

Supplementary Information

8	7	6	5	4	3	2	1	SI No.
n-i-p	n-i-p	n-i-p	n-i-p	n-i-p	n-i-p	n-i-p	n-i-p	Orientation of Layers
Single	Single	Single	Single	Single	Single	Single	Single	PSC Type
WS2	ZnO	ZnO	PCBM	IGZO	WS2	TiO2	WO3	ETL(s)
Single	Single	Single	Single	Single	Single	Single	Single	ETL Type
P3HT	CuI	CuI	CuI	CuI	CuI	CuI	CuI	HTL(s)
Single	Single	Single	Single	Single	Single	Single	Single	HTL Type
FTO	FTO	ITO	ITO	ITO	ITO	ITO	ITO	Front Contact
Au	Au	NA	NA	NA	NA	NA	NA	Back Contact
CH3NH3SnI3	CsSn0.5Ge0.5I3	CH3NH3PbI3	CH3NH3PbI3	CH3NH3PbI3	CH3NH3PbI3	CH3NH3PbI3	CH3NH3PbI3	Perovskite name
1	0	1	1	1	1	1	1	MA
0	0	0	0	0	0	0	0	FA
0	1	0	0	0	0	0	0	Cs
0	0	1	1	1	1	1	1	Pb
1	0.5	0	0	0	0	0	0	Sn
0	0.5	0	0	0	0	0	0	Ge
0	0	0	0	0	0	0	0	Br
0	0	0	0	0	0	0	0	Cl
1	1	1	1	1	1	1	1	I
1.31	1.5	1.55	1.55	1.55	1.55	1.55	1.55	Bandgap of Perovskite (eV)
0.13	0.4	0	0	0.26	0.05	0.36	0.06	del CB
2.38	0.2	0.39	0.39	0.39	0.39	0.39	0.39	del VB
2200	35	50	50	50	50	50	50	ETL (nm)
100	400	700	700	700	700	700	700	Perovskite (nm)
3	35	50	50	50	50	50	50	HTL(nm)
0.83	1.203	1.2249	1.2502	1.2732	1.2724	1.2718	1.2497	Voc (V)
20.64	24.21	24.787	24.7607	22.3149	22.9693	22.2412	24.7872	Jsc (mA/cm²)
61.09	84.07	69.51	70.27	75.39	72.19	72.41	70.53	FF (%)
10.47	24.51	21.1	21.75	21.42	21.1	20.48	21.85	PCE (%)

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18	17	16	15	14	13	12	11	10	9
n-i-p	n-i-p	n-i-p	n-i-p	n-i-p	n-i-p	n-i-p	n-i-p	n-i-p	n-i-p
Single	Single	Single	Single	Single	Single	Single	Single	Single	Single
ZnO	PCBM	TiO2	SnO2	IGZO	WS2	WS2	WS2	WS2	WS2
Single	Single	Single	Single	Single	Single	Single	Single	Single	Single
Cu2O	Cu2O	Cu2O	Cu2O	Cu2O	D-PBTTT-14	CuI	CuSCN	Cu2O	Spiro-OMeTAD
Single	Single	Single	Single	Single	Single	Single	Single	Single	Single
FTO	FTO	FTO	FTO	FTO	FTO	FTO	FTO	FTO	FTO
Au	Au	Au	Au	Au	Au	Au	Au	Au	Au
CH3NH3SnI3	CH3NH3SnI3	CH3NH3SnI3	CH3NH3SnI3	CH3NH3SnI3	CH3NH3SnI3	CH3NH3SnI3	CH3NH3SnI3	CH3NH3SnI3	CH3NH3SnI3
1	1	1	1	1	1	1	1	1	1
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	1	1	1
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	1	1	1
1.31	1.31	1.31	1.31	1.31	1.31	1.31	1.31	1.31	1.31
-0.07	-0.27	-0.27	-0.17	-0.01	0.13	0.13	0.13	0.13	0.13
0.11	0.11	0.11	0.11	0.11	0.12	0.38	0.18	0.11	0.37
200	1	900	500	100	2400	2300	2200	2500	2300
700	500	400	700	400	700	400	400	500	400
50	50	50	100	50	100	100	10	100	10
10	1.28	1.38	1.52	9.57	2.19	2.21	2.2	2.21	2.18
10.34	11.38	7.19	5.52	10.52	21.73	21.71	21.72	21.73	21.71
7.56	51.5	30.89	25.94	7.88	34.31	34.17	34.26	34.14	34.53
7.85	7.53	7.56	2.18	7.93	16.39	16.38	16.39	16.4	16.37

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28	27	26	25	24	23	22	21	20	19
n-i-p	n-i-p	n-i-p	n-i-p	n-i-p	n-i-p	n-i-p	n-i-p	n-i-p	n-i-p
Single	Single	Single	Single	Single	Single	Single	Single	Single	Single
SnO2	SnO2	SnO2	SnO2	SnO2	ZnO	TiO2	SnO2	PCBM	IGZO
Single	Single	Single	Single	Single	Single	Single	Single	Single	Single
CuSCN	Cu2O	CuSbS2	P3HT	Spiro-OMeTAD	CuSCN	CuSCN	CuSCN	CuSCN	CuSCN
Single	Single	Single	Single	Single	Single	Single	Single	Single	Single
FTO	FTO	FTO	FTO	FTO	FTO	FTO	FTO	FTO	FTO
Au	Au	Au	Au	Au	Au	Au	Au	Au	Au
CH3NH3PbI3	CH3NH3PbI3	CH3NH3PbI3	CH3NH3PbI3	CH3NH3PbI3	CH3NH3SnI3	CH3NH3SnI3	CH3NH3SnI3	CH3NH3SnI3	CH3NH3SnI3
1	1	1	1	1	1	1	1	1	1
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
1	1	1	1	1	0	0	0	0	0
0	0	0	0	0	1	1	1	1	1
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	1	1	1
1.5	1.5	1.5	1.5	1.5	1.31	1.31	1.31	1.31	1.31
0.07	0.07	0.07	0.07	0.07	-0.07	-0.27	-0.17	-0.27	-0.01
0.13	0.06	0.18	0.23	0.33	0.18	0.18	0.18	0.18	0.18
90	90	90	90	90	200	4	30	1	10
450	450	450	450	450	500	500	500	400	700
100	100	100	100	100	10	50	50	100	50
1.19	1.14	0.96	0.97	1.13	9.99	1.39	1.38	1.28	4.69
25.61	25.61	25.59	25.56	25.6	10.37	11.52	9.33	11.39	10.92
87.81	88.59	80.18	86.52	83.5	7.57	49.18	36.72	51.47	15.5
26.74	25.97	19.7	21.52	24.18	7.84	7.87	4.7	7.53	7.96

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35	34	33	32	31	30	29
n-i-p	n-i-p	n-i-p	n-i-p	n-i-p	n-i-p	n-i-p
Single	Single	Single	Single	Single	Single	Single
Li:TiO2	SnO2	SnO2	TiO2	SnO2	TiO2	ZnO
Single	Single	Single	Single	Single	Single	Single
Spiro-OMeTAD	MoOx	MoOx	Cu2O	Spiro-OMeTAD	Spiro-OMeTAD	Spiro-OMeTAD
Single	Single	Single	Single	Single	Single	Single
FTO	FTO	FTO	FTO	FTO	FTO	FTO
Au	Au	Au	Au	Au	Au	Au
CH3NH3PbI3	FA0.83Cs0.17PbI1.5Br1.5	FA0.83Cs0.17PbI1.5Br1.5	CH3NH3PbI3	FA0.85Cs0.15Pb(0.85Br0.15)3	CH3NH3PbI3	CH3NH3PbI3
1	0	0	1	0	1	1
0	0.83	0.83	0	0.85	0	0
0	0.17	0.17	0	0.15	0	0
1	1	1	1	1	1	1
0	0	0	0	0	0	0
0	0	0	0	0	0	0
0	0.5	0.5	0	0.15	0	0
0	0	0	0	0	0	0
1	0.5	0.5	1	0.85	1	1
1.5	1.85	1.85	1.55	1.59	1.5	1.5
0.2	0.15	0.15	0.3	0.1	0.36	0
0.33	0.5	0.5	0.08	0.9	0.33	0.33
100	50	50	5	70	90	90
400	500	500	400	500	450	450
140	40	50	160	150	100	100
1.08	1.44	1.39	1.12	1.27	1.12	1.12
28.4	17.04	16.37	22.26	22.24	24.98	25.1
84.85	81.83	77.16	82.2	67.46	81.86	81.86
24.23	20.1	17.65	20.42	19.17	23.04	23.21

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44	43	42	41	40	39	38	37	36
n-i-p	n-i-p	n-i-p	n-i-p	n-i-p	n-i-p	n-i-p	n-i-p	n-i-p
Single	Single	Single	Single	Single	Single	Single	Single	Single
CdS	ZnO	IGZO	C60	WS2	CdZnS	SnO2	TiO2	NO ETL
Single	Single	Single	Single	Single	Single	Single	Single	Single
Spiro-OMeTAD	Spiro-OMeTAD	Spiro-OMeTAD	Spiro-OMeTAD	Spiro-OMeTAD	Spiro-OMeTAD	Spiro-OMeTAD	Spiro-OMeTAD	Spiro-OMeTAD
Single	Single	Single	Single	Single	Single	Single	Single	Single
FTO	FTO	FTO	FTO	FTO	FTO	FTO	FTO	FTO
Au	Au	Au	Au	Au	Au	Au	Au	Au
CH3NH3PbI3	CH3NH3PbI3	CH3NH3PbI3	CH3NH3PbI3	CH3NH3PbI3	CH3NH3PbI3	CH3NH3PbI3	CH3NH3PbI3	CH3NH3PbI3
1	1	1	1	1	1	1	1	1
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	1	1
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	1	1
1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.55
0.6	0.1	0.26	0	0.05	0.3	0.1	0	0.1
0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
100	100	100	100	100	100	100	100	0
600	600	600	600	600	600	600	600	450
100	100	100	100	100	100	100	100	450
0.71	0.95	0.96	0.92	0.93	0.96	0.94	0.94	1.04
26.34	26.36	26.36	26.25	26.4	26.35	26.24	26.35	22.63
77.91	83.25	82.35	69.99	82.88	82.09	83.17	83.2	81.42
14.64	20.91	20.83	16.95	20.44	20.79	20.5	20.59	20

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53	52	51	50	49	48	47	46	45
n-i-p	n-i-p	n-i-p	n-i-p	n-i-p	n-i-p	n-i-p	n-i-p	n-i-p
Single	Single	Single	Single	Single	Single	Single	Single	Single
TiO2	TiO2	TiO2	TiO2	TiO2	TiO2	ZnO	SnO2	PCBM
Single	Single	Single	Single	Single	Single	Single	Single	Single
Cu2O	PEDOT:PSS	Spiro-OMeTAD	CuI	NiO	Spiro-OMeTAD	Spiro-OMeTAD	Spiro-OMeTAD	Spiro-OMeTAD
Single	Single	Single	Single	Single	Single	Single	Single	Single
FTO	FTO	FTO	FTO	FTO	FTO	FTO	FTO	FTO
Au	Au	Au	Au	Au	Au	Au	Au	Au
CH3NH3GeI3	CH3NH3GeI3	CH3NH3GeI3	CH3NH3GeI3	CH3NH3GeI3	CsPbI3	CsPbI3	CsPbI3	CH3NH3PbI3
1	1	1	1	1	0	0	0	1
0	0	0	0	0	0	0	0	0
0	0	0	0	0	1	1	1	0
0	0	0	0	0	1	1	1	1
0	0	0	0	0	0	0	0	0
1	1	1	1	1	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	1	1
1.9	1.9	1.9	1.9	1.9	1.73	1.73	1.73	1.5
0.9	0.9	0.9	0.9	0.9	0.05	0.05	0.05	0
0.17	0.1	0.11	0.1	0.2	0.23	0.23	0.23	0.33
150	150	150	150	150	25	25	25	100
350	400	350	450	300	350	350	350	600
200	200	150	100	100	170	170	170	100
1.92	0.97	1.91	1.92	1.93	1.064	1.065	1.067	0.93
14.2	14.69	13.92	14.78	13.91	18.22	18.24	18.28	26.38
79.28	86.97	68.76	70.64	74.97	75.16	75.18	75.18	82.48
21.6	12.35	18.28	20.05	19.3	14.57	14.62	14.67	20.34

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63	62	61	60	59	58	57	56	55	54
n-i-p	n-i-p	n-i-p	n-i-p	n-i-p	n-i-p	n-i-p	n-i-p	n-i-p	n-i-p
Single	Single	Single	Single	Single	Single	Single	Single	Single	Single
ZnO	SnO2	C60	IGZO	C60	C60	C60	C60	TiO2	TiO2
Single	Single	Single	Single	Single	Single	Single	Single	Single	Single
PEDOT:PSS	PEDOT:PSS	PEDOT:PSS	PEDOT:PSS	NiO	CuSbS2	CuSCN	PEDOT:PSS	Spiro-OMeTAD	D-PBTTT-14
Single	Single	Single	Single	Single	Single	Single	Single	Single	Single
FTO	FTO	FTO	FTO	FTO	FTO	FTO	FTO	FTO	FTO
Au	Au	Au	Au	Au	Au	Au	Au	Au	Au
CH3NH3GeI3	CH3NH3GeI3	CH3NH3GeI3	CH3NH3GeI3	CH3NH3GeI3	CH3NH3GeI3	CH3NH3GeI3	CH3NH3GeI3	FASnI3	CH3NH3GeI3
1	1	1	1	1	1	1	1	0	1
0	0	0	0	0	0	0	0	1	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	1	0
1	1	1	1	1	1	1	1	0	1
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	1	1	1
1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.41	1.9
0.12	0.02	-0.08	0.18	-0.08	-0.08	-0.08	-0.08	0.48	0.9
0.88	0.88	0.88	0.88	0.62	0.1	0.58	0.88	0	0.16
50	50	50	50	50	50	50	50	30	150
650	650	650	650	550	950	550	650	350	250
50	50	50	50	50	50	50	50	200	150
0.88	0.93	0.94	0.81	1.14	1.66	1.18	0.94	0.915	1.92
20.82	23.4	23.38	23.04	28.42	23.59	28.42	23.38	22.65	14.09
60.64	60.39	61.66	54.36	65	60.29	65.45	61.66	67.74	79.52
11.05	13.19	13.5	10.16	21.04	23.58	21.93	13.5	14.03	21.56

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73	72	71	70	69	68	67	66	65	64
n-i-p	n-i-p	n-i-p	n-i-p	p-i-n	n-i-p	n-i-p	n-i-p	n-i-p	n-i-p
Single	Single	Single	Single	Single	Single	Single	Single	Single	Single
TiO2	ZnOS	ZnO	WS2	PCBM	PCBM	TiO2	ZnO: NR	PCBM	TiO2
Single	Single	Single	Single	Single	Single	Single	Single	Single	Single
NPB	CuI	Cu2O	CuSCN	NiO	Spiro-OMeTAD	Spiro-OMeTAD	Spiro-OMeTAD	PEDOT:PSS	PEDOT:PSS
Single	Single	Single	Single	Single	Single	Single	Single	Single	Single
FTO	FTO	FTO	FTO	FTO	FTO	FTO	FTO	FTO	FTO
Au	Au	Carbon	Au	Au	Au	Au	Au	Au	Au
CH3NH3PbI3	CH3NH3PbI3	CH3NH3PbI3	CH3NH3SnI3	CH3NH3SnI3	CH3NH3SnI3	CH3NH3SnI3	CH3NH3SnI3	CH3NH3GeI3	CH3NH3GeI3
1	1	1	1	1	1	1	1	1	1
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
1	1	1	0	0	0	0	0	0	0
0	0	0	1	1	1	1	1	0	0
0	0	0	0	0	0	0	0	1	1
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	1	1	1
1.5	1.55	1.55	1.31	1.3	1.26	1.26	1.26	1.9	1.9
0.27	0.37	0.1	0.11	0.03	0.27	0.03	0.13	-0.08	-0.08
0.04	-0.3	0.08	0.29	0.21	1.16	1.16	1.16	0.88	0.88
50	50	50	200	85	500	500	500	50	50
400	350	450	700	600	500	400	500	650	650
100	100	450	50	30	800	500	500	50	50
0.92	1.24	1.02	0.89	0.98	1.3	0.9	0.88	0.87	0.93
24.78	23.78	24.85	28.6	33.45	13	32.65	32.49	23.07	23.44
87.31	87.96	82.4	82.62	70.33	68	80.1	80.75	55.37	60.75
20.04	26.11	20.94	19.84	22.95	11.56	23.35	23.11	11.16	13.3

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83	82	81	80	79	78	77	76	75	74
n-i-p	n-i-p	n-i-p	n-i-p	n-i-p	p-i-n	n-i-p	n-i-p	n-i-p	n-i-p
Single	Single	Single	Single	Single	Single	Single	Single	Single	Single
C60	PCBM	TiO2	Zn0.75Mg0.25O	CdZnS	C60	TiO2	TiO2	TiO2	TiO2
Single	Single	Single	Single	Single	Single	Single	Single	Single	Single
CuSbS2	CuI	CuO	MASnBr3	MASnBr3	NO HTL	P3HT	Spiro-OMeTAD	PEDOT:PSS	MEH-PPV
Single	Single	Single	Single	Single	Single	Single	Single	Single	Single
FTO	FTO	FTO	FTO	FTO	FTO	FTO	FTO	FTO	FTO
Au	Au	Au	Au	Au	Au	Au	Au	Au	Au
CH3NH3SnI3	CH3NH3SnI3	CH3NH3SnI3	CH3NH3SnI3	CH3NH3SnI3	CH3NH3SnI3	CH3NH3PbI3	CH3NH3PbI3	CH3NH3PbI3	CH3NH3PbI3
1	1	1	1	1	1	1	1	1	1
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	1	1	1	1
1	1	1	1	1	1	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	1	1	1
1.3	1.3	1.3	1.3	1.3	1.3	1.5	1.5	1.5	1.5
-0.3	-0.3	0.06	-0.14	0.03	-0.27	0.27	0.27	0.27	0.27
-0.28	0.5	-0.07	-0.07	-0.07	0	0.44	0.34	0.24	0.24
30	30	30	30	30	30	50	50	50	50
1000	1100	1000	350	350	400	400	450	450	400
50	50	50	200	200	0	100	150	150	150
1.0204	0.8758	0.9714	0.95	0.87	0.86	0.79	0.99	0.96	0.9
32.3917	34.745	34.7186	33.85	31.42	32.46	27.59	26.21	25.28	25.18
69.4	69.23	73.33	82.01	68.88	73.72	78.83	87.87	87.85	86.88
22.94	25.05	24.73	26.33	18.71	20.54	17.3	23.18	21.6	19.82

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93	92	91	90	89	88	87	86	85	84
n-i-p	p-i-n	p-i-n	p-i-n	p-i-n	p-i-n	n-i-p	n-i-p	n-i-p	n-i-p
Single	Single	Single	Single	Single	Single	Single	Single	Single	Single
SnO2, M-TiO2	DMEC70	DMEC60	PC71BM	PC61BM	PCBM	ZnO	SnO2	IGZO	ZnO
Single	Single	Single	Single	Single	Single	Single	Single	Single	Single
Spiro-OMeTAD	PEDOT:PSS	PEDOT:PSS	PEDOT:PSS	PEDOT:PSS	NiMgLiO	Spiro-OMeTAD	CuSbS2	CuSbS2	CuSbS2
Single	Single	Single	Single	Single	Single	Single	Single	Single	Single
Glass	FTO	FTO	FTO	FTO	FTO	FTO	FTO	FTO	FTO
Ag	Al	Al	Al	Al	Au	Au	Au	Au	Au
MAPbI3	CH3NH3PbI3	CH3NH3PbI3	CH3NH3PbI3	CH3NH3PbI3	CH3NH3PbI3	CH3NH3GeI3	CH3NH3SnI3	CH3NH3SnI3	CH3NH3SnI3
1	1	1	1	1	1	1	1	1	1
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
1	1	1	1	1	1	0	0	0	0
0	0	0	0	0	0	0	1	1	1
0	0	0	0	0	0	1	0	0	0
0	0	0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	1	1	1
1.6	1.5	1.5	1.5	1.5	1.5	1.9	1.3	1.3	1.3
0.18	0	0	0	0	0.3	0.7	-0.2	-0.04	0.06
0.36	0.1	0.1	0.1	0.1	0.15	0.3	-0.28	-0.28	-0.28
240	100	100	100	100	80	50	30	30	30
160	330	330	330	330	300	400	1100	900	600
220	40	40	40	40	20	50	50	50	50
1	0.95	0.92	0.95	0.91	1.072	1.74	1.0186	1.1518	0.8872
20.86	22.44	21.73	21.03	20.92	20.62	16.27	34.6143	34.6411	33.6155
77	75.8	75.8	75.5	76	74.8	64.51	69.28	62.52	72.3
16.11	16.4	15.2	14.5	14.5	16.2	18.3	24.43	24.94	21.56