Effect of Substrate Temperature on Structural, Optical and Surface Morphological properties of E-beam Evaporated TiO_2 Photoelectrode

Md. Faruk Hossain[1], Shigeki Naka, and Hiroyuki Okada[2] (University of Toyama)
E-mail: [1] dr.faruk_eee@ruet.ac.bd , and [2] okada@eng.u-toyama.ac.jp

【Introduction】Compact TiO_2 layer is most promising electron transport layer in solar cell applications [1]. Recently, comparable electronic properties for the TiO_2 layers have been achieved to deposit TiO_2 by several methods such as atomic layer deposition (ALD), high-pressure pressing, chemical sintering, sol−gel, electron beam evaporation (EBE) and electrodeposition [2, 3]. 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 [3].

【Experimental】The TiO_2 films were deposited on indium-doped tin oxide (ITO) substrate by EBE system with different substrate temperatures. The chamber was evacuated to a background pressure below 4×10^{-6} Torr, Perovskite was layered on TiO_2 by spin-coating method in N_2 environment. For fabrication of solar cell, Spiro-OMeTAD and gold materials were used as hole-transport material and metal contact, respectively. The prepared TiO_2 films 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.

【Results and discussions】Figure 1(a) shows the XRD pattern. The crystallinity of these films has great influenced by the substrate temperature. The crystallinity peaks are increased and strongest with the increase of substrate temperature. The TiO_2 films prepared at room temperature shows amorphous structure. Perovskite/TiO_2 electrode shows very crystalline peaks. From Fig. 1(b), the TiO_2 films have good transparency (~75%). The band edge of these films is red-shifted with increase of substrate temperature which means that the TiO_2 film with increased temperature is more photoactive. Figure 1(c) exhibits the FESEM image of TiO_2 films prepared with different substrate temperatures. It is cleared that the grain cluster are more visible and open with the increase of substrate temperature. The grain cluster size increases with increase of substrate temperature. The surface of perovskite layer on TiO_2 film is very uniform, compact with large cluster and more connection among grains.

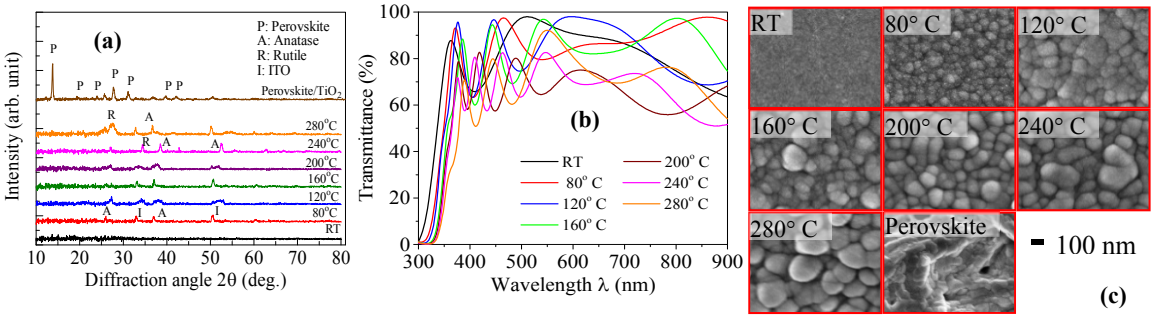

Fig. 1 (a) XRD pattern, (b) Transmittance spectra, and (c) FESEM images of TiO_2 electrode prepared with different substrate temperatures.

【Conclusion】 The TiO_2 electrode were successfully prepared by EBE system with different substrate temperatures. The TiO_2 films had good crystallinity. The surface of TiO_2 film was become more open and porous with visible grain cluster size. The cell performance was varied by these prepared TiO_2 electrodes with different substrate temperatures.

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【References】

[1]. N.G. Park, J. Phys. Chem. Lett. 4, 2423 (2013).
[2]. D. M. Rojas, H. Sun, D. C. Iza, J. Weickert, L. Chen, H. Wang, L. S. Mende, J. L. M. Driscoll, Progr. Photovoltaics, 21, 393 (2013).
[3]. M. F. Hossain, S. Naka, H. Okada, the 24th International Workshop on Active-Matrix Flat Panel Displays and Devices (AM-FPD), P-31, July 4-7, 2017, Ryukoku University Avanti Kyoto Hall, Kyoto, Japan.