Supporting information for

The Detrimental Effect of Excess Mobile Ions in planar

CH$_3$NH$_3$PbI$_3$ Perovskite Solar Cells

*Yuanhang Cheng, [a] Ho-Wa Li, [a] Jian Qing,[a, b] Qing-Dan Yang,[a] Zhiqiang Guan,[a, b]*

Chen Liu,[a] Sin Hang Cheung,[c] Shu Kong So,[c]Chun-Sing Lee,[a, b] Sai-Wing Tsang[a]*

[a]Department of Physics and Materials Science, City University of Hong Kong, Hong
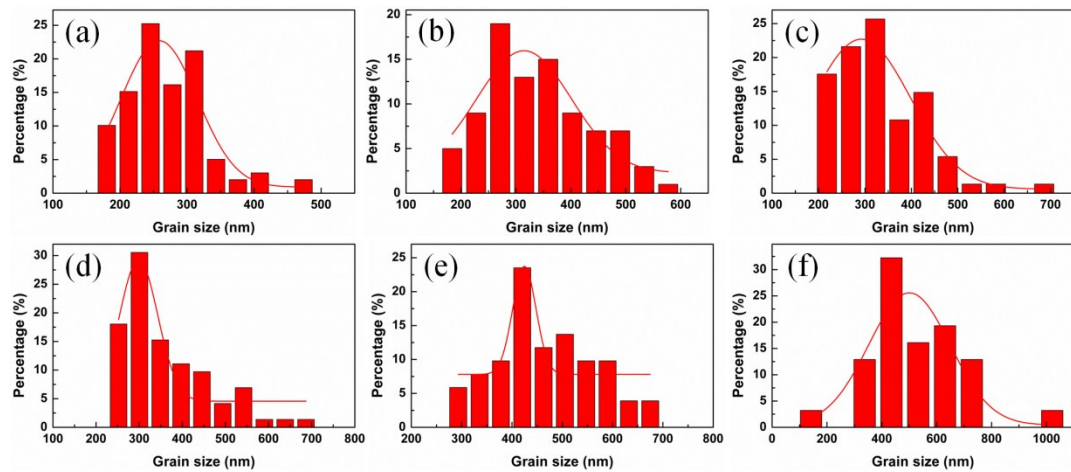
Kong SAR, P. R. China

[b]Center of Super-Diamond and Advanced Films (COSDAF), City University of Hong

Kong, Hong Kong SAR, P. R. China

[c]Department of Physics, Kong Kong Baptist University, Hong Kong SAR, P. R.

China

Corresponding author: saitsang@cityu.edu.hk (S-W Tsang)
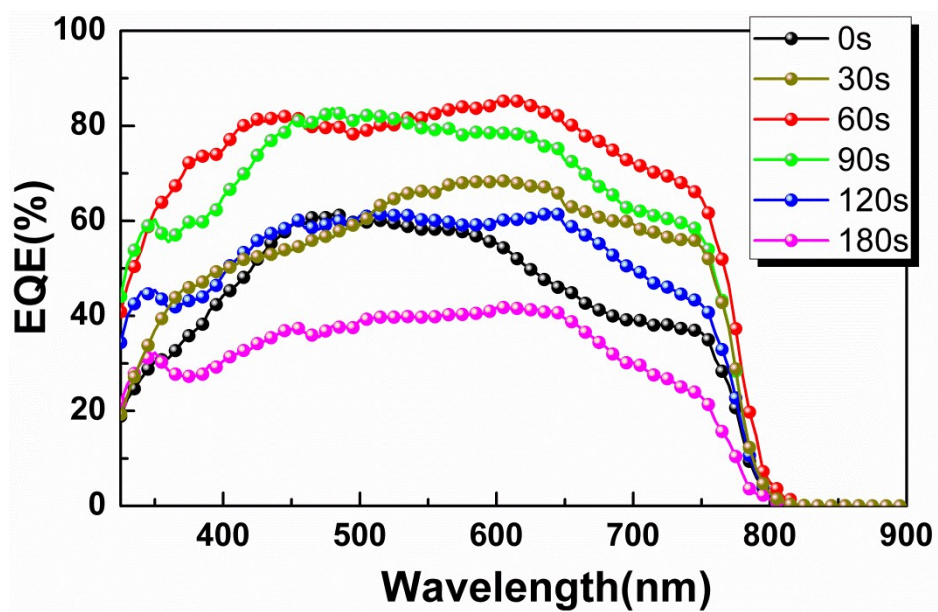
Figure S1 EQE spectra of perovskite solar cells with different MAI loading times from 0 s to 180 s.

Figure S2 The grain size distribution of perovskite films prepared with different MAI loading times ranging from (a) 0 s, (b) 30 s, (c) 60 s, (d) 90 s, (e) 120 s, and (f) 180 s.
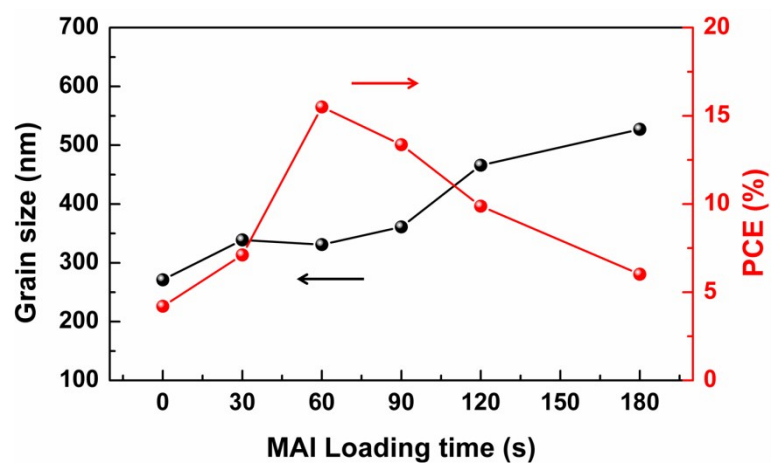
Figure S3 Evolution of perovskite grain size and PCE of the devices upon the MAI loading time in the perovskite films preparation procedure.
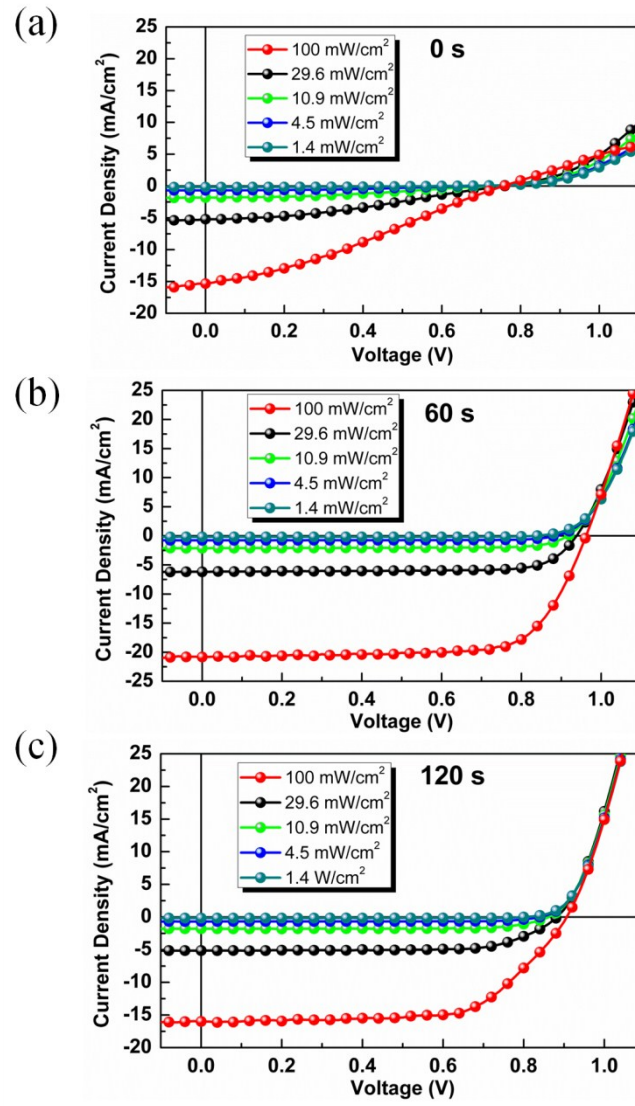
Figure S4 Light intensity dependent *J-V* characteristics of perovskite solar cells prepared with different MAI loading times (a) 0 s, (b) 60 s, and (c) 120 s.
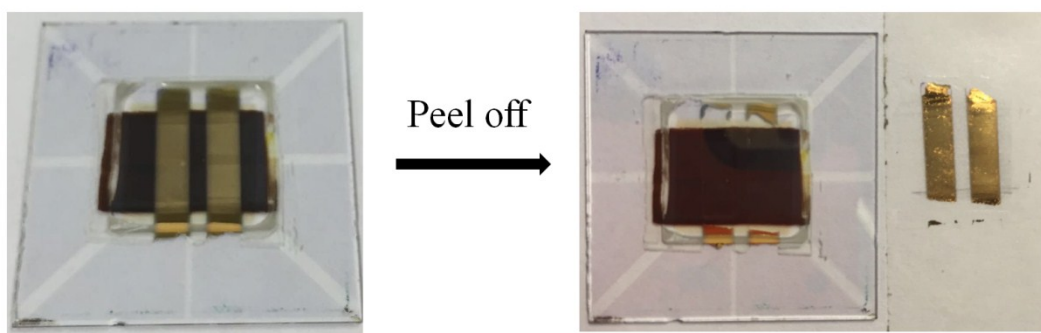
Figure S5 Peel off the Au electrode from the perovskite solar cell using the tape for the XRD measurements.
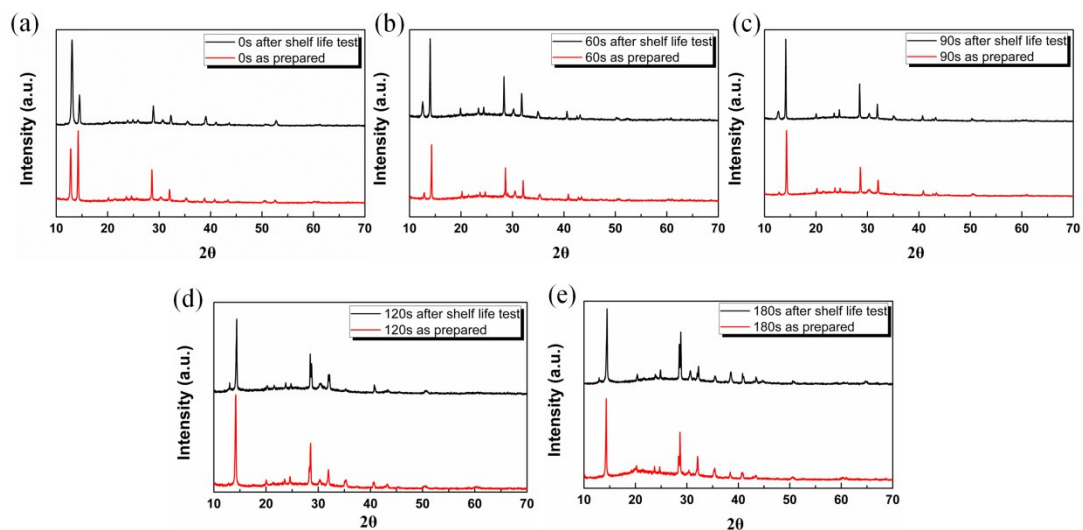
Figure S6 XRD patterns of perovskite films prepared with different MAI loading times (a) 0 s, (b) 60 s, (c) 90 s, (d) 120 s, and (e) 180 s before and after the shelf-life tests.
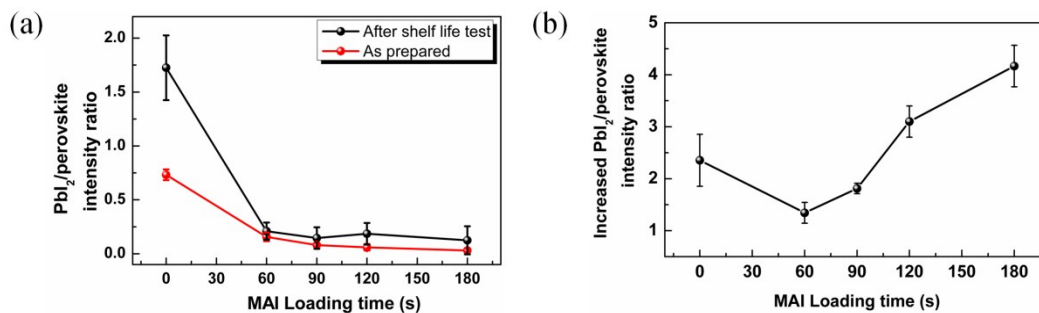
Figure S7 (a) Intensity ratio of PbI$_2$ and perovskite extracted from the XRD patterns of perovskite films prepared with different MAI loading times. (b) Increased PbI$_2$/perovskite intensity ratio extracted from the XRD patterns employing the following equation:

$$increased\ PbI_2/perovskite\ intensity\ ratio = \frac{PbI_2\ /\ perovskite\ (after\ shelf-life\ tests)}{PbI_2\ /\ perovskite\ (before\ shelf-life\ tests)}.$$
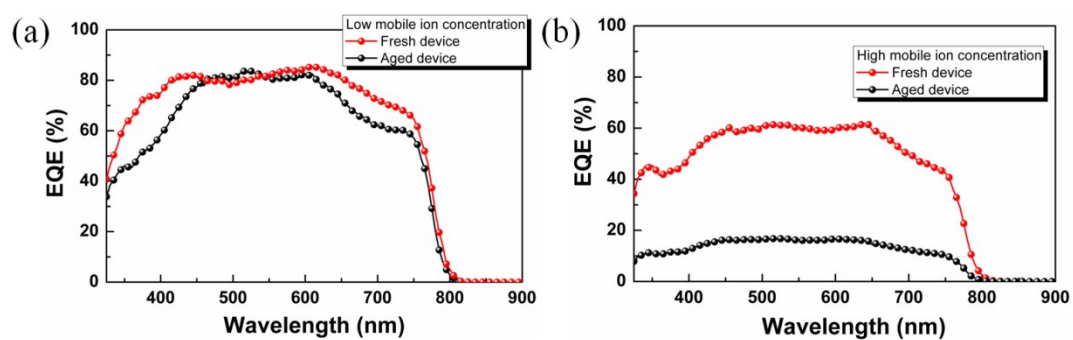
Figure S8 EQE spectra of perovskite solar cells with low (a) and high (b) mobile ion concentration before and after shelf-life measurements.