

Supplementary Information for

Suppressing Charge Carrier Recombination in Halide Perovskite Solar Cells by Ferroelectric Polarization

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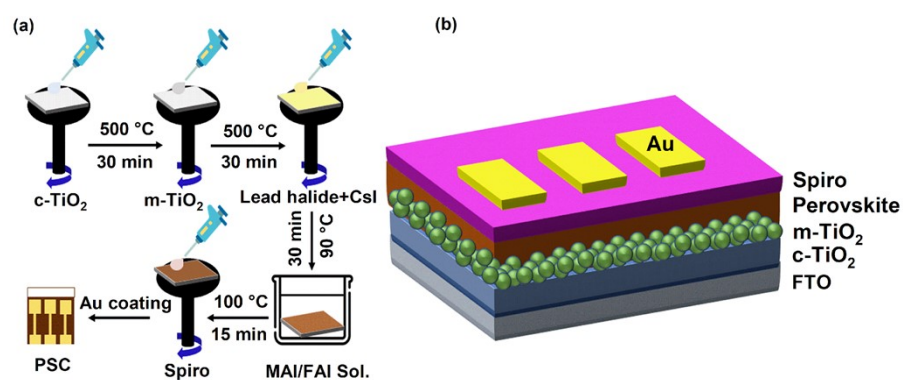


Figure S1. (a) Fabrication method and (b) schematic structure of PSC.

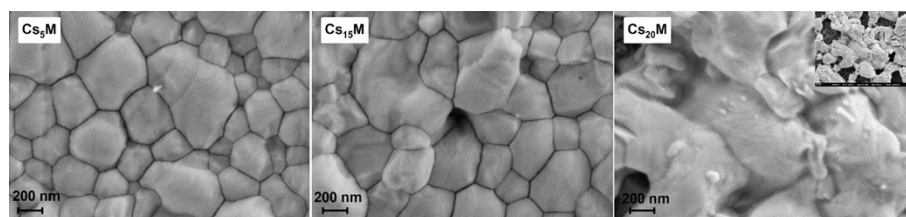


Figure S2. FESEM images of the perovskite layers fabricated with varying amounts of CsI.

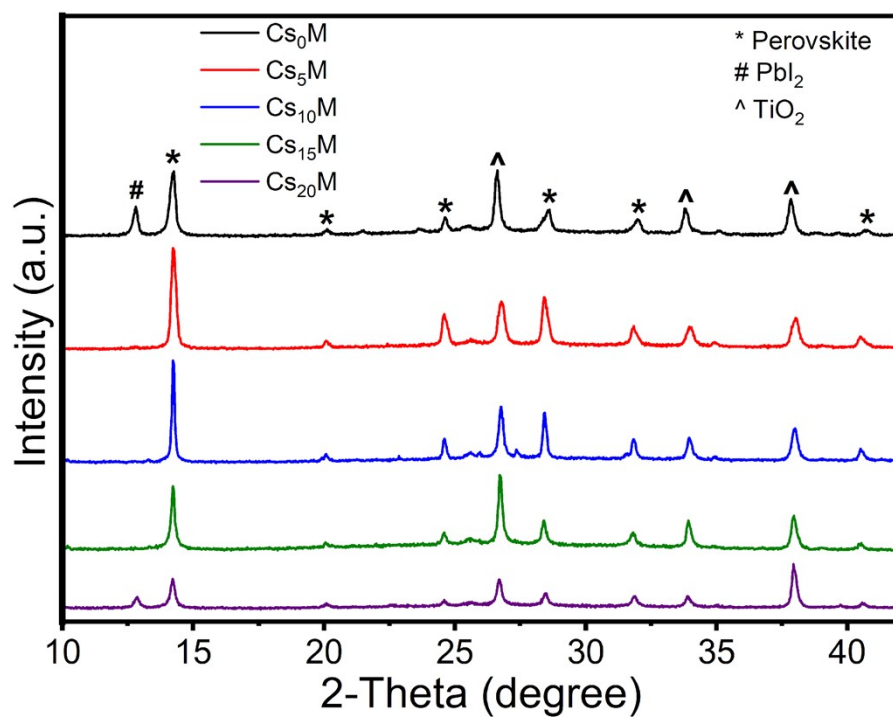


Figure S3. XRD patterns of the perovskite layers fabricated with varying amounts of CsI.

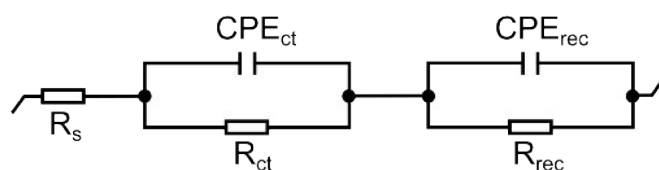


Figure S4. An equivalent circuit diagram used to analyze Nyquist plots. CPE represents a constant phase element, R_s , R_{ct} , and R_{rec} are series, charge transfer, and recombination resistances, respectively.

Table S1. R_{ct} and R_{rec} data of Cs_xM PSCs prepared with varying amounts of CsI.

PSCs	R_{ct} (Ω)	R_{rec} (Ω)
Cs_0M	81	768
Cs_5M	78	984
$Cs_{10}M$	80	1043
$Cs_{15}M$	84	915
$Cs_{20}M$	82	556

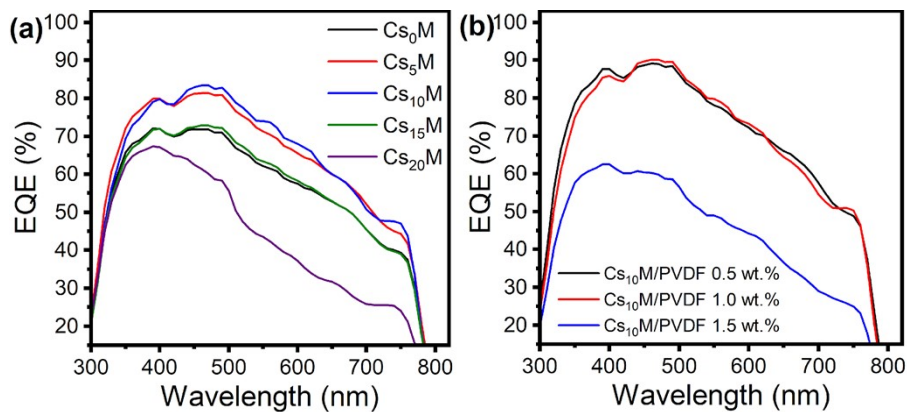


Figure S5. External quantum efficiency (EQE) of PSCs with (a) varying CsI and (b) PVDF amounts.

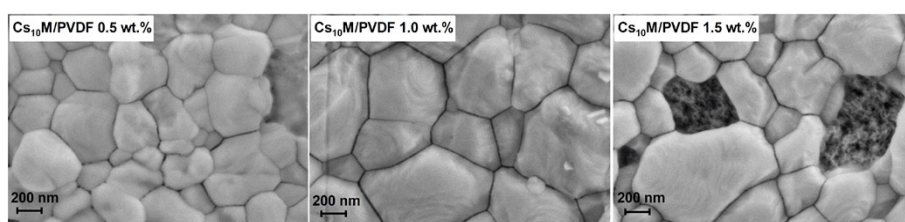


Figure S6. FESEM images of Cs_{10}M prepared with different amounts of PVDF.

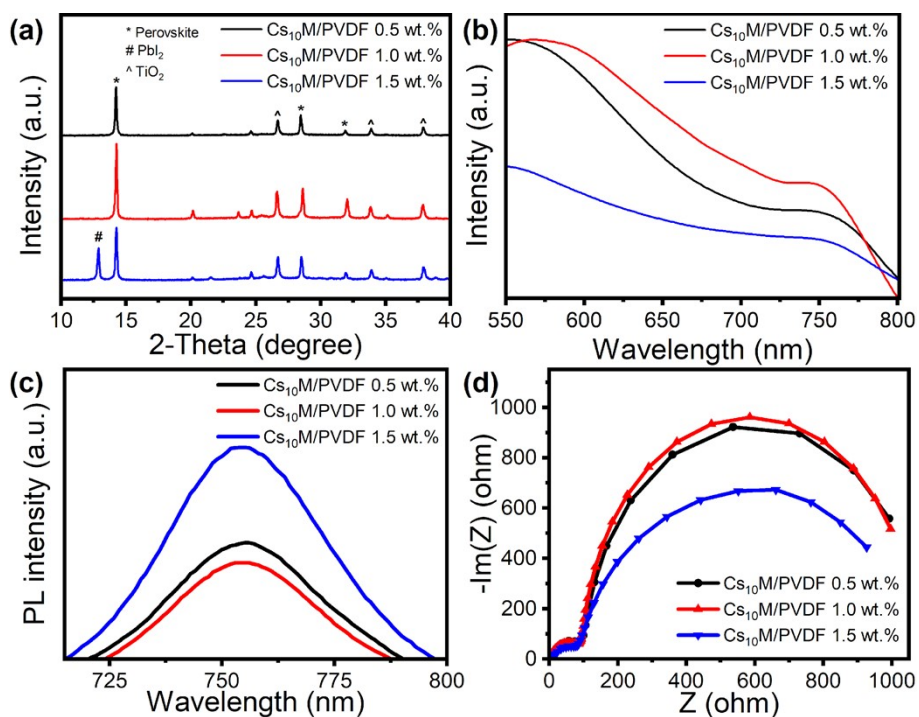


Figure S7. XRD patterns of the perovskite layers (a), UV-Vis absorption (b), SS-PL spectra (c), and EIS (d) of different perovskite layers with 10 wt.% CsI and varying amounts of PVDF.

Table S2. R_{ct} and R_{rec} data of $Cs_{10}M$ PSCs prepared with varying amounts of PVDF.

PSCs	R_{ct} (Ω)	R_{rec} (Ω)
$Cs_{10}M/0.5$ wt.% PVDF	82	1194
$Cs_{10}M/1.0$ wt.% PVDF	80	1245
$Cs_{10}M/1.5$ wt.% PVDF	81	673

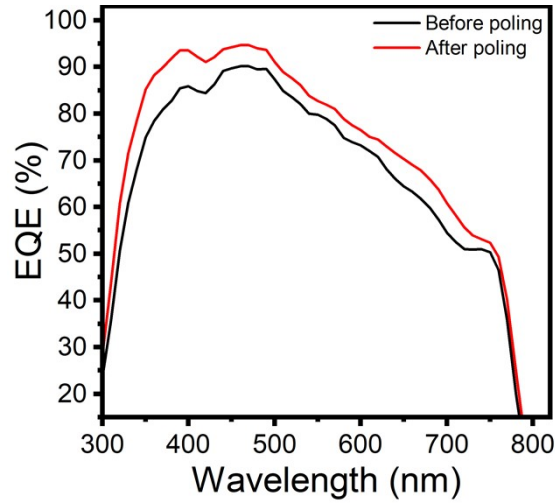


Figure S8. EQE of $Cs_{10}M/1.0$ wt.% PVDF before and after positive poling.

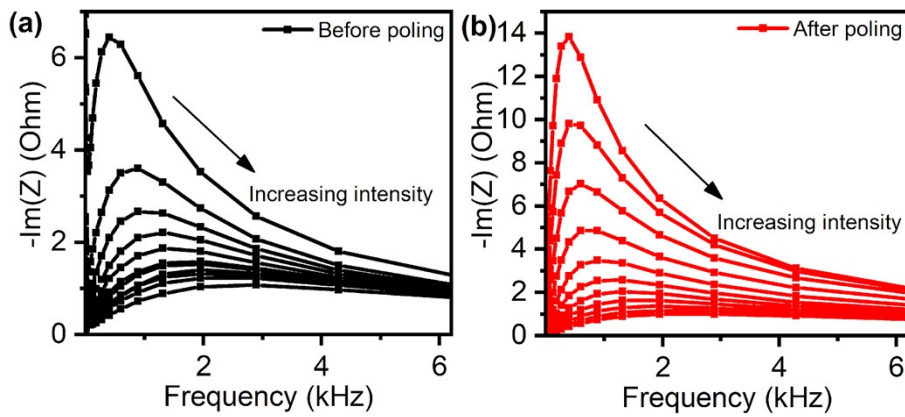


Figure S9. Bode-type plots of PSCs (a) before and (b) after poling.

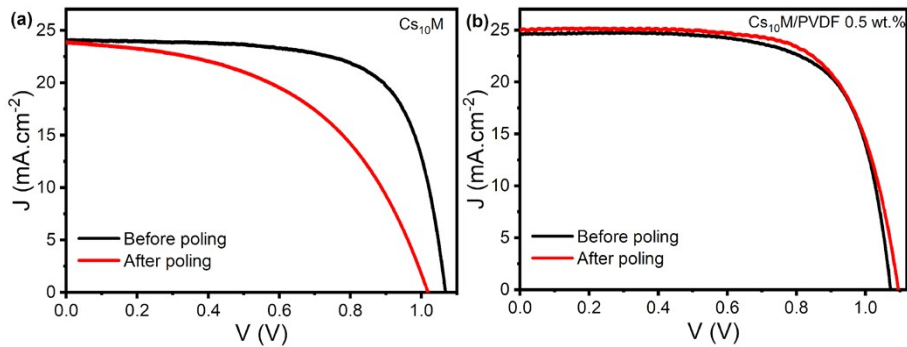


Figure S10. J-V plots of $Cs_{10}M$ PSCs with (a) and without (b) 0.5 wt.% PVDF before and after poling.

Table S3. Photovoltaic parameters of Cs₁₀M PSCs prepared with and without 0.5 wt.% PVDF. The average values and standard deviations were calculated from 10 devices.

PSCs	J _{sc} (mA.cm ⁻²)	V _{oc} (V)	FF	PCE %
Cs ₁₀ M, before poling	24.07 (23.91 ± 0.26)	1.06 (1.05 ± 0.02)	0.7 (0.69 ± 0.01)	17.9 (17.5 ± 0.3)
Cs ₁₀ M, after poling	23.81 (23.44 ± 0.41)	0.99 (0.98 ± 0.01)	0.50 (0.49 ± 0.01)	12.2 (11.5 ± 0.4)
Cs ₁₀ M/PVDF 0.5 wt.%, before poling	24.65 (24.43 ± 0.30)	1.07 (1.06 ± 0.01)	0.7 (0.7 ± 0.01)	18.7 (18.3 ± 0.2)
Cs ₁₀ M/PVDF 0.5 wt.%, after poling	25.01 (24.93 ± 0.18)	1.09 (1.08 ± 0.01)	0.7 (0.69 ± 0.01)	19.1 (18.94 ± 0.2)

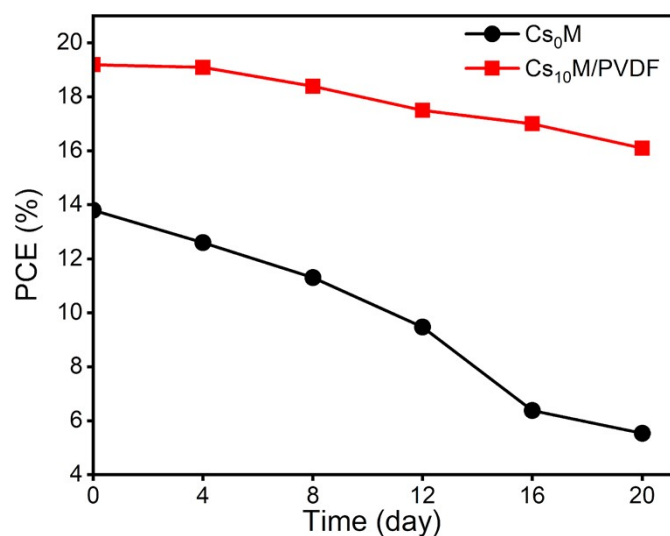


Figure S11. Changes in PCEs of PSCs prepared with (red) and without (black) PVDF.