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Supporting Information

Low-Temperature, Solution-Deposited Metal Chalcogenide Films as Highly Efficient Counter Electrodes for Sensitized Solar Cells

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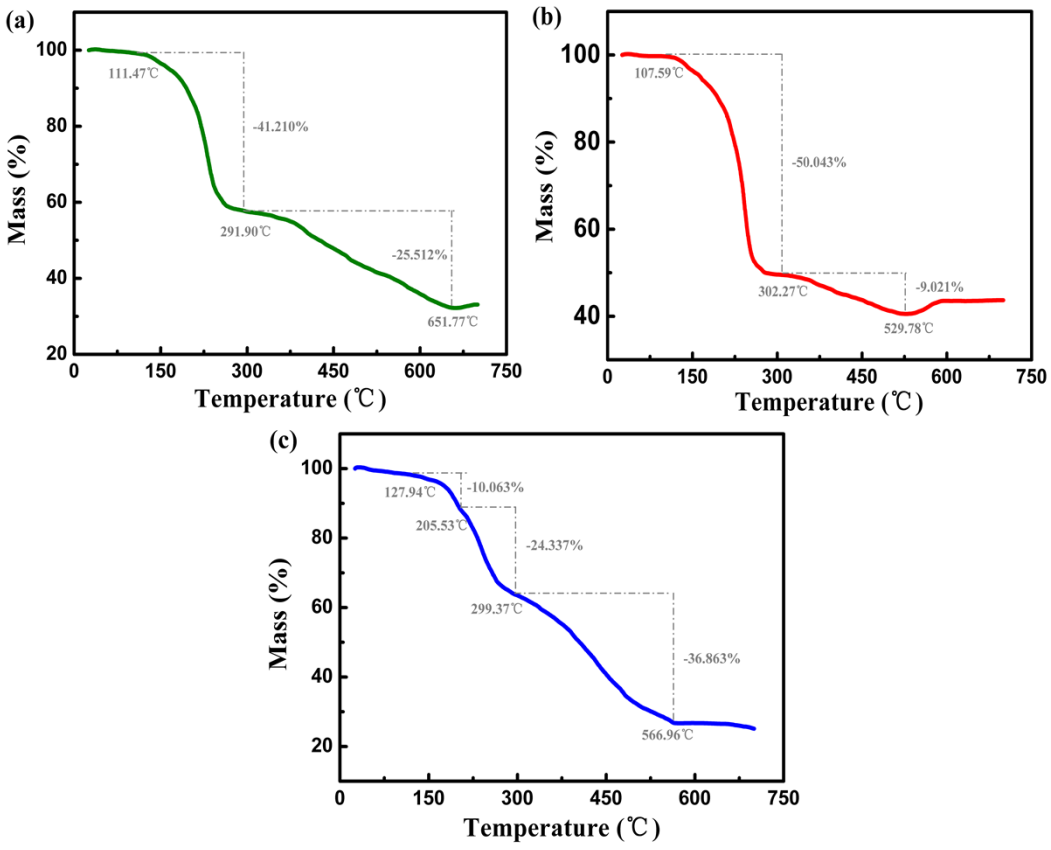

Figure S1. TGA curves of (a) FeSe, (b) $Cu_{1.9}S$, and (c) Cu_2Se solid precursors, obtained by pre-

drying solutions at 110°C for 10 min. TGA conditions: 20 mL/min nitrogen, at a heating rate of 10°C/min to 700°C.

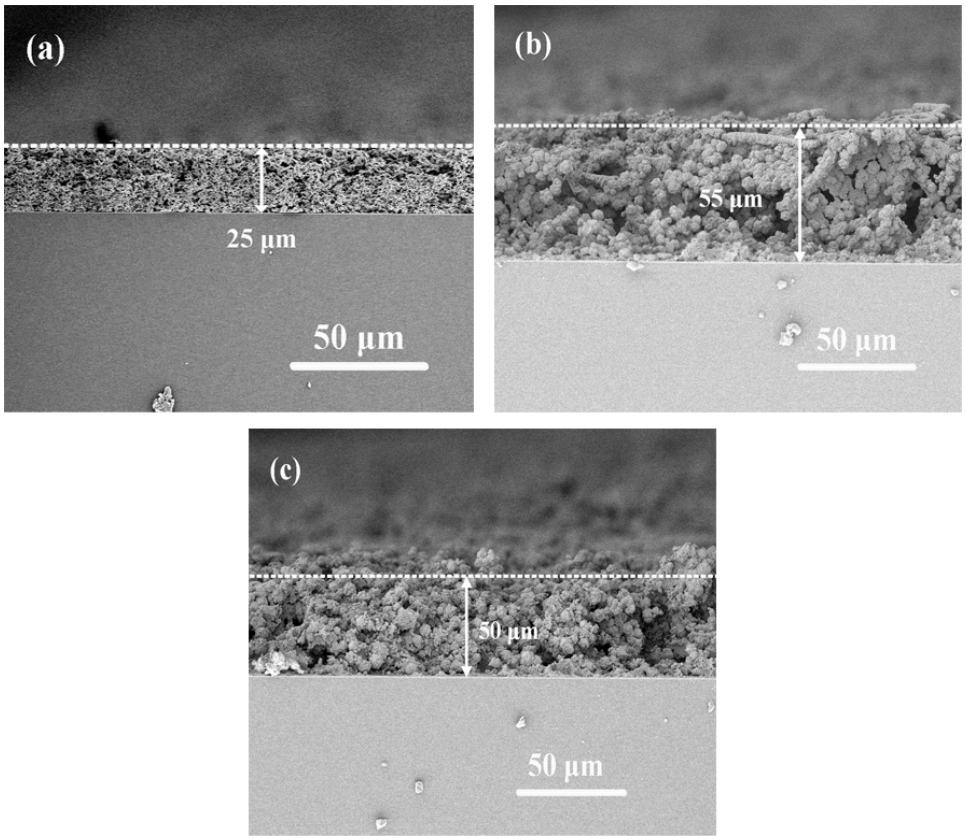

Figure S2. Cross-sectional SEM images of drop-cast films of (a) $FeSe_2$, (b) $Cu_{1.8}S$, and (c) CuSe on FTO glass.

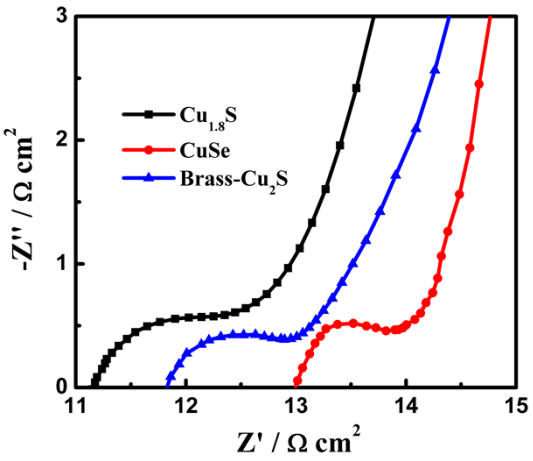

Figure S3. Enlarged R_{ct} part of the Nyquist plot of the integrated solar cells with three different CEs, measured in the dark under a forward bias of -0.55 V with the frequency ranging from 0.07

Hz to 100 KHz, a 5 mV ac amplitude was used. R_{ct} values obtained by fitting the spectra of the $Cu_{1.8}S$, CuSe, and Cu_2S CEs were 0.8 $\Omega \cdot cm^2$,0.5 $\Omega \cdot cm^2$, and 0.6 $\Omega \cdot cm^2$, respectively.

Table S1. Photovoltaic Performance of the DSCs with Different CEs and the Fitted EIS Parameters of Symmetric Cells.

Sample	V_{oc}/mV	J_{sc}/mA cm^{-2}	FF	PCE/%	Sample	R_s/Ω cm^2	R_{ct}/Ω cm^2	Z_N/Ω cm^2	ΔE_p/mV
$1^{\#}FeSe_2$	752	15.99	0.74	8.90	$1^{\#}FeSe_2$	12.73	0.19	0.25	259
$2^{\#}FeSe_2$	754	16.10	0.75	9.10	$2^{\#}FeSe_2$	12.56	0.18	0.24	256
$3^{\#}FeSe_2$	754	16.09	0.75	9.10	$3^{\#}FeSe_2$	11.89	0.20	0.27	278
$4^{\#}FeSe_2$	752	16.06	0.74	8.94	$4^{\#}FeSe_2$	11.44	0.17	0.23	239
	753±1	16.06±0.05	0.74±0.01	9.01±0.09		12.15±0.65	0.18±0.01	0.25±0.02	258±20
$1^{\#}Pt$	752	15.54	0.72	8.41	$1^{\#}Pt$	12.41	0.72	0.40	344
$2^{\#}Pt$	753	15.62	0.73	8.58	$2^{\#}Pt$	12.00	0.71	0.39	335
$3^{\#}Pt$	749	15.38	0.72	8.29	$3^{\#}Pt$	10.92	0.73	0.40	340
$4^{\#}Pt$	750	15.76	0.71	8.39	$4^{\#}Pt$	11.95	0.72	0.41	330
	751±2	15.58±0.20	0.72±0.01	8.42±0.13		11.82±0.80	0.72±0.01	0.40±0.01	337±7

Table S2. Comparison of the Photovoltaic Device Characteristics Measured with Representative Photoanodes from Different Batches Assembled with a $FeSe_2$ Counter Electrode.

Sample	V_{oc}/mV	J_{sc}/mA cm^{-2}	FF	PCE/%
1	753	16.03	0.74	8.93
2	754	16.10	0.73	8.86
3	754	15.85	0.74	8.84
4	753	16.11	0.74	8.97

Table S3. Photovoltaic Performance of the QDSCs with Different CEs and the Fitted EIS

Parameters of Symmetric Cells.

Sample	V_{oc}/mV	J_{sc}/mA cm^{-2}	FF	PCE/%	Sample	R_s/Ω cm^2	R_{ct}/Ω cm^2
1#Pt	546	13.30	0.34	2.47	1#Pt	8.9	414.2
2#Pt	547	12.81	0.38	2.66	2#Pt	8.8	426.1
3#Pt	542	12.89	0.33	2.31	3#Pt	8.9	420.3
	545±3	13.01±0.30	0.35±0.03	2.48±0.17		8.8±0.1	420.2±5.9
1#$Cu_{1.8}S$	550	15.00	0.52	4.29	1#$Cu_{1.8}S$	8.7	1.3
2#$Cu_{1.8}S$	552	14.96	0.53	4.37	2#$Cu_{1.8}S$	8.9	1.2
3#$Cu_{1.8}S$	549	14.56	0.54	4.32	3#$Cu_{1.8}S$	8.8	1.1
	550±2	14.84±0.24	0.53±0.01	4.31±0.11		8.8±0.1	1.2±0.1
1#Cu_2S	556	15.30	0.53	4.51	1#Cu_2S	9.1	0.8
2#Cu_2S	555	15.43	0.55	4.71	2#Cu_2S	9.0	0.9
3#Cu_2S	560	15.20	0.54	4.59	3#Cu_2S	9.2	0.9
	557±3	15.31±0.12	0.54±0.01	4.60±0.12		9.1±0.1	0.9±0.1
1#CuSe	562	15.57	0.55	4.81	1#CuSe	9.1	0.8
2#CuSe	562	15.70	0.56	4.94	2#CuSe	8.7	0.7
3#CuSe	561	15.62	0.56	4.91	3#CuSe	8.9	0.8
	561±1	15.63±0.11	0.56±0.01	4.89±0.06		8.9±0.2	0.7±0.1

Table S4. Comparison of the Photovoltaic Device Characteristics Measured with Representative Photoanodes from Different Batches Assembled with a CuSe (or $Cu_{1.8}S$) Counter Electrode.

Sample CuSe	V_{oc}/mV	J_{sc}/mA cm^{-2}	FF	PCE/%	Sample $Cu_{1.8}S$	V_{oc}/mV	J_{sc}/mA cm^{-2}	FF	PCE/%
1	562	15.65	0.56	4.92	1	551	14.88	0.53	4.34
2	561	15.50	0.56	4.87	2	550	14.90	0.52	4.26
3	561	15.63	0.55	4.82	3	551	14.63	0.52	4.19
4	560	15.71	0.56	4.92	4	549	14.85	0.53	4.32