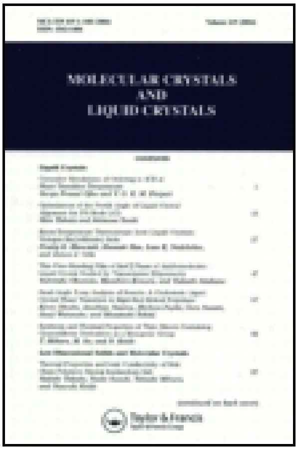

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Application of Zinc Oxide-Silver Electrode for Bottom Emission Organic Light Emitting Diode

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The process for depositing indume-tin oxide (ITO) electrode on polymer substrate is not readily applicable at high temperature and shows poor electrical properties than the conventional ITO deposition process on glass substrate. Especially, the deformation of polymer substrate and residual stress yield the crack which degrade the performance of organic light emitting diode (OLED) unit. In this study, we developed low resistance ITO electrode, AZO(ITO-ZnO-Ag-ZnO-ITO) to apply to the fabrication of the bottom emission OLED unit. The performance of the AZO exhibited low surface resistance as 8 ohm and the ITO electrodes were additionally deposited to guarantee the same work function as conventional ITO. The emissive efficiency was 92% at 550 nm which almost corresponds to that of the conventional ITO.

Keywords: Ag; indume-tin oxide; OLED; zinc oxide

INTRODUCTION

Organic light emitting diode (OLED) has many advantages of low voltage operation, self-radiation, light weight, thin thickness, wide view angle and fast response time to overcome the weaknesses of existing liquid crystal display (LCD). Therefore, It has drawn lots of attention as a promising display device and has already developed for manufactured goods [1–4]. Also, the OLED is regarded as the most feasible candidate for flexible display.

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Indium-tin oxide (ITO) thin films show a low electrical resistance and high transmittance in the visible range of the spectrum, but its resistivity is rather high to be adapted as a transparent electrode in case of the advanced flexible OLED. One of the ways to realize an improved flexible OLED is to use multi-layer electrodes which have lower sheet resistance than single layer of ITO films of the same thickness as a pixel electrode. The multi-layer structure having Ag metal layer was initially investigated for application to low resistivity coating. In this study, the multi-layer film was developed with structure of ITO/ZnO/Ag/ZnO/ITO to solve the durability of Ag. The electrical and optical characteristics of ITO/ZnO/Ag/ZnO/ITO demonstrated the same performance as ITO/Ag/ITO. It was also found that the ITO/ZnO/Ag/ZnO/ITO exhibited enhanced durability.

EXPERIMENTAL

In this research, ITO, ZnO and Ag thin films were deposited to fabricate the bottom emission OLED by a magnetron sputtering system which equips three cathodes. RF(13.56 MHz) and DC powers were supplied through two cathodes [5]. The ITO/ZnO/Ag/ZnO/ITO multi-layer films were successively deposited on the polyethylene terephthalate (PET) substrate without vacuum break. The deposited electrodes were patterned by photolithography. O2 plasma was treated for 3 min to improve the surface roughness of the AZO and emissive efficiency.

The structure of organic layers was composed with 15 nm thick 4,4′,4″-tris[N-(1-naphthyl)-N-phenylamino]-triphenylamine) (2-TNATA) as a hole injection layer, 30 nm thick N,N′-diphynyl-4N,N′-bis(1-naphthalyl),benzidine(-NPD) as a hole transfer layer, 40 nm thick tris(8-hydroxyquinoline)aluminum (Alq3) with 1% coumarine 6 (C6) doped as a emissive layer and 5 nm thick BCP as a hole blocking layer. The cathode was 10 nm Al [6–9]. The organic thin films were deposited at the rate of 0.5 Å/sec and the cathode was 2–3 Å/sec [10–12]. Moreover, the thickness of the films were measured by the stylus method using the Alphastep 200. The film resistivity was measured using the 4-point probe. The optical properties of the films were also measured by the UV/Vispectrophotometer (spectra).

In case of the OLED, not only the resistance of electrode but also surface work function and flatness need to be considered for improving emissive efficiency. Therefore. the additional ITO electrodes were deposited on both side of ZnO/Ag/ZnO meter (Minolta LS-100).

RESULTS AND DISCUSSION

The emissive efficiency was almost equivalent to the conventional ITO electrode as can be seen in Figures 1 and 2. The current density was lower than the conventional ITO because the sonication process was omitted as shown in Figure 2. It can be assumed as a result from the contaminations remaining on the electrode surface.

In addition to electrical property, the transparency and reflectance of the AZO demonstrated 80% performance as compared to those of the conventional ITO electrode as shown in Figures 3 and 4. However, it was found that the emissive efficiency at 550 nm was 92% which almost corresponds to that of the conventional ITO. Furthermore, it was observed that the resistance was a half in comparison with the conventional ITO electrode.

The passive type of the OLED units employing the AZO and the conventional ITO electrodes were fabricated and the experiments under same electrical conditions were conducted on both respectively to compare each performance of them.

The passive type is more appropriate than the active type to measure electro-optical characteristics accurately since the gate line and data line of the passive type adopts the same materials as a pixel electrode while the active type has independent pixel electrodes.

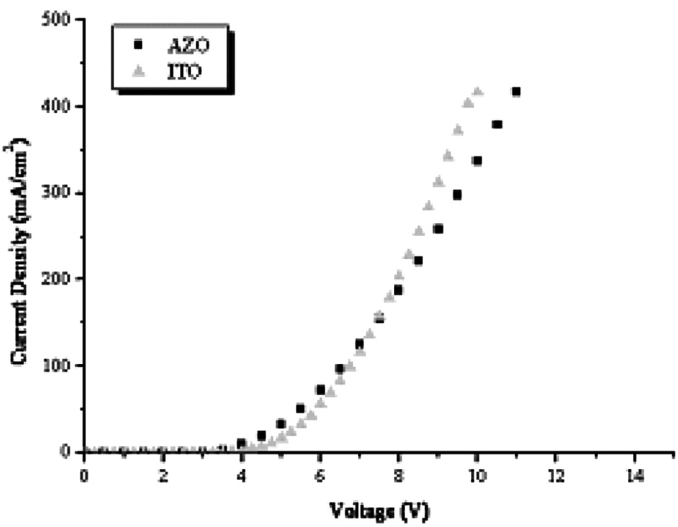


FIGURE 1 *I-V* characteristics of AZO bottom emission oled.

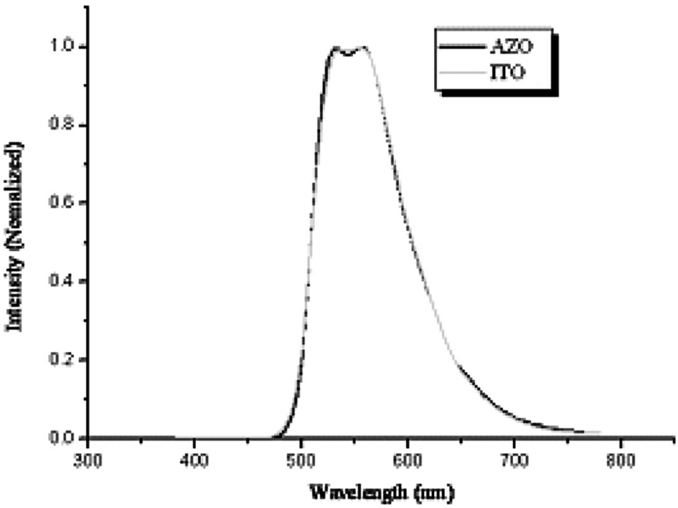


FIGURE 2 Luminance intensity from the AZO bottom emission oled.

The Figure 5 shows the image of operated OLED with AZO electrode. It was obviously observed that the emission efficiency of the AZO is compatible with the conventional ITO electrodes. It was

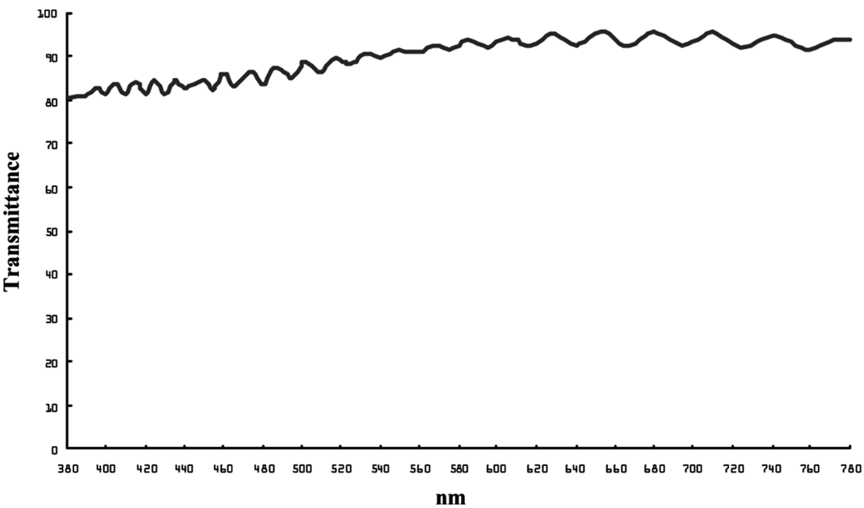


FIGURE 3 Transmittance of AZO film.

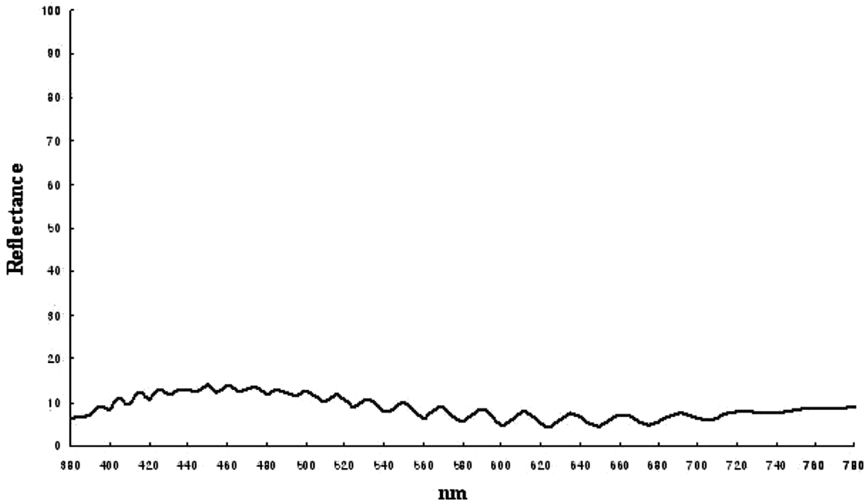
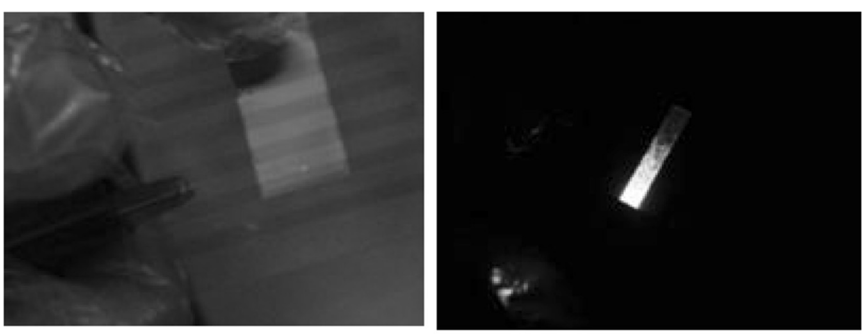


FIGURE 4 Reflectance of AZO film.

revealed that the electro-optical characteristic of ITO/ZnO/Ag/ZnO/ITO was as considerable as it can substitute the ITO/Ag/ITO, and besides ITO/ZnO/Ag/ZnO/ITO had enhanced durability. In this parper, the AZO(ITO-ZnO-Ag-ZnO-ITO) for I flexible OLED application was fabricated to improve poor electro-optical characteristics on the polymer substrate which has been pointed out as a limitation of the ITO electrodes.

The multi-layer film of ITO/ZnO/Ag/ZnO/ITO structure exhibited high optical transmittance in the visible range and low sheet resistance



(a) (b)

FIGURE 5 Driving configuration of AZO bottom emission OLED.

and subsequently fabricated bottom emission OLED with the AZO electrodes also demonstrated competitive features as compared to the conventional ITO electrode.

CONCLUSIONS

As a result, it was found that high performance device, which have equivalent emissive efficiency and better electro-optical characteristics in comparison with the conventional ITO electrodes, was fabricated employing AZO(ITO-ZnO-Ag-ZnO-ITO) through this experiment.

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