Electronic Supplementary Material (ESI) for Nanoscale.

Supplemental information

Efficient and stable semitransparent perovskite photovoltaics via a Lewis base incorporation

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Figure S1. (A) An incomplete deposition of the perovskite thin layers on the Lewis base without alkyls (triphenylphosphine, TPP)/MeO-2PACz/ITO/glass. (B) A large contact angle (61^{o}) of the perovskite precursor solutions on the triphenylphosphine/MeO-2PACz/ITO/glass. To avoid the issues of the incomplete deposition and the inferior contacts at interfaces, we proposed the component strategy using the Lewis base and PCBM blends.

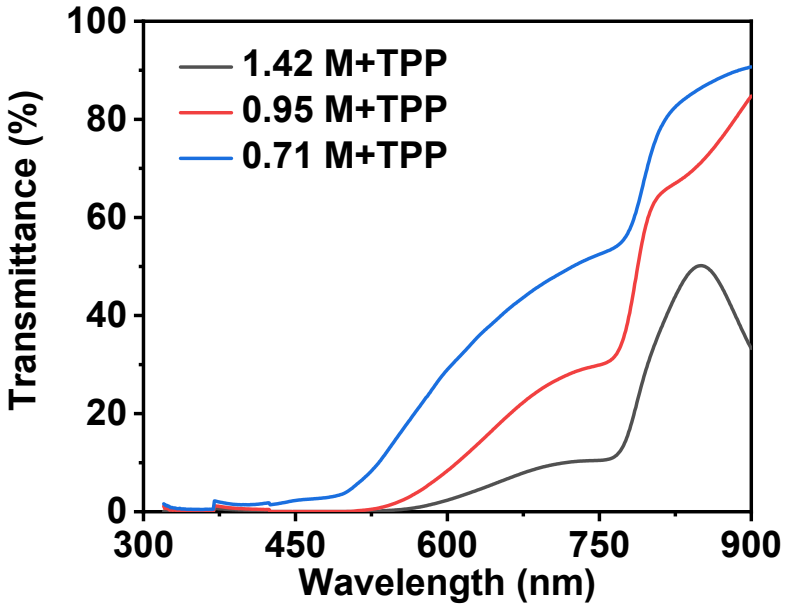

Figure S2. Transmittance spectra of the ST-PSCs with AVTs of 4.93%, 14.38% and 25.65%.

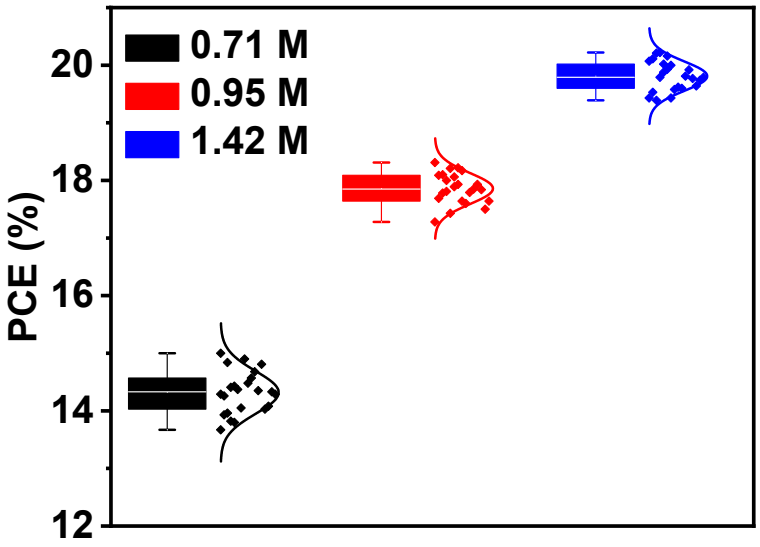

Figure S3. Numerical distribution characteristics of PCEs of the optimized ST-PSCs with the Lewis base incorporation.

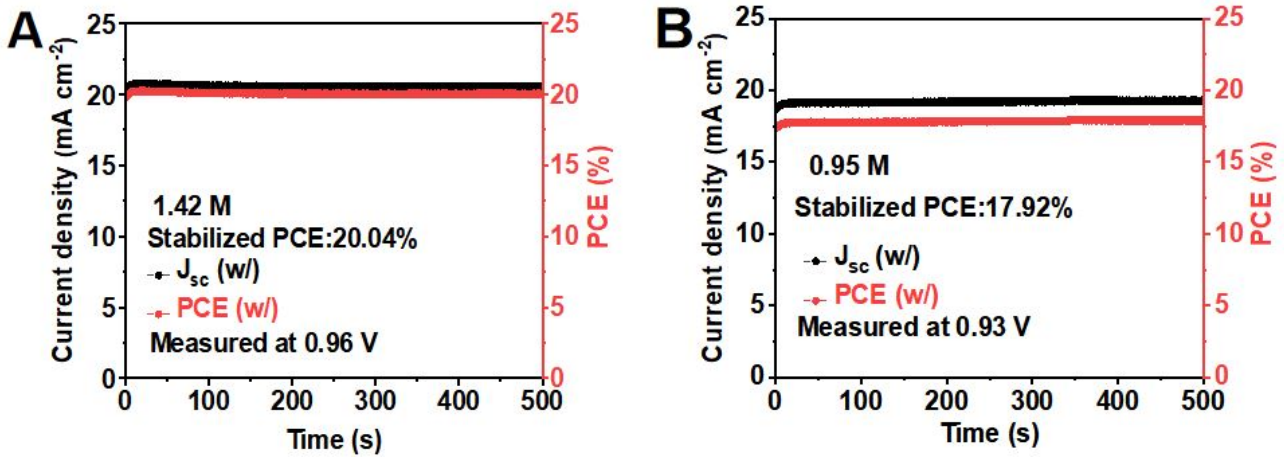

Figure S4. (A,B) Steady-state photo-current and power outputs of the ST-PSCs based on the 1.42 M and 0.95 M perovskites with the TPP treatments.

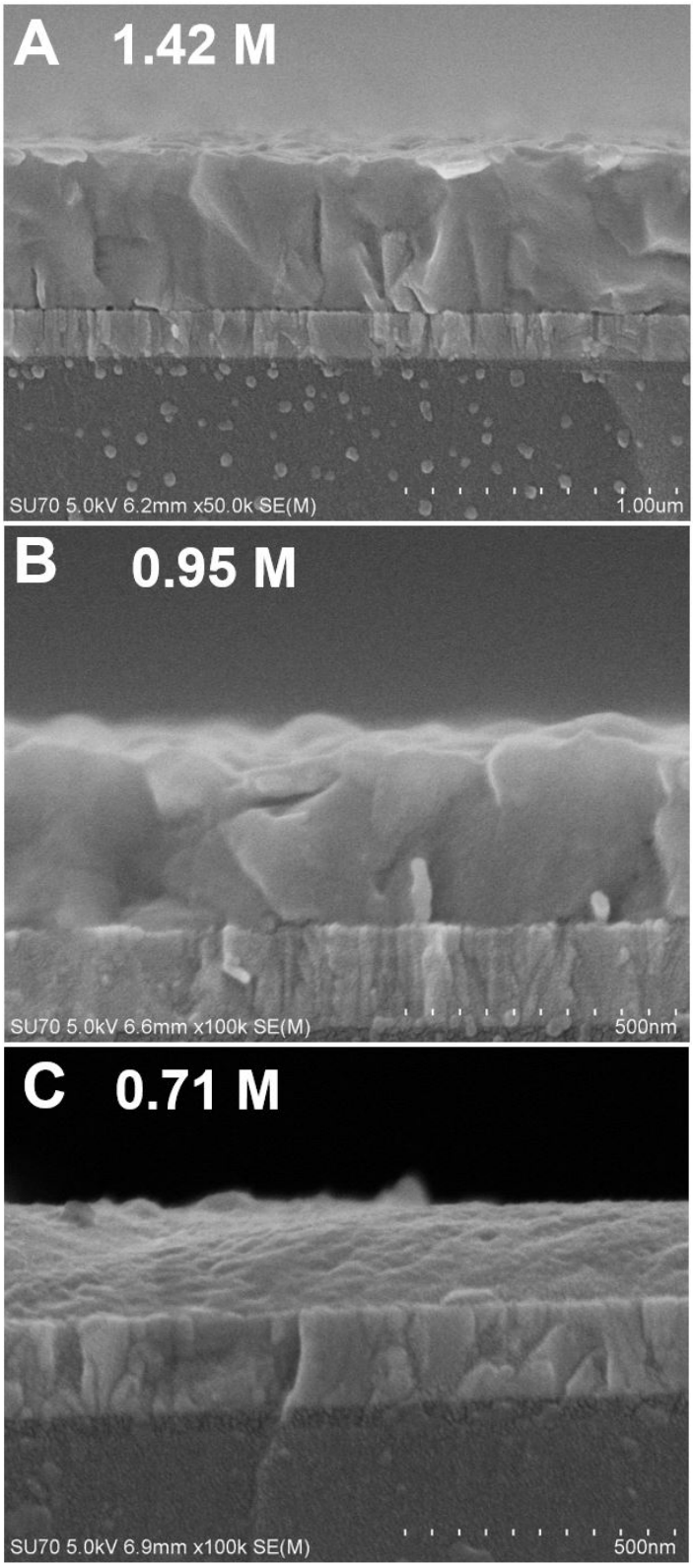

Figure S5. Cross-sectional morphology of the perovskite layers. A) 1.42 M, B) 0.95 M, and C) 0.71 M.

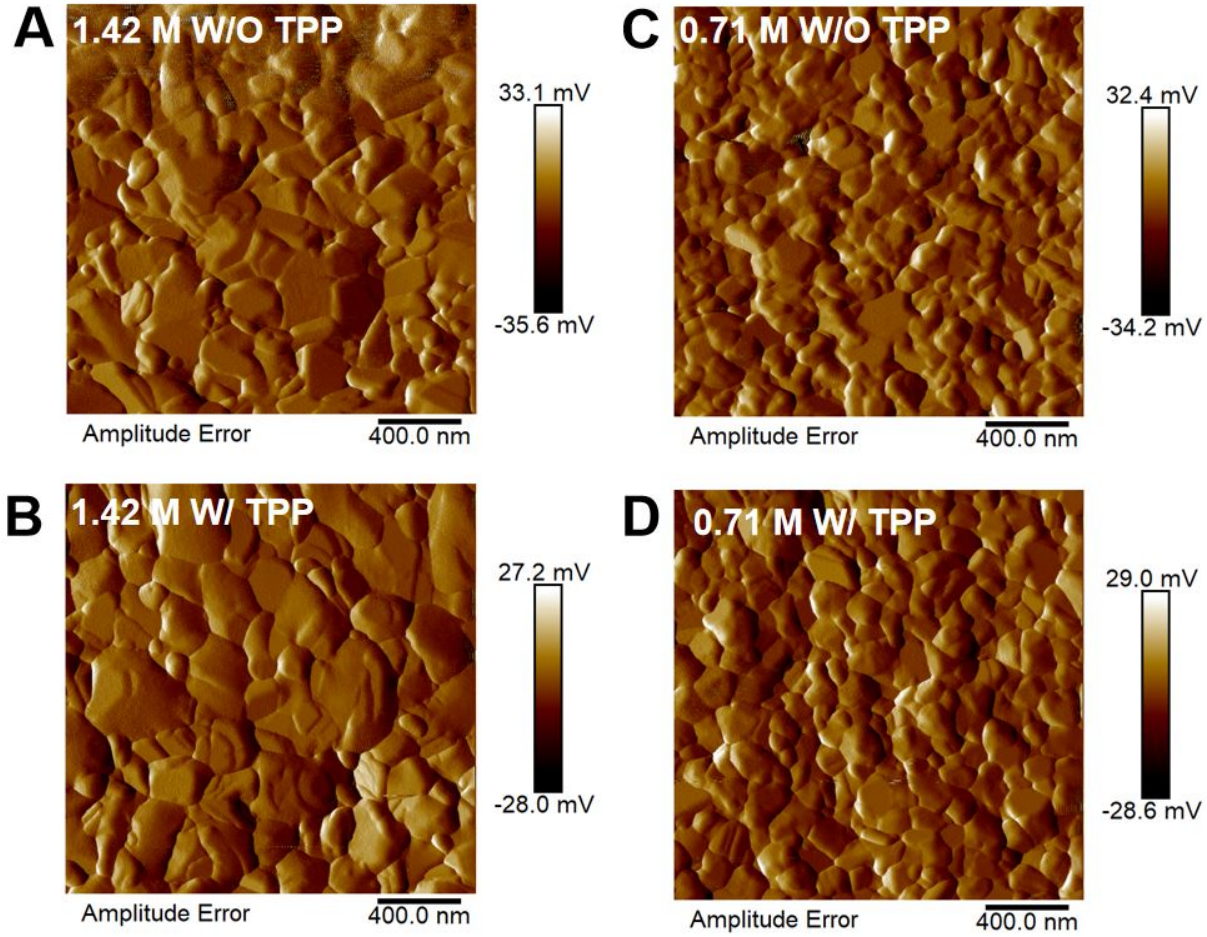

Figure S6. Voltage amplitude errors of the 1.42 M (A,B) and 0.71 M (C,D) perovskite thin layers without and with the Lewis base treatments.

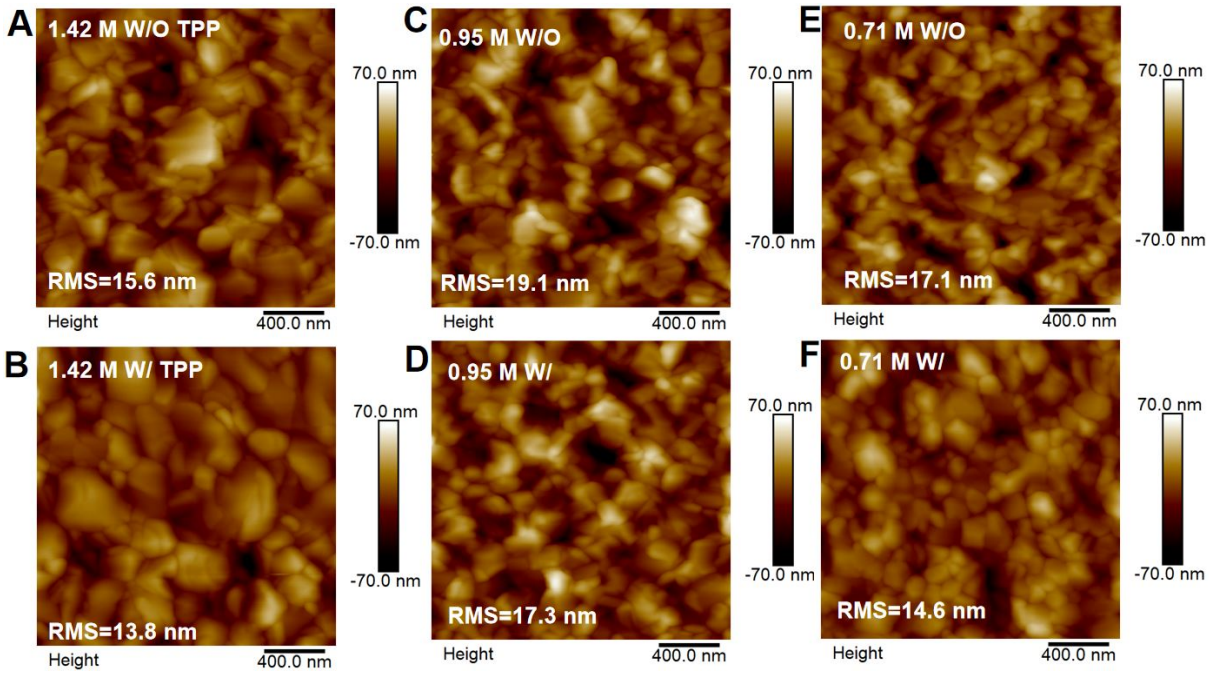

Figure S7. The morphology of the perovskite thin layers without and with the Lewis base treatments. The results showed a lower root-mean-square roughness after the Lewis base treatments.

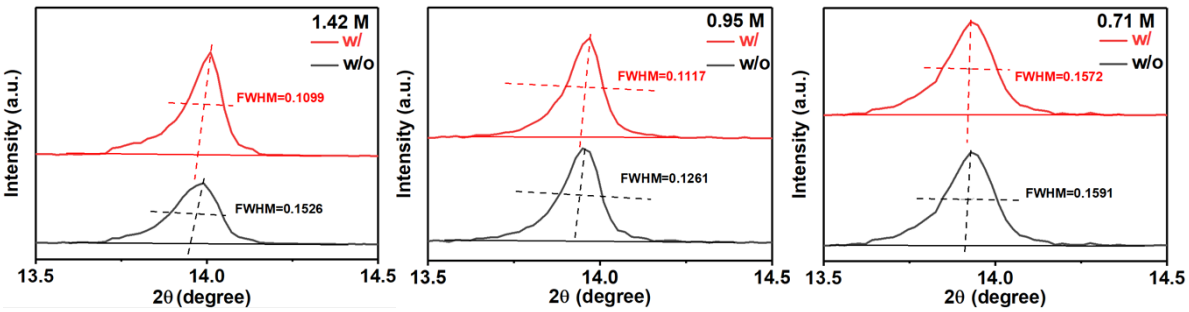

Figure S8. XRD spectra of the 1.42-, 0.95- and 0.71 M perovskite layers those showed the FWHM values of the (101) peaks.

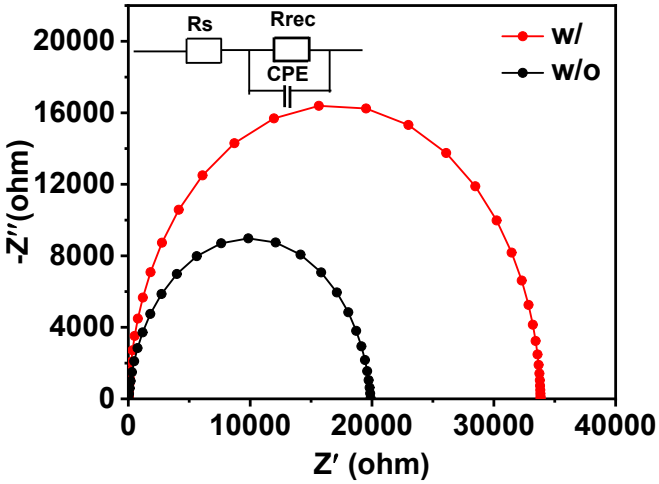

Figure S9. Nyquist plots under dark of the semitransparent PSCs without and with the TPP modifications.

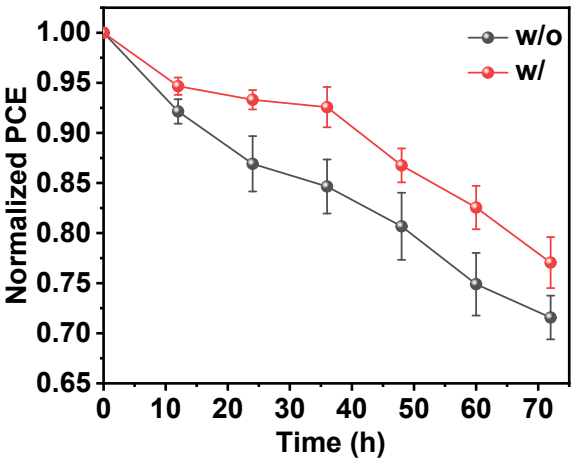

Figure S10. Air stability of the semitransparent PSCs without and with the TPP modifications.

Table S1. Photovoltaic performances of the three kinds of the semitransparent PSCs without (a) and with (b) the TPP treatments, respectively.

Concentration	Scanning	V_{OC} [*V*]	J_{SC} [mA cm^{-2}]	FF [%]	PCE [%]	PCE_{ave} [%]	AVT [%]	LUE [%]
1.42 M	Forward[a]	1.093	22.66	76.90	19.06	18.54	4.65	0.88
	Backward[a]	1.095	22.84	76.25	19.07		4.65	0.88
	Forward[b]	1.120	22.68	79.56	20.20	19.78	4.93	0.99
	Backward[b]	1.112	22.76	79.89	20.22		4.93	0.99
0.95 M	Forward[a]	1.097	20.24	76.26	16.93	16.79	13.51	2.29
	Backward[a]	1.099	20.26	76.47	17.02		13.51	2.30
	Forward[b]	1.123	20.64	77.94	18.07	17.89	14.38	2.60
	Backward[b]	1.118	20.73	79.03	18.32		14.38	2.63
0.71 M	Forward[a]	1.024	17.79	74.03	13.49	13.20	24.38	3.29
	Backward[a]	1.024	17.83	74.25	13.56		24.38	3.31
	Forward[b]	1.039	18.04	79.94	14.98	14.71	25.65	3.84
	Backward[b]	1.043	18.02	79.75	15.00		25.65	3.85

Table S2. Comparisons of the PCE, AVT and LUE values of all the semitransparent PSCs.

Device structure	**Top electrode**	**PCE [%]**	**AVT [%]**	**LUE [%]**	**Ref.**
ITO/MeO2PACZ/$Cs_{0.05}(FA_{0.98}MA_{0.02})_{0.95}Pb(I_{0.98}Br_{0.02})_3$/PCBM @TPP/BCP/Ag/CBP	Ag/CBP	**20.22**	4.93	**1.00**	**Here**
FTO/TiO_2/$CH_3NH_3PbI_{3-x}Cl$/spiro-MeOTAD/MoOx /Au-seed/Cu/MoO_x	MoO_x/Au/Cu/ MoO_x	**12.50**	5.00	**0.63**	4
ITO/MeO2PACZ/$Cs_{0.05}(FA_{0.98}MA_{0.02})_{0.95}Pb(I_{0.98}Br_{0.02})_3$/PCBM @TPP/BCP/Ag/CBP	Ag/CBP	**18.32**	14.38	**2.63**	**Here**
ITO/SnO2/Cs0.1MA0.15FA0.75PbI2.49Br0.51/spiro-MeOTAD/MoOx/Cu/Ag	MoO_x/Cu/Ag/ MoO_x	**13.44**	8.67	**1.17**	2
FTO/SnO_2/C_{60}-SAM/$Cs_{0.05}(FA_{0.85}MA_{0.15})_{0.95}Pb(I_{0.85}Br_{0.15})_3$/ poly-VNPB/MoOx/Au/MoOx	MoOx/Au/MoO_x	**16.1**	10.1	**1.61**	3
FTO/$ZnTiO_3$/FAMAPb(IBr)$_3$/QDs/NiOx/Au	Au	**14.25**	14.50	**2.07**	5
FTO/TiO_2/$MAPbI_{3-x}Br_x$/Spiro-OMeTAD/Au	Au	**18.27**	10.00	**1.83**	9
ITO/SnO_2/CsFAMA/spiro-MeOTAD/MoOx/Ag/WO_x	MoO_x/Ag/WO_x	**15.40**	10.17	**1.57**	15
ITO/SnO2/$FAPbI_3$/spiro-OMeTAD/MoO3/Ag/WO_3	MoO_3/Ag/WO_3	**15.33**	12.18	**1.87**	16
ITO/SnO_2/ $FA_{0.5}MA_{0.38}Cs_{0.12}PbI_{2.04}Br_{0.96}$/ spiro-OMeTAD/$MoO_3$/Ag/ WO_3	MoO_3/Ag/WO_3	**13.16**	16.55	**2.18**	16
ITO/SnO_2/ $FA_{0.5}MA_{0.38}Cs_{0.12}PbI_{2.04}Br_{0.96}$/ spiro-OMeTAD/$MoO_3$/Ag/ WO_3	MoO_3/Ag/WO_3	**14.94**	14.54	**2.17**	16
ITO/MeO2PACZ/$Cs_{0.05}(FA_{0.98}MA_{0.02})_{0.95}Pb(I_{0.98}Br_{0.02})_3$/PCBM @TPP/BCP/Ag/CBP	Ag/CBP	**15.00**	**25.65**	**3.85**	**Here**
FTO/SnO_2/$Cs_{0.05}(MA_{0.17}FA_{0.83})_{0.95}Pb(I_{0.83}Br_{0.17})_3$/spiro-OMeTAD/Au NRs+TOAB	Au NRs+TOAB	**13.70**	27.00	**3.70**	1
ITO/P3CT-N/$CsPbI_2Br$/ PCBM/C_{60}/BCP/Ag/MoO_x	Ag/MoOx	**11.04**	21.19	**2.30**	6
ITO/PTAA/$MAPbI_3$-HEC/PCBM/BCP/Au	Au	**11.60**	20.69	**2.4**	7
ITO/PTAA/CH3$NH_3(I_{0.75}Br_{0.15})_3$/PCBM/BCP/Ag/MoOx	Ag/MoOx	**12.82**	21.00	**2.69**	8
ITO/PTAA/$MAPbI_3$/ PCBM-BCP/Al	Al	**14.40**	20.00	**2.88**	10
ITO/NiOx/$CH_3NH_3PbI_3$/polyethylenimine ethoxylated (PEIE)/Cu	Cu	**11.95**	20.00	**2.39**	11
FTO/SnO_2/KCsFAMA/Spiro-OMeTAD/rGO/AgNWs/rGO_3	rGO/AgNWs/ rGO_3	**14.69**	20.11	**3.25**	12
ITO/$MPbI_3$/C_{60}/BCP/Ag	Ag	**10.30**	22.00	**2.27**	13
ITO/NiOx/$CH_3NH_3PbI_3$/PCBM/$Zr(acac)_4$/Ag/CsF	Ag/CsF	**11.74**	23.00	**2.70**	14

Table S3. The lifetimes of the control and modified perovskite/ITO samples.

	A_1	τ_1 (ns)	A_2	τ_2 (ns)	τ_a (ns)
control	1271.03	5.90	411.53	39.17	28.60
TPP	1490.79	6.81	532.60	42.33	31.30

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