Supporting Information

Triple Cation Perovskite Doped with Small Molecule F4TCNQ for High Efficient Stable Photodetectors

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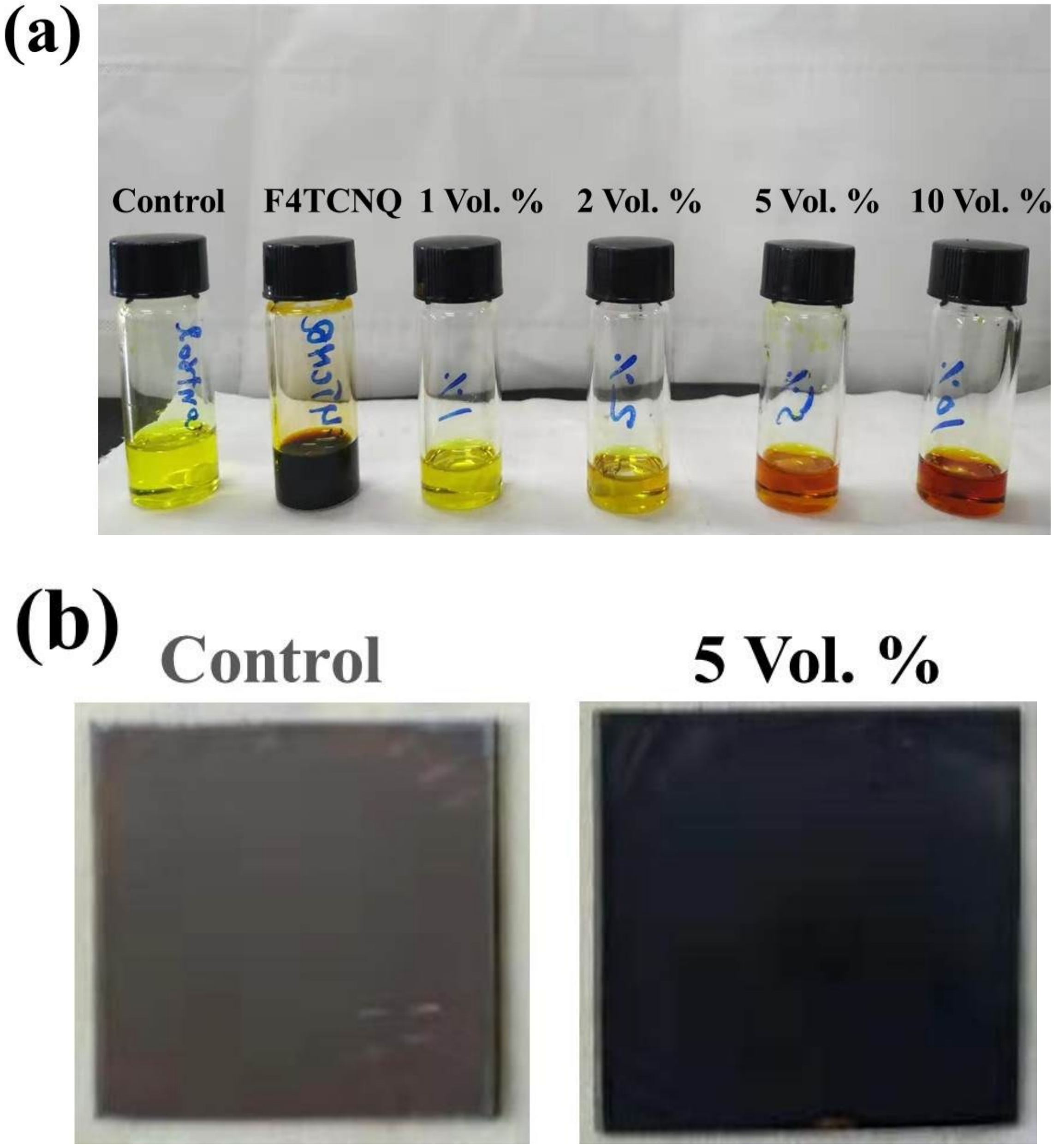

Figure S1. a) Variation in color of perovskite precursors with different incorporating ratios of F4TCNQ. b) Perovskite films spin-coated from control and 5 Vol. % precursors.

Figure S1b shows the color of control and 5 Vol. % films. The color of the film changes from brown to black. It shows that the addition of F4TCNQ has influenced the crystallization process of perovskite film. Therefore, color changes from brown to black.

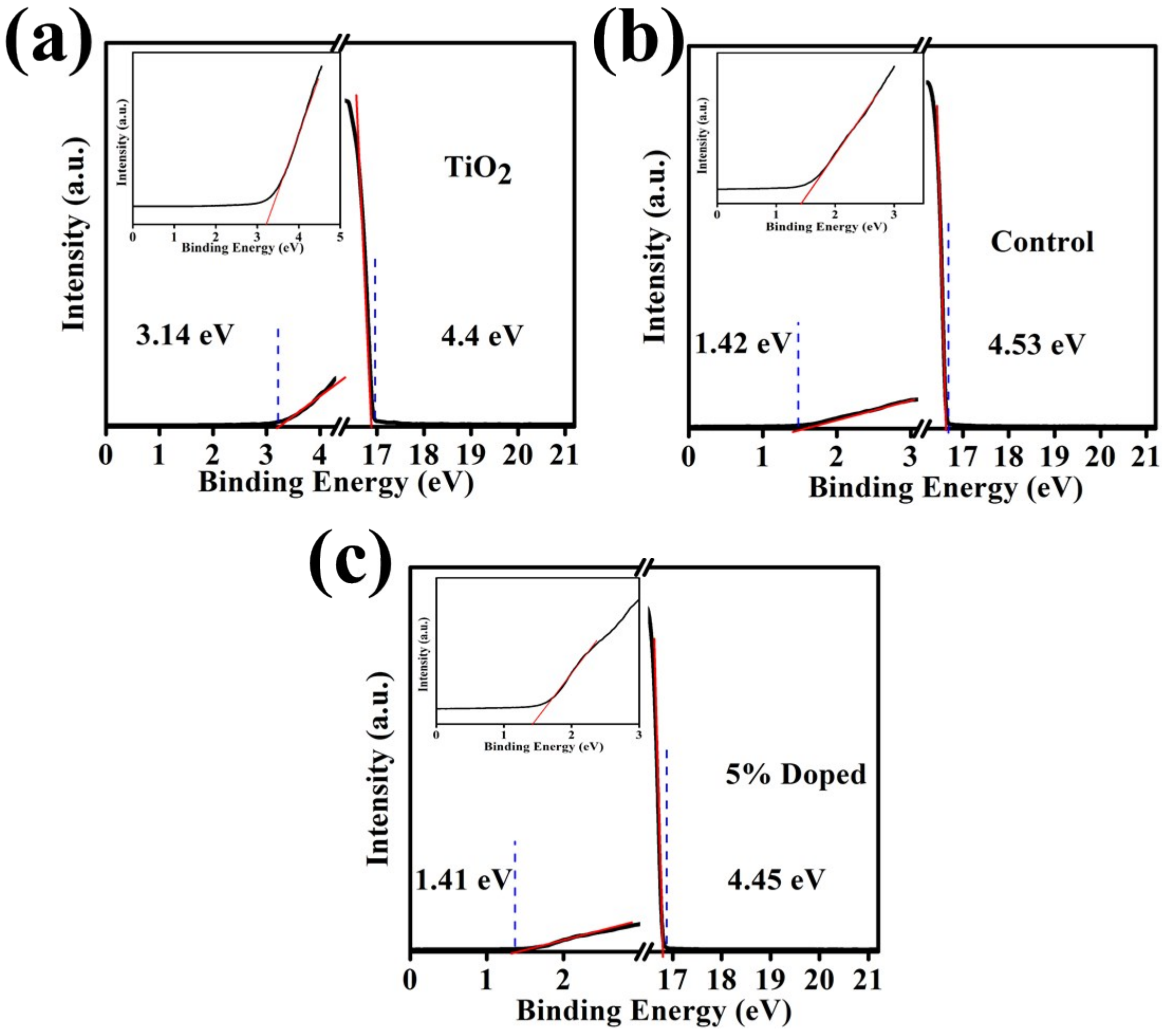

Figure S2. Ultraviolet photo-electron spectroscopy (UPS) spectra of (a) TiO_2, (b) Control, and (c) 5 Vol. % films. The inset shows the cut off position of the lower binding energy.

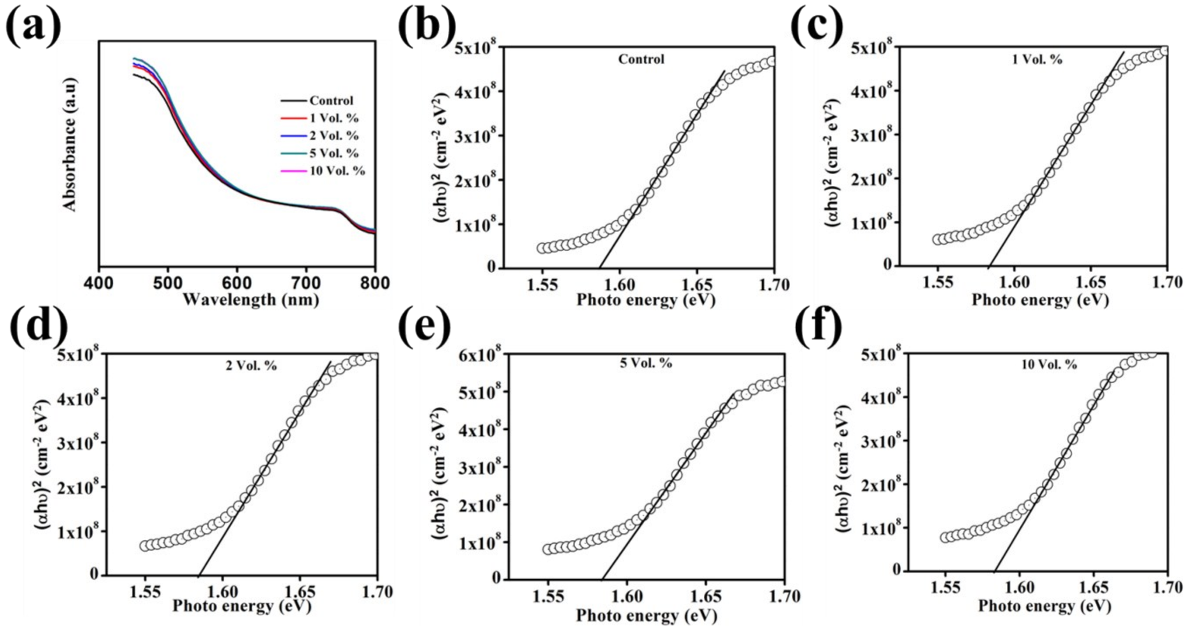

Figure S3. a) Absorption spectra of control, 1 Vol. %, 2 Vol. %, 5 Vol. %,10 Vol. % films. Tauc plot of b) control, c) 1 Vol. %, d) 2 Vol. %, e) 5 Vol. %, and f) 10 Vol. % films.

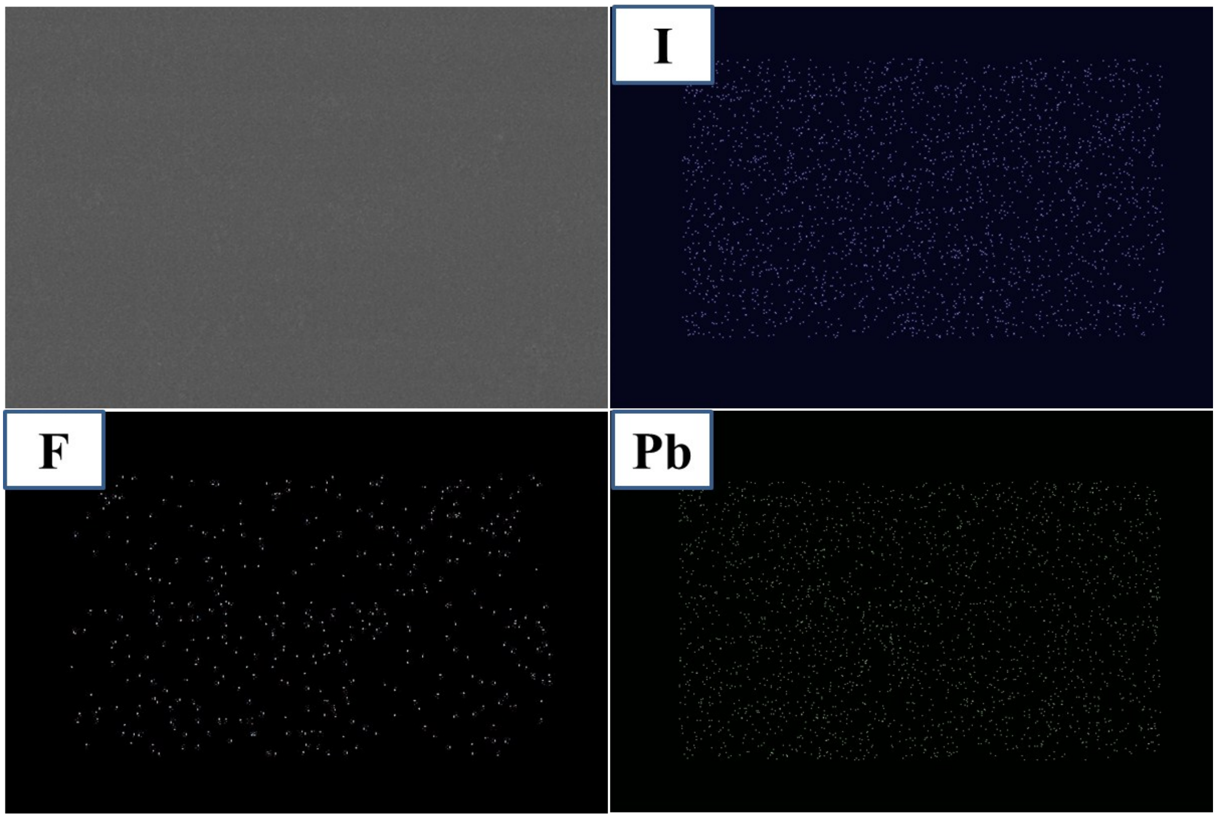

Figure S4. SEM-EDX elemental mapping of the perovskite film incorporated with 5 Vol. % F4TCNQ.

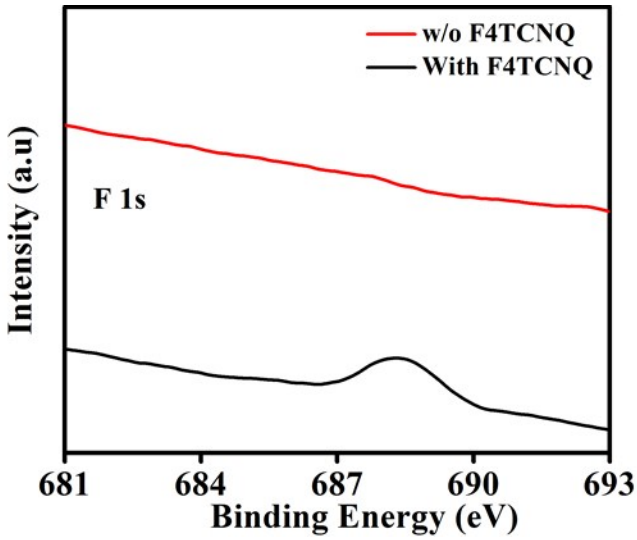

Figure S5. XPS spectra of F 1s region for the perovskite film made with/without F4TCNQ.

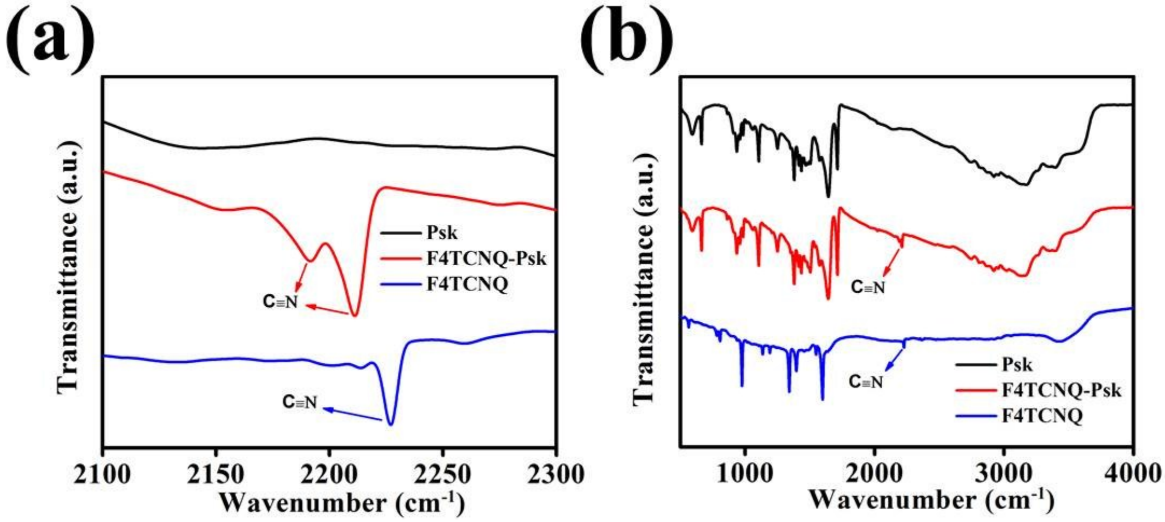

Figure S6. Fourier transform infrared (FTIR) spectrum of perovskite with and without F4TCNQ doping.

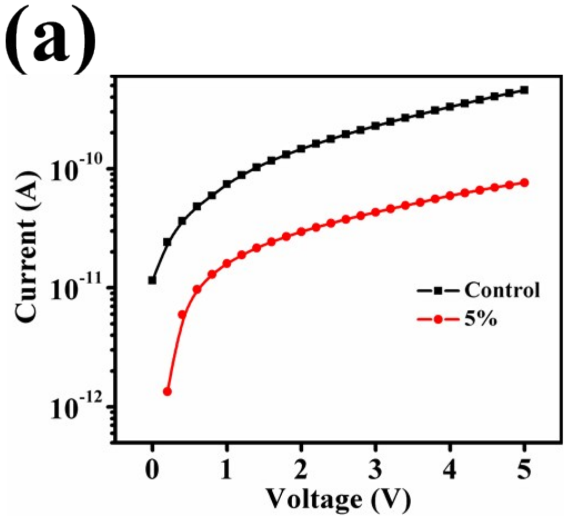

Figure S7. I-V curves of the single layer device a) under dark, and b) under light illumination of 0.1 mW cm^{-2} and applied bias of 5 V.

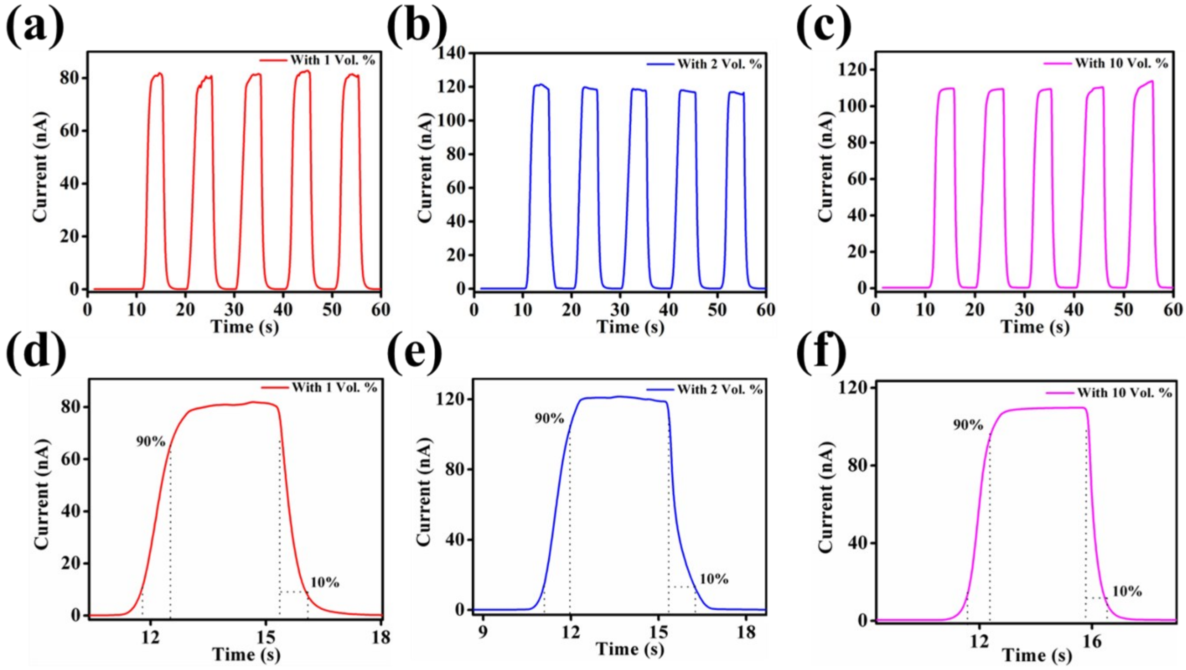

Figure S8. On-Off switching properties of a) 1 Vol. %, b) 2 Vol. %, and c) 10 Vol. % devices. Single cycle rise and decay processes for a) 1 Vol. %, b) 2 Vol. %, and c) 10 Vol. % devices.

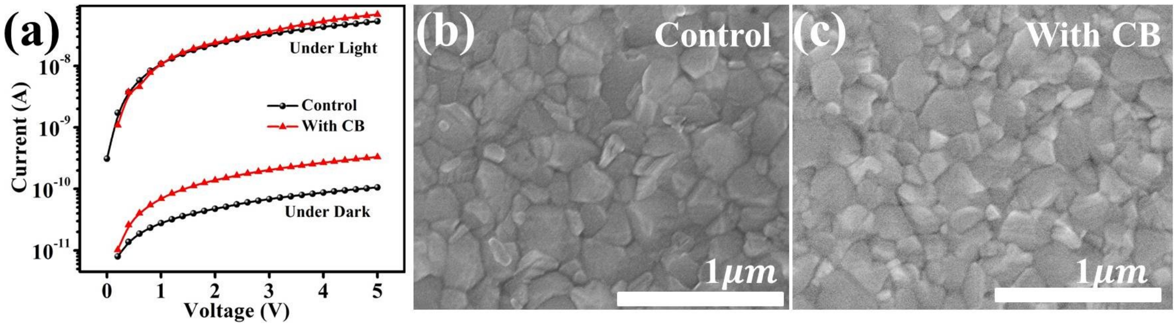

Figure S9. (a) I-V characteristics of Control device and the device doped with CB. SEM images of (b) Control film (c) With CB.

Table S1. The lattice constant and Lattice strain of perovskite with different molar ratio of F4TCNQ.

Sample	a [nm]	Lattice Strain
Control	0.8794	0.000512
1% F4TCNQ	0.8813	0.000508
2% F4TCNQ	0.8820	0.000499
5% F4TCNQ	0.8826	0.000458
10% F4TCNQ	0.8827	0.000498

Table S2. Comparison of all the photodetector devices.

	I_d [A]	I_L [A]	R [A W^{-1}]	On/Off	Rise & Decay [s]
Control	1.05×10^{-10}	5.30×10^{-8}	0.88	504	0.96/0.86
1%	7.06×10^{-11}	7.55×10^{-8}	1.25	1078	0.60/0.66
2%	5.13×10^{-11}	1.24×10^{-7}	2.06	2500	0.70/0.79
5%	4.67×10^{-11}	3.24×10^{-7}	5.41	6937	0.53/0.60
10%	6.58×10^{-11}	9.85×10^{-8}	1.64	1496	0.63/0.68

Table S3. Detailed parameters of device stability.

	I_d [A]	I_L [A]	R [A W^{-1}]	On/Off
Control	4.57×10^{-10}	3.27×10^{-8}	0.54	72
5 Vol. %	5.13×10^{-11}	2.89×10^{-7}	4.81	5621

Table S4. Performance of photodetector devices based on different perovskite materials.

Materials	Spectral range [nm]	Power	R [A W^{-1}]	On/Off ratio	Rise/Decay time	ref
$MAPbI_3$	300-800	0.01 mW cm^{-2}	83 (365 nm) 5.5 (780 nm)	324 33	< 0.2 s < 0.1 s	S1
$MAPbI_3$/rGO	-	3.2 mW cm^{-2}	0.073 (520 nm)	168	40.9/28.8 ms	S2
$MAPbBr_{3-x}I_x$	300-600	2 mW cm^{-2}	0.055	-	<20/<20 μs	S3
$MA_{0.5}FA_{0.5}Pb_{0.5}Sn_{0.5}I_3$/ Ascorbic acid	800-950	100 mW cm^{-2}	>0.2	-	-/7.4 μs	S4
$(FASnI_3)_{0.6}(MAPbI_3)_{0.4}$	350-900	7.3 mW cm^{-2}	0.4	-	6.9/9.1 μs	S5
MAPbI3/PDPP3T	350-950	0.5 mW cm^{-2}	0.010 (365 nm) 0.025 (650 nm) 0.005 (937 nm)	-	-	S6
$FA_{1-x}Cs_xPbI_3$	240-750	0.1 mW cm^{-2}	5.7	6300 (0.5 V) 2100 (3 V)	45/91 ns	S7
$MAPbBr_2I$/graphene	250-700	1.05 nW	$6x10^5$	1.2	0.12/0.75 s	S8
PCBM-$CH_3NH_3PbI_3$	400-1000	100 mW cm^{-2}	0.01 (0.6 V) 0.27 (10 V)	3000	>0.12/>0.18 s	S9
$MAPbI_3$	300-800	5 mW cm^{-2}	0.11	10^4	90/120 ms	S10
$(CsPbI_3)_{0.05}[(FAPbI_3)_{0.83}(MAPbBr_3)_{0.17}]_{0.95}$	400-800	3.5 mW cm^{-2}	1.63 (10 V)	10^5	19/84 ms	S11
$TiO_2/MAPbI_3$	400-800	0.5 mW cm^{-2}	0.12	4000	0.49.0.56 s	S12
$FA_{0.83}Cs_{0.17}Pb(I_{0.9}Br_{0.1})_3$ /Dye (Cy_1BF_4 & $CyPF_6$)	400-1100	-	0.01-0.02	-	65/74 μs	S13
$CH_3NH_3PbI_3$/RhB	400-800	500 μW cm^{-2}	0.043	287	60/40 ms	S14
$MAPbI_xCl_{3-x}$/Spiro-OMeTAD	300-850	100 mW cm^{-2}	0.10 (550 nm)	69.1	0.2/0.2 s	S15
$MAPbBr_3$/EA/TiO_2	400-520	0.5 mW cm^{-2}	0.13	2700	0.49/1.17 s	S16
This work	400-800	0.1 mW cm^{-2}	5.41	6937	0.53/0.60 s	-

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