DOCTORAL THESIS

Charge distribution in multi-emissive layer OLED

Kim, Ji Young

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ABSTRACT

Organic light-emitting diodes (OLEDs) have been considered as the future lighting and display system and rapidly growing since 1987. It has been already used in many commercial applications such as OLED televisions, cell phone displays, and lighting systems. The OLED has higher luminous efficiency and extremely thinner layer compare to any other lighting devices, also it has flexibility and self-emission. However, there are still some drawbacks for the device performances such as lifetime especially on blue organic films, cost of manufacturing process, and moisture that we need to work on before wide-scale commercialization like LCD or LED.

This thesis has focused on developing a charge distribution such as deriving empirical equations in multi-emissive layer OLED, improving external quantum efficiency (EQE) and lowering roll-off. Key results are summarized as follows:

(1) We seek to establish a quantitative method to estimate the holes and electrons ratio in the recombination zones. The result shows a trend in the charge recombination ratio depending on the hole and electron transport layer (HTL/ETL) thickness. We obtained an empirical relationship between electron/hole transport layer thicknesses and emission ratio in emissive layer (EML). In addition, the electroluminescence (EL) spectra were analyzed by fitting a Gaussian distribution for the two emissive layers to calculate the intensity ratio of the energy transitions. The arrival time of hole and electrons from each electrode was determined using the thickness and mobility of NPB as hole transport layer and TPBi as electron transport layer. From these initial

results, we derived an empirical mechanism to meet with an exponential relationship that can allow us to design custom- made OLEDs.

(2) We fabricated White OLEDs in which the emissive layers are chemically doped with blue and red fluorescent dopants of BUBD-1 and DCJTB. This work continues by estimating of emission ratio between red and blue emissive layers by changing the thicknesses of HTL and ETL. The recombination of charge carriers was first identified the location and then we derived an empirical equation for peak intensity ratio of EL spectra with respect to thickness of the HTL/ETL to determine how recombination zone depends on the HTL and ETL thickness. The EL spectra of WOLEDs were fitted with a Gaussian distribution for the two emissive layers using host-dopant system and intensity ratio of blue and red emission peak is 61:39 when thickness of HTL and ETL are 80nm and 20nm, respectively. Also, this intensity ratio of blue and red emission peak (61:39) has the CIE color coordinates of (0.34, 0.40). We obtained a preliminary relationship between thickness of electron/hole transport layer and ratio of two emission peaks.

(3) The improved external quantum efficiency (EQE) and reduced roll-off properties of blue phosphorescent organic light-emitting diodes (PHOLEDs), were obtained with structure, ITO/NPB (40 nm)/TCTA (20 nm)/mCP:FIrpic (7%)(30 nm)/TPBi (30 nm)/Liq (2 nm)/Al (80 nm) by incorporating a TCTA inter-layer. We compared the properties of BCP and TPBi as the ETL with a typical structure of HTL/ EML/ETL in OLEDs and utilized inter-layer in the optimized structure to enhance EQE to 52% at 5.5 V, also stabilize the roll-off of 63%. The use of inter-layer in blue PHOLEDs exhibits a current efficiency

of 10.04 cd/A, an EQE of 6.20% at 5.5 V and the highest luminance of 10310 cd/m^2 at 9.5 V.

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