# Supporting Information

## Improved Charge Extraction through Interface Engineering for 10.12%-efficiency and Stable $CsPbBr_3$ Perovskite Solar Cells

Jingwei Zhu,[a] Mixue Tang,[a] Benlin He,*[a] Wenyu Zhang,[a] Xueke Li,[a] Zekun Gong,[a] Haiyan Chen,[a] Yanyan Duan[c] and Qunwei Tang*[b]

[a] *School of Materials Science and Engineering, Ocean University of China, 238 Songling Road, Qingdao 266100, P.R. China*

[b] *College of Information Science and Technology, Jinan University, 601 Huangpu Avenue West, Guangzhou 510632, P.R. China*

[c] *State Centre for International Cooperation on Designer Low-Carbon and Environmental Material (SCICDLCEM), School of Materials Science and Engineering, Zhengzhou University, Zhengzhou 450001, P.R. China*

*** Corresponding Authors**. E-mail: blhe@ouc.edu.cn, tangqunwei@jnu.edu.cn

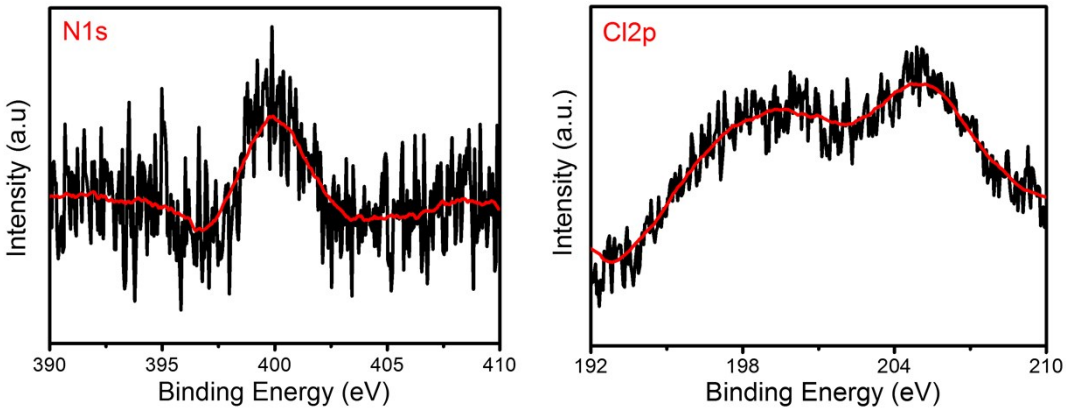


**Fig. S1.** N1s and Cl2p XPS spectra of $TiO_2$/AC sample.

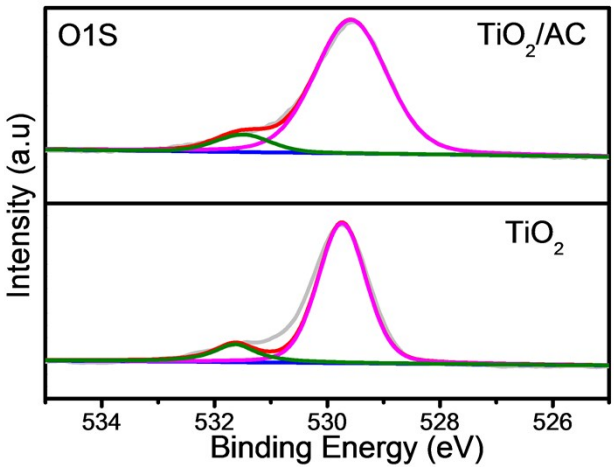


**Fig. S2.** The deconvoluted O1s XPS spectra of different $TiO_2$ films.

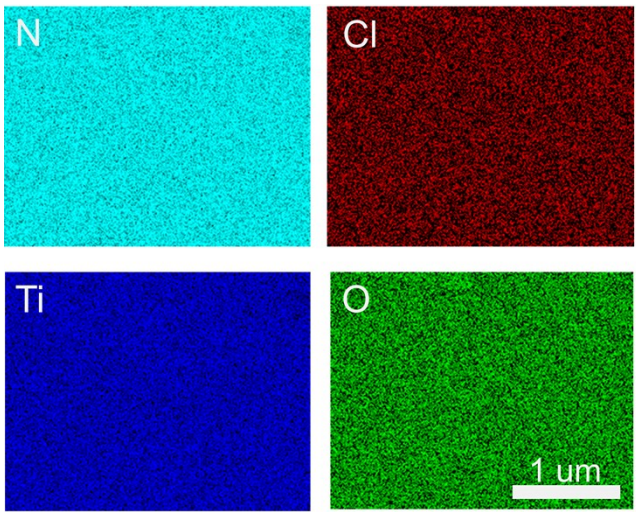


**Fig. S3.** EDS mapping images of N, Cl, Ti and O from *m*-$TiO_2$/AC film.

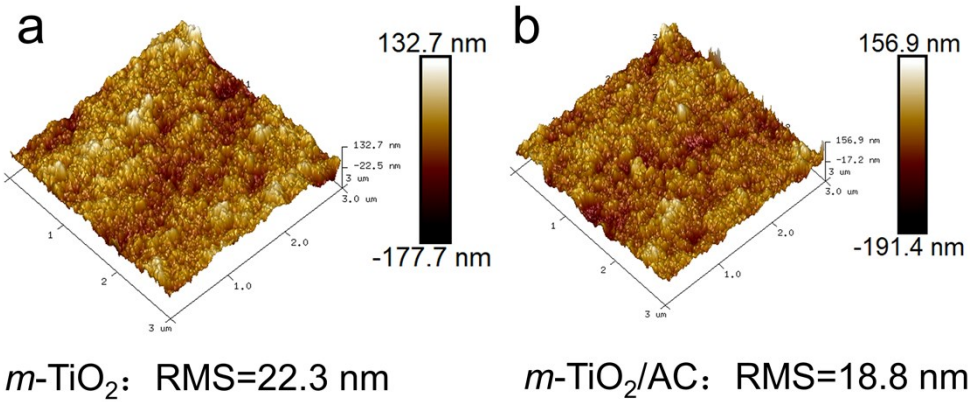


**Fig. S4.** AFM images of different *m*-$TiO_2$ films.

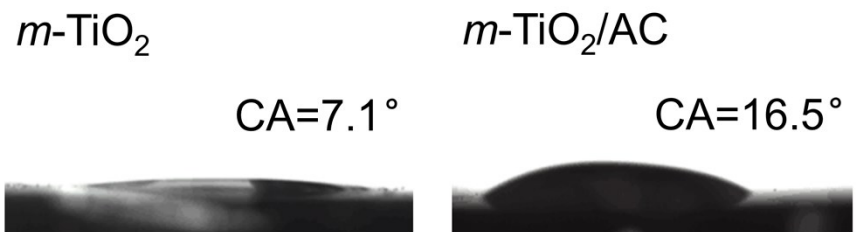


**Fig. S5.** The contact angle of DMF on the different *m*-$TiO_2$ films.

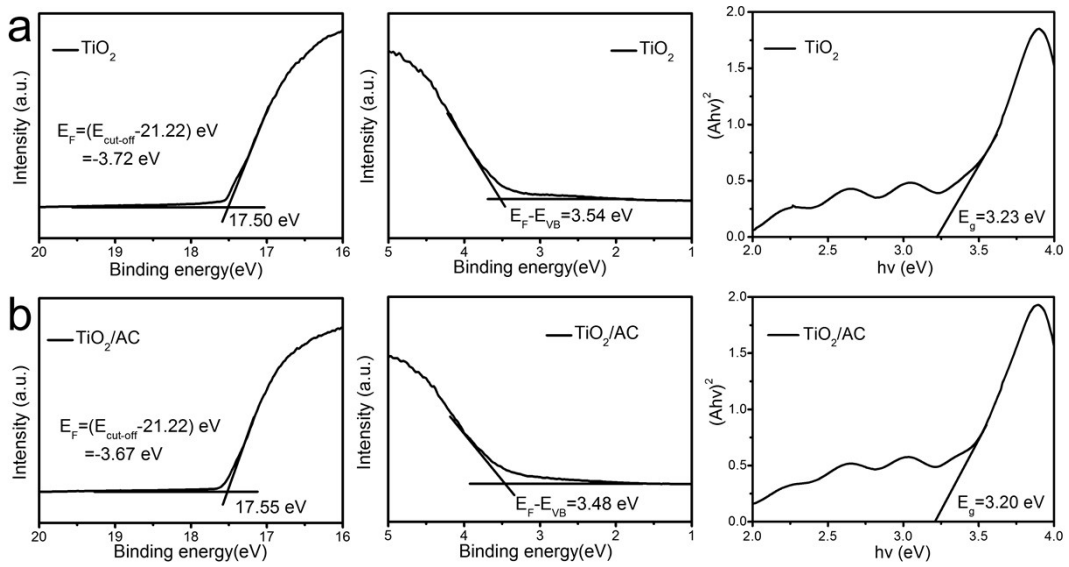


**Fig. S6.** Ultraviolet photoelectron spectra (UPS) and the Tauc plots for various $TiO_2$ films.

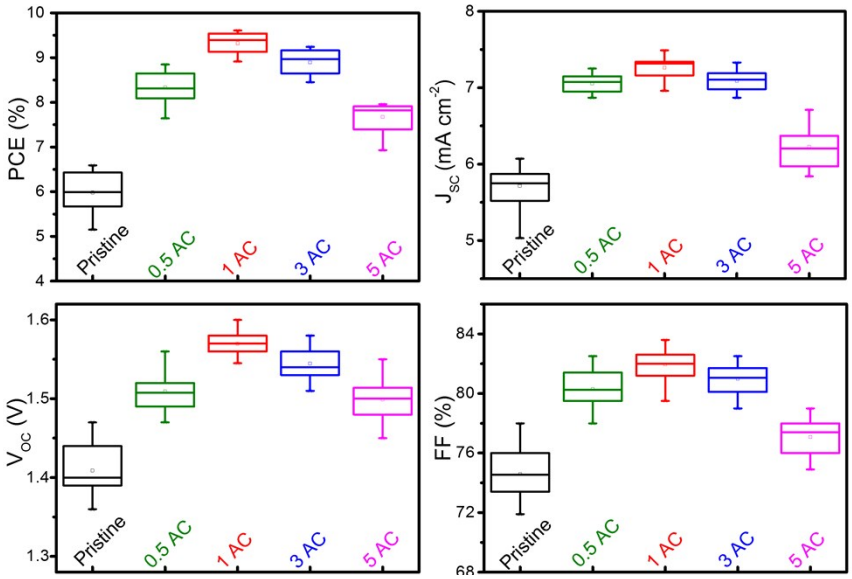


**Fig. S7.** Statistical distribution of PCE, $J_{SC}$, $V_{OC}$ and FF for thirty random control and AC modified devices.

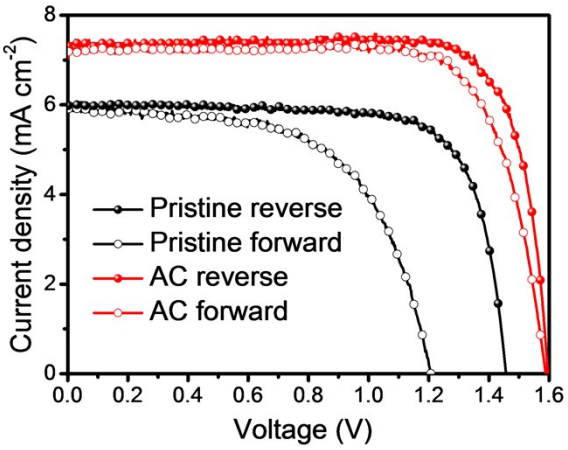


**Fig. S8.** Hysteresis analysis of control and AC modified $CsPbBr_3$ PSCs.

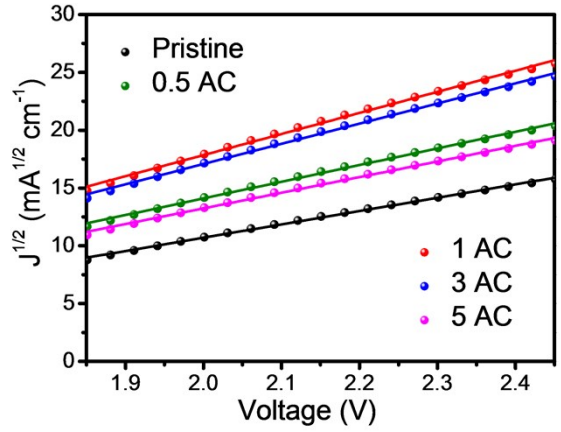


**Fig. S9.** The $J^{1/2}$-$V$ curves of the electron-only devices with a structure of FTO/$TiO_2$/without or with AC/$CsPbBr_3$/PCBM/Carbon.

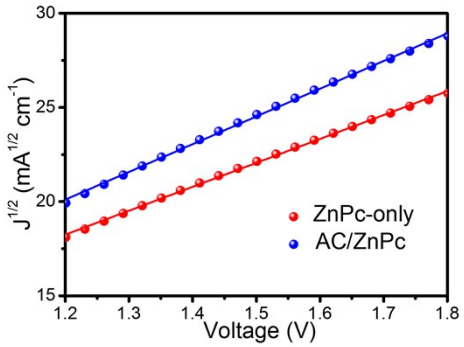


**Fig. S10.** The $J^{1/2}$-$V$ curves of various hole-only devices.

**Table S1.** The FWHM of the main peaks of different $PbBr_2$ films in XRD.

| Planes | (011) | (101) | (111) | (013) | (004) | (201) |
|---|---|---|---|---|---|---|
| $PbBr_2$ | 0.056 | 0.089 | 0.125 | 0.073 | 0.027 | 0.136 |
| AC/$PbBr_2$ | 0.073 | 0.112 | 0.143 | 0.082 | 0.039 | 0.153 |

**Table S2.** The $V_{TFL}$, $N_t$, $J_D$ and $\mu_e$ value of various samples.

| samples | $V_{TFL}$ (V) | $N_t$ ($10^{16}$ $cm^{-3}$) | $J_D$ ($10^{15}$ $cm^{-2}$) | $\mu_e$ ($10^{-5}$ $cm^2$ $V^{-1}s^{-1}$) |
|---|---|---|---|---|
| Pristine | 1.175 | 1.411 | 1.32 | 4.06 |
| 0.5 AC | 1.136 | 1.364 | 2.57 | 8.11 |
| 1 AC | 1.094 | 1.314 | 6.92 | 23.20 |
| 3 AC | 1.125 | 1.352 | 5.22 | 16.80 |
| 5 AC | 1.162 | 1.396 | 1.71 | 5.32 |

**Table S3.** The carrier lifetimes obtained from TRPL spectra of various $CsPbBr_3$ samples.

| Samples | $\tau_{ave}$ (ns) | $\tau_1$ (ns) | $A_1$ (%) | $\tau_2$ (ns) | $A_2$ (%) |
|---|---|---|---|---|---|
| Pristine | 0.51 | 0.34 | 62.14 | 2.51 | 37.86 |
| 0.5 AC | 0.25 | 0.15 | 54.33 | 1.70 | 45.67 |
| 1 AC | 0.18 | 0.13 | 67.78 | 1.15 | 32.22 |
| 3 AC | 0.20 | 0.14 | 67.02 | 1.59 | 32.68 |
| 5 AC | 0.28 | 0.17 | 56.97 | 1.76 | 43.03 |

**Table S4.** The carrier lifetimes obtained from TRPL spectra of various $CsPbBr_3$ samples.

| Samples | $\tau_{ave}$ (ns) | $\tau_1$ (ns) | $A_1$ (%) | $\tau_2$ (ns) | $A_2$ (%) |
|---|---|---|---|---|---|
| ZnPc-only | 0.20 | 0.14 | 69.96 | 1.27 | 30.04 |
| AC/ZnPc | 0.12 | 0.09 | 70.32 | 0.76 | 29.68 |