Extended Abstracts of the 2009 International Conference on Solid State Devices and Materials, Sendai, 2009, pp633-634

Front-Light Source using Inverted Organic Light-Emitting Diodes with Micro Cathode Arrays

Kohei Urata, Shigeki Naka and Hiroyuki Okada

Graduate School of Science & Engineering, University of Toyama
3190, Gofuku, Toyama 930-8555, Japan
Phone: +81-76-445-6731 E-mail: nak@eng.u-toyama.ac.jp

1. Introduction

Organic light-emitting diodes (OLEDs) have excellent properties of a low driving voltage and bright emission. In a dark ambient condition, front-light system is necessary for non-emission type displays, such as, reflective liquid crystal displays and electrophoretic displays. For this front light system, following requirements have to be satisfied: (1) light is only emitted to the display (bottom) side and was not emitted to the user (top) side. Light emission to the user side become worse the contrast ratios defined as a ratio of light emission of top side to bottom side. (2) Viewing angle dependence and non-uniformity have to be reduced wihch were problems in the present front-light with guide plate.

To overcome these issues, OLED front-light source can be arranged a shade to the user side. In addition, OLED front-light source have excellent properties of uniformity, wide view angle, and no light leakage at any viewing angle [1]. However, the device needs the fine patterning of the cathode after deposition of organic layers. In this study, we examined inverted OLED front-light source having the micro shading cathode array patterned before deposition of organic layers.

2. Experimental

Figure 1 shows the device concept of the OLED front-light source under study. Device was formed with a blinding array cathode on a transparent support electrode.

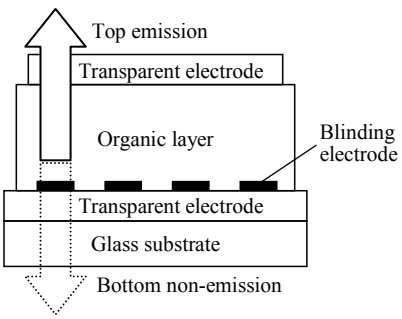

Fig. 1 Device concept

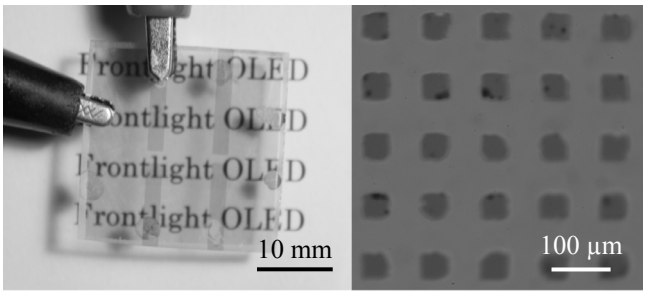

Fig.2 Photograph of flont-light OLED

In this structure, light was shielded to bottom side (the observer side) and was emitted only top side (a cover irradiatied display).

We fabricated the OLED front-light using ITO as a support electrode, Al as a blinding cathode, LiF as an electron injection layer, Alq_3 as an emission layer, α-NPD as a hole transport layer, MoO_3 as a hole injection layer, and Au as an anode. The Al cathode was deposited through a screen mesh mask (‘‘alpha mesh screen’’ from Hitachi Maxell, Ltd). The size of the screen mesh mask was 250 meshes per inch and aperture ratio of 37% [2]. Also, semi-transparent Au electrode was used for ultra thin anode. The MoO_3 was effective for a buffer layer in order to reduce penetration of Au atom during Au anode deposition [3,4]. Device structure was glass substrate/ ITO (200 nm)/ Al (30 nm)/ LiF (1 nm)/ Alq_3 (50 nm)/ α-NPD (70nm)/ MoO_3 (50nm)/ Au (10nm). The device area is 2×2 mm^2.

For improving device characteristics, we inserted the vapor-deposited MoO_3 (x nm) between ITO and Al. The thickness (x) of MoO_3 varied among 10, 30, and 50 nm.

Top evaluate a transmittance, a wavelength of 555 nm was used. Device characteristics were measured using semiconductor parameter analyzer (HP4155B) and emission intensity was measured using a luminance meter (Topcon BM-3).

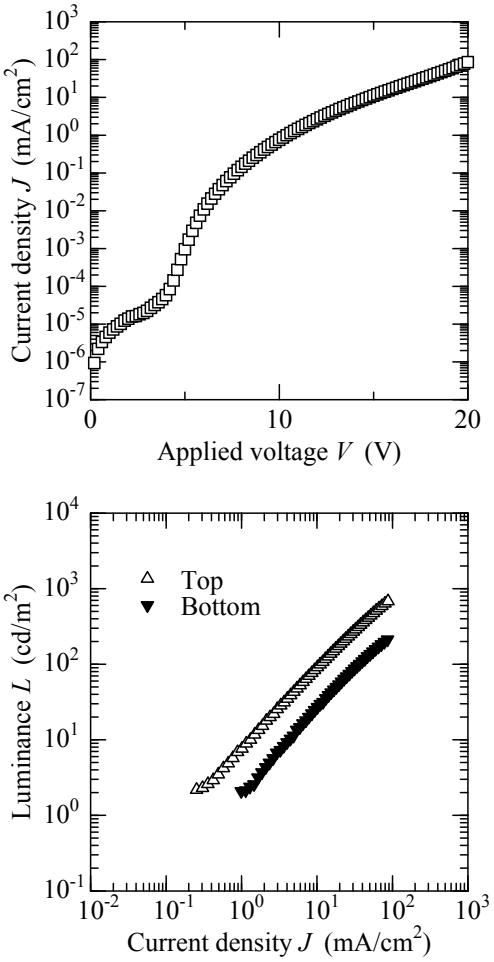

Fig. 3 Device characteristics without MoO_3 on bottom ITO.
(open: Top side, filled: Bottom side)

3. Results and discussion

Figure 2 shows an appearance of front-light OLED and a microscopic observation of emission pattern. Figure 3 shows current density vs applied voltage and luminance vs current density characteristics. Maximum luminance of bottom and top sides were 211 and 682 cd/m^2, respectively. In addition, a contrast ratio of top side to bottom side was 3:1, and transmittance was 40%. The contrast ratio was not sufficient because of the increase of the bottom side emission with the electron injection from bottom ITO support electrode [5].

To improve the contrast ratio, we have examined stack of MoO_3 on bottom ITO support electrode. Figure 4 shows characteristics of these devices. In the device with 10 nm MoO_3, maximum luminance of bottom and top side

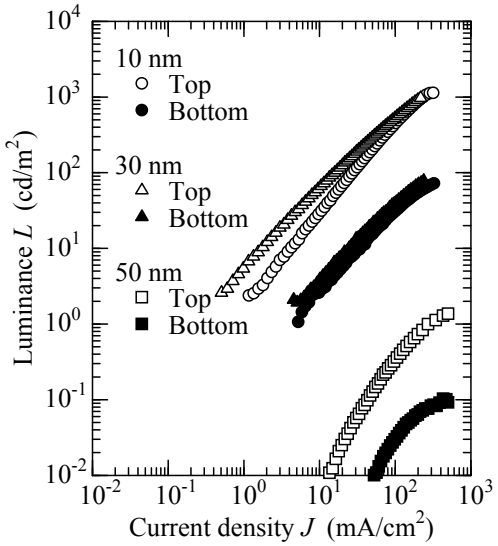

Fig. 4 Device characteristics with MoO_3 on bottom ITO varied with MoO_3 thickness.
(open: Top side, filled: Bottom side)

emission was 72 and 1,140 cd/m^2, respectively. The contrast ratio was improved 19:1 and the transmittance was 44%. Stacked MoO_3 on ITO is effective to suppress the electron injection from ITO to Alq_3. As a result, the contrast ratio was improved.

4. Conclusions

We had demonstrated OLED front-light with micro cathode array. Maximum luminance of top side emission was 1,140 cd/m^2, and the contrast ratio was 19:1. With improve in the contrast ratio, we will expect for application to the front-light in the future.

References

[1] N. Koma, T. Ikehara, K. Tanase, Y. Karasawa, Y. Tanaka, Y. Watana be, S. Miyashita, M. Atobe, J. SID **17/5** (2009) 473.

[2] T. Tsuji, S. Naka, H. Okada, and H. Onnagawa, Curr. Appl. Phys. **5** (2005) 1.

[3] T. Miyashita, S. Naka, H. Okada, and H. Onnagawa, Jpn. J. Appl. Phys. **44** (2005) 3682.

[4] T. Miyashita, S. Naka, H. Okada, and H. Onnagawa, Proc. IDW/AD'05 (2005) 617.

[5] T. Amemiya, S. Naka, and H. Okada, Ext. Abst. 2008 SSDM (2008) 636.