Extended Abstracts of the 2009 International Conference on Solid State Devices and Materials, Sendai, 2009, pp635-636

Performance Improvement of Top Emission OLED by Using Heat Dissipation UV glue for encapsulation

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1. Introduction

Organic light emitting diode (OLED) is the new generation for flat panel displays. It has the advantages such as self-illumination, large view angle (>170°), high illumination efficiency, and easy to produce on various substrates. In order to increase the opening rate so that the active panel would not be affected by thin film transistors, research in top-emitting OLED (TEOLED) have rapidly evolved. Lots of research has also been done for the required transparent cathode and high reflective anode [1-4]. In addition, much research had been done for the OLED lifetime, which besides of water vapor and oxygen corrosion, the created heat by OLED device is also a factor for lifetime reduction. As the temperature of the device increase, the organic layer results in crystallization, to further cause decay and the device breakdown [5,6]. Thus the produced TEOLED in this research, we used heat dissipation UV glue to improve the effect of the joule heat to device when it was operated under a high current density. In addition, it increased the device view angle, benefited the encapsulation of OLED device, and also increased the lifetime.

2. Experiment

In this study, the OLED structure investigated was glass/ Al (75nm)/ Au (2nm)/ m-MTDATA (15nm)/ NPB (30nm)/ Alq_3 (60nm)/ LiF (0.2nm)/ Al (2nm)/ Ag (14nm). Before depositing the metal anode, ultrasonically cleaning the substrates in proper order with acetone (8 minutes), methanol (8 minutes) and de-ionized water (DI-Water) (8 minutes). After blow drying with a nitrogen, the substrates were baked in an oven at 100℃ for 10 min. The prepared substrates were placed in the metal evaporation chamber, and Al (with high-reflectivity) and Au (with high work function) were deposited under 4×10^{-6} torr to create an anode at first. Next, the substrates were moved to the organic evaporation chamber for the deposition of organic thin films under 2×10^{-6} torr. The hole injection layer (HIL) was (4, 4', 4''-tris (N-3-methphenyl-N-phenyl-amino)-triphenylamine, m-MTDATA) 15nm, the hole transport layer (HTL) was (N,N'-Bis (naphthalen-1-yl) -N,N'-bis (phenyl)-benzidine, NPB), and the emitting and electron transport layer (EML/ETL) was (Tris(8-hydroxy-quinolinato) aluminum, Alq3). Finally, the substrates were then moved back to the metal evaporation chamber for the deposition of metal cathode LiF/Al/Ag. After the devices were completed, a heat dissipation UV glue, in cooperation with ITRI, was spin coated onto the surface of device and then curing by UV light for 5 seconds. The device light-emitting area was 36 mm^2. Finally, the optoelectronic properties of the devices were measured. Spectra Scan PR650 was employed to measure luminance and a light spectrum, and the power supply Keithley 2400 was employed to determine current-volt characteristics. An Infrared Thermo Tracer NEC TH-7716 was employed to measure heat dissipate from the backside of device.

3. Result and Discussion

Table I TEOLED devices parameters

Device		Passivation layer (NPB/ LiF)	Heat dissipation UV glue
A	OLED structure	No	No
B			Yes
C		Yes	No
D			Yes

Table I is the parameters list of the TEOLED devices. From the curves of current density against luminance in Figure 1, it can be realized that the spin coated heat dissipation UV glue onto the surface of device did not cause damage or affected the electric properties of the device. For the comparison of the luminance for the device, since the spin coated heat dissipation UV glue for Device B used mica nanoparticles doping within the UV glue, the surface if the spin coated device would be rougher. Therefore the luminance and efficiency of Device B would be lower than Device A, but the difference is insignificant. The maximum luminances for Device A and Device B were 9573 cd/m^2 (13V) and 9439 cd/m^2 (13V), respectively. In addition, the efficiencies of Device A and Device B were 5.7 cd/A (9V) and 5.4cd/A (9V), respectively.

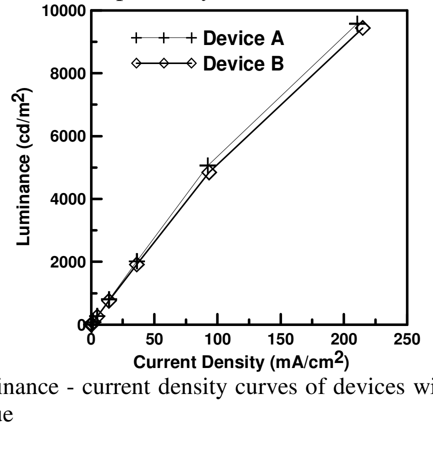
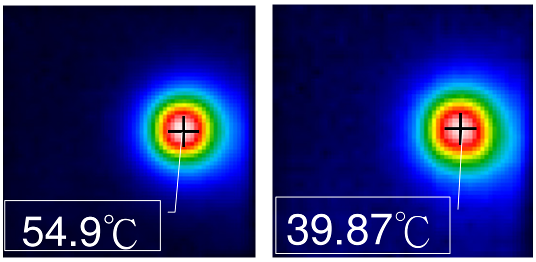


Fig. 1 Luminance - current density curves of devices with/ without spin UV glue

Table II comparison of the devices optoelectronic property with surface temperature.

Devices	Voltage (V)	Luminance (cd/m^2)	Current Density (mA/cm^2)	Yield (cd/A)	Surface Temperature (℃)
A	10	805.9	14.16	5.6	28.59
	11	2016	36.10	5.58	38.74
	12	5060	92.32	5.48	54.90
B	10	759.2	14.09	5.38	25.89
	11	1916	36.15	5.29	36.08
	12	4844	93.35	5.18	39.87

Table II is a comparison of the devices optoelectronic properties with surface temperature. Figure 2 (a) and (b) were the heat distribution images at 12V for the devices backside of Device A and Device B respectively measured with an infrared thermo tracer. When the devices were operated under a high voltage and high current density, an abundant amount of heat would accumulate at the emitting areas of devices. Therefore by spin coated heat dissipation UV glue on the surface of device, the maximum temperature had effectively reduced from 54.9℃ to 39.87℃.



(a) Device A (b) Device B

Fig. 2 Heat distribution images of the devices substrate (backside)

Figure 3 shows the corresponding EL intensity of devices at different view angles. Since the heat dissipation UV glue in the experiment contained mica nanoparticles, thus once the UV glue was spin coated onto the surface of device, the roughing of the device surface by the nanoparticles increased the EL intensity for each view angle.

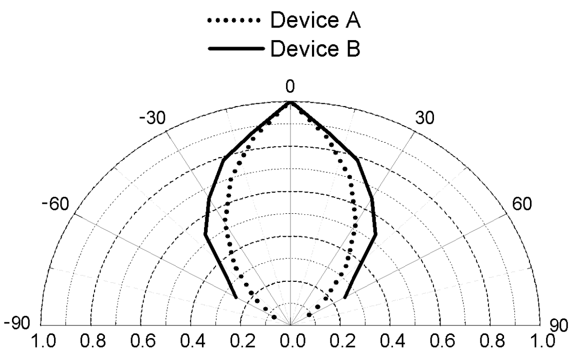


Fig. 3 Polar plots of measured EL intensities (normalized to the 0° intensity) for devices A and B

Finally the heat dissipation UV glue was applied to the capping glass for TEOLED encapsulation. When the device was completed, the encapsulation was finished by deposition the passivation layer of NPB/ LiF thin film on devices surface and using glass capping. From the lifetime curves of devices in Figure 4, it can be seen that the lifetime of device by deposition NPB (50nm)/ LiF (10nm) thin film with a glass capping (Device C) was 38 hours. If the thickness of the LiF was increased to 30nm and the heat dissipation UV glue was spin coated inside the capping glass (Device D), which uses the heat dissipation property to dissipate the created joule heat even more efficiently during device operation, the device lifetime was further enhance to 85 hours.

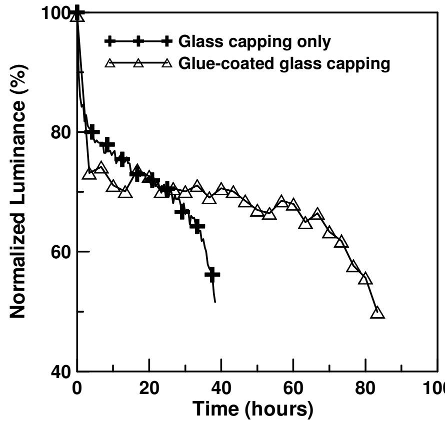


Fig. 4 Lifetime curves of devices with/ without UV-glue

4. Conclusions

In the experiment, the heat dissipate property of the spin coated heat dissipation UV glue was used, to improve the effect of the joule heat to the device when it was operated under a high current density. Although spin coating heat dissipation UV glue on the device would make the surface rougher due to the doping of mica nanoparticles within the glue, the optoelectronic properties of the device will not be influenced, which the maximum luminance and efficiency were 9439 cd/m^2 (13V) and 5.4 cd/A (9V) respectively. As for aspect of the device's surface temperature, the spin coated heat dissipation UV glue approximately reduced the temperature 15℃ (from 54.90℃ to 39.87℃) when compared with the uncoated device. In addition, since the heat dissipation UV glue was doped with mica nanoparticles, it achieved to enhance the luminance intensity of the device for each view angle. Also when the device was encapsulation by NPB/ LiF thin film with a glass cap, and the inner side of the cap was spin coated with the heat dissipation UV glue, the lifetime for the device greatly increased 2 times.

Acknowledgements

This project was supported by the National Science Council for the funding of this project No. NSC- 97-2221-E-150-007.

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