

Supporting information

Influence of Cobalt Additive in spiro-OMeTAD on Charge Recombination and Carrier Density in Perovskite Solar Cells investigated by Impedance Spectroscopy

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KEYWORDS: Perovskite solar cells, charge recombination, carrier density, impedance spectroscopy, FK102 cobalt complex, spiro-OMeTAD

Figure S1. Histogram of photovoltaic parameters of six devices for *Rep_1*. Reverse scan data are given in red, and forward scan data are given in blue.

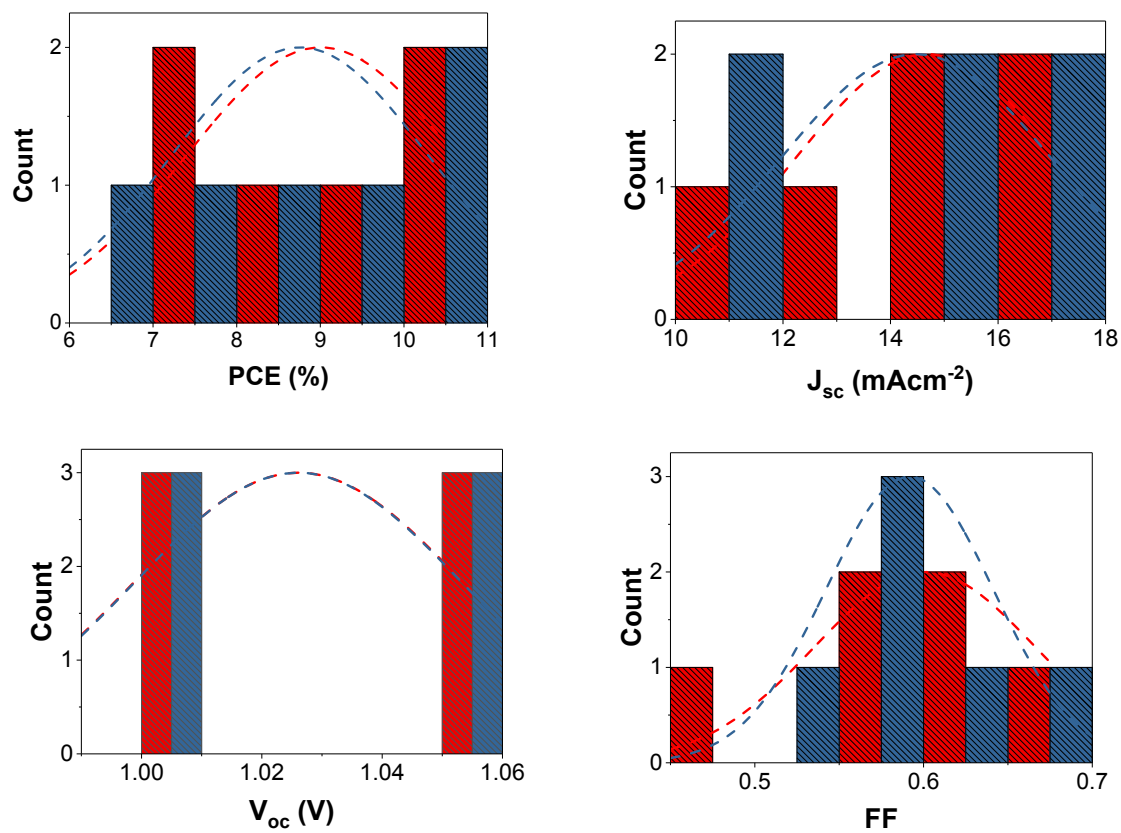


Figure S2. Histogram of photovoltaic parameters of six devices for *Rep_2*. Reverse scan data are given in red, and forward scan data are given in blue.

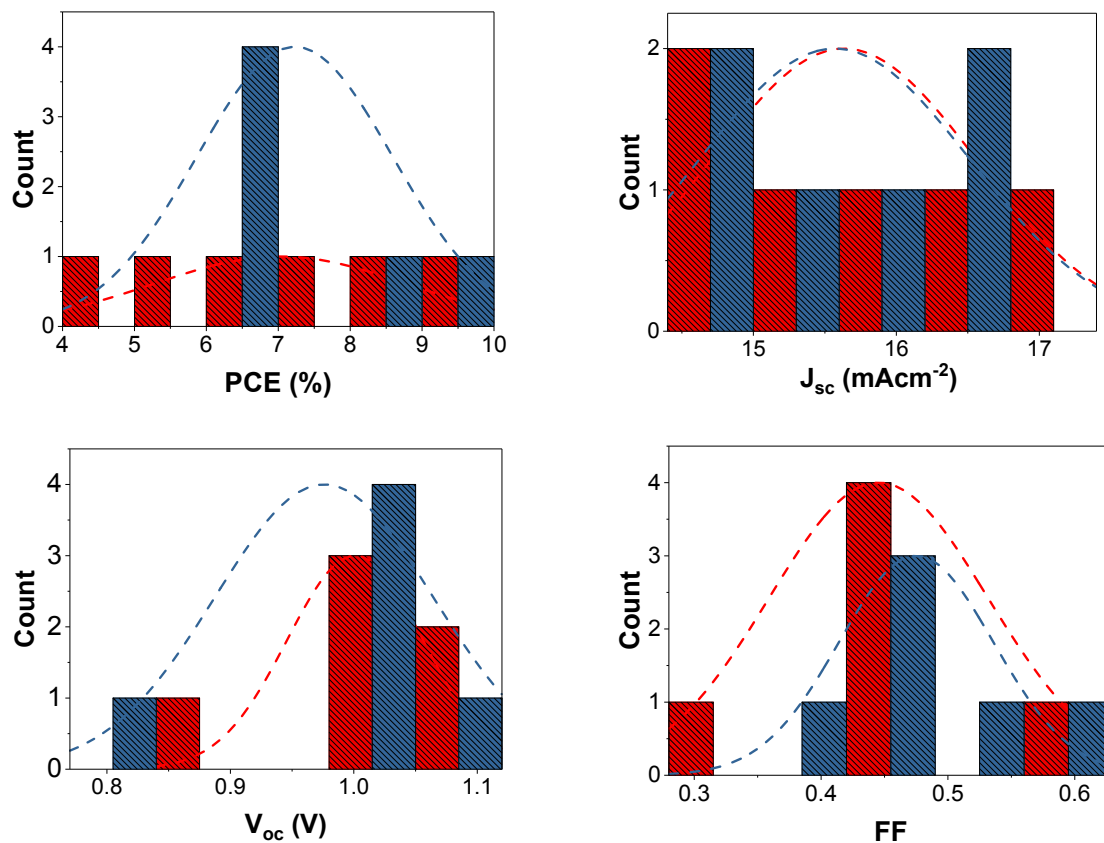


Figure S3. Histogram of photovoltaic parameters of five devices for *Rep_3*. Reverse scan data are given in red, and forward scan data are given in blue.

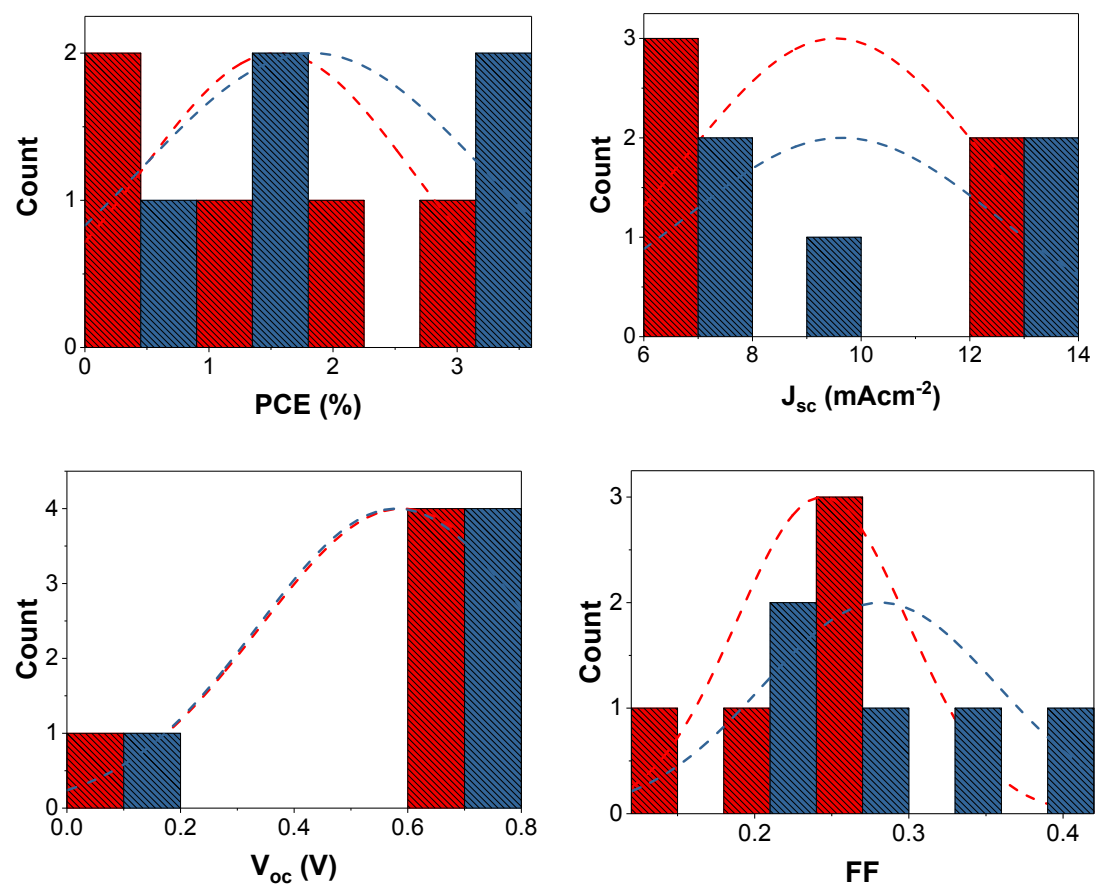


Figure S4. Histogram of photovoltaic parameters of six devices for *Rep_4*. Reverse scan data are given in red, and forward scan data are given in blue.

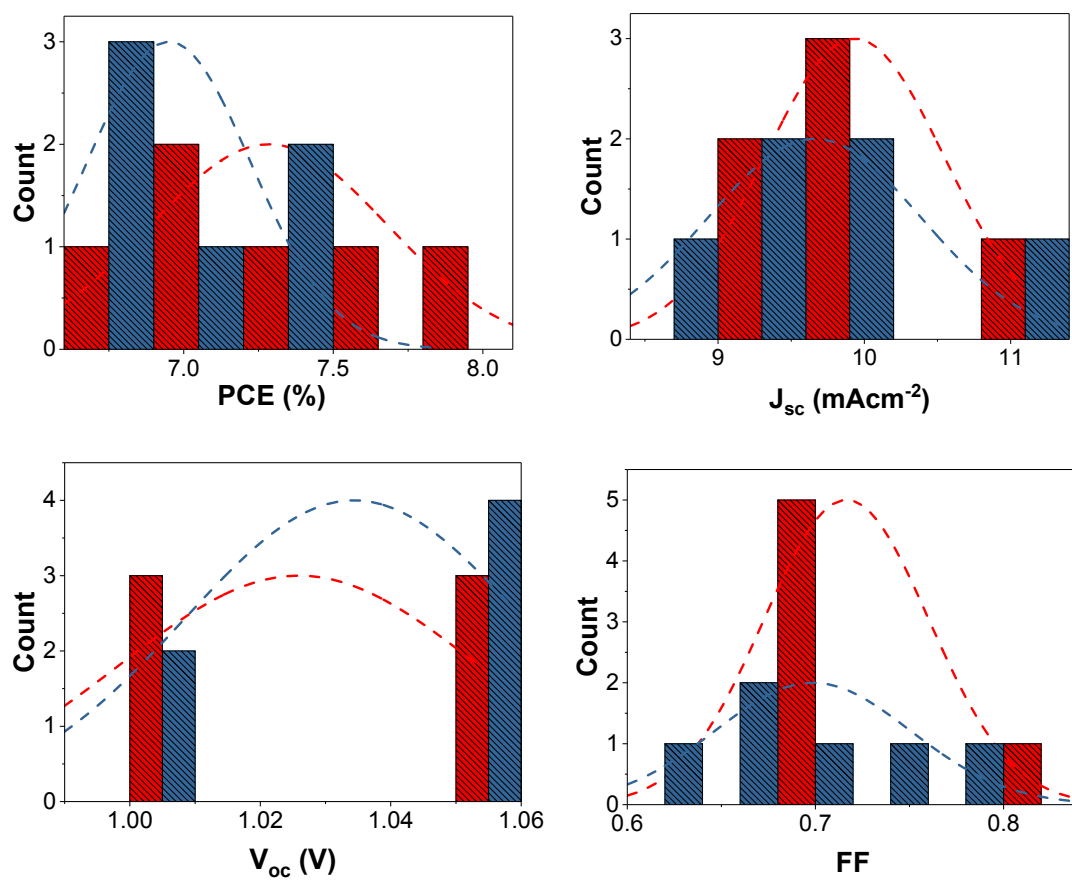


Figure S5. Comparison in JV curve of Rep_1 before and after IS measurement. The photovoltaic performance is found to be degraded after the IS measurement under constant illumination of around 42 min. 100 mW/cm², 10 mV/s.

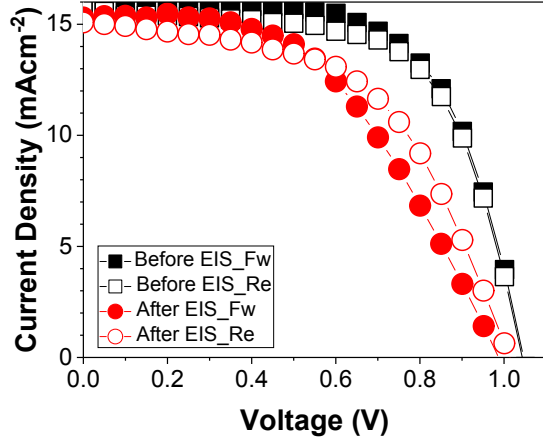
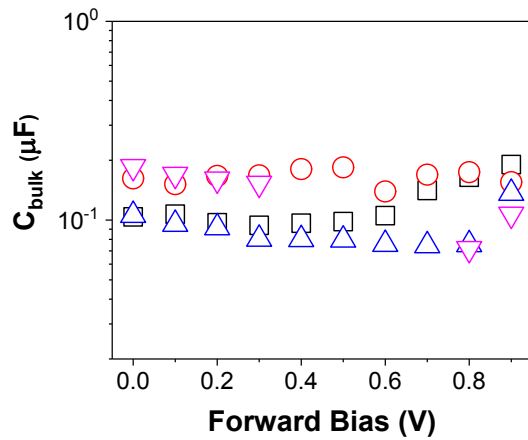


Table S1. Photovoltaic parameters of Rep_1 before and after IS measurement.

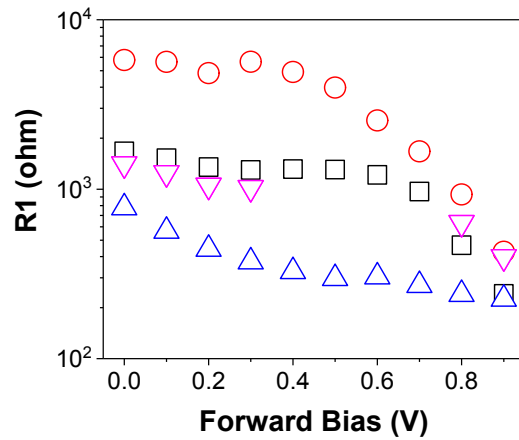
	PCE (%)	J_{sc} (mAcm ⁻²)	V_{oc} (V)	FF
Before_IS_re	10.61	15.73	1.05	0.59
Before_IS_fw	10.38	15.64	1.05	0.58
After_IS_re	6.99	11.72	1.00	0.60
After_IS_fw	6.17	11.33	1.00	0.54

Figure S6. a) Geometric capacitance C_{bulk} , b) transport resistance, R_1 and c) dielectric relaxation time, τ_1 of the bulk perovskite layer extracted from the high frequency semi-circle of Nyquist plots measured at 0.1 Sun.

a)



b)



c)

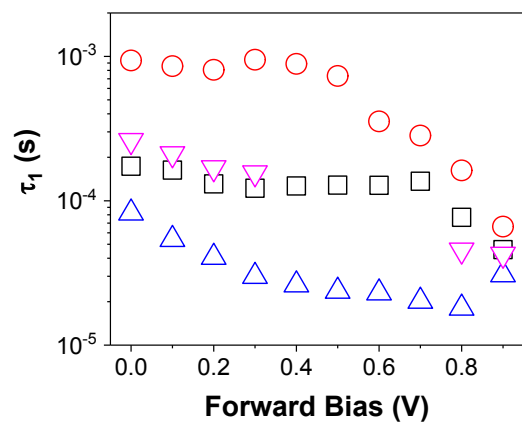


Figure S7. Electron lifetime as a function of forward bias extracted from the IS measurement at 0.1 Sun illumination.

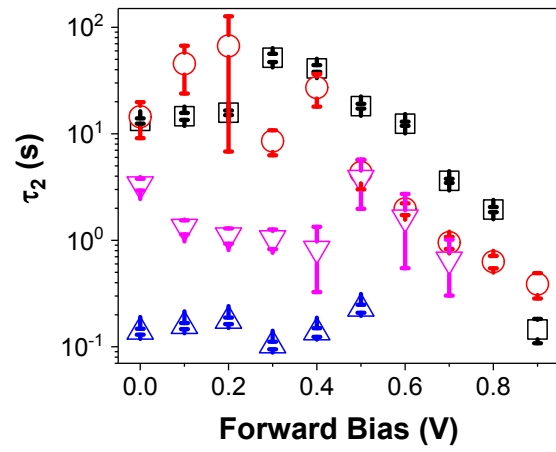


Table S2. Photovoltaic parameters of *Rep_1* and *Rep_2* on day 7 measurement.

	PCE (%)	J_{sc} (mAcm ⁻²)	V_{oc} (V)	FF
Rep_1_Re	7.1 ± 1.6	13.0 ± 1.7	1.0 ± 0.0	0.5 ± 0.1
Rep_1_Fw	6.8 ± 1.9	12.3 ± 1.3	1.0 ± 0.0	0.5 ± 0.1
Rep_2_Re	3.2 ± 2.6	10.4 ± 2.4	0.7 ± 0.5	0.4 ± 0.1
Rep_2_Fw	3.3 ± 2.0	10.4 ± 2.4	0.8 ± 0.3	0.4 ± 0.0

Figure S8. Histogram of photovoltaic parameters of three aged devices for *Rep_3*. Reverse scan data are given in red, and forward scan data are given in blue.

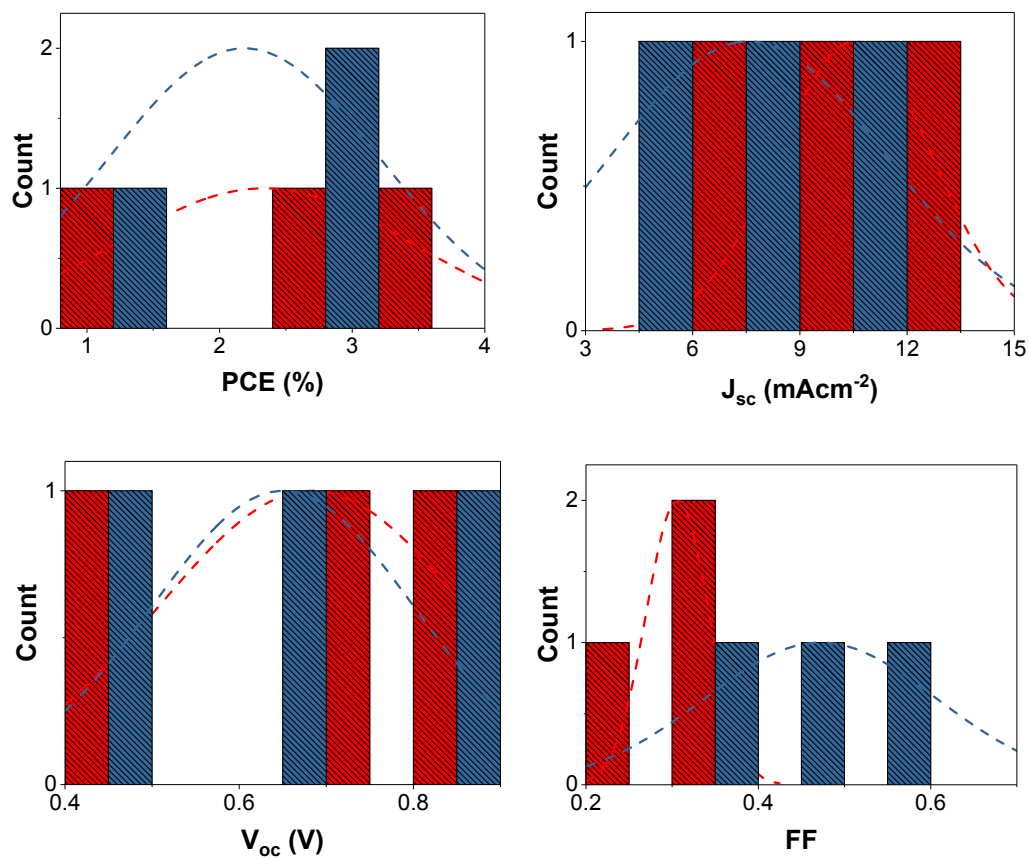


Figure S9. Histogram of photovoltaic parameters of three aged devices for *Rep_4*. Reverse scan data are given in red, and forward scan data are given in blue.

