Thin composite film passivation through RF sputtering method For Large-sized Organic Display Devices

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Abstract

Transparent thin composite films (TCFs) were deposited on OLED devices by means of RF sputtering method and their passivation-properties were evaluated by comparing to the e-beam evaporating method. This composite film formed by mixed ratio of MgO (3wt %): SiO_2 (1wt %) was developed from pallet as a source of e-beam evaporator to 6-inch size target for sputtering in order to apply for large-sized organic display devices. Water Vapor Transmission Rates (WVTR) of the deposited films were measured as a function of thickness to assess the effectiveness of this film as a passivation layer and it applied to real devices. From this study, we can confirm that the passivation layer formed by TCFs using RF sputtering method sufficiently shows the potentiality of application to passivation layer for organic display devices.

1. Introduction

Organic Light Emitting Diodes (OLEDs) have attracted wide attention due to their excellent device properties such as low driving voltage, high brightness, and wide viewing angle [1]. However, organic materials used to form the light-emitting layer of OLEDs are susceptible to moisture and oxygen [2-4]. It is well known that OLEDs have limited lifetime because of decrease in EL efficiency under atmosphere condition. Therefore the passivation of an OLEDs is very important in commercial application. One of the most popular techniques used for forming passivation layer is e-beam evaporating method by the inorganic composite materials [5]. In case, TCFs was worked as a good barrier against moisture and oxygen in order to avert the diffusion process, and was thoroughly covered with the organic layer and the cathode. But, these factors should be more stringent in the case of commercial display unit, which have huge applicability in consumer electronics. In addition, in case of e-beam process, it is difficult to apply for large-sized display devices. Thus, it is necessary to develop a thinner and low-cost passivation technique for OLEDs.

In generally, sputtering is the primary alternative to evaporation for metal film deposition in semiconductor fabrication. First discovered in 1852 [6], sputtering was developed as a thin film deposition technique by Langmuir in the 1920s [7]. It is better than step coverage the evaporation, includes far less radiation damage the e-beam evaporation, and is much better at producing layer of compound materials and alloy. These advantages have made sputtering TCFs deposition technique in choice

Table 1. The process condition of sputtering method and the value of WVTRs

RF power	Ar rate (sccm)	Deposition time (min)	Thickness (nm)	Deposition rate (Å/sec)	Permeation (g/m2-day)
150W	30	60min	~50nm	0.2	30.14
200W	30	60min	~65nm	0.27	30.9
250W	30	60min	~100nm	0.41	28.74
300W	30	60min	~266nm	0.73	6
400W	30	60min	~312nm	0.9	0.8

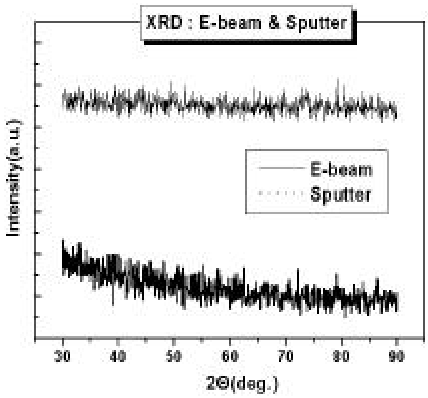

Figure 1. Analysis on XRD graph of two type's method

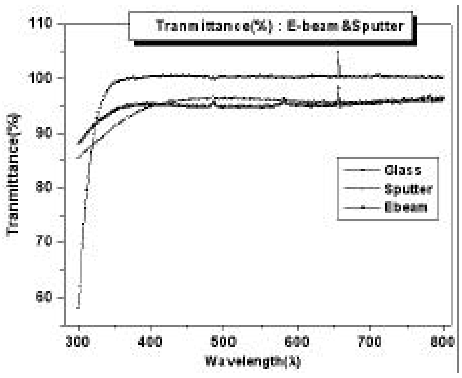

Figure 2. Analysis on optical transmittance graph of two type's method

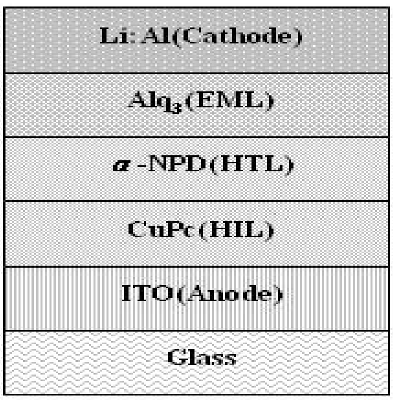

Figure 3. The structure of the OLEDs

for our Organic-based process. In addition, MgO-based inorganic composite films proposed by K.H.Kim et al [8] showed the lowest value of WVTR compare to other inorganic materials.

In this study, the applicability of TCFs as passivation layer to enhance the lifetime of OLEDs in the atmosphere was investigated. We fabricated composite materials as the shape of 6-inch target mixed with MgO as base materials and SiO_2 as cooperated material. And then, the composite materials were deposited onto the plastic film by RF sputtering method and water vapor transmission rates (WVTRs) were measured by the MOCON facility. The WVTRs as functions of thickness of TCFs, analysis of TCFs materials and passivation properties of OLED were investigated.

2. Results

These inorganic composite materials are deposited into 500㎛ thick- PES (polyethersulfone) film and OLED devices using RF sputtering method in vacuum chamber with base pressure of < 10^{-5} torr. In order to reduce the damage for organic layer, we preserve the deposition temperature less than 100°C and the distance between target and substrate is about 8cm.

The process condition of sputtering method and the value of WVTRs as a function of thickness are listed in Table 1. The sputtering yield is defined as the number of atoms ejected from a target surface per incident ion. It is most fundamental parameter of sputtering process. Yet, all of the surface interaction phenomena involved that contribute to yield of a given surface are not completely understood. Moreover, in case of MgO-based TCF using RF-sputtering method, it was firstly proposed and applied to OLED devices in this study. However, we can control the deposition rate as a function of RF-power. As comparing to process of metal deposition in the same condition, the value of deposition rate is low and as increasing the thickness of TCFs, the value of WVTRs is decrease. From this result, we can understand that the optimum thickness for passivation layer is over 300nm.

As we previously mentioned about properties of MgO-based TCF, we compare to the basically properties both of two type. Figure 1 and Figure 2

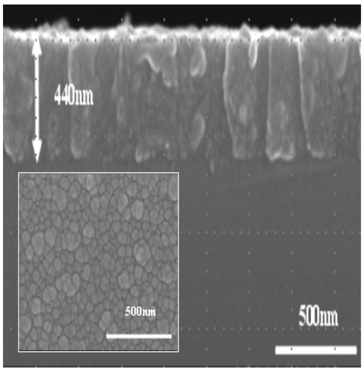

Figure 4. SEM image of MgO-based TCFs

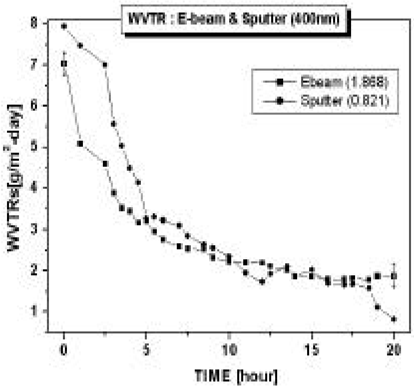

Figure 5. The value of WVTRs of both type's method at the same thickness

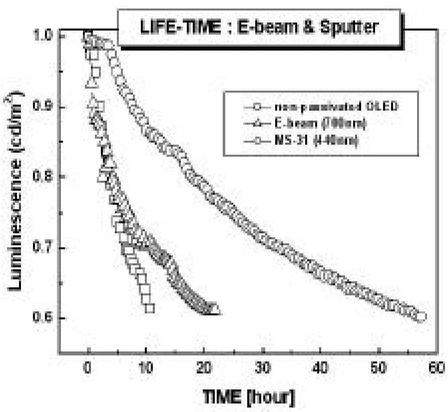

Figure 6. Analysis on lifetime-graph of OLED devices applied to MgO-based TCFs as a passivation layer.

shows the XRD and Transmittance properties in two cases. It is well known that the quality of thin film affects the crystallinity and material properties of the grown film. Surface of thin film plays an important role as functions of the high density and low density. Both of them exhibited amorphous peak such as a glass. Originally, structure of glass had a high density. But, inorganic thin film can show crystal peak with a relatively low density. Therefore, TCFs were reduced by attack of water vapor permeation. Also, transmittance properties of both layer is over 90% and it will be apply to flexible display devices. From previous result, we deposit the TCFs as a passivation layer on the OLED devices. Figure 3 shows the structure of the OLEDs. For the anode, we use indium-tin-oxide (ITO) on a glass substrate (from Samsung corning Corp., 20 ? /?). These substrates are cleaned in ultrasonic baths of ethanol, acetone, and DI water. We use CuPc(Copper Phthalocyanine) as the HIL(Hole Injection Layer), a-NPD([N, N`-di(naphthalene-1-yl)-N,N`-diphenyl-benzidine]) as the HTL(Hole Transport Layer), Alq_3([tris(8-hydroxyquinolinato)aluminum]) as the EML(Emitting Layer) or ETL(Electron Transport Layer), and Li:Al as the cathode. All layers are deposited on the substrates by thermal evaporator in vacuum chamber with base pressure of < 10-6 torr. The deposition rates of the organic and metallic layers are approximately 0.2-0.4Å/sec and 1.5-2.0Å/sec, respectively.

To reduce the value of WVTRs, we modify the Ar follow rate at 60sccm. SEM image of MgO-based TCFs was show in figure 4 and it's the value of WVTRs shows in figure 5 comparing to e-beam method at the same thickness. In figure WVTRs, we can understand that the density of TCFs formed by RF-sputtering is higher than that formed by E-beam evaporating method.

Figure 6 shows the results of measuring the lifetime of OLED after applying TCFs based on MgO. The lifetime of OLED paaivated with RF sputtering method is measured using Keithley 237 and Minolta luminance meter LS-110. The emission area of OLED was a 0.5mm×1.5mm and operating current is 4mA in air ambient. The value of WVTR formed by RF sputtering method is better than those of e-beam evaporated films as a passivation layer of OLED. As previous result, OLED device passivated with RF-sputtering method is longer than those of others. Thus, we can expect that MgO-baesd TCF can be applied to passivation layer as a effectively excludes reaction with moisture and oxygen in air.

3. Conclusion

In this study, the TCF formed by RF-sputtering method as a passivation layer was newly adopted to protect the organic light emitting device (OLED) from atmospheric moisture and oxygen. As a result, the lifetime of passivated OLEDs is enhanced than that of non-passivated OLEDs. Thus, we can confirm that the MgO-based TCF was the more suitable material as a passivation layer to protect the OLED. Therefore, TCF passivation layer can be applied to large-sized organic display devices and flexible display in the future

4 References

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