Supporting Information

Efficient panchromatic inorganic-organic heterojunction solar cells with consecutive charge transport tunnels in hole transport material

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The TiO$_2$ (anatase) colloidal solution was prepared according to a previous report.\textsuperscript{1} Subsequently, it was diluted in ethanol at 1:2.5 by weight and stirred overnight to form a paste. Patterned conducting fluorine-doped SnO$_2$ (FTO) glass (15 Ω/□) was etched with Zn powder and 2 M aqueous HCl solution. Then it was cleaned with successive sonication in milliQ water, isopropanol and acetone for 5 min and dried with clean dry air. To make a dense TiO$_2$ under layer, the cleaned FTO glass was immersed in 0.15 M aqueous TiCl$_4$ solution at 60 °C for 30 min. After rinsing with water, it was dried with clean dry air and sintered in air at 510 °C for 30 min. The TiO$_2$ paste was deposited on FTO glass by using a spin-coating technique at the speed of 2000 rpm for 30 s and annealed in air at 510 °C for 30 min. The TiO$_2$ film was ~600 nm in thickness measured by a surface profilometer (XP-2, AMBIOS Technology Inc., USA). CH$_3$NH$_3$PbI$_3$ precursor solution was prepared according to a previous report.\textsuperscript{2} The CH$_3$NH$_3$PbI$_3$ precursor solution was spin-coated on TiO$_2$ films at speed of 2000 rpm for 30 s and dried at 100 °C for 20 min in glovebox. The hole transport material (HTM) was a chlorobenzene solution containing 10 mg/mL P3HT, 0.2 M 4-tert-butylpridine (TBP), 0.06 M bis (trifluoromethane) sulfonimide lithium salt. A second P3HT solution with MWNTs accounting for 2 wt% of P3HT was also prepared. Thereafter the different HTM solutions were coated on the CH$_3$NH$_3$PbI$_3$ deposited TiO$_2$ films using spin-coating technique at 2000 rpm for 50 s and dried at 120 °C for 30 min in glovebox. Then a gold electrode was deposited on top by magnetic sputtering. The active area of the hybrid solar cells was 0.09 cm$^2$. For DC conductivity measurement, P3HT or P3HT-MWNTs solution was cast on clean glass and dried in a glovebox. The Van der Pauw four-probe method, using Keithley 2402 source meter, was employed for conductivity measurement of the P3HT and P3HT-MWNTs samples.
Fig. S1 X-ray Diffraction (XRD) pattern of (a) TiO$_2$ and (b) CH$_3$NH$_3$PbI$_3$ deposited on TiO$_2$.

In Fig. S1b, the peaks with "*" were attributed to TiO$_2$ and the peaks without one were attributed to CH$_3$NH$_3$PbI$_3$.

Fig. S2 TEM image of (a) TiO$_2$ nanoparticles, (b) CH$_3$NH$_3$PbI$_3$ deposited TiO$_2$ nanoparticles and (c) magnified picture of CH$_3$NH$_3$PbI$_3$ deposited TiO$_2$.
