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Luminance Characteristics of Organic Electroluminescent Devices Based on Znq2 by Heating

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열처리된 Znq2에 기초한 유기 EL소자의 발광특성

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초 록 출발물질로서 zinc chloride 및 zinc acetate로부터 Znq2가 성공적으로 합성되었다. 정공운송층으로 N-N′-diphenyl-N-N′-bis(3-methylphenyl)-1,1′-biphenyl-4,4′-diamine (TPD)와 발광층 및 전자운송층으로 bis(8-oxyquinolino)zinc(II)(Znq2)을 이용하여 ITO/TPD/Znq2/Al의 순서로 유기EL 소자를 제작하였다. 열처리 온도에 따라 각각의 조건에서 준비된 Znq2의 효율을 검토하였고, PL스펙트럼은 Znq2가 황녹색의 발광을 나타내는 570nm에서 주 피크를 가지며 이것은 EL스펙트럼과 일치하여 이 발광이 Znq2로부터의 발광임을 알 수 있었다. V-J 곡선은 전하주입이 4V부터 발생함을 알 수 있었으며, 최대 발광휘도 및 효율은 각각 1600cd/m², 0.9lm/W였다. 이상의 실험결과로부터 Znq2가 유용한 EL발광물질로서 가능성이 있음을 나타낸다.

Abstract The 8-hydroxyquinoline Zinc(Znq2) were prepared successfully from zinc chloride and zinc acetate as two kinds of starting material. The organic electroluminescent devices(ELDs) were fabricated by the structure of ITO/TPD/Znq2/Al with N-N′-diphenyl-N-N′-bis(3-methylphenyl)-1,1′-biphenyl-4,4′-diamine(TPD) which acts hole transporting layer and bis(8-oxyquinolino) zinc(II)(Znq2) which acts as emission and electron transporting layer. EL efficiency of Znq2 prepared by heating was investigated. The 570nm of main emission peak which is yellowish green was investigated by photo luminesence(PL) and this results shows that electro luminescence(EL) is from Znq2. The V-J curve shows that carrier injection were investigated from 4V. Maximum luminance and luminance efficiency were 1600cd/m², 0.9lm/W. From this results, the Znq2 can be one of the useful organic EL material.

Key word: N-N′-diphenyl-N-N′-bis(3-methylphenyl)-1,1′-biphenyl-4,4′-diamine(TPD), Carrier Injection, Full-color, Electroluminescent devices(ELDs), Bis(8-oxyquinolino) Zinc(II)(Znq2), Recombination, Emission, Cathode-ray tubes(CRTs)

1. Introduction

Recently, with the accelerated promotion of the information society interfaced with information display, much attention has been focused on flat panel displays which need low electric power and low energy and occupy less space than cathode-ray tubes (CRT).[1,2] Carrier injection type electroluminescent devices have a faster response speed than liquid crystal display (LCD), which is typical example of current flat display technology and dominant recent display industry. But LCD is a nonluminescent devices compared with organic electroluminescent (EL), field effect display (FED), plasma display panel (PDP), which is selfluminescent EL devices. Self-luminescent EL devices provides a clear and high resolution and full-color, high luminance at low driving voltage.[3~5] Because of that reason, organic EL is drawing special attention. In order to enhance EL efficiency, electron and hole transporting layer have been used in organic EL diode since Tang reported high brightness organic EL devices with 8-hydroxyquionoline aluminium (Alq3) emitter.[1] By adapting multilayer and high efficiency material, improving EL efficiency could be possible, too. Saito[6] demonstrated that luminescent hole-transporting materials can be an emission layer in EL devices when combined with an appropriate electron transporting layer.[7~9] When emission layer is sandwiched between a hole transporting layer and electron transporting layer, the excitons produced in the emission layer are confided to the emission layer, and are thus prevents from diffusing to the electrode where they would be quenched.[10]

In this paper, we fabricated multilayer, hole transporting layer and electron transporting layer, emission layer where Znq2[11] was used as a electron transporting and emssion layer. Heating was performed to enhance color purity and emission intensity. TheN-N′-diphenyl-N-N′-bis(3-methylphenyl)-1.1′-biphenyl-4,4′-diamine (TPD) was used as a hole transporting layer. EL spectra, EL efficiency and brightness was investigated.

2. Experimental

2-1. Materials

ITO-coated glass sheets (thickness, 1000Å, resistance, 15Ω/□) were supplied from Samsung Corning Glass Co., Ltd. An ITO layer on a glass substrate was etched to form 2mm-wide stripes using aqua regia. The cleaning of etched ITO substrate was performed in boiling H_2O_2 and NH_4OH solution followed by ultrasonication treatment. Fig. 1 was prepared ITO substrate and Fig. 2 was hole (a) and electron transporting

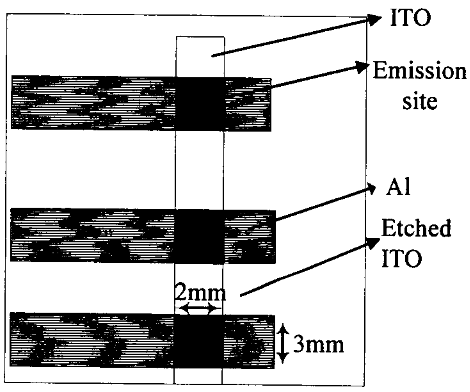
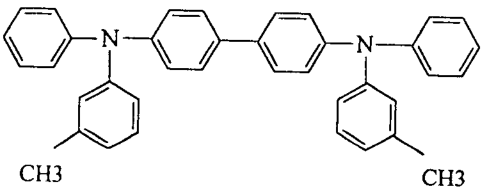
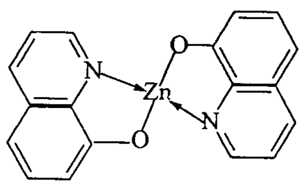


Fig. 1. The fabricated EL cell in this work.



(a)



(b)

Fig. 2. The used organic material as a hole transporting(a) and emission layer(b).
(a) N-N′-diphenyl-N-N′-bis(3-methylphenyl)-1,1′-biphenyl-4,4′-diamine, (b) Bis(8-oxyquinolino)zinc(Ⅱ)

organic material (b) used in this work. Znq2 (b) was also used as a emission materials. The Znq2 was prepared from zinc acetate and zinc chloride.

2-2. Fabrication of EL devices

The EL cell were fabricated with conventional vacuum vapor deposition in a vacuum of 10^{-5}torr. Organic materials were evaporated from tantalium boats and were deposited onto patterned ITO glass substrates. The deposition rate for organic materials were 3Å/s. The ITO/TPD/Znq2/Al electrode were evaporated successively. Two-millimeter-wide stripes, which made with ITO stripes, were formed, providing $2\times3mm^2$ active emission area.

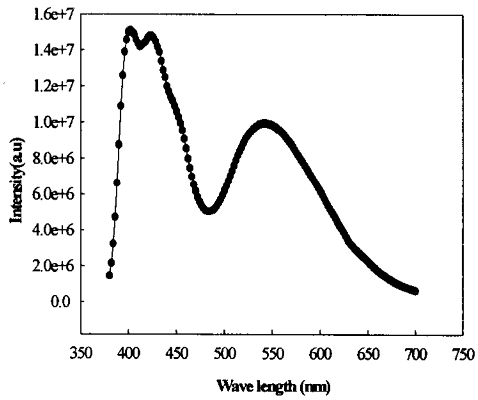
2-3. Measurement of EL characteristics

EL spectra and photoelectro characteristics was investigated with spectrometer (PMA-10), Luminanometer (Dr 2550 mill-lab), Universal source (HP3245A).

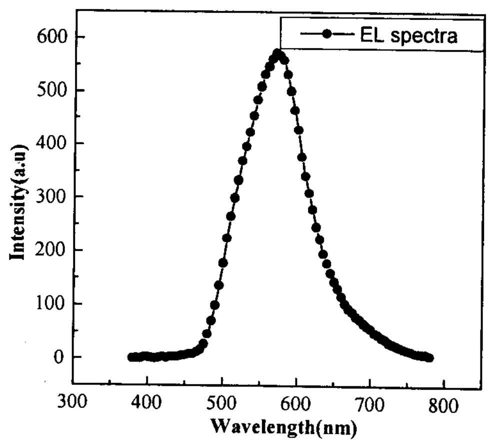
3. Results and Discussion

3-1. PL and EL spectra

PL (Fig. 3 (a) and EL (Fig. 3 (b) spectra of Znq2 pre-



(a)



(b)

Fig. 3. PL(a) and EL(b) emission spectra of Znq2 as a emitting materials. The structure of EL cell is ITO/TPD/Znq2/Al electrode.

pared in this work was shown at Fig. 3. About 440nm of emission PL peak is from TPD and 570nm of emission peak is from Znq2. Fig. 3(b) shows that the half width of wave length is 110nm, formed gaussian curve. Maximum peak was appeared at 580nm, indicatedyellowish green color. Compared with PL spectra of Znq2, this EL emission peak was caused from Znq2. CIE x and CIE y was 0.404, 0.5387.

3-2. Voltage-current density relationships

Fig. 4 shows the voltage-current density relationships in EL cell fabricated with Znq2 prepared from zinc acetate by heating at various temperature. Current density was decreased as heating temperature increased, suggested luminance will not increase anymore by heating.

Fig. 5 shows the voltage-current density relationships in EL cell fabricated with Znq2 prepared from $ZnCl_2$ by heating at various temperature. Current density was increased sharply as heating temperature was increased. This means high current density cause rapid

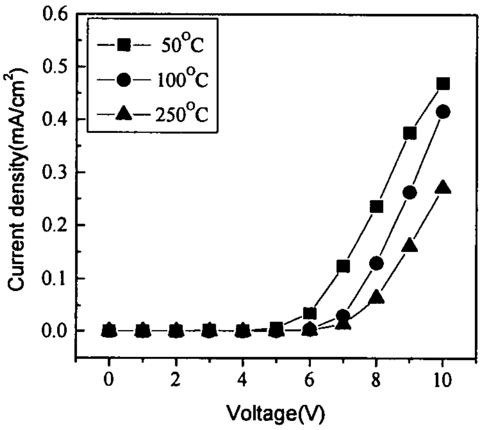


Fig. 4. V-J characteristics of Znq2 prepared from zinc acetate treated by various heating temperature.

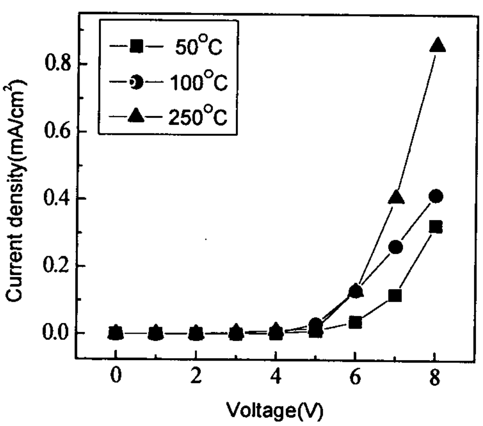


Fig. 5. V-J characteristics of Znq2 prepared from zinc chloride treated by various heating temperature.

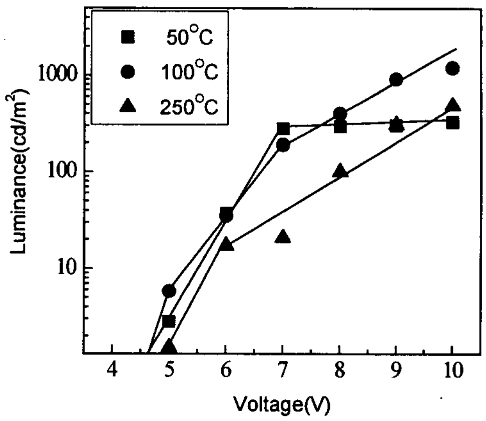


Fig. 6. V-L characteristics of Znq2 prepared from zinc acetate treated by various heating temperature.

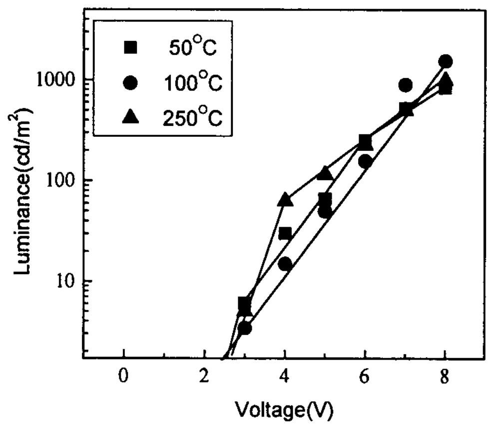


Fig. 7. V-L characteristics of Znq2 prepared from zinc chloride treated by various heating temperature.

degradation of EL cell. Current density characteristics of Znq2 prepared from zinc acetate and zinc chloride was different by heating.

3-3. Voltage-luminance characteristics

Fig. 6 shows the luminance-voltage relationships fabricated from Znq2 prepared from zinc acetate by heating at various temperature. Znq2 treated at 100℃ shows 1000cd/m^2 brightness, compared with 700cd/m^2 at 250℃. Znq2 at 50℃ does not increase anymore above 6.5V of driving voltage. This means heating cause molecular arrangement of organic material. 330, 1200 and 487cd/m^2 of maximum luminance was achieved at 50, 100 and 250℃, respectively.

Fig. 7 shows the luminance-voltage relationships fabricated from Znq2 prepared from zinc chloride by heating at various temperature. Luminance of Znq2 treated at 50, 100℃ was linearly increased by voltage. But luminance of Znq2 treated at 250℃ was decreased from 4V of driving voltage, compared with various heating temperature. 840, 1550 and 1000cd/m^2 of maximum luminance was achieved at 50, 100 and 250 ℃ heating temperature, respectively.

From the results of Fig. 6 and Fig. 7, even though heating can be the factor for increasing EL efficiency, 100 ℃ of heating temperature is optimal temperature. It is suggested that organic impurity disappear through heating but aggregation was occurred above 200℃.

3-4. Luminance-current density relationships

Fig. 8 show luminance-current density characteristics of Znq2 prepared from zinc acetate by various heating temperature. Znq2 treated at 100℃ has a effective efficiency, that is, high luminance was investigated with low current density. Znq2 treated at 50, 250℃, even though current density increase, luminance does not increase by driving voltage.

Fig. 9 shows luminance-current density characteristics of Znq2 prepared from zinc chloride by heating temperature. Znq2 treated at 50, 100℃ shows high luminance characteristics at low current density, but Znq2 at 250℃ shows low luminance at high current density.

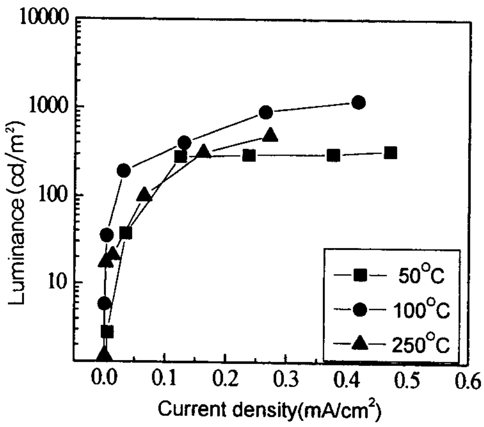


Fig. 8. J-L characteristics of Znq2 prepared from zinc acetate treated by various heating temperature.

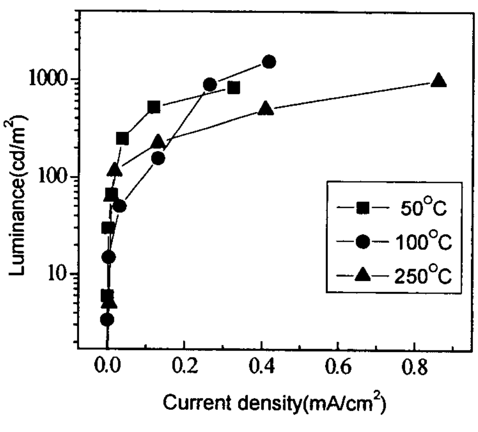


Fig. 9. J-L characteristics of Znq2 prepared from zinc chloride treated by various heating temperature.

Table 1. The maximum luminance, driving voltage and current density at the maximum luminance with Znq2 prepared from zinc acetate.

	Maximum luminance (cd/m²)	Driving voltage(V)	Current density (mA/cm²)
50℃	330	10	0.4702
100℃	1200	10	0.4165
250℃	487	10	0.2715

Table 2. The maximum luminance, driving voltage andcurrent density at the maximum luminance with Znq2 prepared from zinc chloride.

	Maximum luminance (cd/m²)	Driving voltage(V)	Current density (mA/cm²)
50℃	840	8	0.3257
100℃	1550	8	0.4165
250℃	1000	8	0.8597

From this results, 100℃ has a high EL efficiency. 1600cd/m^2 of luminance was investigated and EL efficiency was 0.9 lm/W.

The characteristics of maximum luminance, current density, driving voltage with Znq2 prepared from zinc acetate, zinc chloride was shown at Table 1 and Table 2.

4. Conclusion

The Znq2 which prepared from zinc acetate and zinc chloride was treated at 50, 100 and 250 ℃. The Znq2 was used as an electron transporting and emission layer and TPD was used as a hole transporting layer. The structure of ITO/TPD/Znq2/Al was fabricated by vacuum evaporated deposition method. The voltage-current density, voltage-luminance, current density-luminance characteristics was investigated.

The Znq2 prepared from zinc acetate shows that current density was decreased as heating temperature increase. But The Znq2 prepared from zinc chloride shows that current density was increased as heating temperature increase. The Znq2 treated at 100℃ shows stable current density, and high luminance characteristics, both zinc acetate and zinc chloride. Also this results corresponds with the fact that same phenomena was investigated at UV projection. The maximum luminance of 1200cd/m^2 from zinc acetate and 1600cd/m^2 from zinc chloride was investigated.

From this work, we conclude Znq2 prepared from zinc chloride which is treated at 100℃ shows highest performance, about 1600cd/m^2 of luminance at the 0.

$6mA/cm^2$ of current density. The EL emission peak was located at 570nm, and corresponded well to the photoluminescence peak wavelength of the Znq2 deposited on to glass itself.

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