Preparation of high-efficiency all-perovskite tandem devices

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Although the efficiency of the organic-inorganic hybrid perovskite solar cell (PSCs) has reached 25.7%, it still has not surpassed silicon-based solar cells[1]. At the same time, poor stability also makes the competitiveness of single-layer PSCs not obvious compared with silicon solar cells. Since 2015, narrow bandgap PSCs have been widely reported due to their better light absorption[2]. However, wide bandgap perovskites should not be neglected as they are important for fabricating tandem PSCs[3]. Here, we demonstrate a series of monolayer molecules with different alkyl chain lengths as interfacial modifiers to modify the PTAA and perovskite layer for improving the optoelectronic properties of PSCs by improving the quality of perovskite films and increasing the transport and extraction of interfacial carriers. The target device achieves a PCE of 16.57%, which is one of the highest PCE of the WBG-PSCs. Besides, the all-perovskite tandem solar cells gave a high PCE of 25.24%.

Figure 1a shows the typical *J-V* curves of the control and target PSCs. The champion control device with a PCE of 14.46% (a short circuit current (J_{SC}) of 17.15 mA/cm², an opencircuit voltage (V_{OC}) of 1.117 V, and a fill factor (FF) of 75.53%), while the devices based on 3,3PrPACz, 4,3BuPACz, and 6,3HePACz modification got the highest PCE of 15.49% (a J_{SC} of 17.59 mA/cm², a V_{OC} of 1.141 V and an FF of 77.20%), 16.57%, and 15.29%, respectively. Figure 1b exhibits the corresponding incident photon-to-electron conversion efficiency (IPCE) spectra of the best-performing control device and PTAA/monolayer molecules devices, with the integrated current densities of 16.99 mA/cm² for the control device, 17.34 mA/cm² for the 3,3PrPACz-modified device, in good agreement with the *J-V* characterization. Finally, all-perovskite tandem solar cells were fabricated further to improve the PCE of PSCs. The structure of the solar cell is exhibited in Figure 1c. Figure 1d presents the *J-V* curves of the cells modified by 4,3BuPACz. A high PCE of 24.21% was obtained (a J_{SC} of 16.210 mA/cm², a V_{OC} of 1.793 V, and an FF of 83.3%) with forwarding scan and 23.92% with reverse scan (a J_{SC} of 16.028 mA/cm², a V_{OC} of 1.757 V and an FF of 84.9%), which shows the negligible hysteresis.



Figure 1 a) J-V curves and (b) IPCE curves of the champion devices without and with monolayer

molecule modification. (c) Schematic structure of all-perovskite tandem solar cell employed in this work. (d) *J-V* curves of the champion all perovskite tandem solar cells with 4,3BuPACz modification.

Reference

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