

Stress Regulation via Surface Micro-etching and Reconstruction for Enhancing Triple-Cation Perovskite Solar Cells with the Efficiency of 25.54%

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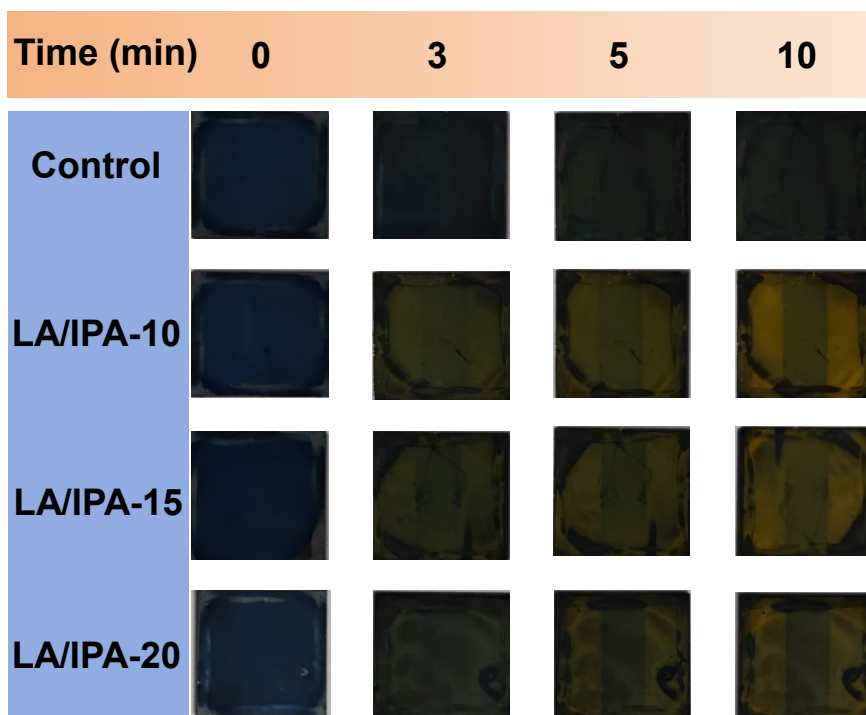


Figure S1. The state change of perovskite films soaked in mixed solution with the different LA/IPA ratio for 10 minutes.

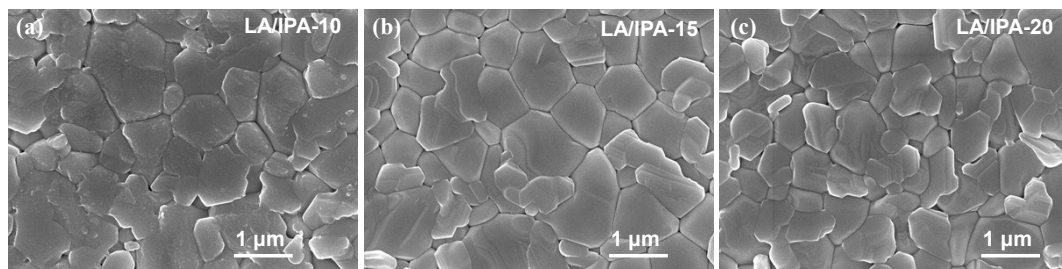


Figure S2. Surface SEM images of perovskite films etched by mixed solutions with the different LA/IPA ratios of a) 1:10, b) 1:15 and c) 1:20.

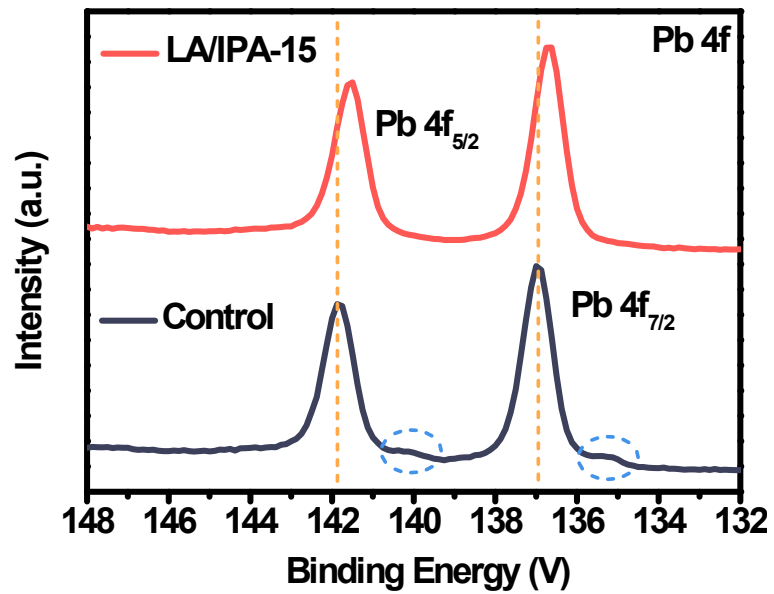


Figure S3. The XPS spectra of Pb 4f for control and LA/IPA-15 treated perovskite films.

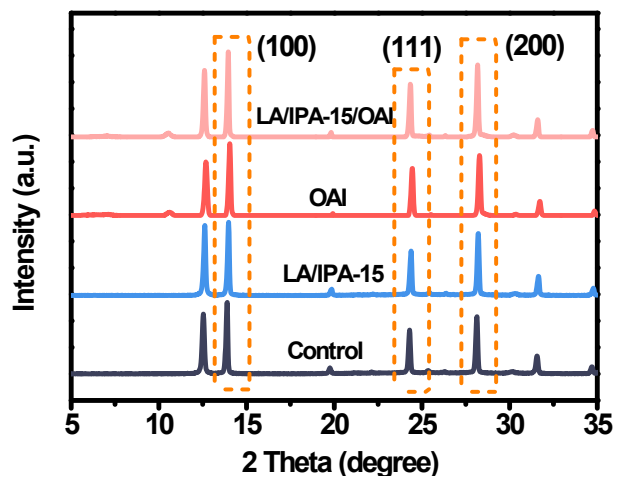


Figure S4. XRD pattern of control, LA/IPA-15, OAI and LA/IPA-15/OAI treated perovskite films.

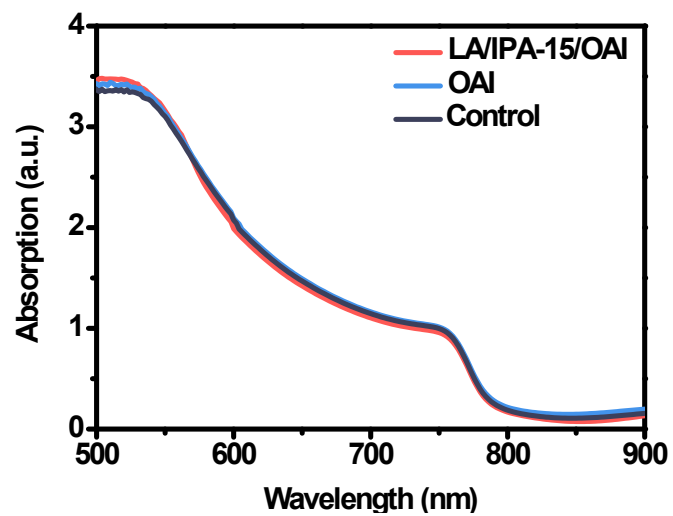


Figure S5. UV-vis light absorption spectrum of different perovskite films.

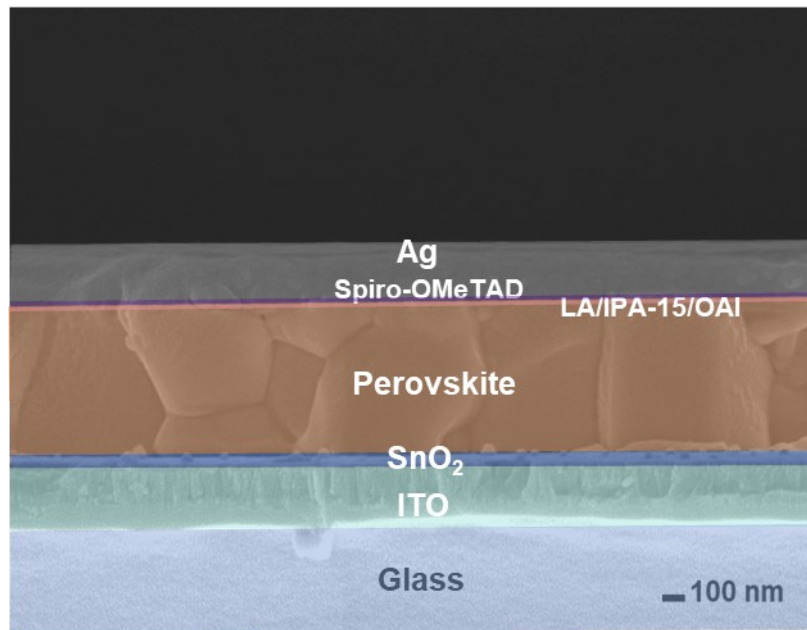


Figure S6. Cross-section SEM images of the LA/IPA-15/OAI treated device.

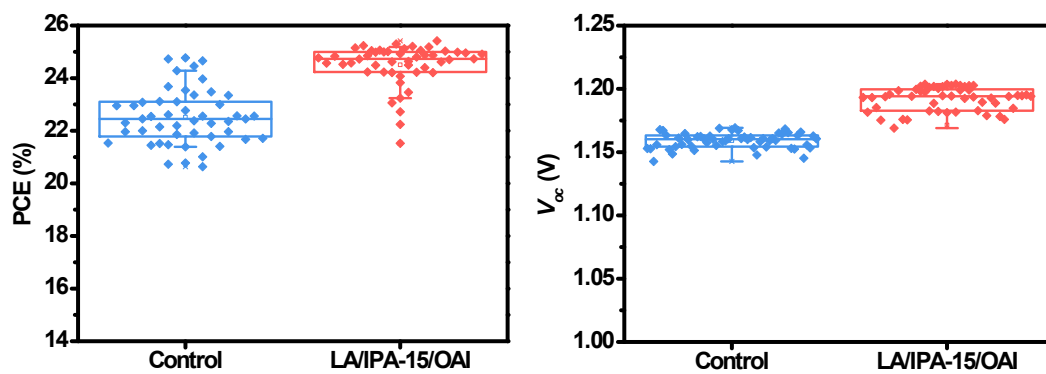


Figure S7. Statistical diagram of PCE and V_{oc} for the control and LA/IPA-15/OAI treated PSCs.

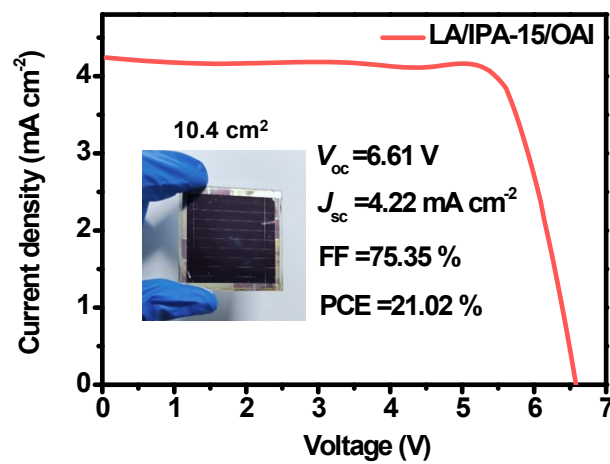


Figure S8. J - V curve of LA/IPA-15/OAI treated PSC mini-module with an area of 10.4 cm^2 .



Figure S9. Water contact angle (CA) of perovskite films with different treatments.

Table S1. The fitting parameters of TRPL spectra for the control and target samples.

Samples	A_1	τ_1 (ns)	A_2	τ_2 (ns)	τ_{ave} (ns)
Control	1.04	21.90	0.16	127.04	77.47
LA/IPA-15/OAI	0.34	58.84	0.27	359.90	308.52

Table S2. The fitting data of EIS for the control and target devices.

Samples	$R_s (\Omega)$	$R_{tran} (\Omega)$	$R_{rec} (\Omega)$
Control	68	4390	11425
LA/IPA-15/OAI	34	2141	21587

Table S3. Photovoltaic performance statistics of representative triple-cation PSCs during the past three years.

Perovskite component	V_{oc} (V)	J_{sc} (mA cm ⁻²)	FF (%)	PCE (%)	Year	Ref.
$\text{Cs}_{0.05}(\text{FA}_{0.98}\text{MA}_{0.02})_{0.95}\text{Pb}(\text{I}_{0.98}\text{Br}_{0.02})_3$	1.17	24.85	81.33	23.68	2022	[S1]
$(\text{CsPbI}_3)_{0.05}[(\text{FAPbI}_3)_{0.97}(\text{MAPbBr}_3)_{0.03}]_{0.9}$	1.21	25.21	80.12	24.43	2022	[S2]
$(\text{Cs}_{0.05}\text{FA}_{0.95}\text{PbI}_3)_{0.975}(\text{MAPbBr}_3)_{0.025}$	1.18	25.58	82.11	24.78	2023	[S3]
$\text{Cs}_{0.07}\text{FA}_{0.9}\text{MA}_{0.03}\text{Pb}(\text{I}_{0.92}\text{Br}_{0.08})_3$	1.20	24.50	81.80	24.20	2023	[S4]
$(\text{Cs}_{0.05}\text{FA}_{0.75}\text{MA}_{0.20})\text{Pb}(\text{I}_{0.96}\text{Br}_{0.04})_3$	1.20	25.58	82.68	25.43	2023	[S5]
$\text{Cs}_{0.03}\text{FA}_{0.945}\text{MA}_{0.025}\text{Pb}(\text{I}_{0.975}\text{Br}_{0.025})_3$	1.16	25.07	84.88	24.74	2024	[S6]
$\text{Cs}_{0.07}\text{FA}_{0.9}\text{MA}_{0.03}\text{Pb}(\text{I}_{0.975}\text{Br}_{0.025})_3$	1.20	25.25	82.99	25.04	2024	[S7]
$\text{Cs}_{0.03}\text{FA}_{0.945}\text{MA}_{0.025}\text{Pb}(\text{I}_{0.975}\text{Br}_{0.025})_3$	1.20	25.40	83.79	25.54	2024	This work

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