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Table S1. The key properties of single-EML devices with different doping concentrations of $Ir(mppy)_3$.

Device	$V_{turn-on}$ (V)	B[a] (cd/m^2)	η_c[b] (EQE[c]) (cd/A)	η_p[d] (lm/W)	η_c[e] (cd/A) (EQE[f]) (1000 cd/m^2)	$CIE_{x,y}$[g]
7%	3.1	83830	47.71 (14.43%)	29.07	43.70 (13.20%)	(0.276, 0.623)
8%	3.0	86400	50.40 (15.18%)	32.18	47.71 (14.36%)	(0.283, 0.621)
9%	3.0	85310	51.59 (15.50%)	31.63	45.49 (13.65%)	(0.274, 0.627)
10%	3.0	87940	54.09 (16.23%)	35.15	51.11 (15.32%)	(0.284, 0.623)
11%	3.1	86840	51.57 (15.49%)	32.85	45.96 (13.77%)	(0.275, 0.627)
12%	3.1	80610	52.34 (15.64%)	33.27	47.57 (14.18%)	(0.278, 0.623)

[a] The data for maximum brightness (B), [b] maximum current efficiency (η_c), [c] maximum external quantum efficiency (EQE), [d] maximum power efficiency (η_p), [e] current efficiency (η_c) at the practical brightness of 1000 cd/m^2, [f] external quantum efficiency (EQE) at the practical brightness of 1000 cd/m^2, [g] Commission Internationale de l'Eclairage coordinates ($CIE_{x,y}$) at 10 mA/cm^2.

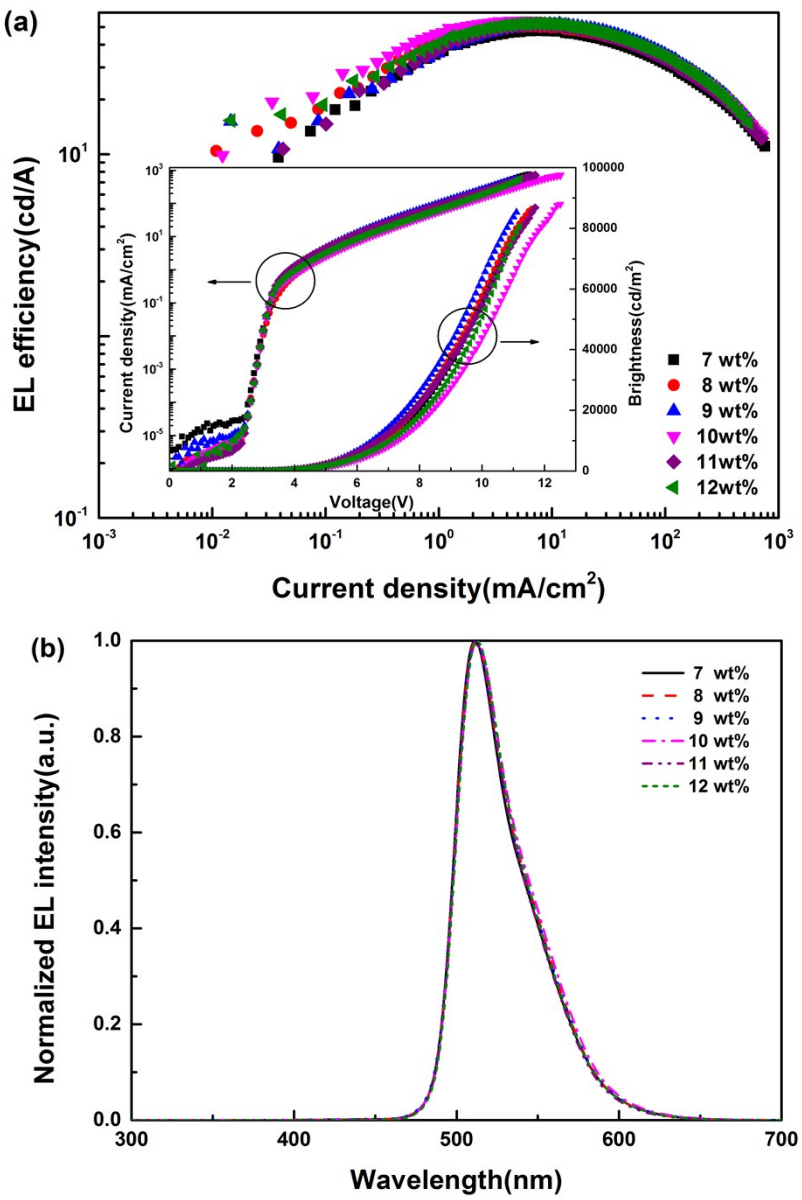

Figure S1 (a) EL efficiency-current density (η-J) characteristics of single-EML devices with $Ir(mppy)_3$ at different doping concentrations. Inset: Current density-brightness-voltage (J-B-V) characteristics of single-EML devices with $Ir(mppy)_3$ at different doping concentrations. **(b)** Normalized EL spectra of single-EML devices with $Ir(mppy)_3$ at different doping concentrations operating at 10 mA/cm^2.

Table S2. The key properties of double-EMLs devices with different doping concentrations of $Ir(mppy)_3$.

Device	$V_{turn-on}$ (V)	B[a] (cd/m^2)	η_c[b] (EQE[c]) (cd/A)	η_p[d] (lm/W)	η_c[e] (cd/A) (EQE[f]) (1000 cd/m^2)	$CIE_{x, y}$[g]
7%	3.1	90740	67.58 (20.4%)	51.31	65.85, (19.9%)	(0.289, 0.621)
8%	3.0	89990	72.64 (21.9%)	52.96	70.27, (21.2%)	(0.298, 0.617)
9%	3.0	84400	74.60 (22.3%)	55.58	74.60, (22.3%)	(0.291, 0.624)
10%	3.1	96770	79.43 (23.6%)	63.79	77.64, (23.1%)	(0.286, 0.627)
11%	3.1	89140	78.41 (23.4%)	61.17	76.55, (22.9%)	(0.292, 0.622)
12%	3.2	86310	70.41 (20.9%)	51.93	69.24, (20.6%)	(0.291, 0.627)

[a] The data for maximum brightness (B), [b] maximum current efficiency (η_c), [c] maximum external quantum efficiency (EQE), [d] maximum power efficiency (η_p), [e] current efficiency (η_c) at the practical brightness of 1000 cd/m^2, [f] external quantum efficiency (EQE) at the practical brightness of 1000 cd/m^2, [g] Commission Internationale de l'Eclairage coordinates ($CIE_{x, y}$) at 10 mA/cm^2.

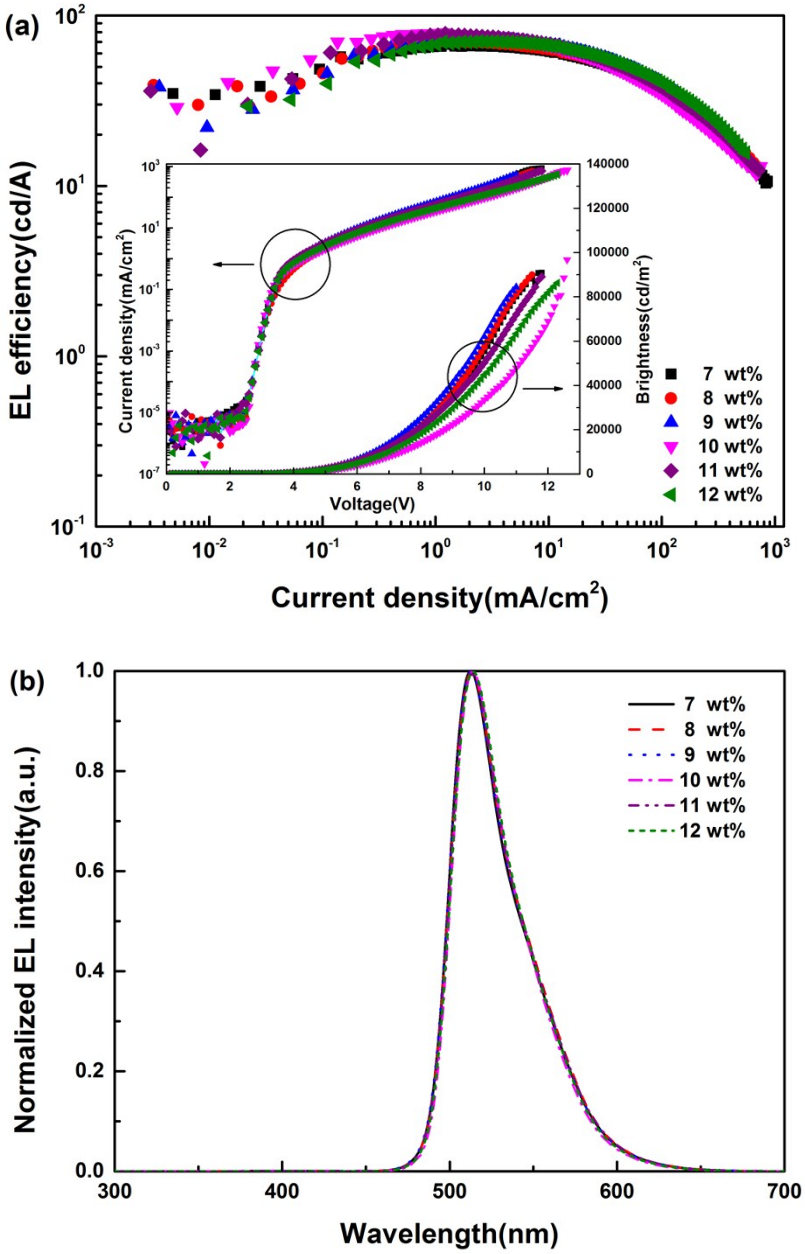

Fig. S2 (a) EL efficiency-current density (η-J) characteristics of double-EMLs devices with $Ir(mppy)_3$ at different doping concentrations. Inset: Current density-brightness-voltage (J-B-V) characteristics of double-EMLs devices with $Ir(mppy)_3$ at different doping concentrations. **(b)** Normalized EL spectra of double-EMLs devices with $Ir(mppy)_3$ at different doping concentrations operating at 10 mA/cm^2.

Table S3 The key properties of double-EMLs devices with ETL at different thicknesses.

Device	$V_{turn\text{-}on}$ (V)	B[a] (cd/m^2)	η_c[b] (EQE[c]) (cd/A)	η_p[d] (lm/W)	η_c[e] (cd/A) (EQE[f]) (1000 cd/m^2)	$CIE_{x, y}$[g]
50 nm	3.1	96770	79.43 (23.6%)	63.79	77.64, (23.1%)	(0.286, 0.627)
60 nm	3.2	116600	91.37 (25.7%)	66.75	86.36, (24.3%)	(0.294, 0.638)
70 nm	3.2	118400	95.22 (26.8%)	69.75	91.47, (26.8%)	(0.301, 0.635)
80 nm	3.2	122900	85.12 (24.9%)	62.09	81.23, (8.0%)	(0.299, 0.628)
90 nm	3.2	120800	83.57 (24.0%)	62.12	80.87, (5.3%)	(0.307, 0.628)

[a] The data for maximum brightness (B), [b] maximum current efficiency (η_c), [c] maximum external quantum efficiency (EQE), [d] maximum power efficiency (η_p), [e] current efficiency (η_c) at the practical brightness of 1000 cd/m^2, [f] external quantum efficiency (EQE) at the practical brightness of 1000 cd/m^2, [g] Commission Internationale de l'Eclairage coordinates ($CIE_{x, y}$) at 10 mA/cm^2.

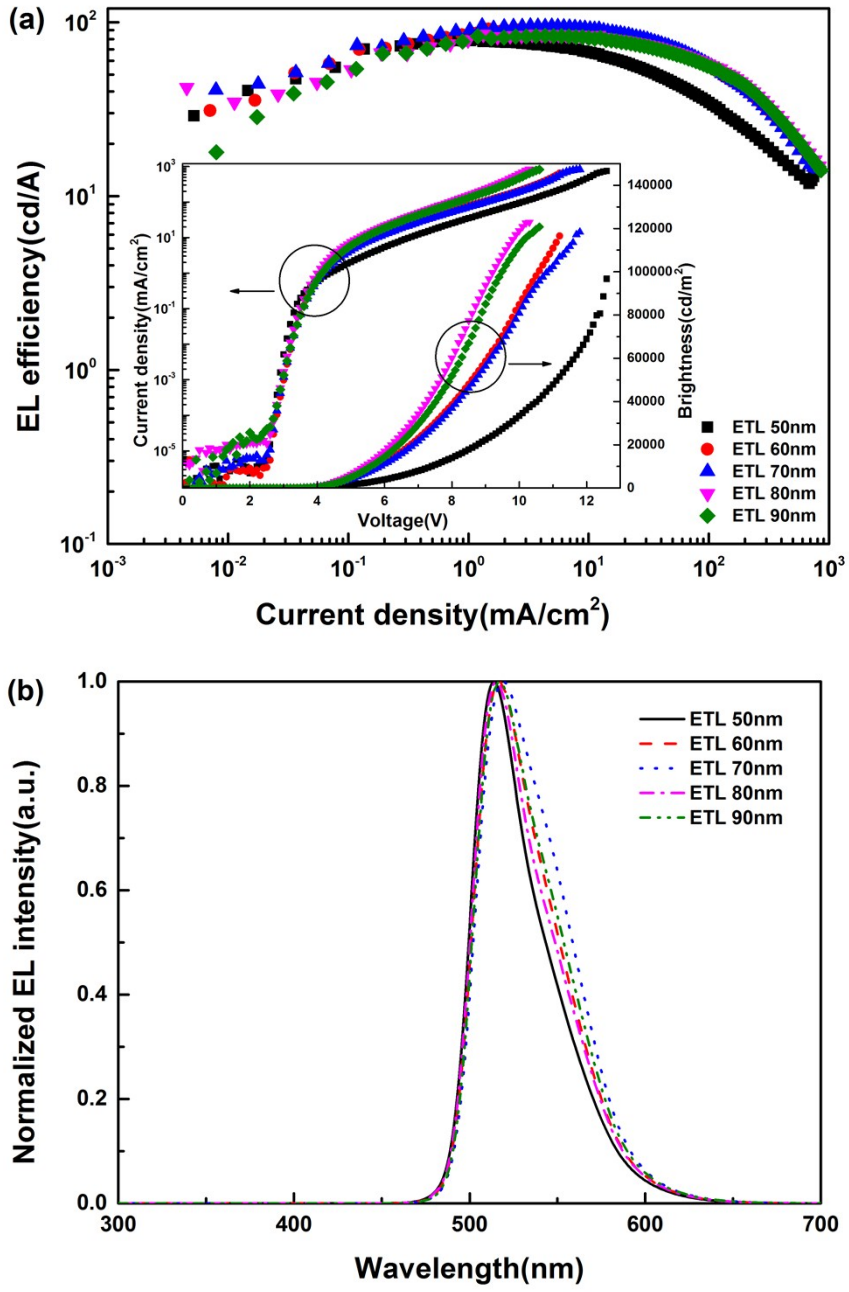

Fig. S3. (a) EL efficiency-current density (η-J) characteristics of double-EMLs devices at different thickness of ETL. Inset: Current density-brightness-voltage (J-B-V) characteristics of double-EMLs devices at different thickness of ETL. **(b)** Normalized EL spectra of double-EMLs devices at different thickness of ETL operating at 10 mA/cm^2.

Table S4 The key properties of single-EML devices (TcTa as host material) at different thickness of ETL.

Device	$V_{turn\text{-}on}$ (V)	B[a] (cd/m^2)	η_c[b] (EQE[c]) (cd/A)	η_p[d] (lm/W)	η_c[e] (cd/A) (EQE[f]) (1000 cd/m^2)	$CIE_{x, y}$[g]
50 nm	3.0	105700	79.39, (24.5%)	70.46	74.41, (23.3%)	(0.288, 0.629)
60 nm	3.0	110200	94.18, (27.6%)	84.62	92.88, (27.3%)	(0.284, 0.629)
65nm	3.0	118000	95.09, (27.7%)	93.47	93.47, (27.7%)	(0.285, 0.632)
70 nm	3.0	116700	96.08, (29.0%)	84.88	95.90, (29.0%)	(0.292, 0.634)
75nm	3.0	122000	106.90, (30.7%)	97.10	106.90, (30.7%)	(0.287, 0.638)
80 nm	3.0	107000	94.61, (26.9%)	82.01	94.61, (26.9%)	(0.294, 0.636)
90 nm	3.0	106900	90.00, (25.6%)	81.93	89.06, (25.3%)	(0.304, 0.632)

[a] The data for maximum brightness (B), [b] maximum current efficiency (η_c), [c] maximum external quantum efficiency (EQE), [d] maximum power efficiency (η_p), [e] current efficiency (η_c) at the practical brightness of 1000 cd/m^2, [f] external quantum efficiency (EQE) at the practical brightness of 1000 cd/m^2, [g] Commission Internationale de l'Eclairage coordinates ($CIE_{x, y}$) at 10 mA/cm^2.

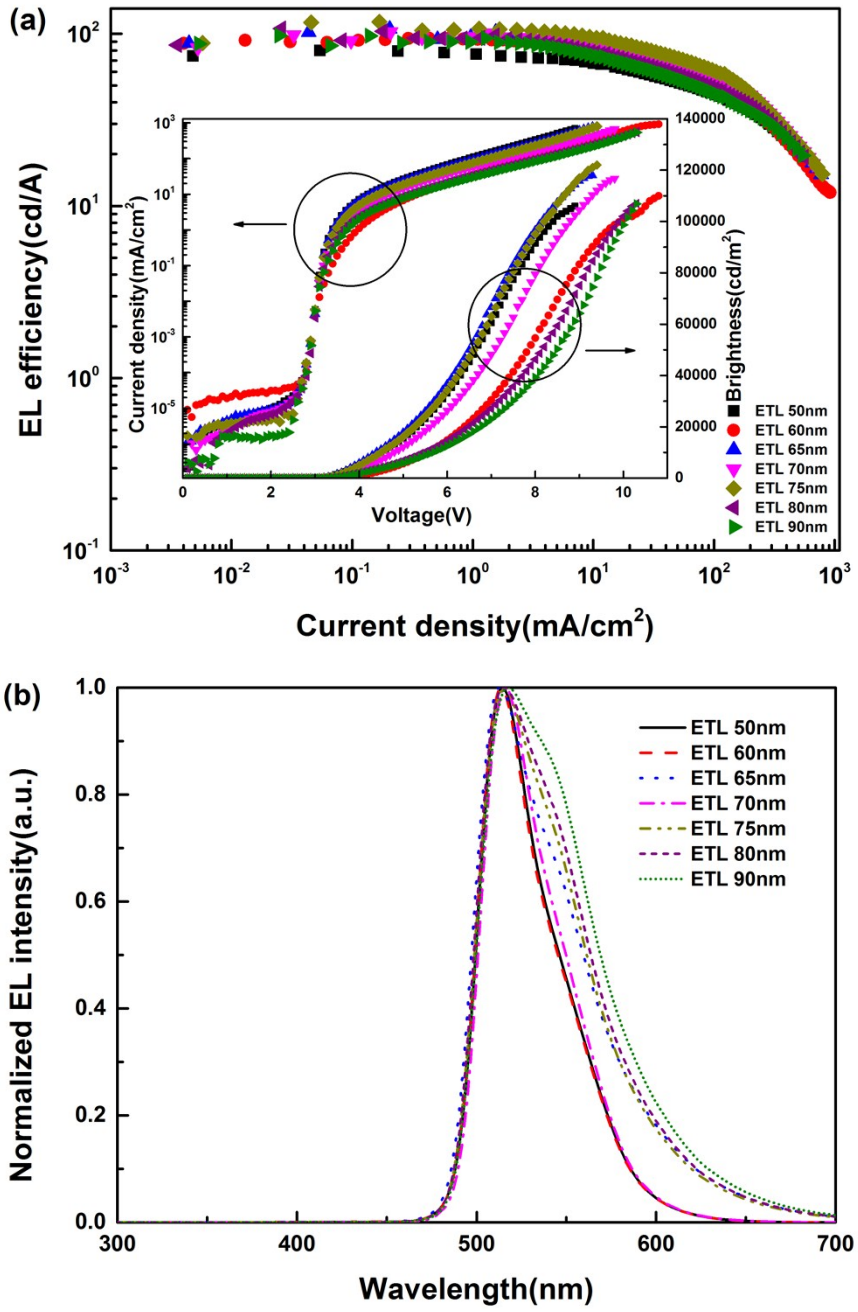

Figure S4. (a) EL efficiency-current density (η-J) characteristics of single-EML devices at different thickness of ETL. Inset: Current density-brightness-voltage (J-B-V) characteristics of double-EMLs devices at different thickness of ETL. **(b)** Normalized EL spectra of single-EML devices at different thickness of ETL operating at 10 mA/cm^2.