

Supporting Information

Control of I-V Hysteresis in $\text{CH}_3\text{NH}_3\text{PbI}_3$ Perovskite Solar Cell

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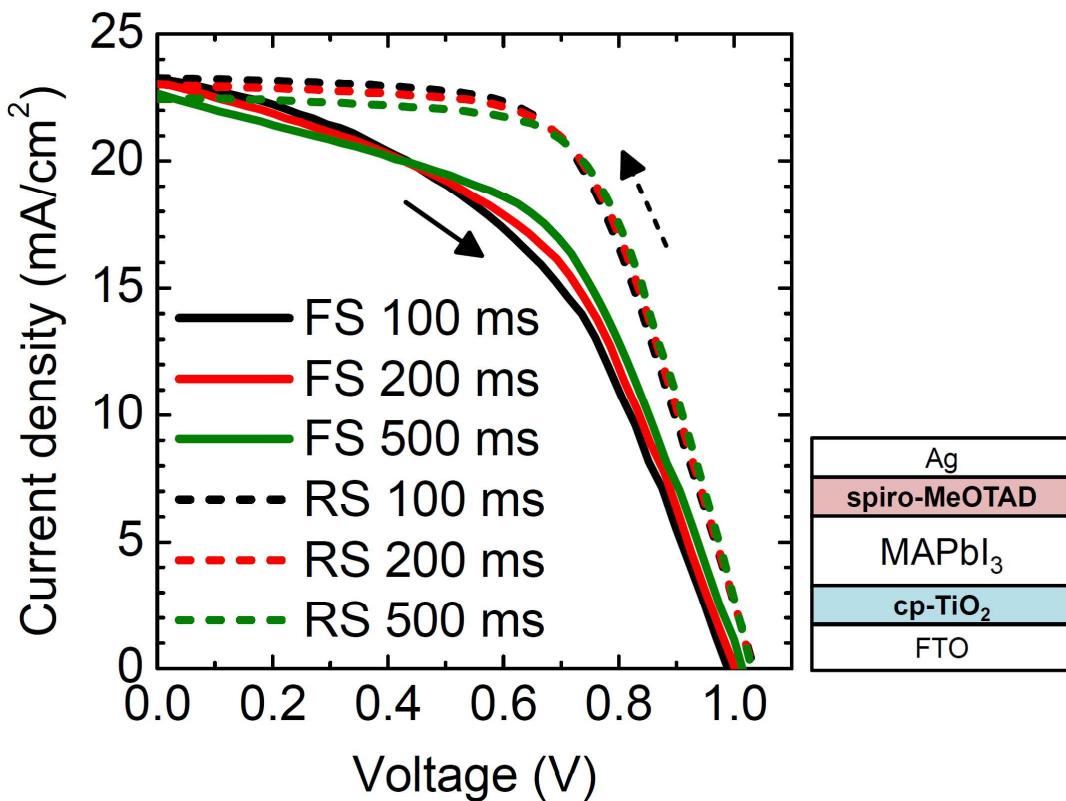


Figure S1 I-V curves of the cp-TiO₂/MAPbI₃/spiro-MeOTAD structure depending on scan direction and voltage settling time (100 ms (black), 200 ms (red), and 500 ms (green)), where solid and dash lines represent forward scan (FS, from short-circuit to open-circuit) and reverse scan (RS, from open-circuit to short-circuit), respectively.

Table S1 Photovoltaic parameters of cp-TiO₂/MAPbI₃/spiro-MeOTAD structure depending on scan direction and voltage settling time.

Scan direction	Voltage settling time	J _{sc} (mA/cm^2)	V _{oc} (V)	FF	PCE (%)	Active area (cm^2)
FS	100 ms	23.25	0.989	0.460	10.59	0.125
	200 ms	23.10	1.002	0.483	11.18	0.125
	500 ms	22.67	1.014	0.513	11.79	0.125
RS	100 ms	23.26	1.035	0.608	14.63	0.125
	200 ms	23.02	1.032	0.621	14.75	0.125
	500 ms	22.44	1.030	0.638	14.76	0.125

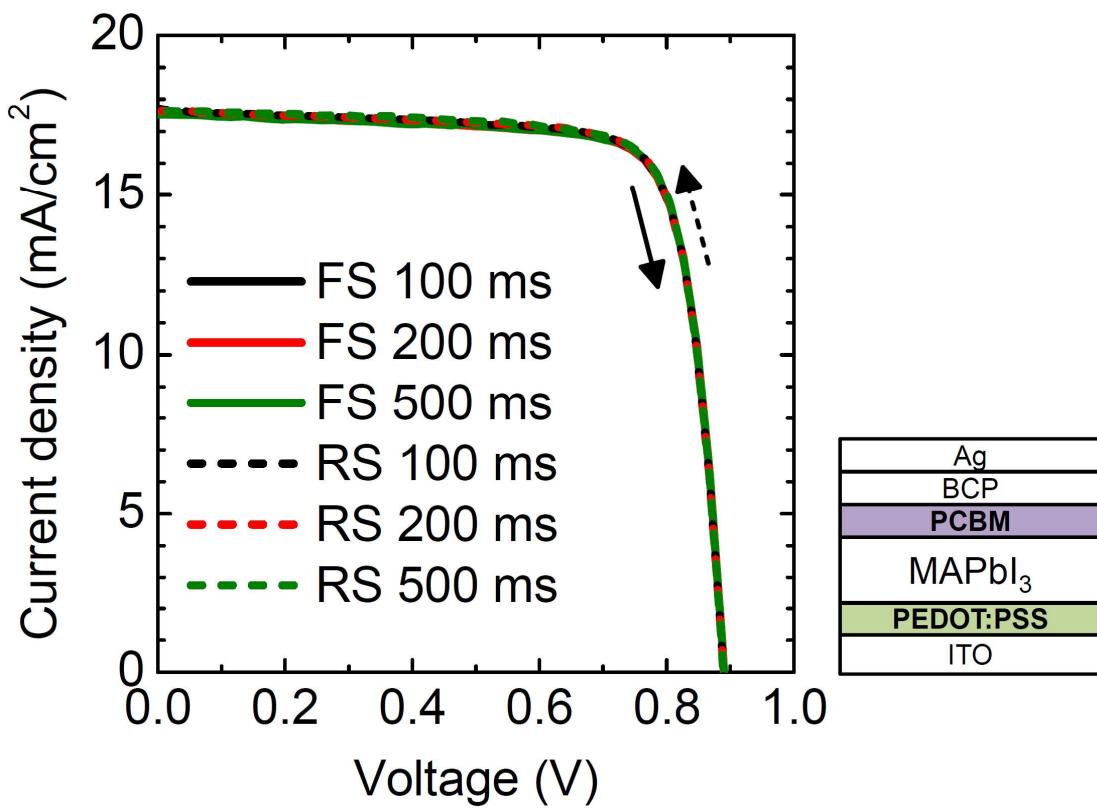


Figure S2 I-V curves of the PEDOT:PSS/MAPbI₃/PCBM structure depending on scan direction and voltage settling time (100 ms (black), 200 ms (red), and 500 ms (green)), where solid and dash lines represent forward scan (FS, from short-circuit to open-circuit) and reverse scan (RS, from open-circuit to short-circuit), respectively.

Table S2 Photovoltaic parameters of PEDOT:PSS/MAPbI₃/PCBM structure depending on scan direction and voltage settling time.

Scan direction	Voltage settling time	J _{sc} (mA/cm ²)	V _{oc} (V)	FF	PCE (%)	Active area (cm ²)
FS	100 ms	17.60	0.890	0.787	12.33	0.125
	200 ms	17.59	0.890	0.788	12.33	0.125
	500 ms	17.53	0.890	0.793	12.37	0.125
RS	100 ms	17.71	0.889	0.785	12.35	0.125
	200 ms	17.64	0.889	0.791	12.40	0.125
	500 ms	17.66	0.889	0.791	12.41	0.125

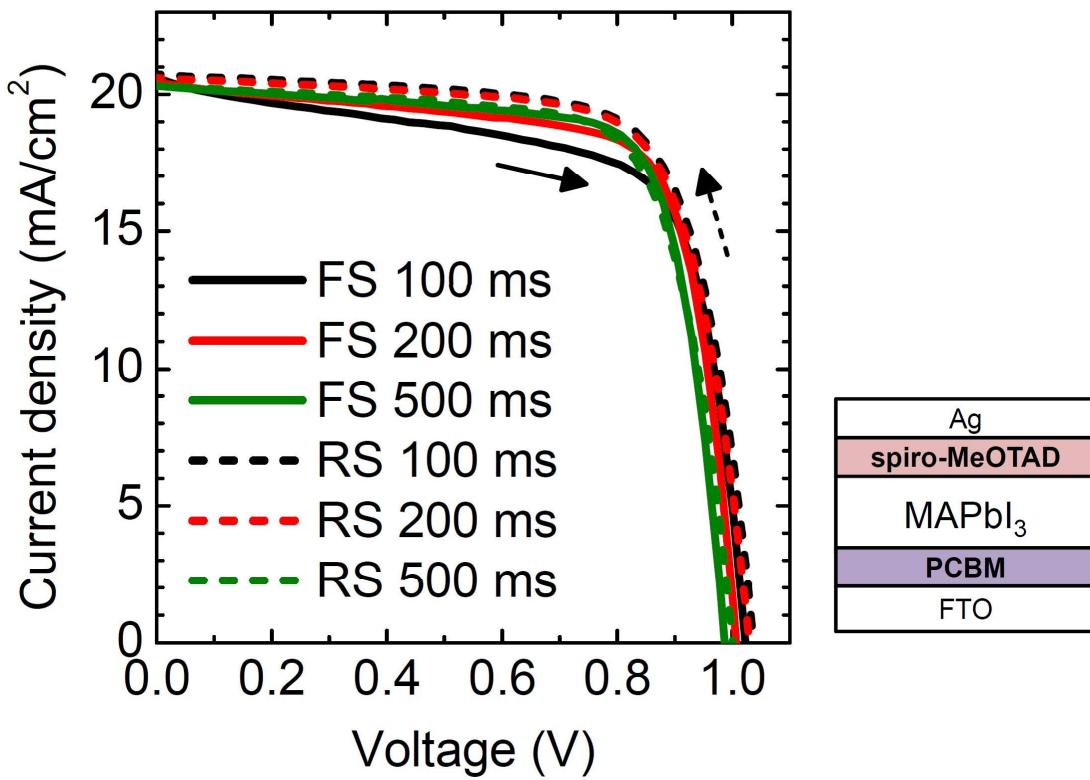


Figure S3 I-V curves of the PCBM/MAPbI₃/spiro-MeOTAD structure depending on scan direction and voltage settling time (100 ms (black), 200 ms (red), and 500 ms (green)), where solid and dash lines represent forward scan (FS, from short-circuit to open-circuit) and reverse scan (RS, from open-circuit to short-circuit), respectively.

Table S3 Photovoltaic parameters of the PCBM/MAPbI₃/spiro-MeOTAD structure depending on scan direction and voltage settling time.

Scan direction	Voltage settling time	J _{sc} (mA/cm ²)	V _{oc} (V)	FF	PCE (%)	Active area (cm ²)
FS	100 ms	20.61	1.02	0.681	14.35	0.125
	200 ms	20.45	1.01	0.728	14.99	0.125
	500 ms	20.31	0.99	0.748	15.00	0.125
RS	100 ms	20.74	1.04	0.722	15.52	0.125
	200 ms	20.60	1.03	0.726	15.39	0.125
	500 ms	20.34	1.00	0.722	14.70	0.125

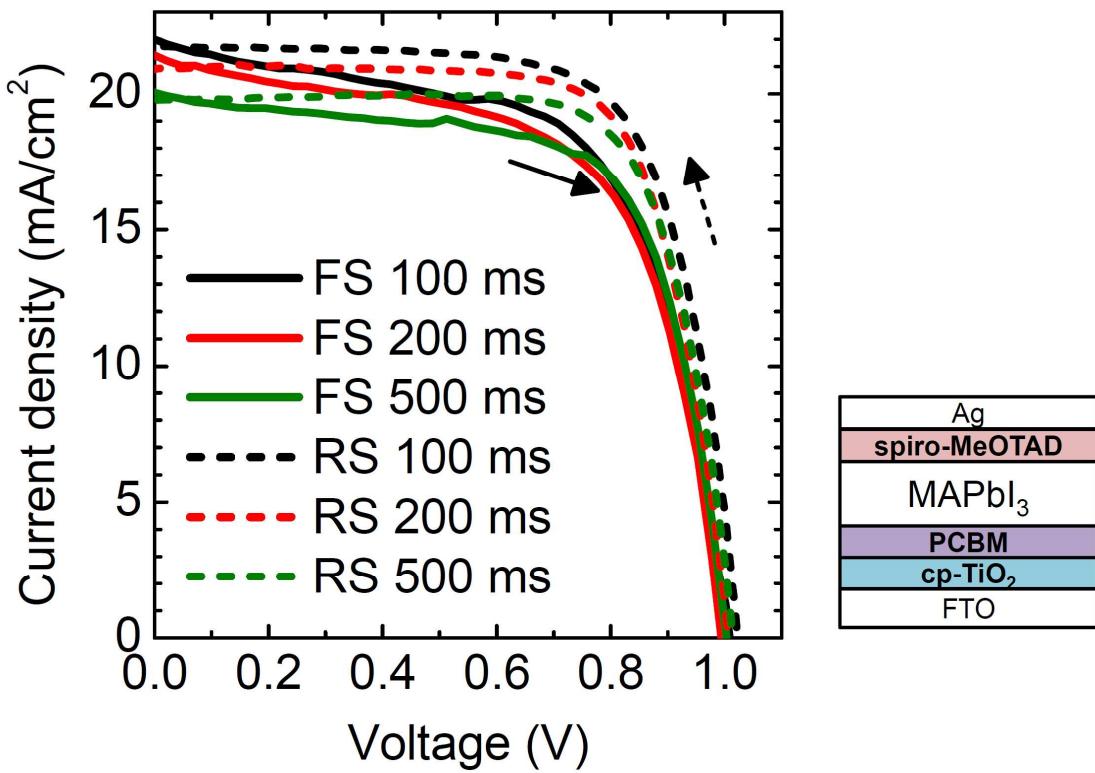


Figure S4 I-V curves of the cp-TiO₂/PCBM/MAPbI₃/spiro-MeOTAD structure depending on scan direction and voltage settling time (100 ms (black), 200 ms (red), and 500 ms (green)), where solid and dash lines represent forward scan (FS, from short-circuit to open-circuit) and reverse scan (RS, from open-circuit to short-circuit), respectively.

Table S4 Photovoltaic parameters of the cp-TiO₂/PCBM/MAPbI₃/spiro-MeOTAD structure depending on scan direction and voltage settling time.

Scan direction	Voltage settling time	J _{sc} (mA/cm ²)	V _{oc} (V)	FF	PCE (%)	Active area (cm ²)
FS	100 ms	21.73	1.02	0.710	15.79	0.125
	200 ms	22.00	1.01	0.615	13.65	0.125
	500 ms	20.91	1.01	0.731	15.38	0.125
RS	100 ms	21.41	0.99	0.619	13.18	0.125
	200 ms	19.78	1.01	0.739	14.82	0.125
	500 ms	20.04	1.00	0.675	13.57	0.125

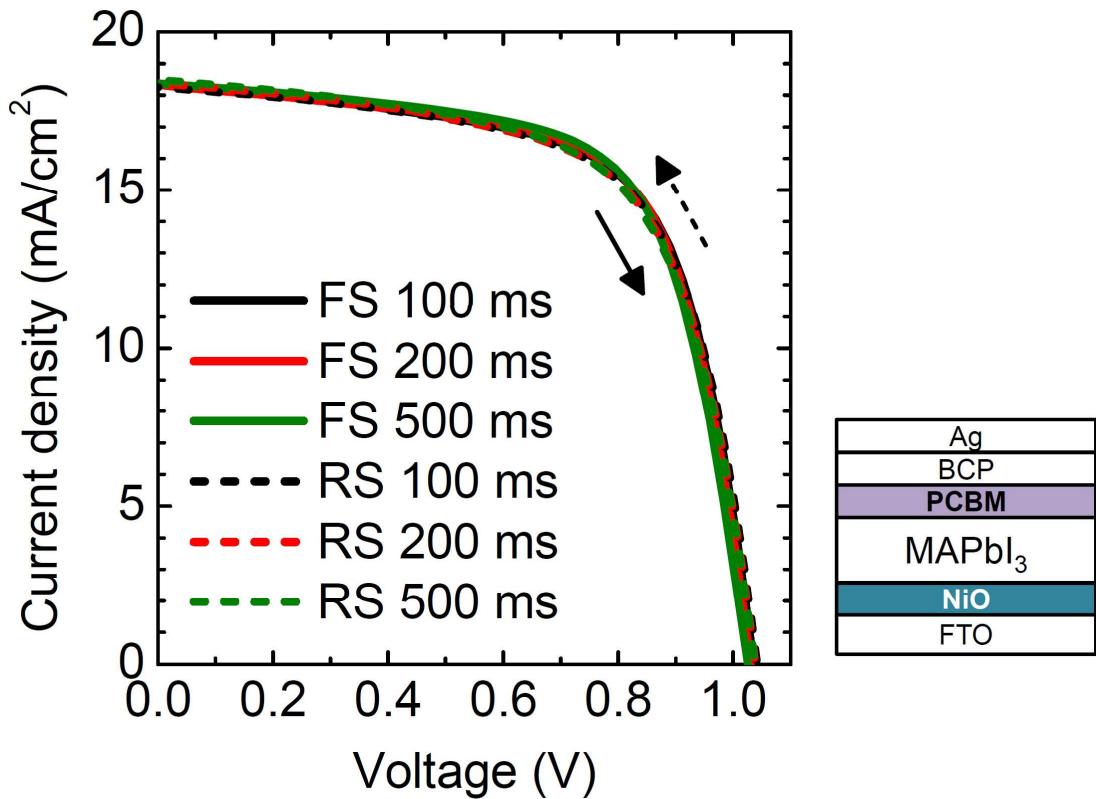


Figure S5 I-V curves of the NiO/MAPbI₃/PCBM structure depending on scan direction and voltage settling time (100 ms (black), 200 ms (red), and 500 ms (green)), where solid and dash lines represent forward scan (FS, from short-circuit to open-circuit) and reverse scan (RS, from open-circuit to short-circuit), respectively.

Table S5 Photovoltaic parameters of the NiO/MAPbI₃/PCBM structure depending on scan direction and voltage settling time.

Scan direction	Voltage settling time	J _{sc} (mA/cm ²)	V _{oc} (V)	FF	PCE (%)	Active area (cm ²)
FS	100 ms	18.37	1.036	0.654	12.45	0.125
	200 ms	18.32	1.030	0.661	12.47	0.125
	500 ms	18.47	1.026	0.662	12.47	0.125
RS	100 ms	18.38	1.036	0.639	12.17	0.125
	200 ms	18.39	1.039	0.639	12.21	0.125
	500 ms	18.49	1.038	0.634	12.17	0.125

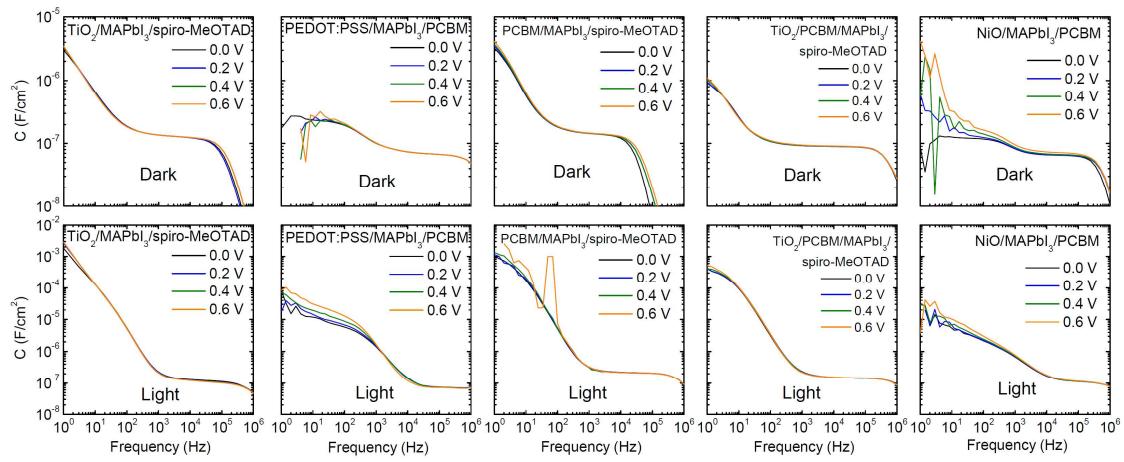


Figure S6 $C-f$ curves depending on applied bias voltage from 0 V to 0.6 V in dark and under one sun illumination (AM 1.5G, 100 mW/cm²). cp- $\text{TiO}_2/\text{MAPbI}_3/\text{spiro-MeOTAD}$, PEDOT:PSS/ $\text{MAPbI}_3/\text{PCBM}$, $\text{PCBM}/\text{MAPbI}_3/\text{spiro-MeOTAD}$, cp- $\text{TiO}_2/\text{PCBM}/\text{MAPbI}_3/\text{spiro-MeOTAD}$, and $\text{NiO}/\text{MAPbI}_3/\text{PCBM}$ structures from left to right.

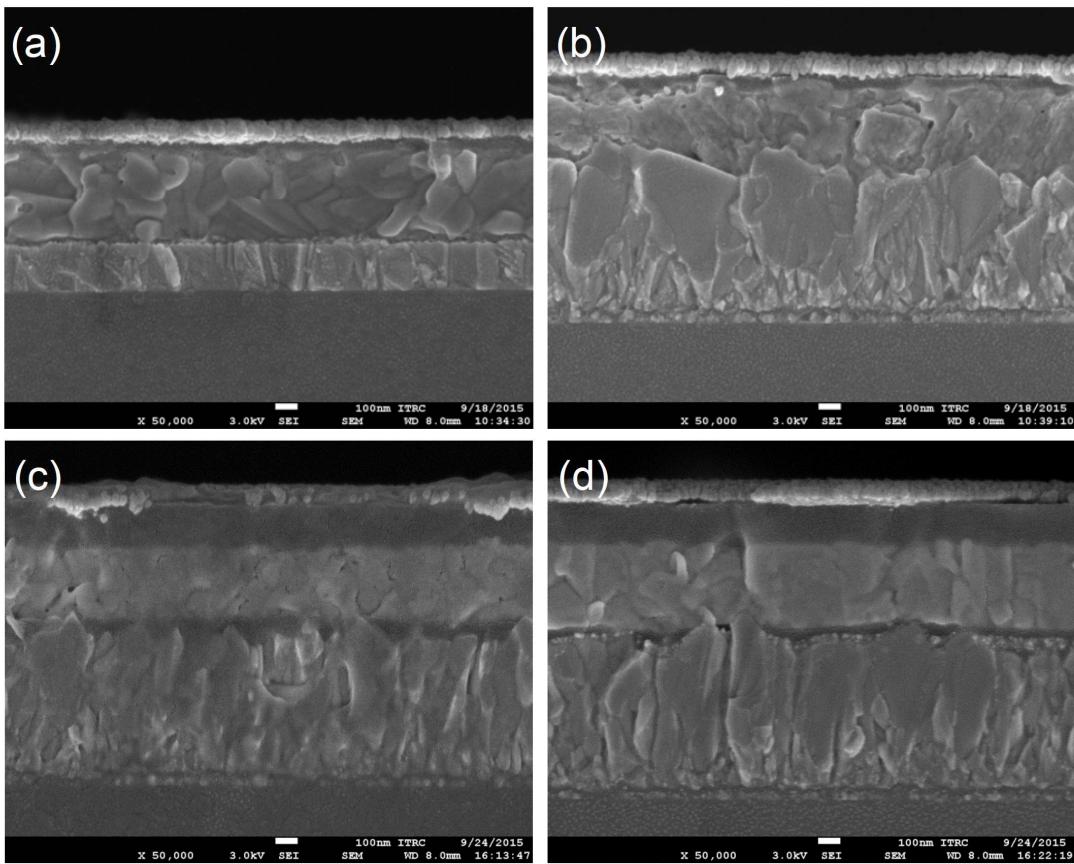


Figure S7 Cross-sectional scanning electron microscopy (SEM) images of perovskite solar cells with layout of (a) PEDOT:PSS/MAPbI₃/PCBM, (b) NiO/MAPbI₃/PCBM, (c) PCBM/MAPbI₃/spiro-MeOTAD, and (d) cp-TiO₂/PCBM/MAPbI₃/spiro-MeOTAD. Scale bars represent 100 nm.