

## Excimer-Based White Phosphorescent OLEDs with High Efficiency

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There are several ways to demonstrate white organic light emitting diodes (OLEDs) for displays and solid state lighting applications. Among these approaches are the stacked three primary or two complementary colors light-emitting layers, multiple-doped emissive layer, and excimer and exciplex emission [1-10].

We report on white phosphorescent excimer devices by using two light emitting materials based on platinum complexes. These devices showed a peak EQE of 15.7%, with an EQE of 14.5% (17 lm/W) at 500 cd/m<sup>2</sup>, and a noticeable improvement in both the CIE coordinates (0.381, 0.401) and CRI (81).

Devices with the structure ITO/PEDOT:PSS/TCTA (30 nm)/26 mCPy: 12% FPt (10 nm) /26 mCPy: 2% Pt-4 (15 nm)/BCP (40 nm)/CsF/Al [device 1], ITO/PEDOT:PSS/TCTA (30 nm)/26 mCPy: 2% Pt-4 (15 nm)/26 mCPy: 12% FPt (10 nm)/BCP (40 nm)/CsF/Al [device 2], and ITO/PEDOT:PSS/TCTA (30 nm)/26 mCPy: 2% Pt-4: 12% FPt (25 nm)/BCP (40 nm)/CsF/Al [device 3] were fabricated. In these cases, the emissive layer was either the double-layer of 26 mCPy:12% FPt and 15 nm 26 mCPy: 2% Pt-4, or the single layer of 26mCPy with simultaneous doping of Pt-4 and FPt.

Device characterization indicates that the CIE coordinates/CRI of device 2 were (0.341, 0.394)/75, (0.295, 0.365)/70 at 5 V and 7 V, respectively. Significant change in EL spectra with the drive voltage was observed for device 2 indicating a shift in the carrier recombination zone, while relatively stable EL spectra was observed for device 1. This indicates a better charge trapping in Pt-4 doped layers [10]. On the other hand, device 3 having a single light-emitting layer (doped simultaneously) emitted a broad spectrum combining emission from the Pt-4 monomer

and FPt excimer. Moreover, excellent color stability independent of the drive voltage was observed in this case. The CIE coordinates/CRI at 4 V (40 cd/m<sup>2</sup>) and 7 V (7100 cd/m<sup>2</sup>) were (0.441, 0.421)/83 and (0.440, 0.427)/81, respectively. A balance in the EL spectra can be further obtained by lowering the doping ratio of FPt. In this regard, devices with FPt concentration of 8% (denoted as device 4) were fabricated and characterized. A shift in the CIE coordinates of device 4 from (0.441, 0.421) to (0.382, 0.401) was observed due to an increase in the emission intensity ratio of Pt-4 monomer to FPt excimer. It is worth noting that the CRI values remained above 80 for such device structure. Moreover, a noticeable stability in the EL spectra with respect to changing bias voltage was measured indicating a uniform region for exciton formation. A summary of device characteristics for all cases discussed above is shown in table 1. The forward light output in each case is approximately 500 cd/m<sup>2</sup>. Other parameters listed are driving voltage (Bias), current density (J), external quantum efficiency (EQE), power efficiency (P.E.), luminous efficiency (cd/A), and CIE coordinates.

To conclude, a highly efficient white phosphorescent excimer-based OLEDs made with two light-emitting platinum complexes and having a simple structure showed improved EL characteristics and color properties. The EQE of these devices at 500 cd/m<sup>2</sup> is 14.5% with a corresponding power efficiency of 17 lm/W, CIE coordinates of (0.382, 0.401), and CRI of 81.

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**TABLE 1. A summary of device characteristics.** Each device is listed by number and structure at which a forward light output of approximately 500 cd/m<sup>2</sup> was achieved. Other parameters listed are driving voltage (Bias), current density (J), external quantum efficiency (EQE), power efficiency (P.E.), luminous efficiency (cd/A), CIE coordinates.

Device	@ 500 cd/m <sup>2</sup>						
	Bias [V]	J [mA/cm <sup>2</sup> ]	EQE [%]	P.E. [lm/W]	L.E. [cd/A]	CIE	CRI
(1)ITO/PEDOT:PSS/TCTA/26mCPy:FPt(12%)/26mCPy:Pt-4(2%)/BCP/CsF/Al	5.6	2.37	11.6	12.7	22.3	0.22, 0.30	53
(2)ITO/PEDOT:PSS/TCTA/26mCPy:Pt4(12%)/26mCPy:FPt(12%)/BCP/CsF/Al	5.0	1.72	14.0	19.6	31.2	0.34, 0.39	75
(3)ITO/PEDOT:PSS/TCTA/26mCPy:FPt(12%):Pt-4 (2%)/BCP/CsF/Al	5.1	2.70	11.3	12.3	18.5	0.44, 0.42	83
(4)ITO/PEDOT:PSS/TCTA/26mCPy:FPt(8%):Pt-4 (2%)/BCP/CsF/Al	5.3	1.69	14.5	17	29.6	0.381, 0.401	81