Development of Transparent Getter for Top Emitting OLEDs

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Abstract

We report the transparent getter performance of $POCl_3$ and amine based system by using the acid-base reaction in the fastest chemical reaction for top emitting OLEDs.

OLED device including synthesized getter component exhibited stable current-voltage curve after 500 hours under 60℃, 90% RH storage condition and showed stable surface performance until 520 hours.

1. Introduction

Organic light-emitting diodes(OLEDs) have been the subject of intensive investigation in the past few years because of their excellent characteristics such as high brightness, low power consumption, fast response time and wide viewing angle [1,2,3]. Especially, many attempts have been focused on Active Matrix(AM) OLED which consists of bottom emitting and top emitting type.

Top emission type has an advantage which has relatively wider emission area compared to bottom emission type, which plays an important role for getting high resolution in small size panel such as MP_3 and mobile phone (see figure 1.) [4,5]. For getting this advantage, top emission mode was required to get several technical issues such as transparent cathode, transparent getter and passivation layer, etc..

In getter study, there have been many reports in industry field [6,7,8]. And calcium oxide has been widely used in commercial product because it has showed good moisture absorption property[9]. In this paper, we firstly report the transparent getter performance of $POCl_3$ and amine based system by using the acid-base reaction in the fastest chemical reaction for top emitting OLEDs.

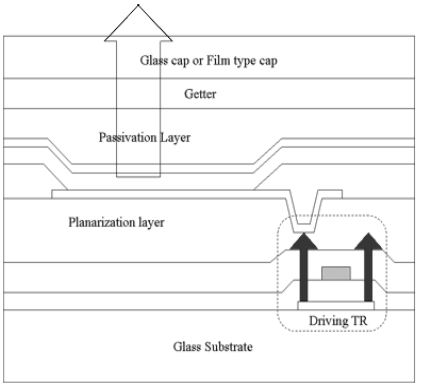


Figure 1. Top emitting type of OLED device.

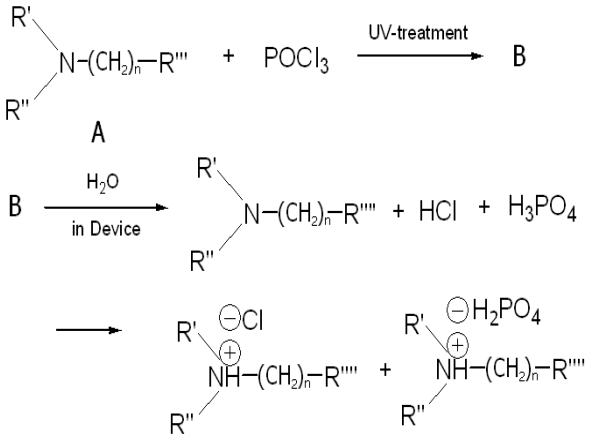
2. Experimental

2.1 Synthesis of binder, Compound A (see scheme Ⅰ.)

To a 50 ml round bottom flask containing ether (2 ml) was added acrylate derivative (3.52 ml). By using a dropping funnel, mixture of ether (9 ml) and amine derivative (1 ml) was slowly dropped into the flask and it was stirred for 2 hours. After ether evaporation, acryl binder(compound A) was obtained by vacuum drying.

2.2 Preparation of transparent getter, Compound B (see scheme Ⅰ.)

To vial bottle containing acryl binder (2 g) was slowly added $POCl_3$ (1.524 g) with stirring. Photo initiator of Hydroxybenzophenone (0.134 g) was also added and the mixed getter slurry is bar-coated on metal cap before UV light exposure. After UV light exposure, metal cap with getter layer is attached on top of OLED device (see figure 2.).



Scheme Ⅰ. Sample preparation of getter and operation mechanism in OLED device.

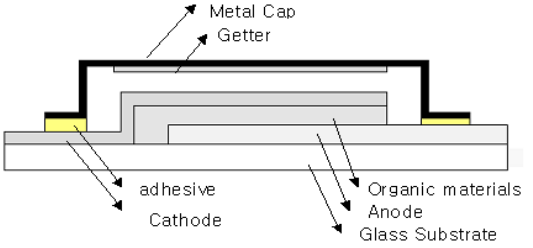


Figure 2. Schematic diagram of test OLED device with getter.

2.3 Characterization of transparent getter

In order to analyze moisture absorption ability, we attached metal cap including synthesized getter with OLED device. OLED device is fabricated with ITO/2-TNATA(60nm)/NPB(15nm)/Alq_3(70nm)/LiF (1nm)/Al(200nm) device, which is popular standard OLED configuration.

We evaluate the getter performance by using Current-Voltage (I-V) characteristics, surface change monitoring and transmittance ratio in visible light range.

3. Results

Tohoku Pioneer reported that device needs to show water -proofed performance after 500 hours at 60℃, 90% RH condition for commercial product [10]. Figure 3. showed I-V characteristics of ITO/2-TNATA/NPB/Alq_3 /LiF/Al device with synthesized getter component as device storage time.

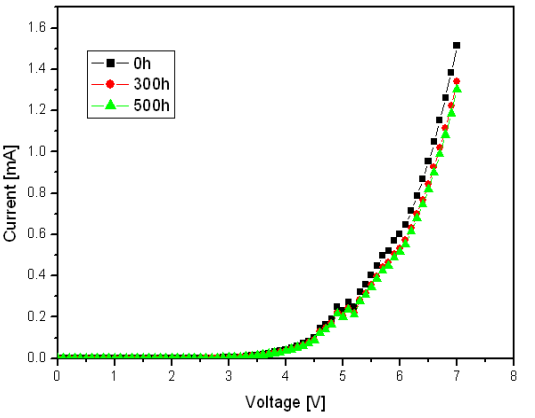


Figure 3. Current-voltage (I-V) characteristics of ITO/2-TNATA/NPB/Alq_3/LiF/Al device with synthesized getter component as device storage time. Storage condition : 60℃, 90% RH.

Standard OLED device with metal cap not including getter component showed collapsed I-V curve after 150 hours, but OLED device including synthesized getter component exhibited very stable I-V curve even after 500 hours under 60℃, 90% RH storage condition.

In case of OLED device without a metal cap or with a metal cap not including getter, active pixel is easily changed to damaged surface having the dark spots. Therefore we inserted synthesized getter component between metal cap and OLED active layer and stored it under 60℃, 90% RH condition.

In order to make the getter effect clear, we prepared two kinds of sample, which has a metal cap without synthesized getter (a) and with synthesized getter (b) as shown in Figure 4.

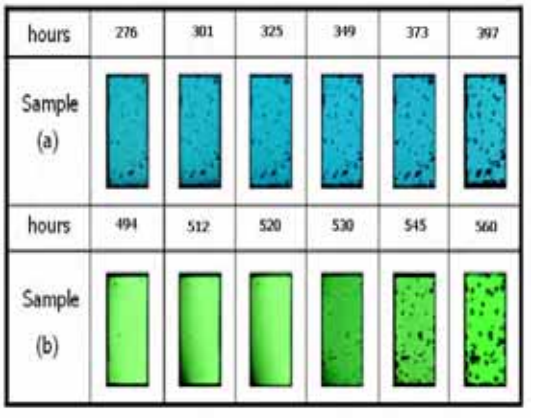


Figure 4. Surface photograph of standard OLED device having a metal cap without synthesized getter (a) and with synthesized getter (b) as the storage time under 60℃, 90% RH. The width and height of active cell is 2mm and 3mm.

It means that sample (a) in Figure 4. was made with only compound A and sample (b) in Figure 4. was composed with compound B having a compound A and $POCl_3$.

In sample (a) case, the device showed some water-proofed device performance until 200 hours, but surface showed many dark spots and edge growth effect and device efficiency was rapidly decreased after 270 hours.

On the contrary , sample (b) showed better stable surface performance until 520 hours compared to sample (a). It means that inner material, $POCl_3$ of getter components is active to fastly absorb the moisture which comes from outside and amine component is also active to fastly absorb the acid caused by $POCl_3$ and moisture.

As we mentioned the important factor of transparent getter in introduction part, transmittance is also required to realize the transparent getter. Figure 5. showed transmittance of getter as a function of visible light wavelength. As show in figure 5, binder exhibited very high transmittance of about 100% and synthesized getter showed 80% transmittance at above 600nm and 40% transmittance at below 600nm.

In order to increase transmittance at overall visible light range, we recently modified getter component kinds and ratios as shown in figure 5. Further studies and development are underway.

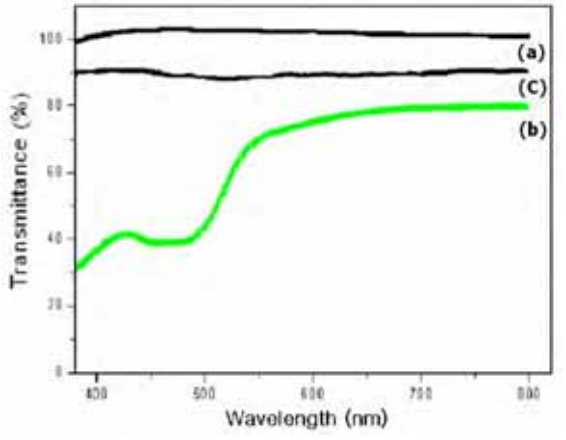


Figure 5. Transmittance of getter as visible light wavelength. (a) : amine derivative(compound A of scheme Ⅰ.), (b) : synthesized getter (compound B of scheme Ⅰ.), (c) : recently modified getter for high transmittance (not finished to characterize getter performance, yet).

We have also checked getter performance with calcium oxide(CaO) as an additive to synthesized getter component system. Although calcium oxide makes non-transparent property, it increased storage life time as shown in figure 6. When we optimized calcium oxide amount as an additive, $POCl_3$ 20wt percentage to amine binder and calcium oxide 40wt percentage to amine binder were maximized to realize longer storage life time of more than 750 hours.

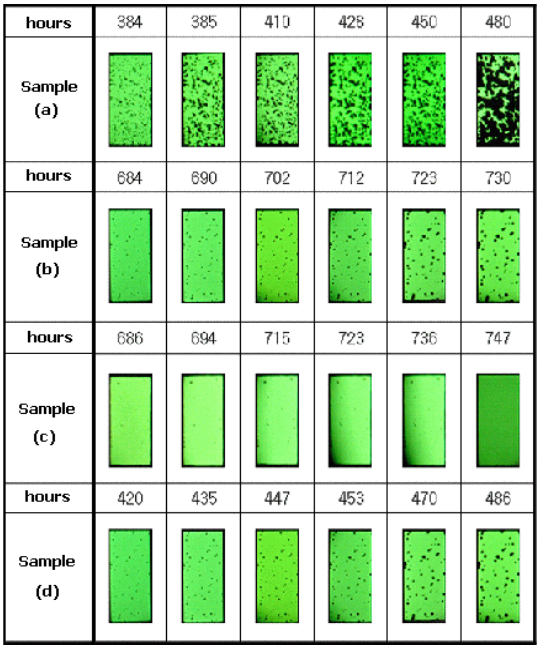


Figure 6. Surface photograph of standard OLED device having a metal cap with synthesized getter and CaO as the storage time under 60℃, 90% RH. (a) : $POCl_3$(10wt% to binder) + CaO(40wt% to binder), (b) : $POCl_3$(15wt% to binder) + CaO(40wt% to binder), (c) : $POCl_3$(20wt% to binder) + CaO(40wt% to binder), (d) : $POCl_3$(30wt% to binder) + CaO(40wt% to binder).

4. Conclusion

We firstly report the transparent getter performance of $POCl_3$ and amine based system for top emitting OLEDs. This getter system could be applied to commercial OLED product.

5. Acknowledgement

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6. References

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