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Luminescence mechanisms of green and blue organic light-emitting devices utilizing hole-blocking layers

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Abstract

Optical and electrical measurements on green and blue organic light-emitting devices (OLEDs) with and without hole-blocking layers (HBLs) were performed, and the luminescence mechanisms of green and blue OLEDs utilizing HBLs were investigated by using energy band diagrams and carrier density distributions. The dependence of the electroluminescence efficiencies on the existence of HBLs was described on the basis of a luminescence mechanism. The density distributions of the electrons and the holes in OLEDs under applied electric fields were estimated from the energy band diagrams, taking into account the electronic parameters and the layer thicknesses. The luminescence efficiencies and the color chromaticities were significantly affected by the existence of the HBLs. These analyses can help improve understanding of the luminescence mechanisms at play in and the electroluminescence efficiencies of green and blue OLEDs with HBLs, and the present results provide important information on the optical properties for enhancing the efficiencies of OLEDs operating in the green and the blue regions of the spectra.

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Recently, organic light-emitting diodes (OLEDs) have been particularly interesting because of their potential applications in next-generation flat-panel displays and large-area flexible displays [1–5]. OLEDs have emerged as excellent candidates for promising applications in the fabrication of full-color flat-panel displays with high brightnesses and high efficiencies because they have the unique advantages of a high-response velocity, a low-power consumption, and a wide-viewing angle [6,7]. However, since OLEDs have inherent problems due to limited self-luminescence [8–11], low efficiency [12], and short lifetime resulting from degradation [3,13,14], potential applications of OLEDs have driven extensive efforts to overcome these inherent problems, especially the low efficiency [15]. The charge transport, recombination, and luminescence processes in OLEDs occur in their organic thin layers [1], and the efficiencies of OLEDs can be improved by introducing various kinds of layers. An electron injection layer (EIL) and a hole injection layer (HIL) were introduced to enhance the injection of carriers. An electron transport layer (ETL) and a hole transport layer (HTL) were used to accelerate carrier transport [16], and a hole-blocking layer (HBL) and an electron-blocking layer (EBL) were inserted between the ETL and the emission layer (EML) or between the HTL and the EML to increase exciton recombination. Among the

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several layers comprising the OLEDs, since the luminescence efficiencies of OLEDs are significantly affected by the existence of HBLs [17], systematic studies on the luminescence mechanism in OLEDs with HBLs are very important for improving their efficiencies and achieving high performance.

This communication reports data for the optical and the electrical properties and on the luminescence mechanism in green and blue OLEDs containing HBLs. Electroluminescence (EL) and current–voltage (*I–V*) measurements were carried out to investigate the optical and the electrical properties of the OLEDs with and without HBLs. The luminescence mechanism was analyzed by using energy band diagrams and carrier density distributions, taking into account electronic parameters and layer thicknesses. The

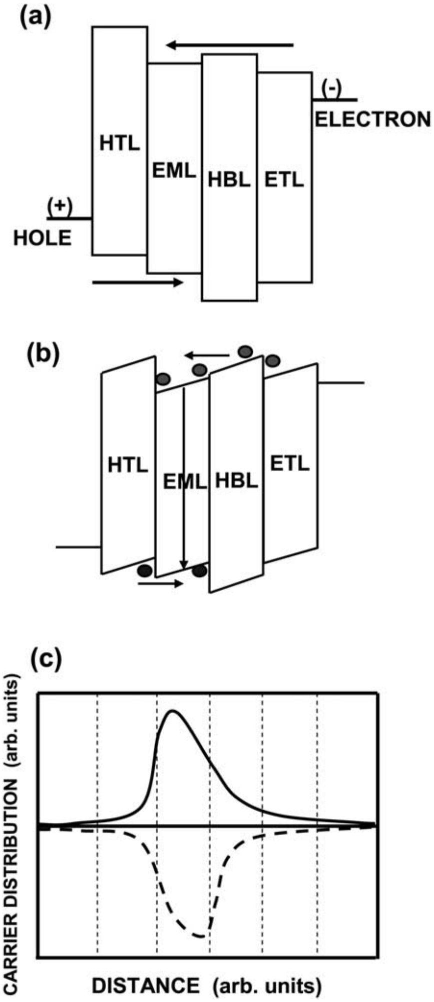

Fig. 1. Typical schematic energy band diagrams of OLEDs with HBLs (a) without an applied electric field and (b) under an applied electric field, together with (c) a schematic diagram of the electron (solid line) and the hole (dashed line) distributions under an applied electric field.

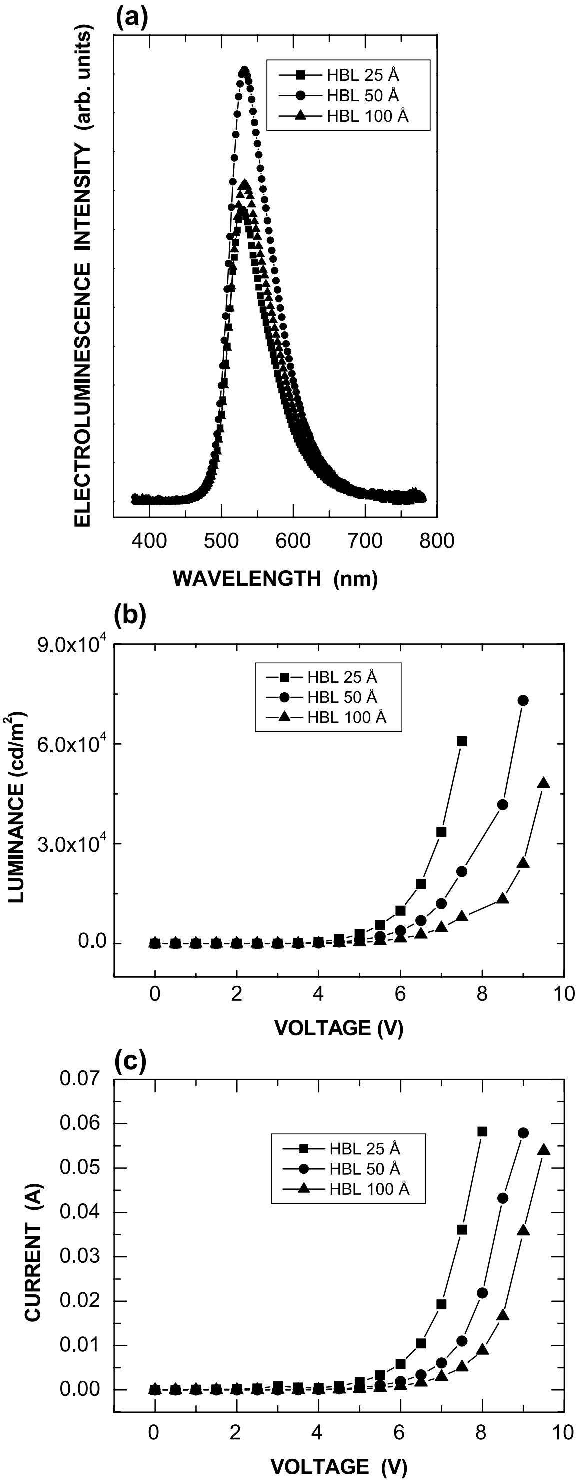

Fig. 2. (a) Electoluminescence spectra of green OLEDs with BAlq HBLs with thicknesses of 25, 50, and 100 Å driven at 3 mA, and (b) luminance and (c) the current of the same devices as functions of the voltage and the current, respectively.