Various structures of white OLED and energy transfer in dopant molecules

You Hyun Kim¹, Chang-Bum Moon¹, Peter Mascher² and Woo Young Kim¹,²,a),b)

¹Department of Green Energy & Semiconductor Engineering, Hoseo University, Asan, Korea
²Department of Engineering Physics, McMaster University, Hamilton, Canada

Abstract

Various white organic light-emitting diode (WOLED) devices have been designed and fabricated using host-dopant system with fluorescent and phosphorescent materials as well as considering additional effects of inducer, quantum well and double emission. To obtain perfect white emission two complementary and three primary color mixings were pursued as changing location of RGB emissive layers in WOLED. We also examine physical quantities influencing such as effective conductivity, threshold potential and characteristic potential barrier throughout quantitative interpretation of WOLED’s electroluminescence spectra to figure out energy transfer in dopant molecules.

Keyword: WOLED, host-dopant, fluorescence, phosphorescence, inducer, quantum well, double emission, energy transfer

1. INTRODUCTION

White organic light-emitting diodes (WOLEDs) have attracted special attention due to their potential applications in not only full-color OLED displays but also the backlight unit of liquid crystal displays (LCDs) as well as the solid-state lighting.¹ To obtain a perfect white emission from the WOLED, doping of mixed fluorophores or phosphors in a single emissive layer² or multi-emissive layer doped with different color-emitting dopants have been proposed.³ Many researchers have investigated the white OLEDs (WOLEDs) and lots of technical development have been reported improvement of an efficiency and white color chromaticity by new emitting materials, optimized layer structures and hybrid type double emissive layers with fluorescent and phosphorescent emitters.⁴ By using EL spectroscopy, we can obtain useful information about both of energy transfer and the molecular energy level structures in the dopant and host materials of OLED device.⁵,⁶ In this study, we propose novel structure of WOELDs using various emissive layers including fluorescent and phosphorescent dopants along with inducer layer, quantum well and optimization of color mixture. Energy transfer in emissive layer is also observed throughout electroluminescence spectra.

2. EXPERIMENTAL AND RESULTS

As shown in Figure 1, WOLED devices using red fluorescent layer with FIrpic doped in mCP and blue phosphorescent layer with DCJTB doped in Alq₃ were fabricated as changing thickness of inducer layer, mCP. Figure 2 describes WOLED’s layer structure including double white emissive layer using BCzVBi and DCJTB as red and blue fluorescent dopants in emissive layers. Other

![Figure 1. WOELD’s energy band diagram with two emissive layer and inducer layer.](image1)

![Figure 2. Energy band diagram of WOLED with double white emissive layer.](image2)

WOELD devices observe energy transfer between host and dopant were prepared with the emissive layer BCzVbi and rubrene doped in TcTa as shown its layer structure in Figure 3.

Depending on device structures, different dopants and host materials for emissive layer were used along with various thickness and inducer layer to optimize WOLED’s electrical and optical performances. The current density
versus applied bias voltages, luminance versus current density, and luminous efficiency versus current density were measured and electroluminescence spectra were examined to figure out energy transfer in dopant molecules. As the bias voltage increases, the holes injected from NPB moves to the charge carrier trapping between the DPVBi and Bphen layers via the HOMO level of the DPVBi layer, which plays a role in the barrier for the hole. From analysis of EL spectroscopy, we have identified the emission spectra to have five transitions in the BCzVBi molecule and three transitions in the Rubrene molecule as shown in Figure 5. A typical spacing of the vibrational levels is of order of ∼0.15 eV and $S_{00}/(S_{01})$, the lowest (first excited) vibrational state of the ground electronic state. Because the spacing between vibrational states is large compared with average thermal energies (∼0.026 eV), nearly all molecules at room temperature are in the $S_{00}$ state.

As the bias voltage increases, the holes injected from NPB moves to the charge carrier trapping between the DPVBi and Bphen layers via the HOMO level of the DPVBi layer, which plays a role in the barrier for the hole. From analysis of EL spectroscopy, we have identified the emission spectra to have five transitions in the BCzVBi molecule and three transitions in the Rubrene molecule as shown in Figure 5. A typical spacing of the vibrational levels is of order of ∼0.15 eV and $S_{00}/(S_{01})$, the lowest (first excited) vibrational state of the ground electronic state. Because the spacing between vibrational states is large compared with average thermal energies (∼0.026 eV), nearly all molecules at room temperature are in the $S_{00}$ state.

3. SUMMARY

Various layer structures of WOLEDs were prepared to observe electrical and optical properties for optimizing their performances. EL spectroscopy made possible systemic study of molecular energy levels including excited states and relative energy transition intensities providing vital fingerprints for energy transfer and color coordinates of white emission.

4. ACKNOWLEDGEMENT

Following are results of a study on the “Leaders Industry-university Cooperation” Project, supported by the Ministry of Education, Science & Technology (MEST).

5. REFERENCES