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Numerical simulation of top-emitting organic light-emitting diodes with electron and hole blocking layers

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Abstract

The few reported high-contrast organic light-emitting diodes (OLEDs) all deal with bottom-emitting OLEDs and may not be readily adapted for top-emitting OLEDs (TOLEDs), which have a few technical merits over bottom-emitting devices for high-performance active-matrix OLED displays (AMOLEDs). The thin-film transistors on the back-plane of an AM substrate reduce the aperture ratio of a pixel that decreases the display brightness. A TOLED, which can provide a more flexible pixel design on an opaque AM substrate, represents a promising technique for achieving a high aperture-ratio AMOLED. In this work, the characteristics of TOLEDs with α-NPD and LiF blocking layers are numerically investigated with the APSYS simulation program. The α-NPD layer is used as an electron blocking layer, while the LiF layer is used as a hole blocking layer. The TOLED structure used in this study is based on a real device fabricated in lab by Yang et al. (Appl. Phys. Lett. 87, 143507, 2005). The simulation results indicate that when the TOLED device is with either α-NPD or LiF blocking layer, the luminance efficiency and radiative recombination rate at the same drive voltage can be markedly improved. The TOLED with α-NPD blocking layer has the best performance when the position of light emission is located at the anti-node of the standing wave due to micro-cavity effect. The TOLED with LiF blocking layer has improved performance because the LUMO of Alq_3 can be lowered by band bending, which leads to better carrier balance and thus increased radiative recombination rate.

Key words: Blocking layer; Micro-cavity effect;
Numerical simulation; OLED