Top Emitting Organic Light Emitting Diode with a Cr Anode on Flexible Substrate

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Abstract

Top-emitting organic light-emitting diode (TEOLED) was fabricated on flexible substrate of PES film. Aluminum and Chromium multilayer was used as an anode of TEOLED and the TEOLEDs of Cr(20nm)/Al(100nm)/Cr(20nm)/NPB(60nm)/Alq(60nm)/LiF(1nm)/Al(2nm)/Ag(20nm)/NPB(200nm) has been fabricated on PES film and Si wafer for control device. The TEOLED on PES film which had good anode surface morphology, showed very similar device characteristics to that on Si wafer.

1. Introduction

Organic light-emitting diodes (OLEDs) have been attracting a great deal of attention for potential use as full-color flat panel display in the next generation.[1,2] To achieve high aperture ratio in active matrix OLED (AMOLED), top emitting organic light emitting diode (TEOLED) has been investigated.

The anode of TEOLED is of great importance to obtain an efficient OLED. The anode of TEOLED has to be reflective and exhibit low injection barrier with a hole injection layer of OLED.[3] Previously, Representative results were reported by G. G. Qin et al, in which TEOLED anodes with *p*-silcon anodes have been used, however, the current efficiencies are about or even less than 0.06cd/A.[4]

Flexible displays offer many potential benefits over other display technologies, including reductions in weight and thickness, improved ruggedness, and nonlinear form factors. However, the electrical characteristic of switching device on flexible substrate is inferior to that on rigid substrate.[5] Therefore, TEOLED is more important to obtain high aperture ratio in flexible AMOLED.

In this presentation, we report on TEOLED based on Chromium anode on flexible substrate. Especially, the fabrication of Chromium anode on flexible substrate and the device characteristics has been investigated.

2. Experimental

The substrate of flexible OLED was PES film which was purchased from Sumitomo Bakelite. Si wafer with silicon oxide surface was also used as a substrate for control experimental. Chromium layer has been deposited by conventional sputtering method and patterned by photolithography. Surface morphology was examined by scanning electron microscope (SEM). The device structure of OLED grown by vacuum thermal deposition was Cr(20nm)/Al(100nm)/Cr(20nm)/NPB(60nm)/Alq(60nm)/LiF(1nm)/Al(2nm)/Ag(20nm)/NPB(200nm

). Finally, NPB was deposited as a passivation layer. Electroluminescence spectra were obtained with a Minolta CS-1000. The current/voltage and luminescence/voltage characteristics were taken with a current/voltage source/measure unit (Keithley 238) and a Minolta LS-100.

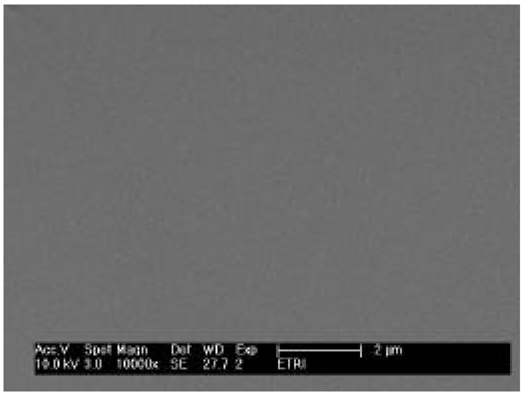
3. Results and Discussion

PES substrate having appropriate under-coating layer was prepared. With the under-coating layer, the out-gassing from the film is also increased. 20nm Cr layer, 100nm Al layer and 20nm Cr layer were used as an anode electrode.

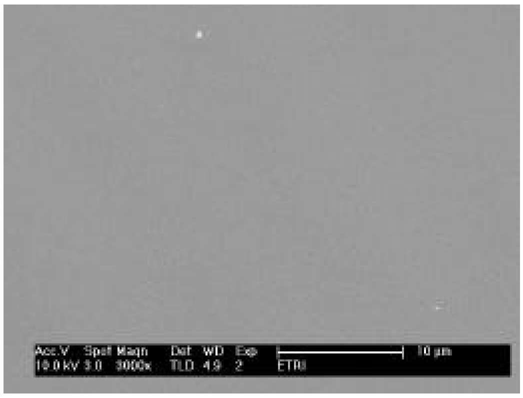
The plasma treated Cr layer is appropriate for anode electrode. But the high residual stress and stiffness of the Cr layer make it difficult to use as an electrode on flexible substrate.

The thickness of the Cr layer was decreased to prevent possible crack of the metal film after bending of the substrate. Al layer was used to buffer the Cr layer and increase the conductivity and reflectivity of the anode layer. Thus, the adhesion strength and the contact electric properties between Al thin film and Cr deposited PES film have become the main concern in achieving high package reliability.

Figure 1 shows the SEM image of Chromium anode on PES film and Si wafer. Our optimum low temperature deposition condition of Cr and Al sputtering resulted in high quality Cr surface in both cases. The detailed surface characteristics are under investigation and will be revealed in the presentation.



(a)



(b)

Fig. 1. The SEM images of Chromium anode. PES film and (b) Si wafer

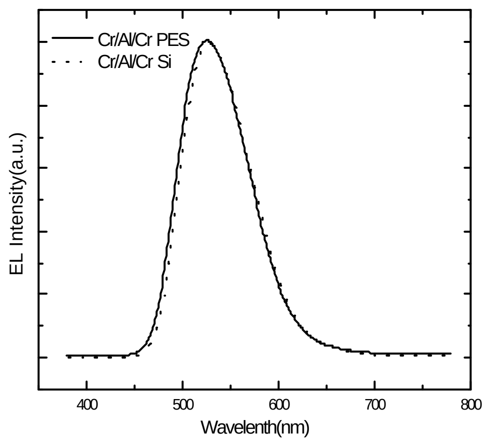


Fig.2. Electroluminescence spectra of TEOLEDs on Si wafer and PES film.

Figure 2 shows Electroluminescence (EL) spectra of TEOLEDs on Si wafer and PES film (at 20mA/cm^2). The EL spectra were very similar to each other and the EL maxima of the TEOLEDs on Si wafer and PES film were about 526 nm. The substrate effects on the EL spectrum could be avoided due to the top emission structure.

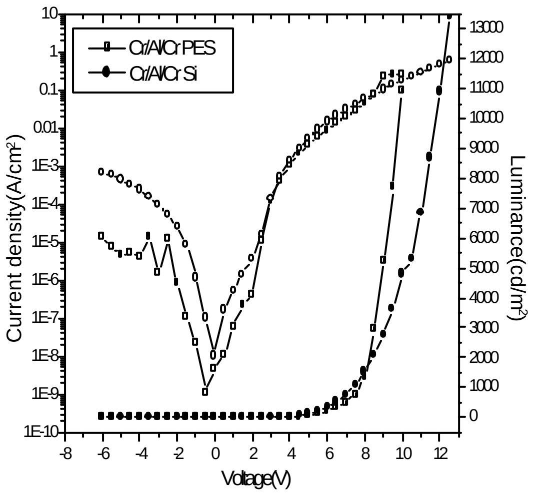


Fig. 3 *I-V-L* characteristics of TEOLEDs on Si wafer (circle) and PES film (rectangular).

Figure 3 shows the current density (*J*)- voltage (*V*)- luminance(*L*) characteristics of the TEOLED devices on the Si wafer and the PES film. The leakage current of the devices were somewhat higher than conventional devices with ITO anode, which showed the leakage current of below 10^{-7} A/cm^2 (not shown here). We believe that the high leakage current might be related to the surface characteristics of the Cr/Al/Cr anode and fabrication optimization is under investigation to reduce leakage current. The turn-on voltage of the device on PES was about < 4 V, which was almost same to the device on Si wafer. The J-V-L characteristics after turn on of the TEOLED on PES film was also very similar to that on Si wafer. However, the luminance maximum of the TEOLED on PES film was much lower than that on Si wafer. The maximum luminances of Si and PES devices were 70,000 and 10,000 cd/m^2, respectively. The low luminance of the TEOLED on PES film might be explained by substrate damage due to joule heat during the device operation in high current density region.

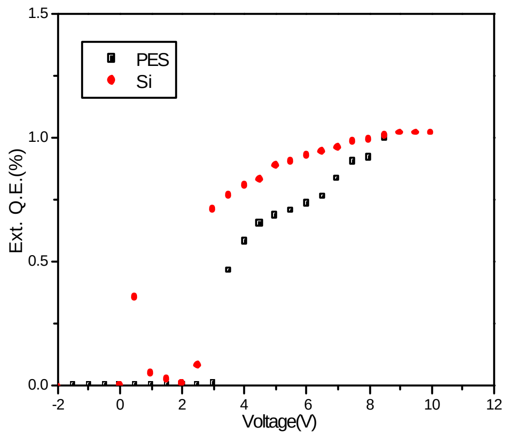


Fig.4. External electroluminescence quantum efficiency *vs*. voltage for the TEOLEDs on Si wafer and PES film.

Figure 4 shows external quantum efficiency *vs.* voltage for the TEOLEDs on Si wafer and PES film. The external quantum efficiencies of TEOLEDs with the Cr/Al/Cr anode were lower than the conventional ITO anode device. We believe that the optimized device structure of Cr/Al/Cr anode device might be different from that of ITO anode device and further device optimization will give better results. As for the external quantum efficiency of the TEOLED on

PES film, it was not much lower than that on Si wafer and therefore, we expect the efficiency which is close to that of the device on Si wafer through device optimization.

4. Summary

Chromium anode has been successfully fabricated on flexible substrate of PES film. The TEOLED on PES film showed very similar device characteristics to that on Si wafer with the proper fabrication condition of anode. Further device optimization and improvement through surface modification are under investigation.

5. Acknowledgement

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6. References

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