

Materials Science & Engineering Doctoral Defense

High Performance White Organic Light-Emitting Diodes

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Abstract

Organic light-emitting diodes (OLEDs) have been successfully implemented in various display applications owing to rapid advancements in material design and device architecture. Their success in the display industry has ignited a rising interest in applying OLEDs for solid-state lighting applications through the development of white OLEDs (WOLEDs). However, to enter the market as a serious competitor, WOLEDs must achieve excellent color quality, high external quantum efficiency (EQE) as well as a long operational lifetime. In this research, novel materials and device architectures were explored to improve the performance of single-stack WOLEDs. A new Pt-based phosphorescent emitter, Pt2O2-p2m, was examined as a single emissive emitter for the development of a stable and efficient single-doped WOLED. A bilayer structure was employed to balance the charges carriers within the emissive layer resulting in low efficiency roll-off at high brightness, realizing a peak EQE of 21.5% and EQEs of 20% at 1000 cd m⁻² and 15.3% at 7592 cd m⁻². A novel phosphorescent/fluorescent, or hybrid, WOLED device architecture was also proposed. To gather a thorough understanding of blue fluorescent OLEDs prior to its use in a WOLED, a study was conducted to investigate the impact of the material selection on the device performance. The use of a low triplet energy host demonstrated an improvement to the operational stability of the blue OLED by reducing the occurrence of degradation events. Additionally, various dopant concentrations and blocking materials revealed vastly different efficiency and lifetime results. Finally, a Pd (II) complex, Pd3O8-py5, with efficient amber-colored aggregate emission was employed to produce a WOLED. Various host materials were investigated to achieve balanced white emission and the addition of an interlayer composed of a high triplet energy material was used to reduce quenching effects. Through this strategy, a color stable WOLED device with a peak EQE of 45% and an estimated LT95 of 50,710 h at 1000 cd m⁻² was realized. The comprehensive performance of the proposed device architecture competes with WOLED devices that are commercially available and reported within the literature domain, providing a strong foundation to further advance the development of highly efficient and stable single-stack WOLEDs.



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