 thin layer is the most promising electron-transport material for PeSC [2]. For getting high efficiency PeSCs with suitable electronic property of TiO_2, several methods such as sol−gel, slot-die coating, spin-coating, electrodeposition, atomic layer deposition, and electron beam evaporation (EBE) have been used [3]. Among them, EBE is most advantageous technique because it is common, versatile and least expensive technology which can produce TiO_2 films with good optical and mechanical properties [4]. In this work, different thickness of TiO_2 films have been deposited on indium tin oxide (ITO) by EBE technique. The photovoltaic performance of PeSC with these TiO_2 films has been investigated.

【Experimental】At first, the ITO substrates were cleaned by the ultrasonic system in acetone, then distilled water, and then dried in pure N_2 steam flow. The different thickness of TiO_2 films were deposited on bare ITO substrate by EBE system. The film thicknesses of TiO_2 films were varied from 30-300 nm measured by computer controlled quartz-crystal. Perovskite layered was fabricated on TiO_2 by spin-coating method in N_2 environment. The Spiro-OMeTAD and gold materials are used as a hole transport material and metal contact, respectively. The prepared TiO_2 films and perovskite/TiO_2 were characterized by using X-ray photoelectron spectroscopy (XPS), field emission scanning electron microscope (FE-SEM). The active cell area was 0.04 cm^2. The photovoltaic performances of PeSCs were measured using a semiconductor device analyzer and solar simulator AM 1.5.

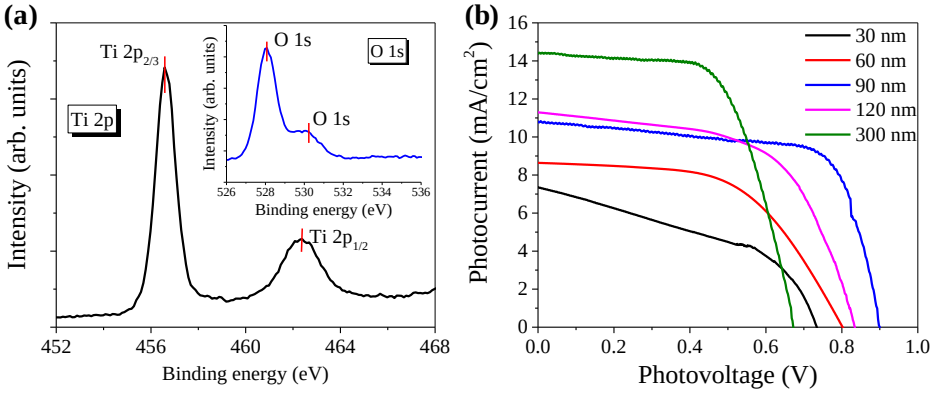

Fig. 1. (a) XPS spectra of TiO_2 films, and (b) I-V curves of PeSC with thickness dependent TiO_2 photoelectrode.

【Results and discussions】Figure 1(a) shows the XPS pattern of 300 nm thick TiO_2 films. The observed Ti $2p_{1/2}$ and $2p_{3/2}$ binding energy peaks are 456.4 and 462.3 eV, respectively, remain same for pure TiO_2. The O 1s spectrum shown in Inset of Fig. 1(a) also indicates that the binding energy of O 1s is resolved into three peaks i.e., 528.2, and 530 eV. The peak at 530 eV represents the O 1s level in the pure TiO_2, which is surrounded by TiO_2 atoms. Fig. 1(b) shows the I-V curves of PeSCs prepared with TiO_2 with different thickness. The PeSC with 90 nm thick TiO_2 film shows highest efficiency of 6.8% compared to PeSC with other thickness of TiO_2 films.

【Conclusion】The perovskite solar cell were successfully fabricated with thickness-dependent TiO_2 films. The cell performance was investigated with various thicknesses of TiO_2 films. The TiO_2 film was chemically pure and amorphous structure. The solar cell with 90 nm thick of TiO_2 film shows the maximum efficiency of 6.8% which is higher than the PeSC with other thickness of TiO_2 films.

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