Direct Observation of Cation-Exchange in Liquid-to-Solid

Phase Transformation in FA_{1-x}MA_xPbI₃ Based Perovskite

Solar Cells

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Figure S1. Detailed view of main XRD peak of MOCPs prepared with NSPS $FA_{0.85}MA_{0.3}PbI_3$ without thermal annealing (stand still for 5 min after spin-coating) and annealed at 130 °C for 2 or 10 min respectively.



Figure S2. Steady state photoluminescence spectrum of pure FA_{0.85}MA_{0.15}PbI₃.



Figure S3. a) XRD patterns of perovskite films prepared with precursor solution $FAPbI_3$ and $FAPbI_3 \cdot 0.3MAI$ annealed at 130 °C for 10 min, b) UV-Vis results of films corresponding to Figure S3a.

Annealing time (min)	V _{oc} [V]	J _{sc} [mA/cm ²]	FF [%]	РСЕ
3	0.95	12.9	55	6.7
5	0.96	16.4	65	10.2
8	0.96	21.6	72	14.9
10	0.96	21.1	73	14.8

Table S1 Device performance of PVSCs fabricated with NSPS $FA_{0.85}MA_{0.3}PbI_3$ adopting different annealing time.



Figure S4. a) XRD patterns of MOCPs prepared with NSPS $FA_{0.85}MA_{0.3}PbI_3$ annealed at 130 °C for 3, 5, 8 and 10 min, respectively. b) SEM results of MOCPs corresponding to Figure S4a.



Figure S5. Top view SEM images of MOCPs prepared with precursor solution of $FA_{0.85}MA_{0.15}PbI_3$, $FA_{0.85}MA_{0.17}PbI_3$, $FA_{0.85}MA_{0.2}PbI_3$, $FA_{0.85}MA_{0.3}PbI_3$, respectively, the scale bar is 1 μ m.



Figure S6. AFM images of MOCPs derived from $FA_{0.85}MA_xPbI_3$ precursor solutions, x ranges from 0.15 to 0.3, the roughness (root mean square (RMS)) is decreased from 39.9 nm (MOCP prepared with SPS $FA_{0.85}MA_{0.15}PbI_3$) to 31.7 nm (MOCP prepared with NSPS $FA_{0.85}MA_{0.3}PbI_3$).