

The emergence and prospects of perovskite light-emitting diodes

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Table S1: Figure of merits of the state-of-the-art perovskite LEDs. The data is grouped with respect to the emission color (blue, green, orange, red and NIR) in the descending order. 2D/3D refers to quasi 2D perovskite emitters. NCs is nanocrystals.

Emission color	No.	Device architecture	Perovskite type	PLQY (%)	Defect density (cm ⁻³)	EL peak emission (nm)	FWHM (nm)	EQE (%)	Brightness (cd.m ²)	Current efficiency (cd.A ⁻¹)	Ref.	Comments
Violet (400 – 424 nm)	1	Only PL emission is shown.	NCs	77.1		404.9 (PL)	--	--	--	--	¹	NO LEDs are shown.
	2	ITO/ZnO/PEI/Cs ₃ Sb ₂ Br ₉ /TCTA/MoO ₃ /Al	NCs			408	70	0.206			²	Retains 90% of the initial EL after 6 h of operation.
	3	ITO/PEDOT:PSS/(PEA) ₂ PbBr ₄ /TPBi/Ca/Al	2D nano-sheets			410	14	0.002			³	
Blue (424 – 491 nm)	4	ITO/PEDOT:PSS/PVK/2D CH ₃ NH ₃ PbBr ₃ /TPBi/LiF/Al	2D	~30		432		~0.004	~1		⁴	
	5	ITO/PEDOT:PSS/PVK/CH ₃ NH ₃ PbBr ₃ /TPBi/LiF/Al	NCs			445		1.18	2473		⁵	
	6	ITO/NiO/Cs ₃ Cu ₂ I ₂ /TPBi/LiF/Al	NCs			445	63	1.12	263.2		⁶	T ₅₀ of 108 h at 6.7V.
	7	ITO/PEDOT:PSS/PVK/2D CH ₃ NH ₃ PbBr ₃ /TPBi/LiF/Al	2D	~30		456		0.024	~1		⁴	
	8	ITO/PEDOT:PSS/PVK/BA ₂ Cs _{n-1} Pb _n (Br/Y) _{3n+1} /TPBi/LiF/Al	2D/3D			465	23	2.4	962	1	⁷	
	9	ITO/PVK/PFI/PEA ₂ PbBr ₄ /(P2m2)/3TPYMB/Liq/Al	2D	77		465	25	2.6	211		⁸	P-PDABr ₂ additive. T ₅₀ at peak EQE is 13.5 min.
	10	ITO/TFB/PFI/CsMn _y Pb _{1-y} Br _x Cl _{3-x} /TPBi/LiF/Al	NCs	12		466	17.9	2.12	245		⁹	Mn ²⁺ doped perovskite
	11	ITO/NiO/PVK/2D/3D perovskite/TPBi/LiF/Al	2D/3D			467	18	5.5	330		¹⁰	Stable blue spectra
	12	ITO/TFB/PFI/CsMn _y Pb _{1-y} Br _x Cl _{3-x} /TPBi/LiF/Al	NCs	28		470	17.1	1.46	389		⁹	Mn ²⁺ doped perovskite
	13	ITO/TFB/PFI/CsMn _y Pb _{1-y} Br _x Cl _{3-x} /3TPYMB/Liq/Al	NCs			471	17	6.3	465		¹¹	DAT-treated CsPb(Br _x Cl _{1-x}) ₃ . T ₅₀ of 99 s at 4.5V.
	14	ITO/NiO/TFB/2D CH ₃ NH ₃ PbBr ₃ /TPBi/LiF/Al	2D/3D NCs			474		4			¹²	
	15	ITO/NiO/TFB/2D CH ₃ NH ₃ PbBr ₃ /TPBi/LiF/Al	2D/3D NCs			476		4.8			¹²	
	16	ITO/PEDOT:PSS/CsPbBr ₃ /PEACl/TPBi/LiF/Al	2D/3D	8.5		477	23	4.8	6000		¹³	
	17	ITO/NiO/PVK/2D/3D perovskite/TPBi/LiF/Al	2D/3D	12		477	18	11	2180		¹⁰	CIE coordinates of (0.107, 0.115). T ₅₀ around 1–2 min at 5mA cm ⁻² (~200 – 600 cd m ⁻²)
	18	ITO/NiO/TFB/2D CH ₃ NH ₃ PbBr ₃ /TPBi/LiF/Al	2D/3D NCs			478		6.3			¹²	
	19	ITO/PEDOT:PSS/Poly-TPD/PEA ₂ Cs _{1.6} MA _{0.4} Pb ₃ Br ₁₀ /TPBi/LiF/Al	2D/3D			479	18	5.2	468		¹⁴	T ₅₀ of 90 min at 100 cd m ⁻² . Perovskite treated with DPPOCl.
	20	ITO/PEDOT:PSS-PTAA/CsPbBr ₃ (4nm)- CsPbBr ₃ (7nm)/TPBi/LiF/Al	NCs	91	2.7×10 ¹⁴ (e) 1×10 ¹⁵ (h)	479	20	12.3	400		¹⁵	Bi-polar shell passivation of NCs/QDs. carrier mobility (≥0.01 cm ² V ⁻¹ s ⁻¹). T ₅₀ of 20 min at 90 cd m ⁻² .

	21	ITO/PEDOT:PSS/CsPbCl _{0.9} Br _{2.1} -PEABr/TPBi/LiF/Al	2D/3D		3.0×10^{16}	480	21	5.7	3780	6.1	¹⁶	T ₅₀ of 10 min at peak EQE. The paper reported width of emission zone to be around 5nm. V _{TH} 3.1 V.
	22	ITO/NiO/TFB/2D CH ₃ NH ₃ PbBr ₃ /TPBi/LiF/Al Thickness = NiO 7nm, PVK 18 18nm, perovskite 9nm, TPBi 35 nm, LiF 1nm, Al 70 nm.	2D/3D NCs	50		483		9.5	700	12	¹²	T ₅₀ of the initial brightness of 100 cd m ⁻² lifetime is 250 s.
	23	ITO/LiF/(Cs/Rb/FA/PEA/K)Pb(Cl/Br) ₃ /LiF/Bphen/LiF/Al	3D		0.66×10^{17}	484	24	2.01	4015	2.11	¹⁷	T ₅₀ of 300 min at 25 mA.cm ⁻² .
	24	ITO/PEDOT:PSS/CsPbBr ₃ :PEACI/TPBi/LiF/Al	2D/3D	49.7		485		11	9040		¹³	T ₅₀ of the initial brightness of 100 cd m ⁻² lifetime is ~100 min.
	25	ITO/NiO(or TFB/PFI)/CsPbBr ₃ Cl _{3-x} /TPBi/LiF/Al	NCs			486		0.5	111		¹⁸	Interface optimization
	26	ITO/PVK/PEA _x PA _{2-x} (CsPbBr ₃) _{n-1} PbBr ₄ /TPBi/LiF/Al	2D/3D	63.5	2.01×10^{17}	486	25	10.11	513	11.87	¹⁹ ¹⁹	(CIE coordinates at (0.085, 0.233), radiative recombination rate = 1.71×10^{22} cm ³ s ⁻¹ . T ₅₀ , 81 min at peak EQE, Perovskite contains 4-(ABA) as additive.
	28	ITO/PEDOT:PSS/PVK/BA ₂ Cs _{n-1} Pb _n (Br/Y) _{3n+1} /TPBi/LiF/Al	2D/3D			487	22	6.2	3340	23.3	⁷	
	29	ITO/(PVK):(F4-TCNQ) (45 nm)/ (PEA) _{0.75} (GA) _{0.25} (35 nm)/(TPPO) (5 nm)/TPBi (45 nm)/LiF (2 nm)/ Al(100 nm)	2D/3D		5.85×10^{18}	488	18	1.5	1107	2.1	²⁰	
	30	ITO/m-PEDOT:PSS (35 nm)/ PEA ₂ (CsPbBr ₃) ₂ PbBr ₄ (25 nm)/ TBPI (40 nm)/LiF (1 nm)/Al (70 nm)	2D/3D	68.1		488	25	12.1	2191	17.58		60% EABr
	30	ITO/PEDOT:PSS/Poly-TPD/PEA ₂ Cs _{1.6} MA _{0.4} Pb ₃ Br ₁₀ /TPBi/LiF/Al	2D/3D	54		489	18	1.3	5141		¹⁴	T ₅₀ of 51 min at 1500 cd m ⁻² . Perovskite treated with DPPOCI.
	31	ITO/(PVK):(F4-TCNQ) (45 nm)/ (PEA) _{0.75} (GA) _{0.25} (35 nm)/(TPPO) (5 nm)/TPBi (45 nm)/LiF (2 nm)/ Al(100 nm)	2D/3D		5.06×10^{18}	492		8.2	1003	13.1	²⁰	Power efficiency 10.5 lm W ⁻¹ .
	32	ITO/m-PEDOT:PSS (35 nm)/ PEA ₂ (CsPbBr ₃) ₂ PbBr ₄ (25 nm)/ TBPI (40 nm)/LiF (1 nm)/Al (70 nm)	2D/3D	72.9		495	23	13.3	2790	24.45	²¹	T ₅₀ of at 100 cd m ⁻² < 5 min. 40% EABr,
Emission color	No.	Device architecture	Perovskite type	PLQY (%)	Defect density (cm⁻³)	EL peak emission (nm)	FWHM (nm)	EQE (%)	Brightness (cd.m⁻²)	Current efficiency (cd.A⁻¹)	Ref.	Comments
Green (491 -571 nm)	33	ITO/NiOx/PVK/perovskite/TPBi/LiF/Al	2D		6.7×10^{16} (e)	510	23	16.6	11330	54.4	²²	silica tetraethoxysilane (TEOS), T ₅₀ of 28 min at 1500 cd m ⁻² .
	34	ITO/NiOx/PVK/perovskite/TPBi/LiF/Al	2D		1.04×10^{17}	510	23	14	9260	44.2	²²	
	35	ITO/PEDOT:PSS/PVK/CsPbBr ₃ /TPBi/Liq/Al	NCs	85		512	21	15.17	18600		²³	Large area 2x2 cm ² size LEDs demonstrated, T ₅₀ of 1.2 h at 1000 cd m ⁻²

36	ITO/ZnO/PEDOT:PSS/CsPbBr ₃ /TPBi/LiF/Al	3D	67.2		512	18	17.2	>10000	51.2	²⁴	ethanolamine (ETA) additive (10.4% and 32.9 cd A ⁻¹ without ETA)
37	PET/AgNWs/ZnO/PEDOT:PSS/CsPbBr ₃ /TPBi/LiF/Al	3D	49		512		17.1	>10000		²⁴	Flexible PeLEDs
38	ITO/ZnO/PEDOT:PSS/CsPbBr ₃ /TPBi/LiF/Al	3D			514		24.5	>10000	75	²⁴	Outcoupling via Ag NWs, 75 cd/A CE, stable over 1000 bending cycles, T50 8 hr
39	ITO/ZnO/PEDOT:PSS/PVK/CsPbBr ₃ /TPBi/LiF/Al	NCs			514	18	20.3		61.9	²⁵	EQE at 1000 cd m ⁻² is 18.3%
40	ITO/ZnO/PEDOT:PSS/PVK/CsPbBr ₃ /TPBi/LiF/Al	NCs			514	18	28.2	20000	88.7	²⁵	Enhanced outcoupling using half-ball lens, EQE at 1000 cd m ⁻² is 25.4%
41	ITO/PEDOT:PSS/CsPbBr ₃ /perovskite/TPBi/LiF/Al	NCs			514	18	10.1	45990	37.14	²⁶	PEG+PEABr additives. 85% color purity, PeLEDs on flexible substrate reach 31 cdA ⁻¹
42	ITO/PEDOT:PSS/PTAA/PEA ₂ Cs _{n-1} PbnBr _{3n+1} /TPBi/LiF/Al	2D	70±8		514		15.5	19540		²⁷	PEABr additive
43	ITO/PEDOT:PSS/PTAA/CsPbBr ₃ /TPBi/LiF/Al	NCs	79	1.05×10 ¹⁸ (e) 3.08×10 ¹⁸ (h)	515		18.7	21000	75	²⁸	T ₅₀ of 30 min at 1000 cd m ⁻² T ₅₀ of 7.2 min at 5000 cd m ⁻² T ₅₀ of 3.4 min at 10,000 cd m ⁻²
44	ITO/PEDOT:PSS/PTAA/CsPbBr ₃ /TPBi/LiF/Al	NCs	43	2.12×10 ¹⁸ (e) 6.7×10 ¹⁸ (h)	515		7.7	7000	20	²⁸	T ₅₀ of 14 min at 1000 cd m ⁻² T ₅₀ of 40 s at 5000 cd m ⁻² T ₅₀ of 30 s at 10,000 cd m ⁻²
45	ITO/PEDOT:PSS/CsPbBr ₃ /TPBi/LiF/Al	3D			517		10.5	16436	5.78	²⁹	CsBr additive. T ₅₀ of 15 h at 100 cd m ⁻²
46	ITO/PEDOT:PSS/CsPbBr ₃ /TPBi/LiF/Al	3D			519		17	25733	32	²⁹	Trifluoroacetate additive. T ₅₀ of 250 h at 100 cd m ⁻²
47	ITO/PEDOT:PSS/PTAA/CsPbBr ₃ /TPBi/LiF/Al	NCs	76		518		16.48	76940	66.7	³⁰	ZnBr ₂ additive, IQE 74.2%
48	ITO/PEDOT:PSS/PTAA/CsPbBr ₃ /TPBi/LiF/Al		79		518		15.6	100080	60.6	³⁰	MnBr ₂ additive
49	ITO/TFB/PVK/Na ₂ Cs _{n-1} PbnBr _{3n+1} /TPBi/LiF/Al	2D/3D			518		15.9	11560	50.3	³¹	NaBr additive, PE 45.1 lm/W. Encapsulated devices were stable for 30 days (only 10% drop in EQE)
50	ITO/NiO _x /TFB/PVK/CsPbBr ₃ /TPBi/LiF/Al	3D			520		16.2	50270	56.9	³²	20% LiBr passivation, PE 44.6 lm/W. T ₅₀ of 1.2h at 1000 cd m ⁻²
51	ITO/ZnO/PVP/Cs _{0.87} MA _{0.13} PbBr ₃ /CBP/MoO ₃ /Al	3D	55		520		10.4	91000	33.9	³³	pure green 90.2% CIE green color, V _{TH} 2.9 V, PVP layer improve charge balance
52	ITO/PEDOT:PSS/PolyTPD/CsPbX ₃ /TPBi/LiF/Al	NCs	95		520		4.59	21470	7.47	³⁴	PEABr additive, 5.17 lm/W

53	ITO/PEDOT:PSS/TFB/PolyTPD/PVK/CsPbBr ₃ /TPBi/LiF/Al	2D/3D			520		7.7	7646206		³⁵	PEABr additive. One of the brightest PeLEDs. EQE roll-off up to 1kA.cm ⁻² via downscaling 5454active area, reduced Joule heating	
54	ITO/a-ZSO(120nm)/CsPbBr ₃ (60nm)/NPD(40nm)/MoO _x (5nm)/Ag (100nm)	3D			523	16	9.3	496320	37	³⁶	33 lm/W	
55	ITO/PEDOT:PSS/PolyTPD/MAPbX ₃ /B3PYMPM/Cs ₂ CO ₃ /Al	NCs			524		12.9	22830		³⁷	P.E of 30.3 lm/W at 1000 cd m ⁻² ,	
56	ITO/PEDOT:PSS/CsPbBr ₃ -MABr/B3PYMPM/LiF/Al	3D			525		20.3	14000	22.81	³⁸	MABr additive, T ₅₀ of 11 min at 7130 cm.m ⁻² . Estimated T ₅₀ at 100 cd m ⁻² is 104.56 h.	
57	ITO/PEDOT:PSS/CsPbX ₃ /TPBi/LiF/Al	3D			525	20	4.76	51890		³⁹	T ₈₂ 80 h at 1000 cd.m ⁻²	
58	ITO/ PEDOT:PSS (20 nm)/ FPEA ₂ MA _{n-1} Pb _n Br _{3n+1} (100 nm)/TmPyPB (40 nm)/LiF (0.8 nm)/Al (100 nm),	2D/3D	70	1.3 × 10 ¹⁵	525		20.36	82480		⁴⁰	T ₅₀ of 6.5 min at 10,000 cd m ⁻² . p-fluorophenethylammonium (p-FPEA+) and CF ₃ KO ₃ S additives.	
59	ITO/ PEDOT:PSS/TFB/FAPbBr ₃ /TPBi/LiF/Al	NCs	78		528		16.3	13970	66.3	⁴¹	3,3-diphenylpropylamine bromide (DPPA-Br) ligand.	
60	ITO/PEDOT:PSS/PFI/FA _{1-x} GA _x PbBr ₃ /TBTB/TPBi/LiF/Al	NCs	92.45		531		23.4	25000	108	⁴²	Comprehensive defect passivation.	
61	ITO/PEDOT:PSS/PFI/FA _{1-x} GA _x PbBr ₃ /TBTB/TPBi/LiF/Al	NCs	92.45		531		45.5		205	⁴²	Enhanced light outcoupling.	
62	ITO/PEDOT:PSS/PEA ₂ (FAPbBr ₃) _{n-1} PbBr ₄ /TPBi/LiF/Al	2D/3D	73.8		532		14.36	7000	62.43	⁴³	TOPO as additive, PE 53.3 lm/W	
63	ITO/PEDOT:PSS:PSS-Na/PEA ₂ (FAPbBr ₃) ₂ PbBr ₄ /TOPO/TPBi/LiF/A		73.5		532		15.4	15765	67.5	⁴⁴		
64	ITO/PEDOT:PSS:PSS-Na/PEA ₂ (MAPbBr ₃) ₂ PbBr ₄ /TOPO/TPBi/LiF/A		85.3		532		0.93	106	3.3	⁴⁴		
65	ITO/SCOP/MAPbBr ₃ /TPBi/ LiF/Al	3D			540		21.8	>40000	87.35	⁴⁵	Enhanced outcoupling using a half-sphere lens, MAPbBr ₃ :TPBi quasi-film. T ₅₀ 251 min at 100 cd.m ⁻²	
Emission color	No.	Device architecture	Perovskite type	PLQY (%)	Defect density (cm ⁻³)	EL peak emission (nm)	FWHM (nm)	EQE (%)	Brightness (cd.m ⁻²)	Current efficiency (cd.A ⁻¹)	Ref.	Comments

Yellow (575 – 585 nm)	66	Device architecture is not provided. Perovskite layer (CsPb(Br _x /I _{3-x}))	NCs	70		572	30	12.4			⁴⁶	luminous efficiency 63.4 lm/W.
Orange (585-625 nm)	67	ITO/(PEDOT:PSS 150 nm)/(PVK 50 nm)/CH ₃ NH ₃ PbBr _x I _{3-x} (60 nm)/(TPBi 45 nm)/LiF/Al (2/150 nm)	NCs			595		0.67	1001		⁵	
	68	Device architecture is not provided. Perovskite EML is CsPb(Br _{1.4} /I _{1.6})	NCs			617	35	12.9			⁴⁶	luminous efficiency 63.4 lm/W
	69	ITO/ZnO/PEI/(OAm) ₂ SnBr ₄ /TCTA/MoO ₃ /Ag	2D	88		625	163	0.1	350		⁴⁷	Pb free perovskite
	70	ITO/ZnO/CsPbI _{2.25} Br _{0.75} /TFB/MoO ₃ /Ag	NCs			619	29	1.4	1559		⁴⁸	
	71	ITO/PEDOT:PSS/PolyTPD/MAPbI _x Br _{3-x} /TPBi/LiF/Al	NCs			625		4.13	598	4.53	⁴⁹	V _{TH} 2.8 V, T ₅₀ of 340 min at 0.1 mA cm ⁻² (initial luminance =22 cd m ⁻²)
Red (625 – 700 nm)	72	ITO/PEDOT:PSS/PEA ₂ SnI ₄ /TPBi/LiF/Al	2D/3D	7		632	21	5	90		⁵⁰	Pure red, color coordinates matching the Rec. 2100 specification for a primary red emitter. T ₅₀ of 15 h at 20 cd m ⁻² .
	73	ITO/PEDOT:PSS/PolyTPD/MAPbI _x Br _{3-x} /TPBi/LiF/Al	NCs			632		20.28	627	31.28	⁴⁹	V _{TH} 3.2 V
	74	ITO/(PEDOT:PSS 150 nm)/(PVK 50 nm)/CH ₃ NH ₃ PbBr _x I _{3-x} (60 nm)/(TPBi 45 nm)/LiF/Al (2/150 nm)	NCs			640		0.53	986		⁵	
	75	ITO/PEDOT:PSS/PolyTPD/(CsPbBr/I) ₃ /TPBi/LiF/Al	NCs			645	33	21.3	794	11.6	⁵¹	Deep-red emission at 649 nm upon ligand exchange, CIE (0.72, 0.28), PE 12.9 lm W ⁻¹ . T ₅₀ of 180 min at 100 cd m ⁻²
	76	ITO/ZnO/PEI/CsPb(Br/I) ₃ /CBP/TCTA/MoO ₃ /Au	NCs	70		648	33	6.3	2216	3.42	⁵²	4.05 lm/W
	77	ITO/a-ZSO(120nm)/CsPbBr ₃ (60nm)/NPD(40nm)/MoO _x (5nm)/Ag (100nm)	NCs			650	40	4.6	20000		³⁶	amorphous Zn-Si-O ETL/EIL
	78	ITO/ZnO/PEI/CsPbI ₃ /TCTA/MoO ₃ /Au	NCs	98	1.93 × 10 ¹⁶	682		12.6	10171		⁵³	Lmax at 10 V.
	79	ITO/ZnO/PEI/CsPb _{0.64} Zn _{0.36} I ₃ /TCTA/MoO ₃ /Au	NCs	98.5	1.75 × 10 ¹⁶	682		15.1	2202		⁵⁴	Zn ²⁺ alloying reduced the defect density by an order of magnitude
	80	ITO/ZnO/PEI/CsPbI ₃ /TCTA/MoO ₃ /Au	NCs		3.23 × 10 ¹⁶	685		9.7	3553		⁵³	octylphosphonic acid ligand with shorter chain reduces defect density.

81	Si/Ag/ZnO/PEI/CsPbI ₃ /TCTA/MoO ₃ /Au	NCs		6.36 × 10 ¹⁶	686		13.7	14725		⁵⁵	Top emitting LED. EQE roll off at 500 mA cm ⁻² demonstrated (EQE at 500 mA.cm ⁻² is 12.5%)
82	ITO/PolyTPD/ CsPbI _{2.8} Br _{0.2} /TPBi/LiF/Al	2D/3D			689		18.6			⁵⁶	4-F-PMAI additive, T ₅₀ reaches over 1200 min at a constant J = 5 mA/cm ² (initial luminance =22 cd m ⁻²)
83	ITO/PEDOT:PSS/PolyTPD/CsPbX ₃ /TPBi/LiF/Al	NCs	93		690		14.08	1444		³⁴	PEAI additive
84	ITO/ZnO/PEI/CsPbI _{3-0.1} /TCTA/MoO ₃ /Ag	NCs	84		691		13.5	1000		⁵⁷	EQE roll off till 500 mA...Sr ²⁺ doped CsPbI ₃
85	ITO/ZnO/PEI/CsPbI ₃ /TCTA/MoO ₃ /Au	NCs	70		691	36	11.8	1050	0.81	⁵⁸	1 lm/W
86	ITO/PolyTPD/CsPbI ₃ /TPBi/LiF/Al	2D/3D			692	36	14.8			⁵⁶	4-F-PMAI additive,
87	ITO/poly-TPD/FA _{0.33} Cs _{0.67} Pb(I _{0.7} Br _{0.3}) ₃ /TPBi/LiF/Al	3D	40	2.52 × 10 ¹⁶ (h) 9.74 × 10 ¹⁶ (e)	694	37	20.9	400		⁵⁹	FPMATFA as an additive. T ₅₀ = 14h at 25 cd.m ⁻² (0.25 h without additive)
88	ITO/poly-TPD/FA _{0.33} Cs _{0.67} Pb(I _{0.7} Br _{0.3}) ₃ /TPBi/LiF/Al	3D			697	39	18,3	200		⁵⁹	
89	ITO/ZnO/PEI/FA _{0.87} Cs _{0.13} PbI ₃ /CBP/MoO ₃ /Au	3D	70		700		15.8	218	1.2	⁶⁰	V _{TH} 1.9 V

Emission color	No.	Device architecture	Perovskite type	PLQY (%)	Defect density (cm ⁻³)	EL peak emission (nm)	FWHM (nm)	EQE (%)	Radiance (W. sr ⁻¹ .m ²)	Current efficiency (cd.A ⁻¹)	Ref.	Comments
NIR (700 – 2500 nm)	90	ITO/PEDOT:PSS/pTPD/Cs _x FA _{1-x} Pb(Br _{1-y} I _y) ₃ /TPBi/LiF/Al	NCs	89		735	27	5.9	3.9		⁶¹	Tunable emission between 700 – 800 nm
	91	ITO/PEDOT:PSS/FAPbI ₃ /TPBi/LiF/Al	3D NCs	4.4		749		7.9	72		⁶²	average crystal size of 5.4 ± 0.8 nm. Device show stable performance for 10 h at J = 3 mA.cm ⁻²
	92	ITO/Poly-TPD/ FPMAPbI ₃ /TPBi/LiF/Al	3D			750		16.1	30		⁶³	LED area 0.04 cm ² . EQE of 12.1% for 1 cm ² . Large area LEDs by doctor blade (28 & 54 cm ²) are also demonstrated (no EQE provided)
	93	ITO/TiO ₂ / PEA ₂ MA ₄ Pb ₅ I ₁₆ /F ₈ /MoO _x /Au	2D/3D	10.9		750		8.8	80		⁶⁴	Energy funneling is demonstrated
	94	ITO/ZnO/(Cs ₁₀ (MA _{0.17} FA _{0.83})/NPD/MoO ₃ /Al	3D			750	15	9.23	99.34		⁶⁵	CIE (0.696, 0.287). V _{TH} 2.8V
	95	ITO/PEDOT:PSS/FAPbI ₃ :Sn/POT2T/Ca/Al	NCs	63		752		17.6	199		⁶⁶	Sn ²⁺ doped FAPbI ₃ .
	96	Glass/SiN nanohole array/ITO/poly-TPD/MAPI ₃ /TPBi/LiF/Al	3D			760		14.6	23.7		⁶⁷	Nanohole array with high-index contrast enhance outcoupling efficiency.
	97	ITO/ZnO/PEIE/ NMA2FAPbI ₇ /TFB/MoO _x /Au	2D/3D	67		763		11.3	82		⁶⁸	

98	ITO/ZnO/PEI/ MAPb _{3-x} Cl _x /TFB/MoO _x /Au	3D				768		3.5	28		⁶⁹	
99	TO/ZnO/PEIE/ NFPI7/TFB/MoOx/Au	2D/3D	60			786		11.7	55		⁶⁸	wallplug efficiency of 5.5%at a J of 100 mA cm ⁻² . T ₅₀ 2 h at J = 10 mA/cm ²
100	TO/ZnO/PEIE/PPAI-FA _{0.83} Cs _{0.17} PbI ₃ /TFB/MoO _x /Au	2D/3D				789		17.5	1282		⁷⁰	T ₅₀ 130 h at 100 mA.cm ⁻²
101	ITO/MZO/PEIE(NMA)2FAPb2I7/TFB-PFO/MoOx/Au	2D/3D	49			795		20.1	4		⁷¹	poly-HEMA polymer. T ₅₀ 46 h at 0.1 mA.cm ⁻²
102	ITO/ZnO/PEIE/FAPbI3:5-AVA/poly-TPD/MoO3/Al	3D				799		20.2	170		⁷²	T ₈₀ 20 h at 57 mA.cm ⁻²
103	ITO/ZnO/PEIE/FAPbI3:5-AVA/poly-TPD/MoO3/Al	3D				799		12.1	20		⁷²	Large area LED (30 mm x 30 mm), T ₅₀ 10 h at 10 mA.cm ⁻²
104	ITO/ZnO/PEIE/ODEA-treated FAPbI3/TFB/MoO3/Au	3D	65			800		21.6	308		⁷³	2,2'-[oxybis(ethylenoxy)] diethylamine additive. T ₅₀ 20h @ 25mA.cm ⁻² .
105	ITO/PEIE/(FAPbI3/TFB-PFO/MoOx/Au	3D	96			800		20.1	5		⁷³	EDEA and HDMA additives. wallplug efficiency of 11% and EQE of 20.1% at J = 200 mA/cm ²
106	ITO/ZnO/PEIE/5-AVACS _{0.17} FA _{0.83} PbI _{2.5} Br _{0.5} /TFB/MoOx/Au	3D				800		17.4	965		⁷⁴	best EQE at J = 600 EQE 17.4 @275 mA/cm ² , no roll-off at 600 mA/cm ² , WPE 9%. T ₅₀ 20 h at 10 mA.cm ⁻²
107	ITO/ZnO/PEIE/FAPbI3:5AVA /TFB/MoO3/Au	3D	70			803		20.7	390		⁷⁵	T ₅₀ 20 h at 100 mA.cm ⁻² Peak wallplug efficiency 18.6%.
108	ITO/ZnO/PEIE/ FAPbI ₃ -DDS/TFB/MoOx/Au	3D	83			803		17.3	250		⁷⁶	EQE 17.3% @ 28 mA.cm ⁻² , T ₅₀ 100 h at 20 mA.cm ⁻² (initial radiance 15 W m ⁻² sr ⁻¹), roll-off at is 620 mAcm ⁻² .
109	ITO/ZnMgO (20 nm)/EDBE (2 nm)/(EDBE)FA3Pb4I13 (200 nm)/TFB (35 nm)/MoO3 (8 nm)/Au (100 nm)	3D				803		12,35	102.56		⁷⁷	2,2-(ethylenedioxy)bis(ethylammonium) additive. ZnMgO ETL. V _{TH} 1.5 V
110	ITO/ZnMgO (20 nm)/FA3Pb4I13 (200 nm)/TFB (35 nm)/MoO3 (8 nm)/Au (100 nm)	3D				804		9.15	14.03		⁷⁷	Without EDBE additive. V _{TH} 2 V
111	Glass/Au (100 nm)/PEIE/ZnO, 37 nm)/MQW perovskite (35 nm)/TFB (76 nm)/MoOx (7 nm)/Au (15 nm)	2D/3D				804		20.2	114.9		⁷⁸	Microcavity top emission. EQE 17.4% at J = 400 mAcm ⁻² .
No.	Device architecture	Perovskite type	PLQY (%)	Defect density (cm ⁻³)	EL peak emission (nm)	FWHM (nm)	EQE (%)	Radiance (W. sr ⁻¹ .m ²)	Current efficiency (cd.A ⁻¹)	Ref.	Comments	

112	ITO/poly-TPD/FPMAI-MAPb _{0.6} Sn _{0.4} I ₃ /TPBi/LiF/Al	3D			917		5	2.7		⁷⁹	tunable emission from 850 to 950 nm, partly Pb-free. V _{TH} 1.65 V. FPMAI additive.
113	ITO/PEDOT:PSS/CH ₃ NH ₃ Sn(Br _{1-x} I _x) ₃ /F8/Ca/Ag	3D	5.3		945	130	0.72	3.4		⁸⁰	V _{TH} 2.2 V. Radiance 3.4 W sr ⁻¹ m ⁻² at 6.9 V (J = 150 mA cm ⁻²)
114	ITO/PEDOT:PSS/CsSnI ₃ /PBD/LiF/Al	3D			950	100	3.8	40		⁸¹	(μ _n ,CsSnI ₃ ≈ 585 cm ² V ⁻¹ s ⁻¹)
115	ITO-ATO/SnO ₂ /Liq/CsPbCl ₃ :Yb ³⁺ /poly-TPD/PEDOT:PSS/Au	3D	60		984		5.9	3100 μW		⁸²	T ₅₀ 58 h at 0.827 mA.cm ⁻² . Irradiance of 3100 μW cm ⁻² at 3.6 V
116	ITO/PEDOT:PSS/PbS- PEA ₂ PbBr ₄ /PBD/LiF/Al	QD-perovskite hybrid	37		980		8.1	7.4		⁸³	PbS QDs in 2D/3D perovskite (PEA ₂ PbBr ₄). EQE roll-off at 170 mA/cm ² .
				1097		6					
				1210		4.5					
				1301		5.35					
				1467		2.8					
		1564		2.85							
117	(ITO)TiO ₂ /MAPbBr ₃ +Ag ₂ S@SiO ₂ /porphyrin/MoOx/Ag	QD-perovskite hybrid			1170		9.75	48.43		⁸⁴	Wallplug efficiency 11.28%. No notable drop in radiance after 20 days.
				1210		13.23	61.1				
				1322		14.33	72.86				
				1397		16.98	80.93				
				1482		8.11	50.44				

Table S2: An account of operational stability of key PeLEDs together with their device architecture and key performance parameters.

Device architecture	EQE (%)	PE* (%)	V _{ON} (V)	Peak brightness	EL peak position (nm)	Lifetime	Measurement conditions	Ref.
ITO/ZnO/PEIE/FAPbI ₃ /TFB/MoO ₃ /Au	14.2	10.3	1.3	241 W.Sr ⁻¹ .m ⁻²	804	T ₅₀ of 23.7h	J = 100 mA.cm ⁻²	85
ITO/PEDOT:PSS/CsPbBr ₃ /TPBi/LiF/Al	10.5	--	2.8	16436 cd.m ⁻²	517	T ₅₀ of 250 h	Measured at 100 cd.m ⁻²	29
ITO/PEDOT:PSS/CsPbBr ₃ /B3PYMPM/Cs ₂ CO ₃ /Al	0.15	--	2.8	7276 cd.m ⁻²	526	L>L ₀ > 15 h	L ₀ =100 cd.m ⁻² , J= 66.67 mA.cm ⁻²	86
ITO/TFB/PVK/CsPb _{0.9} Mg _{0.1} Br ₃ /TPBi/LiF/Al	3.6	--	3	25450 cd.m ⁻²	525	L>L ₀ ≈100 min	L ₀ =100 cd.m ⁻² , ambient,	87
ITO/ZnO/PEIE/FA _{1-x} Cs _x PbI ₃ /TFB/MoO ₃ /Ag	19.6	--	1.4	302 W.Sr ⁻¹ .m ⁻²	780	T ₅₀ of 7 h	J = 20 mA.cm ⁻²	88
ITO/PolyTPD/(BA.MA)Pb. ₂ (I/Br) ₃ /Bphen/Liq/Ag	16.7	10.1	--	110 W.Sr ⁻¹ .m ⁻²	751	T ₅₀ of 47 h T ₅₀ of 12 h	J = 10 mA.cm ⁻² J = 100 mA.cm ⁻²	89
ITO/ZnO/PEIE/NCPI ₇ -MQWs /TFB/MoO ₃ /Au	3.7	--	2.1	440 cd.m ⁻²	688	T ₅₀ of 5 h	J = 10 mA.cm ⁻²	90
ITO/ZnO/PEIE/NFPI ₆ -MQWs /TFB/MoO ₃ /Au	11.7	7	2	55 W.Sr ⁻¹ .m ⁻²	750	T ₅₀ 2 h	J = 10 mA.cm ⁻²	88
ITO/ZnO/PEIE/FAPbI ₃ /TFB/MoO ₃ /Au	21.6	15.8	1.5	308 W.Sr ⁻¹ .m ⁻²	800	T ₅₀ 20 h T ₅₀ 18 min	J = 25 mA.cm ⁻² J = 200 mA.cm ⁻²	73
ITO/AZO/AZO:Cs/ Cs ₁₀ (MA _{0.17} FA _{0.83}) _(100-x) PbCl _{1.5} Br _{1.5} /CuS-GaSnO/WO ₃ /Ag	2.58	--	3.1	6426 cd.m ⁻²	475	L ₅₀ 17 h	J = 1.4 mA.cm ⁻²	91
ITO/AZO/AZO:Cs/ Cs ₁₀ (MA _{0.17} FA _{0.83}) _(100-x) PbBr _{2.97} I _{0.03} /CuS-GaSnO/WO ₃ /Ag	8.21	--	2.5	53570 cd.m ⁻²	569	L ₅₀ 173 h	J = 1.4 mA.cm ⁻²	91
ITO/AZO/AZO:Cs/ Cs ₁₀ (MA _{0.17} FA _{0.83}) _(100-x) PbBr _{0.33} I _{2.67} /CuS-GaSnO/WO ₃ /Ag	13.0	--	2.7	8777 cd.m ⁻²	650	L ₅₀ 491 h	J = 1.4 mA.cm ⁻²	91
ITO/ZMO/PEIE/PPBH(NMA) ₂ (FA)Pb ₂ I ₇ /TFB-PFO/MoO ₃ /Au	20.1	16.2	1.3	50 W.Sr ⁻¹ .m ⁻²	790	T ₅₀ 46 h	J = 0.1 mA.cm ⁻²	71
ITO/ZnO/PEIE/5AVA-FAPbI ₃ /TFB/MoO ₃ /Au	20.7	18.6	1.25	390 W.Sr ⁻¹ .m ⁻²	800	T ₅₀ 20 h	J = 100 mA.cm ⁻²	75
ITO/PEDOT:PSS/CsPbBr ₃ -MABr/B ₃ PYMPM/LiF/Al	20.3	--	2.6	14000 cd.m ⁻²	528	T ₅₀ ~11 min T ₅₀ ~107 h	J = 166 mA.cm ⁻² (at L>3800 cd.m ⁻²) Estimated lifetime at L = 100 cd.m ⁻²	38
ITO/PTAA/3BBA-MAPbI ₃ /PCBM/Cr/Au	3.85	--	1.6	68 W.Sr ⁻¹ .m ⁻²	754	T ₅₀ 96 h T ₅₀ ~5.35 h	J = 200 mA.cm ⁻² J = 1 A.cm ⁻² (tested in air, RH 37%, unencapsulated devices)	92
ITO/PEDOT:PSS/2D/PCBM"/Al	<1%	--	~2	35 W.Sr ⁻¹ .m ⁻²	744	T ₅₀ 15 h	J = 385 mA.cm ⁻²	93

*PE is power efficiency (also called wall plug or energy conversion efficiency).

**2D = (CH₃(CH₂)₃NH₃)₂(CH₃NH₃)_{n-1}Pb_nI_{3n+1}.

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