Supporting Information

Interdiffusion-controlled nucleation strategy for efficient sequential deposited perovskite photovoltaics

Chenglin Wang[a], Zuolin Zhang[a], Xuefan Zhao[a], Yunfei Zhu[a], Mengjia Li [a], Jike Ding[a], Cong Chen[a]*

[a]State Key Laboratory of Reliability and Intelligence of Electrical Equipment, School of Materials Science and Engineering, Hebei University of Technology, Tianjin 300401, China

*Corresponding authors
E-mail: chencong@hebut.edu.cn (C.C)

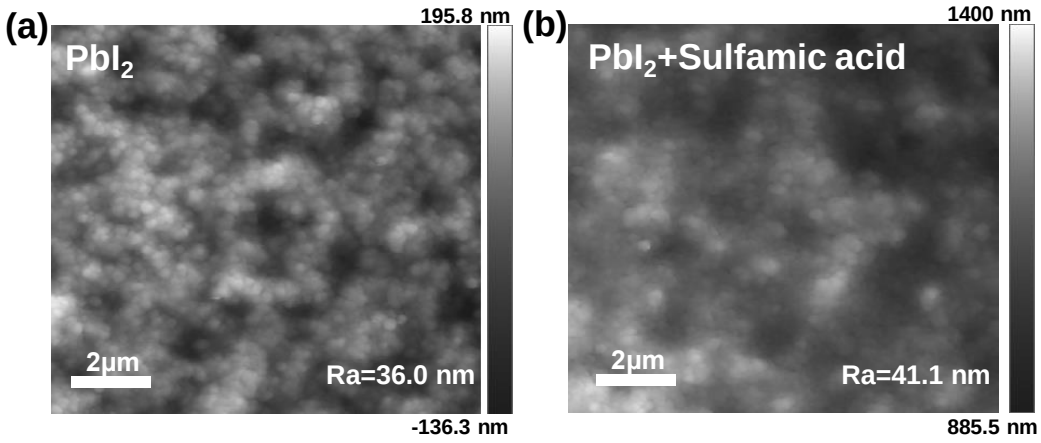

Fig.S1. Surface roughness of (a) the PbI_2 film and (b) the PbI_2 film with ICN modification, which was measured by AFM.

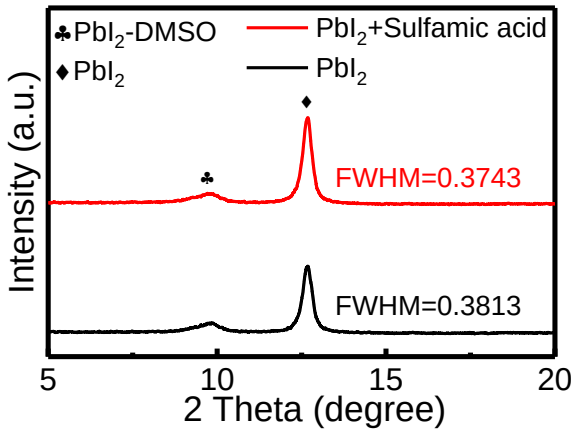

Fig. S2. XRD patterns spectra of the PbI_2 films without and with Sulfamic acid modification.

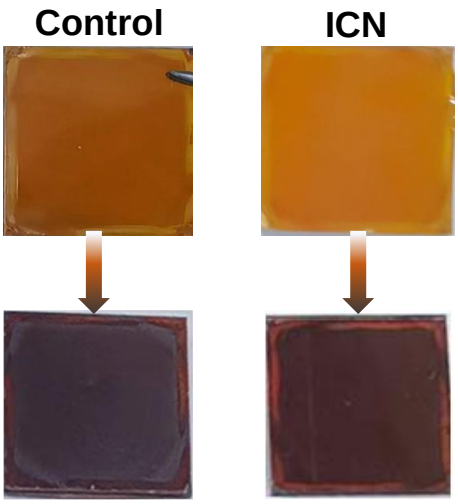

Fig.S3. Photograph of unannealed perovskite films over time.

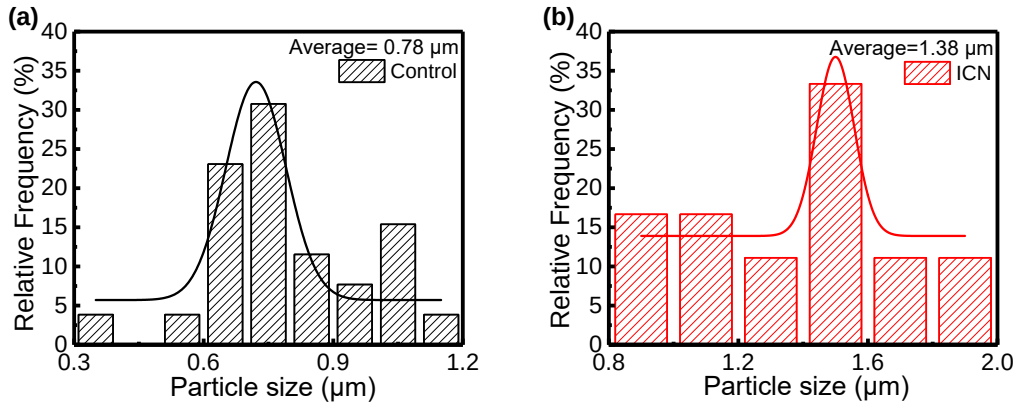

Fig.S4. Statistical distribution of grain size of the perovskite films (a) without and (b) with ICN modification.

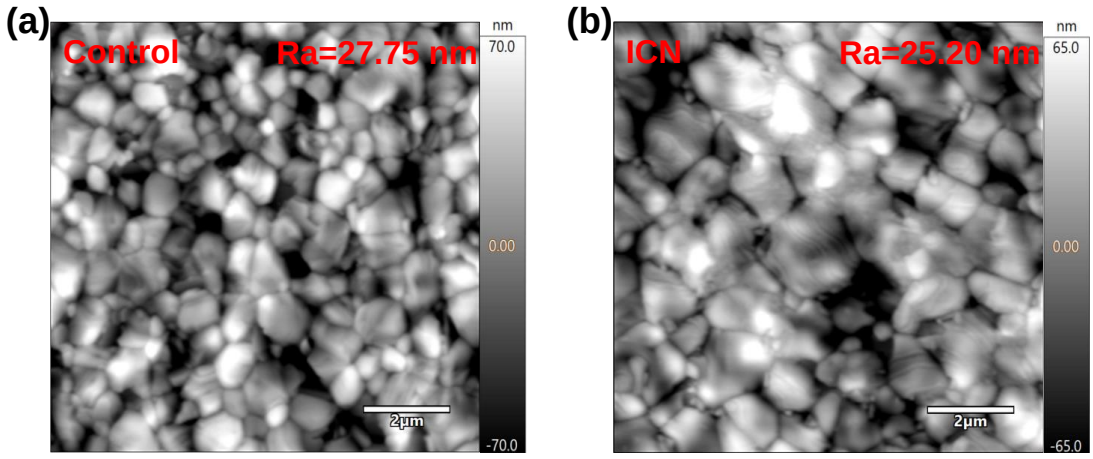

Fig.S5. Surface roughness of the perovskite films (a) without and (b) with ICN modification, which were measured by AFM.

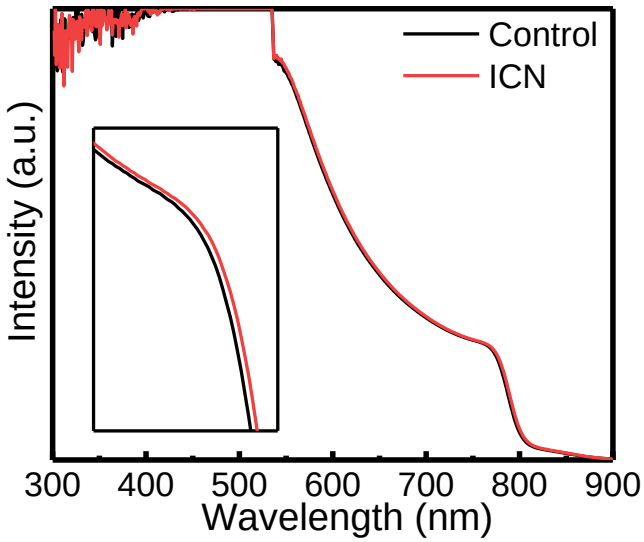

Fig.S6. UV−vis absorption spectra of the perovskite films with and without ICN modification.

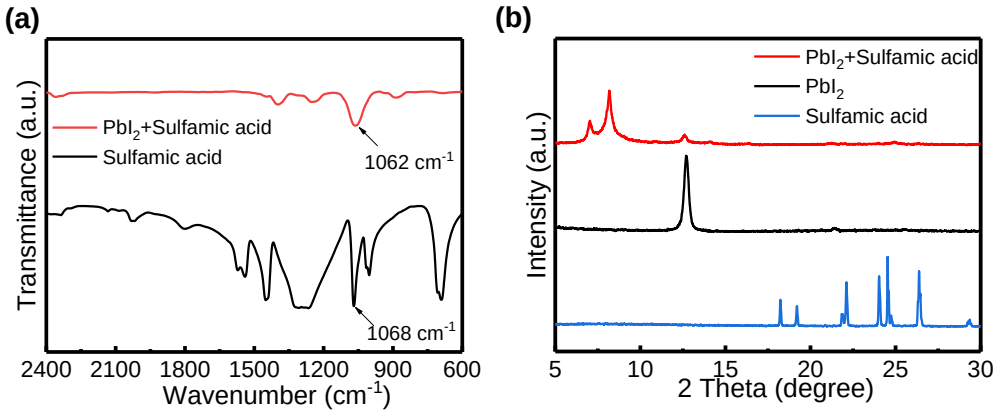

Fig.S7. (a)Fourier transform infrared spectroscopy of Sulfamic acid powder and PbI_2+ Sulfamic acid. (b)XRD patterns spectra of PbI_2 with ICN modification, PbI_2, and Sulfamic acid.

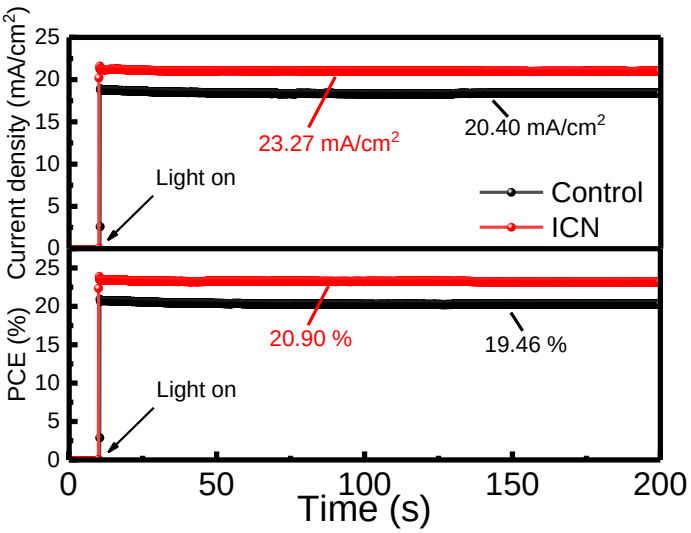

Fig.S8. Current density and PCE were measured at the maximum power point for 200 s.

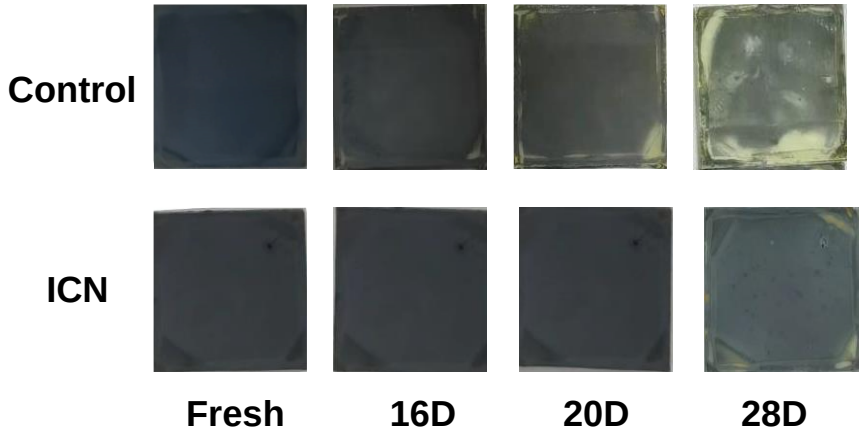

Fig.S9. Photos of morphological changes of the control and the perovskite films with ICN modification over time.

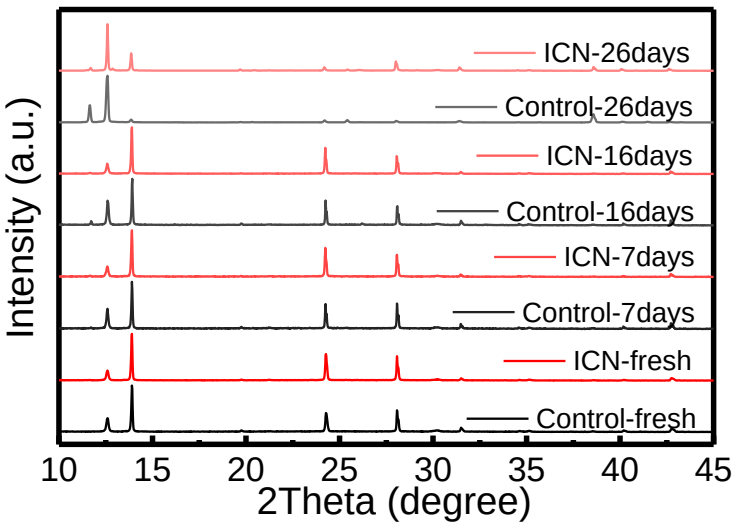

Fig.S10. XRD patterns of the perovskite films over time.

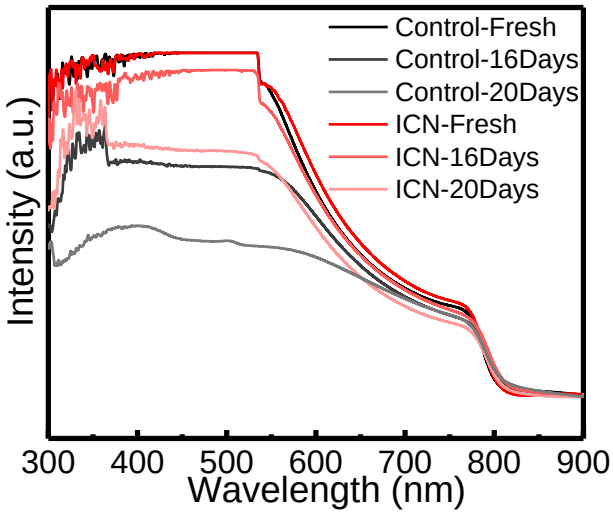

Fig.S11. UV-bis absorption spectrum of the perovskite films change over time.

In addition, we also performed SCLC on the electron transport layer-only devices (Fig. S12b). Calculation analysis confirmed that the V_{TFL} of control and ICN-modified perovskite films is 0.14 V and 0.11 V, respectively. Consequently, the trap density of the control and ICN-modified perovskite films were calculated to be 2.41×10^{15} cm^{-3} and 1.89×10^{15} cm^{-3}, respectively.

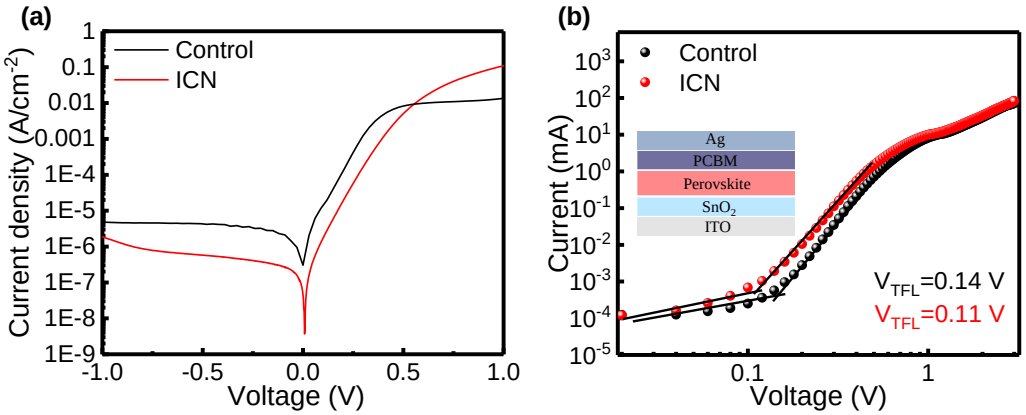

Fig.S12. (a)The dark current of the PSCs with and without ICN modification. (b) Dark J–V curves of the electron transport layer-only devices.

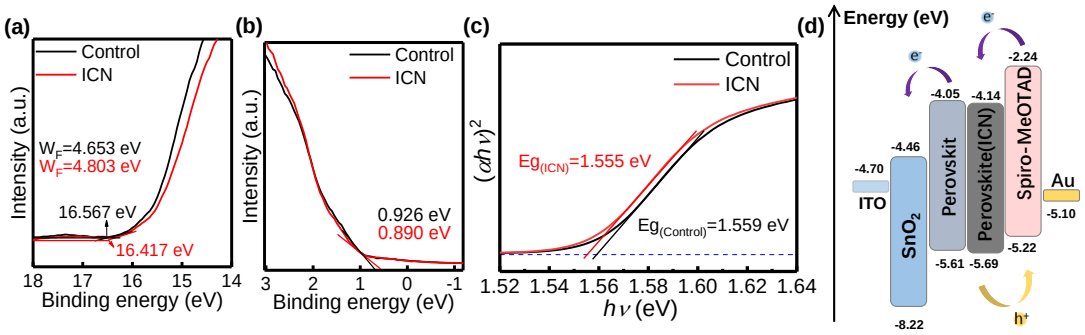

Fig.S13. (a, b) Ultraviolet photoelectron spectra of control and perovskite film with ICN modification, respectively. (c) UV−vis absorption spectra of control and the perovskite film with ICN modification. (d) Energy level diagram of device components.

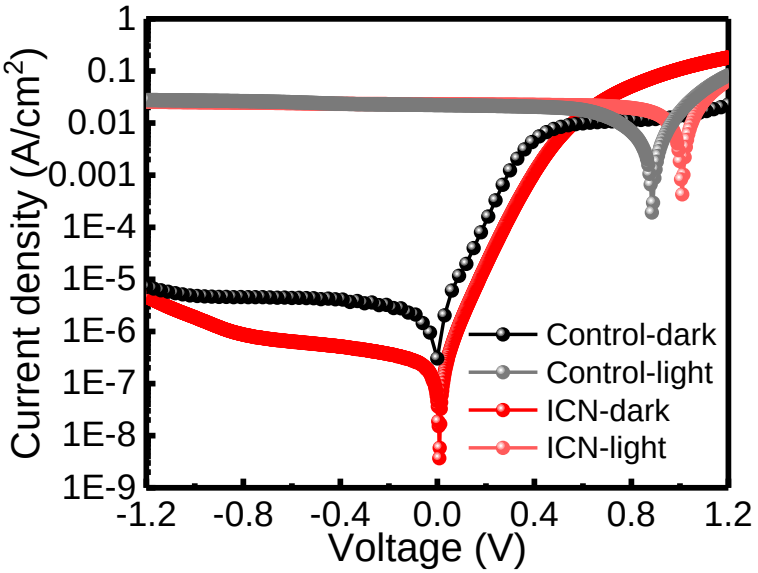

Fig.S14. *J-V* curves of the devices in the dark and under white light illumination (100 mW/cm2).

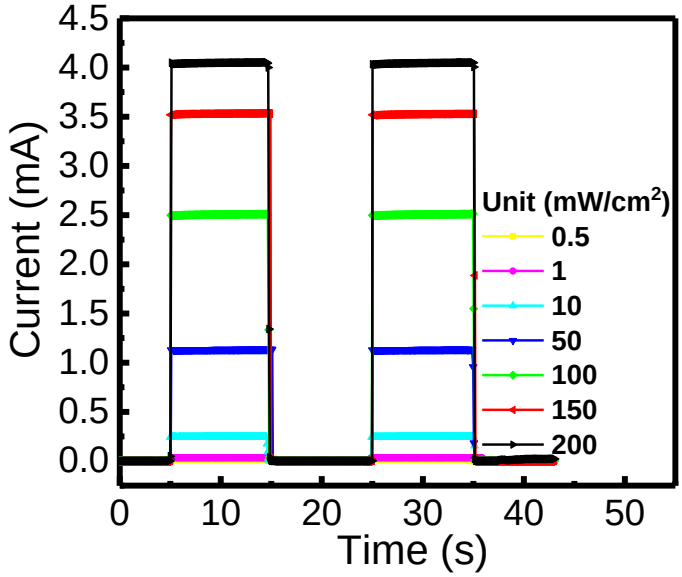

Fig.S15. *I*−*T* curves of the pristine photodetector under various light intensities under 0 V bias.

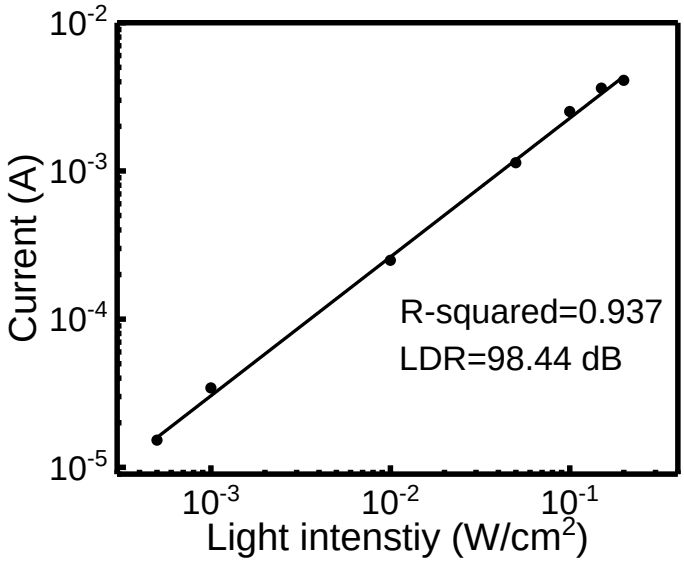

Fig.S16. Power-dependent photocurrent under 0 V bias for the pristine photodetector.

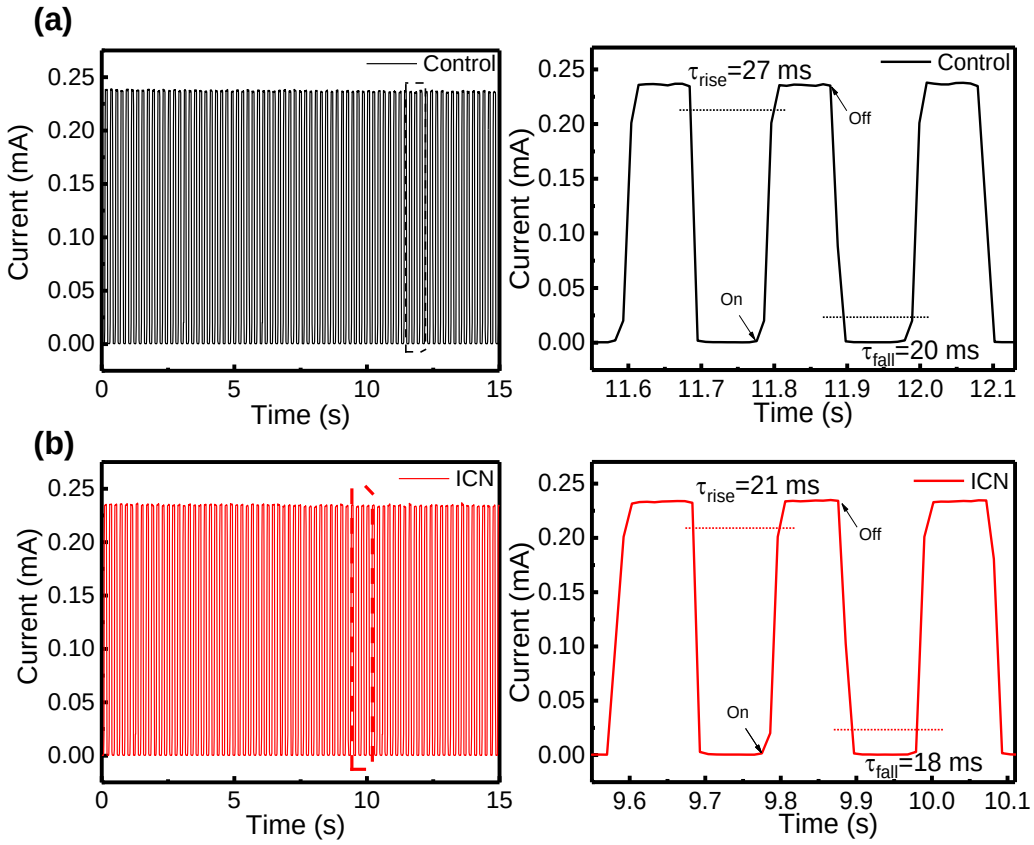

Fig.S17. The photocurrent response curves of (a) the pristine photodetector and (b) the pristine photodetector with ICN modification under 810 nm light source, respectively. Corresponding rise and decay time from the enlarged photocurrent response curve of photodetectors are shown in the right part.

Table S1. Photovoltaic parameters of the PSCs ($FA_xMA_{1-x}Pb(I_yBr_{1-y})_3$) based on the control and the ICN-treated PSCs measured in reverse scan (RS).

Devices	V_{OC} (V)	J_{SC} (mA/cm)	FF (%)	PCE (%)
Control-Avg	1.119	24.84	74.54	20.67
Control-Max	1.127	24.95	76.87	21.09
ICN-Avg	1.135	25.05	77.49	22.04
ICN-Max	1.141	25.21	77.84	22.41

Table S2. Photovoltaic parameters of the PSCs ($FAPbI_3$) based on the control and the ICN-treated PSCs measured in reverse scan (RS).

Devices	V_{OC} (V)	J_{SC} (mA/cm)	FF (%)	PCE (%)
Control-Avg	1.124	25.38	76.78	21.90
Control-Max	1.129	25.18	77.63	22.06
ICN-Avg	1.144	25.72	77.60	22.85
ICN-Max	1.154	25.47	78.51	23.08

Table S3. Fitting data of TRPL curves in Figure 4f based on double exponential function.

Samples	τ_1(μs)	A_1	τ_2(μs)	A_2	τ_{ave}(μs)
Glass/PVSK	0.85	0.42	4.30	0.58	3.87
Glass/PVSK(ICN)	1.31	0.27	7.62	0.73	7.23