Low-Temperature-Processed Brookite-Based TiO_2 Heterophase Junction Electron Transport Layer Boosts Performance of Planar Perovskite Solar Cells

Kanazawa Univ.[1], Tokai Univ. [2], Waseda Univ.[3] Tohoku Univ.[4]

◦M. Shahiduzzaman,[1,2*] S. Visal,[2] M. Kuniyoshi,[2] T. Kaneko,[2] S. Umezu,[3] T. Katsumata,[2] M. Kakihana,[4] S. Iwamori[2], T. Taima,[1] M. Isomura,[2*] and K. Tomita[2*]

***E-mail: shahiduzzaman@se.kanazawa-u.ac.jp; isomura@tokai-u.jp; tomita@keyaki.cc.u-tokai.ac.jp**

Herein, we demonstrate the effects of different titanium oxide (TiO_2) polymorphs, anatase and brookite as electron transport layers (ETLs) to enhance the efficiency of planar perovskite solar cells (PSCs). We design and fabricate low-temperature (<180 °C)-processed brookite based TiO_2 heterophase junctions on fluorine-doped tin oxide (FTO) as the substrate. We investigate and compare anatase (A) and brookite (B) and heterophase anatase–brookite (AB) and brookite–anatase (BA) as ETLs in PSCs. The power conversion efficiencies (PCEs) of PSCs with low-temperature-processed FTO-B as the ETL were as high as 14.92% that is the highest reported efficiency of FTO-B-based single-layer PSC.[1] This signifies that FTO-B acts as an active phase and can be a potential candidate as an n-type ETL scaffold in planar PSCs. Moreover, PSCs with heterophase junction FTO-AB ETLs showed (**Figure a**) PCEs as high as 16.82% that is superior to those of PSCs with anatase (FTO-A; 13.86%) and brookite (FTO-B; 14.92%) as the ETLs. Furthermore, the PSCs with FTO-AB revealed enhanced efficiency and minimized hysteresis compared with those with FTO-BA (13.45%) owing to the better-match band alignment with the perovskite layer, which resulted in superior photogenerated charge carrier extraction and reduced charge accumulation at the interface between the heterophase junction and perovskite, as evidenced by photoluminescence and electrochemical impedance spectroscopy. The planar PSCs exhibited a spectral response that extended from the visible to the near-infrared region with flat absorption peak of intensity 70%–90% at 380–750 nm, as shown in **Figure b**. Therefore, the present work offers an effective strategy to develop heterophase junction ETLs and manipulate the interfacial energy band to further enhance the performance of planar PSCs and allow clean, and eco-friendly fabrication of low-cost mass production.

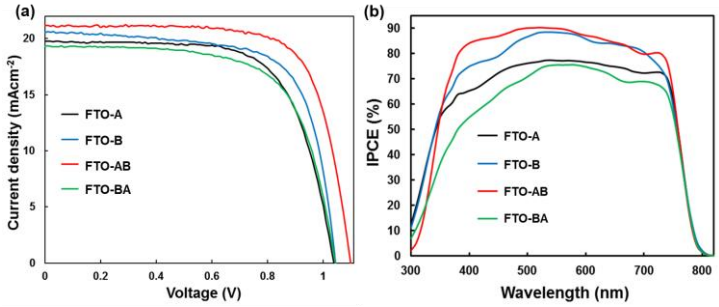

Figure (a) *J-V* characteristics of PSCs with FTO-A, FTO-B, FTO-AB and FTO-BA and (b) IPCE spectra of corresponding devices.

Keywords: Brookite TiO_2 nanoparticles; TiO_2 heterophase junction; planar perovskite solar cells.

1. Shahiduzzaman, M.; Visal, S.; Kuniyoshi, M.; Kaneko, T.; Umezu, S.; Katsumata, T.; Iwamori, S.; Kakihana, M.; Taima, T.; Isomura, M.; Tomita, K. *Nano Lett.* **2018**. (**DOI:** 10.1021/acs.nanolett.8b04744)