Effect of Annealing Temperature on the performance of E-beam Evaporated TiO_2 Photoelectrode for the application of Perovskite Solar Cells

Md. Faruk Hossain[1], Yujiro Yoshibori, 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】 Solid-state sensitized heterojunction solar cells are presently under intense investigation because they present a promising avenue towards cost-effective high efficiency solar power conversion [1]. These devices use molecular dye or semiconductors in form of quantum dots or extremely thin absorber layers as light harvesting agents. Perovskite $(CH_3NH_3)PbI_3$ nanocrystals have attracted attention as a new class of light harvesters for mesoscopic solar cells [2]. The aim of this work is to investigate the effect of annealing temperature on the performance of TiO_2 photoelectrode. The TiO_2 films have been deposited on ITO substrate by electron beam evaporation at room temperature. The properties of as-deposited (ASD) and annealed (ANN) TiO_2 films have been investigated and discussed.

【Experimental】 The TiO_2 films were deposited on indium-doped tin oxide (ITO) substrate by Electron-beam evaporation system at room temperature [3]. After the chamber was evacuated to a background pressure below 4×10^{-6} Torr, The film thicknesses of all the TiO_2 films were around 150 nm measured by computer controlled crystal. Perovskite was layered on TiO_2 by spin-coating method. The α-NPD and MoO_3 were used as hole-transport material. The prepared TiO_2 films were characterized by using X-ray diffractometer (XRD), UV/VIS spectrophotometer, field emission scanning electron microscope (FE-SEM). The active cell area was 0.38 cm^2. The photovoltaic performances of DSCs were measured using a semiconductor parameter analyzer and solar simulator AM 1.5.

【Results and discussions】 Figure 1(a) shows the $(\alpha h\nu)^{1/2}$ versus photon energy curve which is draw by the help of Tauc formulae [4]; The ANN-TiO_2 shows the band gap E_g=2.25 eV which is red-shifted from the ASD-TiO_2 film (3.33 eV), which may be due to crystal formation. From Fig. 1(b), ASD-TiO_2 shows fully amorphous structure where ANN-TiO_2 have high crystalline with rutile and anatase phases. The prepare TiO_2 has also strong perovskite peak.. The Fig. 1(c) displays the difference of absorbance spectrum which is defined as D= (Absorbance of ANN-TiO_2 films)-(Absorbance of ASD-TiO_2 films). It is cleared that the perovskite can absorb the light, so this electrode is very photo-active, Inset of Fig. 1(c1) shows the FESEM image of Perovskite layer on TiO_2 film, which is uniformly distributed whole the surface. Moreover solar cell assembles by ANN-TiO_2 shows the better photovoltaic performance than the solar cell by the ASD-TiO_2 films.

【Conclusion】 The TiO_2 films were successfully fabricated on ITO substrate by electron-beam evaporation system. The ANN-TiO_2 films had good crystallinity. The solar cell with ANN-TiO_2 films was showed good

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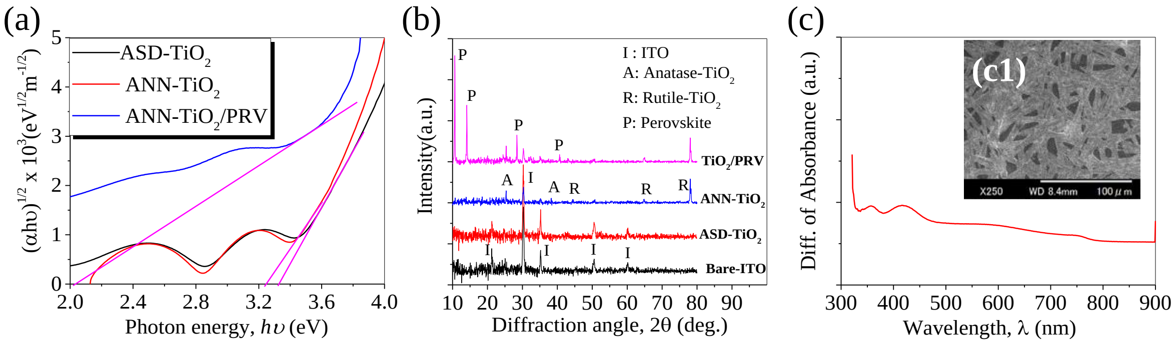

Fig. 1 (a) $(\alpha h\nu)^{1/2}$ versus photon energy curve; (b) XRD pattern for TiO_2/PRV, ANN-TiO_2, ASD-TiO_2, bare-ITO; and (c) Difference of absorbance spectrum, Inset (c1) SEM image of Perovskite layer on TiO_2 film.

【References】

[1]. Hui-Seon Kim et. al., Scient. Rep. 2: 591, 1 (2012).
[2]. Bach, U. et al. Nature 395, 583–585 (1998).
[3]. Y. Yoshibori et. al. Meet. JSAP Hokuriku-Shin-etsu Chapter, A10 (2016).
[4]. J.I. Pankove, Optical Processes in Semiconductors, Dover, New York, 1970, (Chapter 3) p. 34.