Improvement of PMOLED life time using Mg-Zn-F thin film passivation

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Abstract

We manufactured a novel gas permeation thin film passivation by using inorganic Mg-Zn-F target which has better optical characteristics and high electronegativity. We fabricated targets in various composition ratio and formed about 200nm which is limited thickness of the flexible display. Applied to PLED device, the target which composed of MgF_2 and Zn at the ratio of 4:6, WVTR was reached the measurement limit of the equipment, $10^{-3}g/m^2 \cdot day$ and the life time was increased 25 times better than PLED device which is non-passivation.

1. Introduction

Recently, rapid technology development and wide range of spread of information technology caused increasing demand for handsets which have a small sized mobile display. This trend requires a lightweight, thin and low power consumption. Organic light emitting diodes (OLED) have come into the spotlight with the next generation display which acceptable those demands among the various kinds of displays.

OLED have many merits, such as high brightness, fast response characteristics, wide visible angles and simple manufacture process more than LCD and PDP. Significant benefit of OLED displays over traditional liquid crystal displays (LCD) is that OLED do not require a backlight to function. Because there is no need for a backlight, an OLED display can be much thinner than an LCD panel [1].

However, the biggest technical problem for OLED is the limited life time of the organic materials. Moisture and oxygen caused oxidation of the organic material that means the device should be protected from moisture and oxygen. Consequently, OLED is necessary to passivation which interrupts moisture and oxygen, and if exposed, black spots and LED shrinks, which will reduce the life time of the display devices [2-5].

In this study, we have manufactured Mg-Zn-F thin film using target mixed various ratio of MgF_2 to Zn for thin film encapsulation using radio frequency (RF) magnetron sputtering. Considering the gas permeation mechanism, the sputtering method that can deposit boundary parts between islands as lattice defect or nano defect was used to increase the packing density. Manufactured thin film passivation Water Vapor Transmission Rate (WVTR) was equal to or less than $10^{-3}g/m^2 \cdot day$. Thin film composition and gas permeation characteristics were evaluated, and the possibility as a new passivation technology was confirmed. Also it applied to polymer OLED device, improved life time.

2. Experimental

In this study, we fabricated targets for sputtering by mixing MgF_2 and Zn after heating each of them above the melting point, to create thin films where MgF_2 and Zn are physically mixed in an amorphous structure.

Targets were fabricated in various composition ratios by varying the mix ratio of MgF_2 and Zn to 3:7, 4:6 and 5:5 to observe the variation of the Zn ratio by the composition of ratio of MgF_2 and Zn. A thin film was deposited in the atmosphere of Ar

using an RF magnetron sputter. We have manufactured thin film which composed 4 layers on glass substrate in order to confirm properties of passivation.

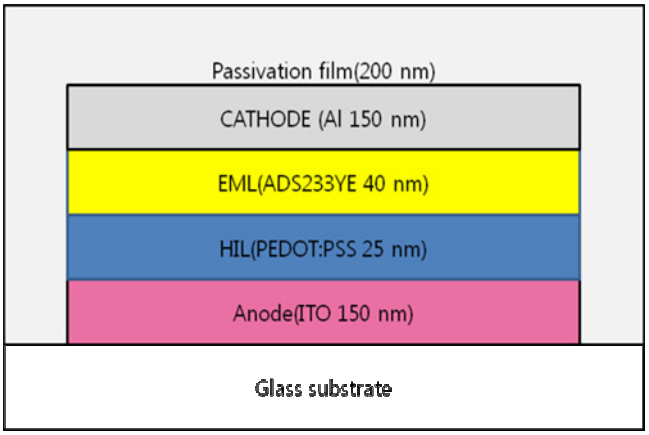

Fig. 1. Schematic diagram of PLED element deposited with passivation film.

In figure 1, the device manufactured 4 layers which consist of anode, hole injection layer (HIL), emission layer(EML) and cathode to evaluate LED device. Indium tin oxide (ITO) was used for anode patterned by photolithography process and deposited on glass to a thickness of 1,500 Å. Then, we formed a HIL about 25 nm thickness using PEDOT:PSS (poly(ethylenedioxythiophene): polystyrene sulphonate, Baytron P AI 4083, H. C. Starck) on ITO. It was used as the buffer layer on the anode mainly to increase the anode work function from 4.7 eV to 5.0 eV and to reduce the surface roughness of the anode to obtain stable and pin-hole-free electrical conduction across the device. Emission layer (poly[9,9-dioctylfluorenyl-2,7-diyl)-co-1,4-benzo-{2,1'-3}-thiadiazole)], ADS 233YE) dissolved in the toluene and formed EML on HIL by spin coating. The Al metal layer for cathode which intersected with anode by thermal evaporation with shadow mask was deposited on EML

The energy levels of the materials involved in the PLED are shown in Figure 2.

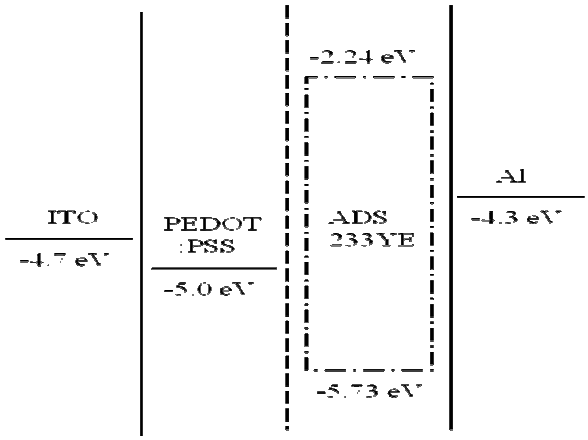

Fig. 2. HOMO and LUMO energy levels of the materials involved in the PLED.

We manufactured the targets which were made of MgF_2 and Zn in order to evaluate the gas permeation status of an OLED glass substrate which has better optical characteristics and high electronegativity with various ratios. Zn atoms were deposited with MgF_2, they are inserted into the molecular lattice and fixed at neutral points. This will increase the packing density and electronegativity of the molecule and prevent the permeation of moisture and oxygen, effectively [6,7]. We produced targets with various ratio of MgF_2 to Zn (5 : 5, 4 : 6 and 3 : 7) to control the amount of Zn in the passivation film,. Mg-Zn-F films were deposited on glass substrate using RF magnetron sputter by the conditions in table 1.

Table 1. Sputtering conditions used to fabricate Mg-Zn-F passivation film.

Parameter	Condition
Target - substrate distance	11 cm
Sputtering pressure	4.7×10^{-5} Torr
Gas flow rate	50 sccm
RF power	100 W
Deposition rate	0.1 nm / min

We confirmed eligible to use passivation film through surface morphology and thickness of the thin film was measured by SEM and AFM. Figure 3,4 shows an SEM and AFM image of Mg-Zn-F single thin film, respectively.

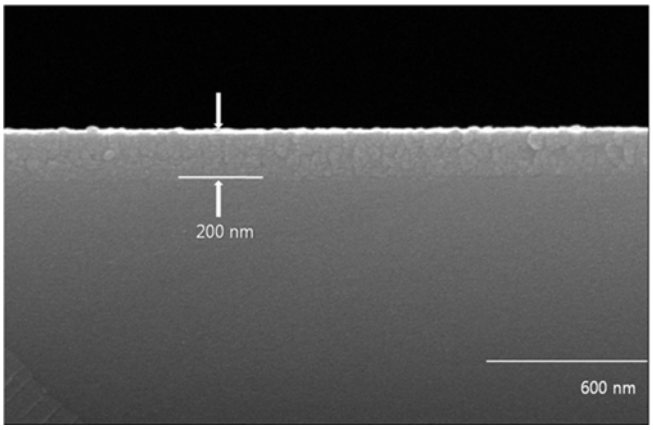

Fig. 3. SEM image of Mg-Zn-F passivation film.

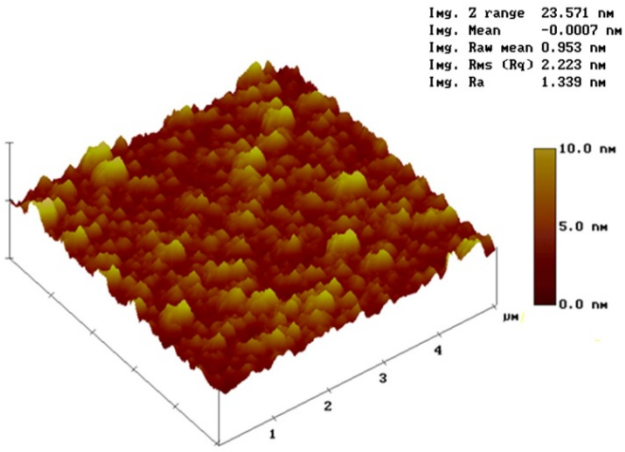

Fig. 4. AFM image of Mg-Zn-F passivation film.

3. Results & Discussion

Target which composed of MgF_2 and Zn at the ratio of 4:6 reached the WVTR measurement limit of the equipment, $10^{-3}g/m^2 \cdot day$ when increase of the Zn portion in thin film in figure 5.

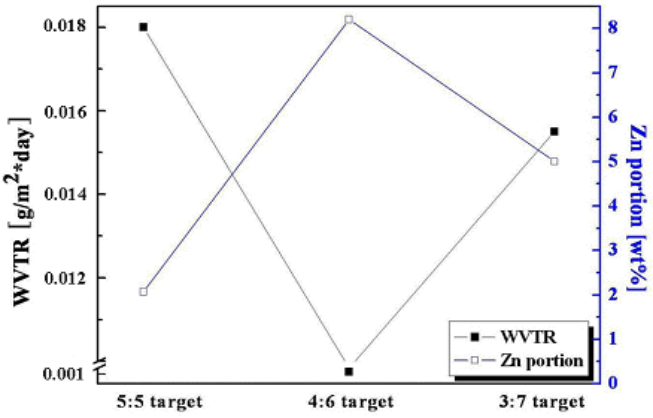

Fig. 5. WVTR and Zn portion data of Mg-Zn-F thin film passivation deposited at 200 ㎚ thickness.

In order to confirm the passivation films, we made PLED device. Turn-on voltage of the device was 5.5 V, maximum luminance was about 8,200 cd/m^2 and efficiency was 1.2 cd/A. As a result in figure 5, we made a device with passivation film which has 4:6 target according to lowest WVTR. We confirmed life time of non-passivation film device was 800 sec at the half of the max luminance but the passivation film device was 20,000 sec at the same condition. Therefore passivation film which has lowest WVTR device can be prevented moisture and oxygen more effectively and improved life time 25 times better than non-passivation device.

4. Summary

We manufactured a novel gas permeation thin film passivation by using inorganic Mg-Zn-F. Passivation film was formed about 200 nm that is limited thickness of the flexible display. Applied to PLED device, life time was increased 25 times better than PLED device which is non-passivation.

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5. References

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