새로운 층을 삽입한 고효율 고발광의 OLEDs 제작 및 그 특성

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Improvement of efficiency and brightness by insertion of the novel layer in OLEDs

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Abstract

An efficiency and brightness of the Organic Light-emitting Diodes(OLEDs) by insertion of the novel layer between a singlet emitter and an electron transporting layer without doping processes, has been improved. The novel layers named as the K-M1 and K-M2 layers have shown the excellent improvement in the carrier balance and recombination efficiency. New devices using the K-M1 and K-M2 layers have shown a high efficiencies of over 15cd/A and 6lm/W(at 20mA/cm^2), and brightness of over 16,000cd/m^2(at 100mA/cm^2), respectively.

Key Words : OLEDs, Carrier injection, Recombination efficiency, Carrier balance

1. INTRODUCTION

Organic Light-emitting Diodes(OLEDs) have received very attractive attention for their potential applications in large area, and full color flat-panel display[1,2]. However, the OLEDs have a failure problem, for example, the thermal degradation due to excessive current[3], and so on. Therefore, there have been a lot of attempts to optimize their efficiencies and stability. It is recognized that high efficiency and brightness is related to improving carrier balance and high recombination efficiency at low current density[4]. The OLEDs are fabricated by the usable functional materials such as the hole blocking layer, many dopants, triplet emitters, and metal cathodes to have a low work-function. However, many doped and functional molecular layers are processed by vacuum evaporation system and it is generally thought that the process time is taken in the longer term. Intrinsically, phosphorescent emitters[5] are potentially efficient compared to "standard" singlet emitters. However, it has often been pointed out that the phosphorescent devices have problems such as lower operational stability and loss of luminance efficiency at high brightness.

In this background, we newly suggest here the realization of the efficient Alq_3([tris (8-hydroxyquinolinato)aluminum])-based OLEDs by insertion of the K-M1 and K-M2 layers between an Alq_3 as the standard singlet emitter and an electron transporting layer to improve the carrier balance and recombination without doping processes. New devices using the K-M1 and K-M2 layers have shown remarkable improvement of the efficiency and brightness.

2. EXPERIMENTAL

The layer structures and position of the K-M1 and K-M2 layers in Alq_3 are listed in Table 1.

Table 1. The layer structures of the OLEDs

Device No.	Organic Layer Structures
BSC	CuPc/α-NPD
A	BSC/Alq_3
B	BSC/Alq_3(10nm)/K-M1/Alq_3(50nm)
C	BSC/Alq_3(30nm)/K-M1/Alq_3(30nm)
D	BSC/Alq_3(50nm)/K-M1/Alq_3(10nm)
E	BSC/Alq_3(10nm)/K-M2/Alq_3(50nm)

For the anode, we use indium-tin-oxide (ITO) substrates and those patterned by photolithographic methods. These substrates are treated by 2-step processes. First, the ITO substrates are cleaned by scrubbing, sonication, and dry in nitrogen ambient glove box. And then, the second cleaning process is used for oxygen plasma treatment. The device structure is composed of CuPc(Copper Phthalocyanine) as the HIL(Hole Injection Layer), -NPD([N, N'-di(naphthalene-1-yl)-N, N'-diphenyl -benzidine]) as the HTL(Hole Transport Layer), Alq_3 as the EML(Emitting Layer) or ETL(Electron Transport Layer), and LiF/Al as the double cathode layer successively on ITO coated substrate. The K-M1 and K-M2 layers are inserted in Alq_3 with an emitting layer thickness varying from 0 to 50nm. The thickness of the K-M1 and K-M2 layers is fixed on 1nm. All layers are deposited by thermal evaporator in vacuum chamber with base pressure of < 10^{-7}torr.

3. RESULTS AND DISCUSSION

Figs. 1 and 2 shows the electric property and bright property as a function of driving voltage and current density. J-V characteristics is extremely sensitive to the position of the K-M1 and K-M2 layers in Alq_3.

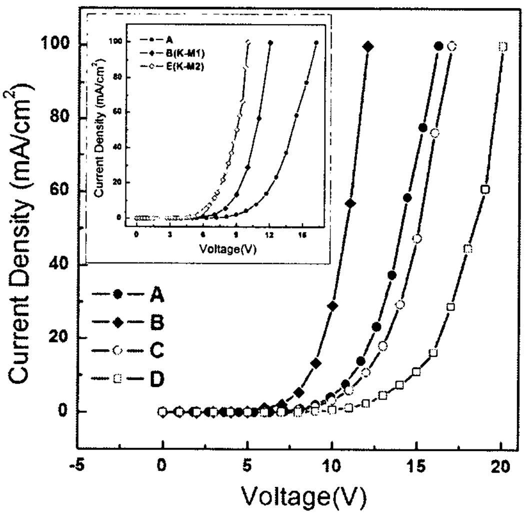

Fig 1. J-V Characteristics

J-V characteristics. Inset: Comparing J-V characteristics of devices A, C, and E

Especially, the devices B and E(see Inset of figs. 1 and 2) with an emitting layer of 10nm require a driving voltage of approximately 12V to generate a current density of $100mA/cm^2$, and turn-on voltage is measured around 3V at $1cd/m^2$. However, J-V graph shifts to right side gradually with increasing emitting layer. This is simply because the conductivity of emitting layer is reduced by position of the K-M1 layer in

Alq3, resulting in the increase of voltage in spite of improved brightness as shown in fig. 2.

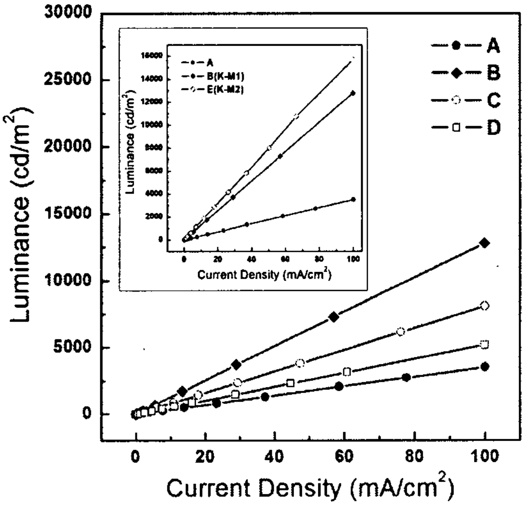

Fig. 2 L-J Characteristics

L-J characteristics of the devices by K-M1 and K-M2 layers. Inset: Comparing with L-J characteristics of devices A, C, and E

In fig. 2, the luminance increases linearly along with the current density for all the devices. Among the fabricated devices, the device E(see Inset of fig. 2) with K-M2 layer achieves a 16000cd/m^2 at 100mA/cm^2 and attains a brightness of 1000cd/m^2 at only under 10mA/cm^2. Also the devices using the K-M1 layer have the brightness improved, compared to device A. The luminance results show that the effective carrier balance and recombination in singlet emitter can be realized by K-M1 and K-M2 layers.

Fig. 3 shows the luminance efficiency as a function of current density using K-M1 and K-M2(see Inset of fig 3.) layers. The luminous efficiencies of device A~E are 3.5, 13, 8.25, 5.06, and 15.7cd/A, respectively, at 20mA/cm^2. The devices using the K-M1 and K-M2 layers have higher luminous efficiency than controlled device A. Similar to the luminance efficiency results, the power efficiency of the device E has shown higher value than other devices as shown in fig. 4 and inset.

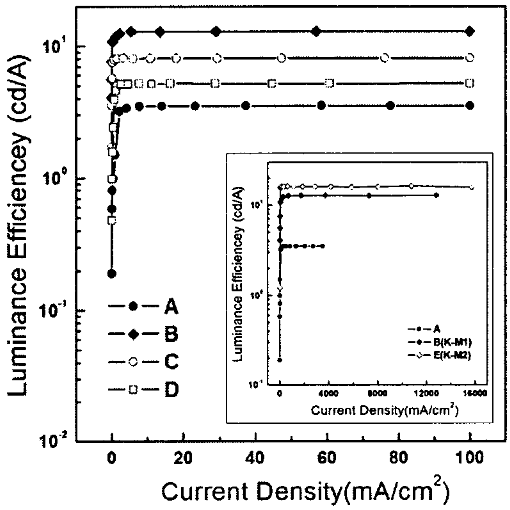

Fig. 3 Luminance efficiency Characteristics

Luminance efficiency characteristics. Inset: Comparing with Luminance efficiency characteristics of devices A, C, and E

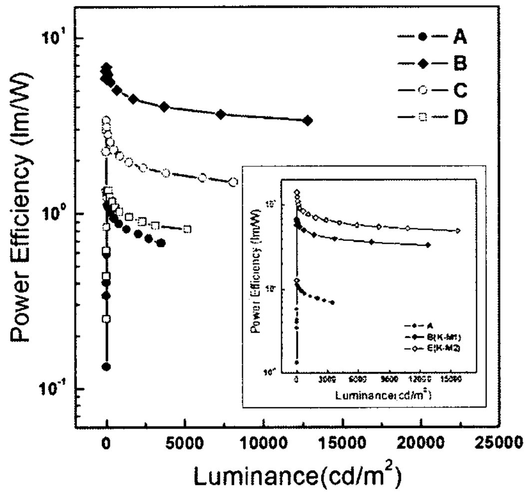

Fig. 4 Power efficiency Characteristics

Power efficiency characteristics. Inset : Comparing with power efficiency characteristics of devices A, C, and E

As a result, the devices using the K-M1 and K-M2 layers have shown the high efficiencies and brightness. Also, the devices properties are more improved gradually, compared to device A. The novel OLEDs are fabricated without doping processes and insertion of other usable organic functional materials. Our new devices by the K-M1 and K-M2 layers showed a high luminance efficiency of over 15cd/A(at 20mA), a power efficiency of over 6lm/W(at 1000cd/m^2), and brightness of over 16,000cd/m^2(at 100mA), respectively.

4. CONCLUSIONS

The novel OLEDs to have very high efficiencies and brightness by the only K-M1 and K-M2 layers has been fabricated without doping processes and insertion of other usable organic functional materials. Therefore, the excellent K-M1 and K-M2 layers offer the very high efficient and bright OLEDs by simple process and low cost.

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