Perovskite Solar Cells with E-beam Evaporated TiO_2 Photoelectrode

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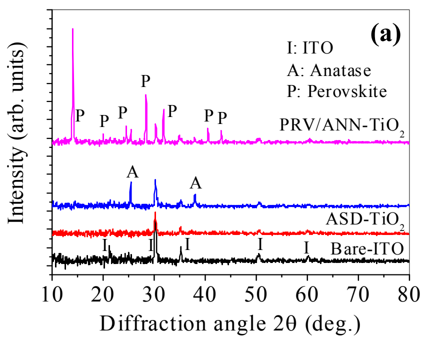
【Introduction】]. Perovskite solar cell (PSCs) has adopted the simple planar p−i−n architecture [1]: the perovskite layer is sandwiched between two electrode buffers that extract charge carriers selectively. The perovskite materials have recently emerged in the center of the field of photovoltaics because of their rapidly boosted power conversion efficiency (PCE) over 17% within 5 years, and their cost-effective and scalable processability [2]. Compact TiO_2 layer is most promising materials in PSCs [3]. Several methods such as atomic layer deposition (ALD), high-pressure pressing, chemical sintering, sol−gel, electron beam evaporation (EBE) and electrodeposition, have been reported in order to achieve comparable electronic properties for the TiO_2 layers [4,5]. Among them, EBE is most promising technique because it is most common, versatile and least expensive technology which can produce TiO_2 films with good optical and mechanical properties [5].

【Experimental】The TiO_2 films were deposited on indium-doped tin oxide (ITO) substrate by Electron-beam evaporation system. After that these prepared films were annealed at 450° C for 1 hour. The film thicknesses of all the TiO_2 films were around 90 nm measured by computer controlled crystal. Perovskite was layered 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 diffractometer (XRD), field emission scanning electron microscope (FE-SEM). The active cell area was 0.02 cm^2. The photovoltaic performances of PSCs were measured using a semiconductor device analyzer and solar simulator AM 1.5.



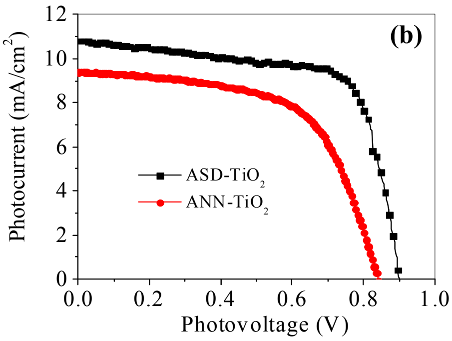


Table 1: Photovoltaic performance of PSCs

	ASD-TiO_2	ANN-TiO_2
Voc (mV)	900	840
Isc (mA/cm^2)	10.81	9.42
FF (%)	69.9	59.9
η (%)	6.78	4.01

Fig. 1. (a) XRD pattern of TiO_2 and PRV/TiO_2 films and (b) I-V curves of PSCs with ASD-TiO_2 and ANN-TiO_2 films.

【Results and discussions】Figure 1(a) shows the XRD pattern. Fig. 1(a) shows the XRD patterns of the TiO_2 and PRV/TiO_2 films deposited with ASD-TiO_2 and ANN-TiO_2. It is to be noted that almost the ASD-TiO_2 thin films has no crystalline peak, which is fully amorphous structure [5]. The ANN-TiO_2 films exhibit very good crystallization that corresponds to the formation of the anatase phase. The ANN-TiO_2 thin film shows highest peak-intensity which means that it has more surface mobility than ASD-TiO_2. Fig. 1(b) shows the I-V curves of PSCs prepared with ASD-TiO_2 and ANN-TiO_2 films. The PSC with ASD-TiO_2 shows highest efficiency of 6.8% compared to PSC with ANN-TiO_2 films.

【Conclusion】The perovskite solar cell were successfully fabricated with e-beam evaporated TiO_2 films. The cell performance was investigated with various substrate temperatures during deposition of TiO_2 films. The TiO_2 films had good crystallinity. The solar cell with ASD-TiO_2 shows the maximum efficiency of 6.8% which is higher than PSC with ANN-TiO_2. It may be due to compactness of ASD-TiO_2 compared to ANN-TiO_2. So, there is no leakage between perovskite and ITO.

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