Recent progress in organic-inorganic halide perovskite solar cells: mechanisms and materials design

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Supplementary information

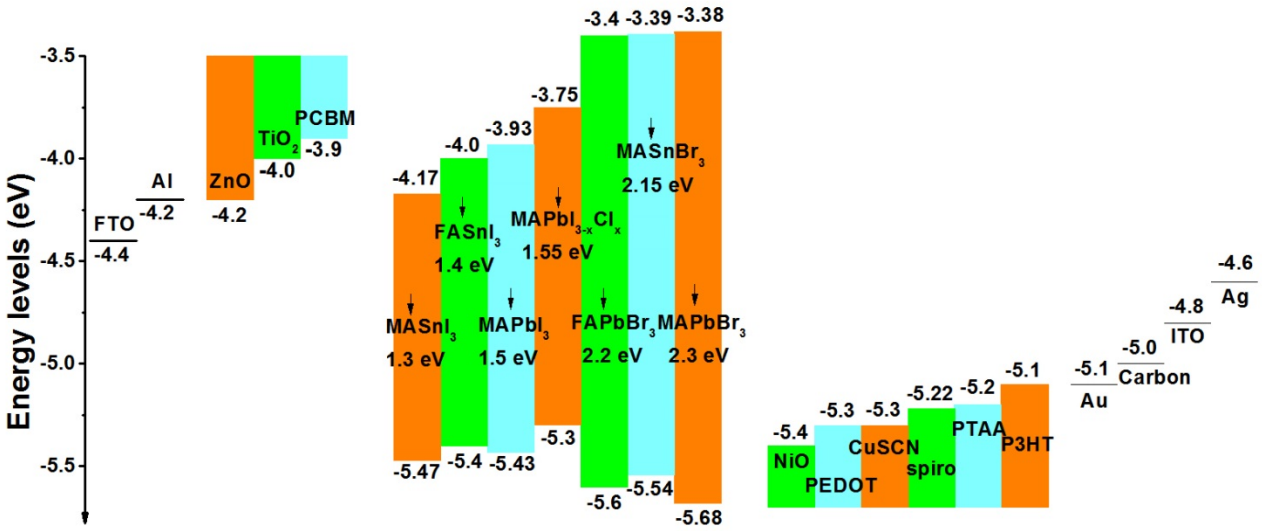

Figure S1. Scheme of energy level of electrodes: FTO,[1, 2] ITO,[3-5] Al,[3, 5] Au,[1] Ag[2] and Carbon[6, 7]; ETMs: TiO_2,[1, 8-11] ZnO[10, 12] and PCBM[3-5]; perovskites: $CH_3NH_3SnI_3$,[13] $NH_2CHCH_2PbI_3$,[14] $CH_3NH_3PbI_3$,[8, 10, 15] $CH_3NH_3PbI_{3-x}Cl_x$,[10, 11] $CH_3NH_3SnBr_3$,[13] $NH_2CHNH_2PbBr_3$[1] and $CH_3NH_3PbBr_3$[9]; HTMs: spiro-OMeTAD,[8, 10, 12, 13] P3HT,[10, 12, 14] PTAA,[15] PEDOT:PSS,[3, 4] CuSCN[10, 12, 16] and NiO[2, 5].

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Table S1. A summary of hybrid perovskite solar cells performance parameters with different anodes. (In order of the appearance in main text)

Structure (from substrate to back electrode)	Methods	J_{SC} [mA/cm^2]	V_{OC} [V]	FF [%]	PCE [%]
Glass-FTO/c-TiO_2/m-ZrO_2/$CH_3NH_3PbI_3$/spiro/Ag[153]	SDM	17.3	1.07	59	10.8
Glass-FTO/c-TiO_2/nr-TiO_2/$CH_3NH_3PbI_3$/spiro/Au[154]	OSPD	15.6	0.955	63	9.4
Glass-FTO/c-TiO_2/nw-TiO_2/$CH_3NH_3PbI_3$/spiro/Au[155]	OSPD	10.67	0.74	54	4.29
Glass-FTO/c-TiO_2/nf-TiO_2/$CH_3NH_3PbI_3$/spiro/Au[156]	SDM	15.88	0.98	63	9.82
Glass-FTO/c-TiO_2/nt-TiO_2/$CH_3NH_3PbI_3$/I^-,I^{3-}/Pt-FTO[157]	SDM	17.9	0.63	57.8	6.52
Glass-FTO/c-TiO_2/m-TiO_2 (15nm) /$CH_3NH_3Pb(I_{0.9}Br_{0.1})_3$/PTAA/Au[158]	OSPD	19.6	1.04	66	12.8
Glass-FTO/c-TiO_2/ns-TiO_2/$CH_3NH_3PbI_3$/spiro/Au[159]	SDM	19.25	0.963	65	12.30
Glass-FTO/hc-TiO_2/m-TiO_2/$CH_3NH_3PbI_3$/spiro/Au[161]	SDM	18.74	0.93	72	12.56
Glass-FTO/np-TiO_2,TiAcAc /m-Al_2O_3/$CH_3NH_3PbI_{3-x}Cl_x$/spiro/Ag[22]	OSPD	21.5	1.02	71	15.9
Glass-FTO/np-TiO_2,graphene/m-Al_2O_3/ $CH_3NH_3PbI_{3-x}Cl_x$/spiro/Au[21]	OSPD	21.9	1.04	73	15.6
Glass-FTO/c-TiO_2/m-TiO_2, graphene quantum dots /$CH_3NH_3PbI_3$/spiro/Au[162]	OSPD	17.06	0.937	63.5	10.15
Glass-FTO/m-TiO_2/ALD-TiO_2/$CH_3NH_3PbI_3$/spiro/Au[163]	SDM	17.64	0.969	67	11.5
Glass-FTO/c-TiO_2/m-TiO_2,HOCO-$(CH_2)_3$-$NH_3^+I^-$/ $CH_3NH_3PbI_3$/spiro/Ag,Au[164]	SDM	19.2	1.00	62	12.0
Glass-FTO/c-TiO_2/m-TiO_2/Y_2O_3/ $CH_3NH_3PbI_{3-x}Cl_x$/spiro/Ag,Au[165]	OSPD	16.55	0.79	-	7.53
Glass-FTO/c-TiO_2/m-TiO_2/Sb_2S_3/$CH_3NH_3PbI_3$/CuSCN/Au[166]	OSPD	17.04	0.56	53	5.03
Glass-FTO/rutile c-TiO_2/$CH_3NH_3PbI_3$/spiro/Au[167]	SDM	19.8	1.05	64	13.7
Glass-ITO/np-TiO_2, TiAcAc/$CH_3NH_3PbI_{3-x}Cl_x$/P3HT/Ag[168]	OSPD	21.0	0.936	69.1	13.6
Glass-FTO /c-TiO_2/rutile m-TiO_2/$CH_3NH_3PbI_3$/spiro/Au[169]	SDM	20.02	1.022	71	14.46
Glass-FTO/c-TiO_2/m-Y-TiO_2/$CH_3NH_3PbI_3$/spiro/Au[170]	OSPD	18.1	0.945	66	11.2
Glass-FTO/c-TiO_2/m-Mg-TiO_2/$CH_3NH_3PbI_3$/P3HT/Au[171]	OSPD	10.4	0.802	50	4.17
Glass-FTO/c-Al-TiO_2/m-Al_2O_3 /$CH_3NH_3PbI_{3-x}Cl_x$/spiro/Ag[172]	OSPD	20.00	1.07	65	13.8
Glass-ITO/PEIE/c-Y-TiO_2/$CH_3NH_3PbI_{3-x}Cl_x$/spiro/Au[4]	OSPD	22.75	1.13	75.01	19.3
Glass-FTO /c-ZnO/nr-ZnO/$CH_3NH_3PbI_3$/spiro/Ag[173]	OSPD	12.7	0.68	58	5.0
Glass-FTO /c-ZnO/$CH_3NH_3PbI_3$/spiro/Au[174]	SDM	11.27	1.08	45.44	5.54
Glass-FTO/c-ZnO/nr-ZnO/$CH_3NH_3PbI_3$/spiro/Au[174]	SDM	16.98	1.02	51.11	8.9

PET-ITO/c-ZnO/nr-ZnO/$CH_3NH_3PbI_3$/spiro/Au[174]	SDM	7.52	0.80	43.14	2.62
Glass-FTO/c-ZnO/m-Al_2O_3/$CH_3NH_3PbI_3$/spiro/Au[132]	SDM	19.68	0.975	41.66	7.86
Glass-FTO/c-ZnO/nr-ZnO/$CH_3NH_3PbI_3$/spiro/Au[175]	SDM	20.08	0.991	56	11.13
Glass-FTO/c-TiO_2/nr-TiO_2/$CH_3NH_3PbI_3$/spiro/Au[175]	SDM	20.92	0.869	55	10.02
Glass-FTO/c-TiO_2/nc-ZnO/$CH_3NH_3PbI_3$/spiro/Au[176]	SDM	16	0.718	41.2	4.8
Glass-ITO/np-ZnO/$CH_3NH_3PbI_3$/spiro/Ag[177]	SDM	20.4	1.03	74.9	15.7
PET-ITO/np-ZnO/$CH_3NH_3PbI_3$/spiro/Ag[177]	SDM	13.4	1.03	73.9	10.2
Glass-FTO/c-Al-ZnO/m-Al-ZnO/$CH_3NH_3PbI_3$/spiro/Ag[178]	SDM	15.1	1.045	76	12.0
Glass-FTO/c-TiO_2/m-TiO_2/C_{60}SAM/$CH_3NH_3PbI_{3-x}Cl_x$/spiro /Ag[180]	OSPD	19.6	0.84	72	11.7
Glass-ITO/PEDOT:PSS/$CH_3NH_3PbI_3$/PCBM/BCP/Al[179]	OSPD	10.32	0.60	63	3.9
Glass-ITO/PEDOT:PSS/$CH_3NH_3PbI_3$/PCBM/Al[38]	OSPD	8.74	0.92	76	6.16
Glass-ITO/PEDOT:PSS/$CH_3NH_3PbI_3$/PCBM/Al [103]	SDM	10.829	0.905	75.6	7.41
Glass-ITO/PEDOT:PSS/$CH_3NH_3PbI_{3-x}Cl_x$ /PCBM/c-TiO_2/Al[181]	OSPD	15.8	0.94	66	9.8
Glass-ITO/PEDOT:PSS/$CH_3NH_3PbI_{3-x}Cl_x$/PCBM/Al[181]	OSPD	17.2	0.84	-	11.5
Glass-ITO/PEDOT:PSS/$CH_3NH_3PbI_{3-x}Cl_x$/PCBM/Al[32]	OSPD	14.3	0.86	60.9	7.5
Glass-FTO/PEDOT:PSS/$CH_3NH_3PbI_{3-x}Cl_x$ /PCBM/Bis-C_{60}/Ag[36]	OSPD	17.5	0.92	73	11.8
Glass-ITO/PEDOT:PSS/polyTPD /$CH_3NH_3PbI_3$/PCBM/Al[182]	DSVD	16.12	1.05	0.67	12.04
Glass-ITO/PEDOT:PSS/polyTPD/$CH_3NH_3PbI_3$/PCBM/Au[183]	DSVD	18.8	1.07	0.63	12.7
Glass-ITO/PEDOT:PSS/$CH_3NH_3PbI_3$/ICBA/C_{60}/BCP/Al[184]	OSPD	15.7	0.97	80.1	12.2
Glass-ITO/PEDOT:PSS/$CH_3NH_3PbI_3$/PCBM/LiF/Al[185]	OSPD	20.7	0.866	78.3	14.1
Glass-ITO/PEDOT:PSS/$CH_3NH_3PbI_3$/ICBA/C_{60}/BCP/Al[49]	IDM	19.6	0.99	79.3	15.4
Glass-ITO/PEDOT:PSS/polyTPD/$CH_3NH_3PbI_3$/PCBM/Au[186]	DSVD	18.2	1.09	75	14.8
Glass-ITO/PEDOT:PSS/polyTPD/$CH_3NH_3PbI_3$ /3TPYMB/Au[186]	DSVD	14.2	0.7	56	5.5
Glass-ITO/polythiophene/$CH_3NH_3PbI_3$/C_{60}/BCP/Ag[187]	SDM	16.2	1.03	70.7	11.8
PET-ITO/PEDOT:PSS/$CH_3NH_3PbI_{3-x}Cl_x$/PCBM/Al[181]	OSPD	16.5	0.86	64	9.2
PET-ITO/PEDOT:PSS/$CH_3NH_3PbI_{3-x}Cl_x$ /PCBM/c-TiO_2/Al[189]	OSPD	14.4	0.88	51	6.4
PET/AZO/Ag/AZO/PEDOT:PSS/polyTPD /$CH_3NH_3PbI_3$/PCBM/Au[190]	DSVD	14.3	1.04	47	7

Notes: For structures: spiro is short for spiro-OMeTAD while c-, hc-, n-,m-, nr-, nw-, nf-, nt- and ns- of TiO_2 refer to compact, high compact, nanoparticle, mesoporous, nanorod, nanowire, nanofiber, nanotube and nanosheet structure, respectively. For perovskite synthesis methods: SDM and OSPD mean sequential deposition and one step precursor deposition methods, respectively; while DSVD and IDM mean dual-source vapour deposition and interdiffusion deposition methods, respectively.

Table S2. A summary of hybrid perovskite solar cells performance parameters with different cathodes. (In order of the appearance in main text)

Structure (from substrate to back electrode)	Methods	J_{SC} [mA/cm^2]	V_{OC} [V]	FF [%]	PCE [%]
Glass-FTO /c-TiO_2/ns-TiO_2/$CH_3NH_3PbI_3$/Au[17]	OSPD	16.1	0.6316	57	5.5
Glass-FTO /c-TiO_2/np-TiO_2/$CH_3NH_3PbI_3$/Au[191]	OSPD	18.8	0.712	60	8
Glass-FTO/c-TiO_2/m-TiO_2/$CH_3NH_3PbI_3$/Au[192]	SDM	19	0.84	68	10.85
Glass-FTO/c-TiO_2/m-TiO_2/$CH_3NH_3PbI_3$/Au[194]	SDM	17.8	0.905	65	10.49
Glass-FTO/c-TiO_2/m-TiO_2/$CH_3NH_3PbI_3$/Au[50]	MTSD	16.0	0.948	69	10.47
Glass-FTO/c-TiO_2/m-TiO_2/$CH_3NH_3PbI_3$/Al_2O_3/Au[195]	-	10.67	0.789	-	5.07

Glass-FTO/c-TiO_2/m-TiO_2/$CH_3NH_3PbI_3$/TPB/Au[196]	MTSD	14.1	0.786	61	6.71
FTO-glass/c-TiO_2/m-TiO_2/$CH_3NH_3PbI_3$/Al_2O_3/spiro/Au[198]	OSPD	11.11	0.86	46	4.6
Glass-FTO/c-TiO_2/m-TiO_2/$CH_3NH_3PbI_3$/CuI/Au[199]	OSPD	17.8	0.55	62	6.0
Glass-FTO/c-TiO_2/m-TiO_2/$CH_3NH_3PbI_3$/CuSCN/Au[51]	OSPD	14.5	0.63	53	4.85
Glass-FTO/c-TiO_2/m-TiO_2/$CH_3NH_3PbI_3$/CuSCN/Au[200]	MTSD	19.7	1.016	62	12.4
Glass-FTO/c-TiO_2/$CH_3NH_3PbI_{3-x}Cl_x$/CuSCN/Au[201]	OSPD	14.4	0.727	61.7	6.4
Glass-FTO/NiO/$CH_3NH_3PbI_{3-x}Cl_x$/PCBM/Ag[202]	DSVD	14.2	0.786	65	7.26
Glass-FTO/c-NiO/m-NiO/$CH_3NH_3PbI_3$/PCBM/Al[203]	OSPD	4.9	0.83	35	1.5
Glass-ITO/c-NiO/$CH_3NH_3PbI_3$/PCBM/Al[46]	SDM	15.4	1.05	47	7.6
Glass-ITO/c-NiO/$CH_3NH_3PbI_3$/PCBM/BCP/Al[186]	OSPD	12.43	0.92	68	7.8
Glass-ITO/c-NiO/m-NiO /$CH_3NH_3PbI_3$/PCBM/BCP/Al[205]	SDM	13.24	1.040	68	9.51
Glass-FTO/c-NiO/$CH_3NH_3PbI_3$/PCBM/Au[206]	SDM	16.27	0.882	63.5	9.11
Glass-ITO/c-NiO_x/m-NiO/$CH_3NH_3PbI_3$/PCBM/BCP/Al[207]	SDM	19.8	0.96	61	11.6
Glass-ITO/GO/$CH_3NH_3PbI_{3-x}Cl_x$/PCBM/ZnO/Al[209]	OSPD	1.00	17.46	71	12.40
Glass-FTO/c-TiO_2/m-TiO_2/$CH_3NH_3PbI_3$/P3HT/Au[210]	OSPD	12.6	0.73	73.2	6.7
Glass-FTO/c-TiO_2/m-TiO_2/$CH_3NH_3PbI_3$/PCPDTBT/Au[210]	OSPD	10.3	0.77	66.7	5.3
Glass-FTO/c-TiO_2/m-TiO_2/$CH_3NH_3PbI_3$/PCDTBT/Au[210]	OSPD	10.5	0.92	43.7	4.2
Glass-FTO/c-TiO_2/m-TiO_2/$CH_3NH_3PbI_3$/PTAA/Au[210]	OSPD	16.5	0.997	72.7	12.0
Glass-FTO/c-TiO_2/m-TiO_2/$CH_3NH_3PbI_3$/PDPPDBTE/Au[211]	OSPD	14.4	0.8553	74.9	9.2
Glass-FTO/c-TiO_2/m-TiO_2/$CH_3NH_3PbI_3$/PCBTDPP/Au[212]	OSPD	13.86	0.83	48	5.55
Glass-FTO/c-TiO_2/m-TiO_2/$CH_3NH_3PbI_3$/PTB-DCB21/Au[213]	OSPD	15.35	0.888	64	8.7
Glass-FTO/c-TiO_2/m-TiO_2/$CH_3NH_3PbI_3$: Li-salt/PANI/FTO-glass[214]	inject	14.48	0.78	65	7.34
Glass-FTO/c-TiO_2/m-TiO_2/$CH_3NH_3PbI_3$/PTAA/Au[24]	OSPD	21.3	1.04	73	16.2
Glass-FTO/c-TiO_2/m-TiO_2/$CH_3NH_3Pb(I_{1-x}Br_x)_3$/PTAA/Au[24]	OSPD	19.64	1.11	74.2	16.15
Glass-FTO/c-TiO_2/m-TiO_2/C_{60}SAM /$CH_3NH_3PbI_{3-x}Cl_x$/P3HT/Ag[180]	OSPD	14.9	0.81	-	6.7
Glass-FTO /c-TiO_2/m-TiO_2/C_{60}SAM /$CH_3NH_3PbI_{3-x}Cl_x$/PCPDTBT/Ag[180]	OSPD	15.6	0.88	51	6.84
Glass-FTO/c-TiO_2/m-TiO_2/$CH_3NH_3PbI_3$/P3HT-MWNT/Au[215]	OSPD	14.8	0.76	57	6.45
Glass-FTO/c-TiO_2/m-TiO_2/$CH_3NH_3PbI_{3-x}Cl_x$/P3HT/Au[216]	OSPD	12	0.93	58	9.3
Glass-ITO/c-TiO_2/m-TiO_2/$CH_3NH_3PbI_{3-x}Cl_x$/P3HT/Ag[39]	OSPD	20.8	0.921	54.2	10.4
Glass-ITO/c-TiO_2/$CH_3NH_3PbI_{3-x}Cl_x$/P3HT+Li,D-TBP/Ag[52]	OSPD	19.1	0.98	66.3	12.4
Glass-FTO/c-TiO_2/m-TiO_2/$CH_3NH_3PbI_3$ /spiro:FK209+Li,TBP/Au[219]	OSPD	18.3	0.865	66.0	10.4
Glass-FTO/c-TiO_2/m-TiO_2/$CH_3NH_3PbI_3$ /spiro:MY11+Li,TBP/Au[220]	SDM	16.8	1.000	71	11.9
Glass-FTO/c-TiO_2/$CH_3NH_3PbI_{3-x}Cl_x$ /spiro:Li, IrCp*Cl(PyPyz)[TFSI]/Au[221]	OSPD	15.90	1.064	64	10.8
Glass-FTO/c-TiO_2/m-TiO_2/$CH_3NH_3PbI_3$ /spiro:BuPyIm-TFSI:TBP/Ag[222]	SDM	16.26	0.87	56	7.91
Glass-FTO/c-TiO_2/m-TiO_2/$CH_3NH_3PbI_3$ /spiro+spiro$(TFSI)_2$:Li,TBP/Au[223]	SDM	18	0.9	60	10.1
Glass-FTO/c-TiO2/m-TiO_2/$CH_3NH_3PbI_3$/po-spiro:Li,TBP/Au[25]	OSPD	21.2	1.02	77.6	16.7
Glass-FTO/c-TiO_2/m-TiO_2/$CH_3NH_3PbI_3$/2TPA-2-DP/Au[224]	OSPD	16.8	0.91	67.1	9.1
Glass-FTO/c-TiO_2/$CH_3NH_3PbI_{3-x}Cl_x$/DR3TBDTT/Au[225]	OSPD	15.3	0.95	60	8.8
Glass-FTO/c-TiO_2/m-TiO_2/$CH_3NH_3PbI_3$ /KTM3+FK269+Li,TBP/Au[226]	SDM	13.0	1.08	78.3	11.0
Glass-FTO/c-TiO_2/m-TiO_2/$CH_3NH_3PbI_3$/TTF-1/Ag[227]	SDM	19.9	0.86	64.4	11.03
Glass-FTO/c-TiO_2/m-TiO_2/$CH_3NH_3PbI_3$/PNBA/Au[228]	SDM	17.5	0.945	68.9	11.4

Glass-FTO/c-TiO_2/m-TiO_2/$CH_3NH_3PbI_3$/HTM1/Au[229]	SDM	18.1	0.921	68	11.34
Glass-FTO/c-TiO_2/m-TiO_2/$CH_3NH_3PbI_3$/HTM2/Au[229]	SDM	17.9	0.942	69	11.63
Glass-FTO/c-TiO_2/m-TiO_2/$CH_3NH_3PbI_3$ /Py-C+FK269+Li,TBP/Au[230]	OSPD	20.2	0.89	69.4	12.4
Glass-FTO/c-TiO_2/m-TiO_2/$CH_3NH_3PbI_3$ /Triazine-Th-OMeTPA+FK102+Li,TBP/Au[231]	SDM	20.74	0.92	66	12.51
Glass-FTO/c-TiO_2/m-TiO_2/$CH_3NH_3PbI_3$/Fused-F/Au[232]	SDM	17.9	1.036	68	12.8
Glass-FTO/c-TiO_2/m-TiO_2/$CH_3NH_3PbI_3$ /H101+FK102+Li,TBP/Au[233]	SDM	19.1	1.05	65	13.2
Glass-FTO/c-TiO_2/m-TiO_2/$CH_3NH_3PbI_{3-x}Cl_x$/IPFB/spiro/Ag[234]	OSPD	23.38	1.06	67	15.7
Glass-FTO/c-TiO_2/m-TiO_2 /$CH_3NH_3PbI_3$/MMT/spiro/Au[235]	SDM	21.2	0.88	64	11.9
Glass-FTO/c-TiO_2/$CH_3NH_3PbI_{3-x}Cl_x$/spiro/MoO_x/Al[236]	OSPD	19.55	0.990	59.0	11.42
Glass-FTO/c-TiO_2/m-ZrO_2/$CH_3NH_3PbI_3$/graphite[237]	Drop coating	12.4	0.878	61	6.64
Glass-FTO/c-TiO_2/m-TiO_2/m-ZrO_2 /$CH_3NH_3PbI_3$/OMC+flaky graphite[238]	Drop coating	13.23	0.841	63	7.02
Glass-FTO/c-TiO_2/ns-TiO_2/m-ZrO_2/$CH_3NH_3PbI_3$/graphite[239]	SDM	20.1	0.868	61	10.64
Glass-FTO/c-TiO_2/m-TiO_2/m-ZrO_2/ $(CH_3NH_3)_{0.4}(NH_2CHNH_2)_{0.6}PbI_3$/graphite[240]	SDM	20.9	0.921	67	12.9
Glass-FTO/c-TiO_2/m-ZrO_2/$(5\text{-}AVA)_x(MA)_{1-x}PbI_3$/graphite[241]	Drop coating	22.8	0.858	66	12.84
Glass-FTO/c-TiO_2/m-TiO_2/$CH_3NH_3PbI_{3-x}Cl_x$/spiro/CNT[242]	SDM	18.1	1.00	55	9.90
Glass-FTO/c-TiO_2/m-TiO_2/$CH_3NH_3PbI_{3-x}Cl_x$/CNT[242]	SDM	15.46	0.88	51	6.87

Notes: For structures: c-, m-, np- and ns- refer to compact, mesoporous nanoparticle and nanosheet structure. For perovskite synthesis methods: SDM and OSPD mean sequential deposition and one step precursor deposition methods, respectively; while DSVD and MTSD are short for dual-source vapour deposition and modified two-step deposition method.

Table S3. A summary of hybrid perovskite solar cells' performance parameters with different perovskite. (In order of the appearance in main text)

Structure (from substrate to back electrode)	Methods	J_{SC} [mA/cm^2]	V_{OC} [V]	FF [%]	PCE [%]
Glass-FTO /m-TiO_2/Z907/$CH_3NH_3PbBr_3$/I^-,I^{3-}/Pt-FTO[243]	OSPD	11.7	0.54	54	3.4
Glass-FTO/c-TiO_2/m-TiO_2/$CH_3NH_3PbI_3$/PbS QDs/Au[244]	OSPD	24.63	0.3438	43	3.6
Glass-FTO/c-TiO_2/m-Al_2O_3:Au@SiO_2 /$CH_3NH_3PbI_{3-x}Cl_x$/spiro/Ag[245]	OSPD	16.91	1.02	64	11.4
Glass-FTO/c-TiO_2/m-TiO_2/$CH_3NH_3PbBr_3$/PCBTDPP/Au[212]	OSPD	4.47	1.16	59	3.04
Glass-FTO/c-TiO_2/m-Al_2O_3/$CH_3NH_3PbBr_3$/PDI/Au[249]	OSPD	1.08	1.30	40	0.56
Glass-FTO/c-TiO_2/m-TiO_2/$CH_3NH_3PbBr_3$/PIF8-TAA/Au[23]	OSPD	6.1	1.40	79	6.7
Glass-FTO /c-TiO_2/nw-TiO_2/$CH_3NH_3PbI_2Br$/spiro/Au[155]	OSPD	10.12	0.82	59	4.87
Glass-FTO/np-TiO_2/$CH_3NH_3PbI_{3-x}Br_x$/Au[250]	SDM	16.2	0.77	68	8.54
Glass-FTO/c-TiO_2/m-TiO_2/$CH_3NH_3PbI_{3-x}Br_x$/PTAA/Au[251]	OSPD	19.3	0.91	70.2	12.3
Glass-FTO/c-TiO_2/m-Al_2O_3/$CH_3NH_3PbI_{3-x}Cl_x$/CBP/Au[252]	OSPD	4.0	1.50	46	2.70
Glass-FTO/c-TiO_2/m-Al_2O_3 /$CH_3NH_3Pb(Br_xI_{1-x})_{3-y}Cl_y$/spiro/Au[253]	OSPD	19.63	1.015	62.6	12.5
Glass-ITO/PEDOT:PSS /$CH_3NH_3Pb(I_{0.8}Br_{0.2})_{3-x}Cl_x$/PCBM/Bis-C60/Ag[254]	OSPD	14.9	0.99	68	10.0
Glass-FTO /np-TiO_2/$CH_3CH_2NH_3PbI_3$/I^-,I^{3-}/Pt-FTO[256]	OSPD	5.2	0.660	70.4	2.4
Glass-ITO/PEDOT:PSS/$Cs_{0.10}MA_{0.90}PbI_3$/PCBM/Al[257]	OSPD	10.10	1.05	73	7.68

Glass-FTO/c-TiO_2/m-TiO_2/20%SnF_2-$CsSnI_3$/m-MTDATA/Au[258]	OSPD	22.7	0.24	37	2.02
Glass-FTO/c-TiO_2/m-TiO_2/$NH_2CHNH_2PbI_3$/P3HT/Au[259]	in-situ dipping	18.3	0.84	50	7.5
Glass-FTO/c-TiO_2/m-TiO_2/$NH_2CHNH_2PbI_3$/spiro/Au [260]	SDM	6.45	0.97	68.7	4.30
Glass-FTO/c-TiO_2/$NH_2CHNH_2PbI_3$/spiro/Au[14]	OSPD	23.3	0.94	65	14.2
Glass-FTO/c-TiO_2/m-TiO_2 /$(CH_3NH_3)_{0.6}(NH_2CHNH_2)_{0.4}PbI_3$/spiro/Au[261]	SDM	21.2	1.003	70	14.9
Glass-FTO/c-TiO_2/m-TiO_2 /$NH_2CHNH_2PbI_3$/$CH_3NH_3PbI_3$/spiro/Au[262]	SDM	20.97	1.032	74	16.01
Glass-FTO/c-TiO_2/$NH_2CHNH_2PbBr_3$/spiro/Au[263]	SDM	6.6	1.35	73	6.5
Glass-FTO/c-TiO_2/m-TiO_2/$CH_3NH_3Sn_{0.5}Pb_{0.5}I_3$/P3HT/Ag/Au[264]	OSPD	20.04	0.42	50	4.18
Glass-FTO/c-TiO_2/m-TiO_2/$CH_3NH_3Sn_{0.5}Pb_{0.5}I_3$/spiro/Au[265]	OSPD	20.64	0.584	60.32	7.27
Glass-FTO/c-TiO_2/m-TiO_2/$CH_3NH_3SnI_3$/spiro/Au[266]	OSPD	16.30	0.68	48	5.23
Glass-FTO/c-TiO_2/m-TiO_2/$CH_3NH_3SnIBr_2$/spiro/Au[266]	OSPD	11.73	0.82	57	5.73
Glass-FTO/c-TiO_2/m-TiO_2/$CH_3NH_3SnI_3$/spiro/Au[267]	OSPD	16.8	0.88	42	6.4

Notes: For structures: c-, m- and np- refer as compact, mesoporous nanoparticle structure. For perovskite synthesis methods: SDM and OSPD mean sequential deposition and one step precursor deposition methods, respectively.