An Orthogonally Polarized OLED for High Brightness 3D Display

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ABSTRACT

We proposed a polarized organic light emitting diode (pOLED) with patterned with orthogonal directions for high brightness three-dimensional (3D) display. The orthogonally patterned pOLED makes right- and left-handed circularly polarization with a conventional quarter wave plate without any loss of light.

1. INTRODUCTION

Stereoscopic three-dimensional (3D) displays with viewing glasses have been widely developed and commercialized due to their good display performances and unlimited viewing points [1-4]. In the glasses-based 3D displays, to produce the binocular disparity, a display panel should generate two different images arriving at the left and right eyes. The two images with different polarization states are generated by the patterned retarder, which is attached on the outside of the display panel to change the polarization state. When we used a conventional unpolarized organic light emitting diodes (OLEDs) with a film-type patterned retarder (FPR) and linear polarizer, the intensity of emitted light reduced to below 50%.

To overcome this problem, a polarized OLED (*p*OLED) can be used with only a FPR for 3D display. The linearly polarized emitted light changed to right- and left- handed circularly polarized light through FPR without light loss. However, it is expensive and hard to align between display panel and a FPR. In this paper, we proposed a patterned *p*OLED, which is fabricated with rubbing process using shadow mask, for stereoscopic 3D display. Because the polarized lights are orthogonal in each region, we can produce right- and left-handed circularly polarized lights through a conventional unpatterned quarter wave plate (QWP) keeping the light intensity.

2. EXPERIMENT

Figure 1 shows the fabrication process of proposed patterned *p*OLED. Because the emitted light is governed by the orientation of the conjugated polymer, we used a polyimide (PI) alignment material (AL22636, JSR) as a hole transport layer to controlling the alignment direction. The PI was spin-coated on the indium-tin oxide (ITO) substrate. To produce the different alignment direction of the conjugated polymers, we rubbed the PI layer using a cotton roller after thermal imidization on a hot plate. After rubbing on whole area of the PI layer, we rubbed again in perpendicular direction to the first rubbing with patterned shadow mask. Poly(9,9-di-n-octylfluorenyl1-2, 7-diyl)-*alt*-(benzo[2,1,3] thia-diazol-4,8-diyl) (F8BT, American Dye Source) with a nematic liquid crystal phase was used as an emitting layer. The F8BT layer dissolved in toluene was spin-coated on the patterned PI layer. The prepared substrate was annealed at nematic temperature (150 °C) of the F8BT layer onto the hot plate for 10 min. The emitting polymers are aligned along the rubbing direction in each region.

3. RESULT AND DISCUSSION

A stereoscopic 3D display based on OLED needs a polarizer and FPR for producing two different images with different polarization state. In this case, the intensity of unpolarized emitted light through a polarizer reduced below 50%, as shown in Fig. 2 (a). The linearly polarized light changed to right- or left-handed circularly polarized light passing through patterned QWP which has orthogonal optical axes (± 45°). On the contrary, there is no loss of light intensity when we used the proposed patterned *p*OLED with only a conventional QWP, as shown in Fig. 2 (b).

Figure 3(a) shows a photoluminescence (PL) image of the fabricated sample. The image shows uniform emitting light though it has orthogonal emitting directions. Figure 3(b) and 3(c) shows photoluminescence (PL) images of the fabricated sample under two orthogonal linear polarizers. The emitting direction of the OLED was 0° and 90° for each patterned region. In the regions that the optic axes are same between emitting direction of OLED and polarizer, it shows white state. The black state appears at the other regions that the optic axes are orthogonal between emitting direction and polarizer. Note that brightness of the black state between two regions is different. That is because the linear polarization is incomplete. Actually, the polarization ratio of the fabricated OLED sample was 21:1. Another reason is that we rubbed twice for making different alignment direction. Although the alignment direction is governed by the latest rubbing direction, the anchoring energy of the twice rubbing regions is weaker than the other regions. Since the polarization ratio is affected by the azimuthal surface anchoring energy, the polarization ratio is somewhat different. If we study about a photo-alignment method, this problem can be overcome.

For 3D display, we should produce the images which have the right- and left-handed circularly polarization state. Our sample emit the linearly polarization light with orthogonal direction, the unpatterned QWP by ± 45° can make circularly polarization state with different handness. Figure 4(a) shows a PL image of the fabricated patterned *p*OLED sample with non-patterned QWP (-45°). As similar to the Fig. 3(a), the texture was uniform. For confirming the polarization state, we put the circular polarizer on the QWP. Figure 4(b) and 4(c) shows the PL images of the patterned *p*OLED with left- and right-handed circular polarizer, respectively, on the QWP. By the handness of the circular polarization, the black and white states are switched. The reduced brightness was due to the absorbance of the circular polarizers.

4. CONCLUSION

In this paper, we proposed the patterned *p*OLED for high brightness stereoscopic 3D display. The patterned *p*OLED was fabricated using rubbing process with shadow mask. The emitting polymers are aligned along the rubbing directions on the alignment layer, and emit linearly polarized light with orthogonal directions. Passing through the QWP, linearly polarized light changed to right- and left-handed circularly polarized light at each region. Because this proposed system does not need an extra polarizer, the emitted lights preserved without any loss. We expect that the patterned *p*OLED is applicable to not only high performance stereoscopic 3D display but also functional organic electro-optical devices.

5. ACKNOWLEDGEMENTS

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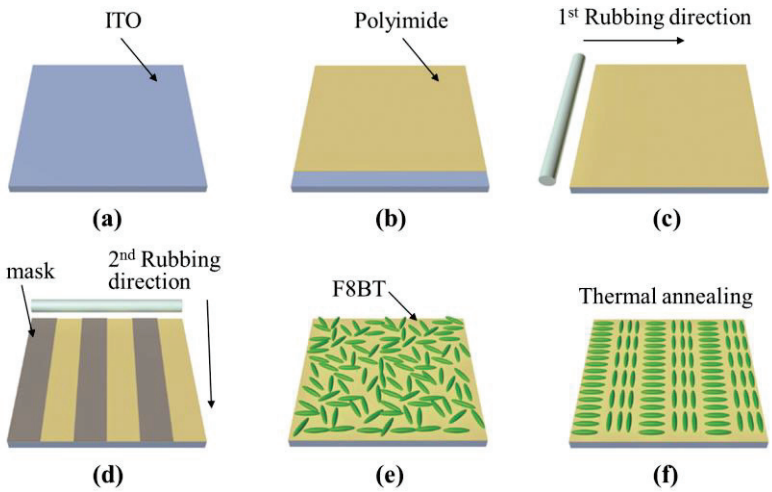

Fig. 1 Schematic diagrams of the fabrication of patterned *p*OLED.

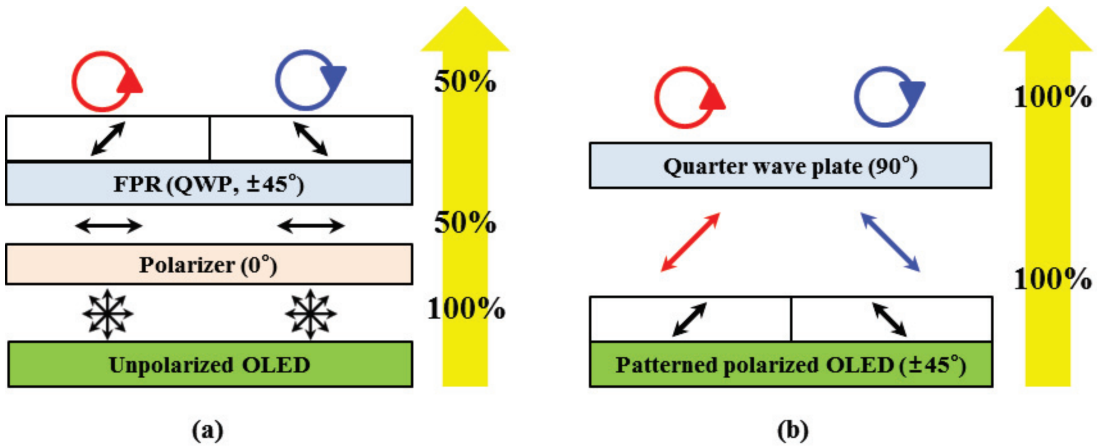

Fig. 2 Schematic diagram of the 3D display with (a) unpolarized OLED and (b) patterned *p*OLED.

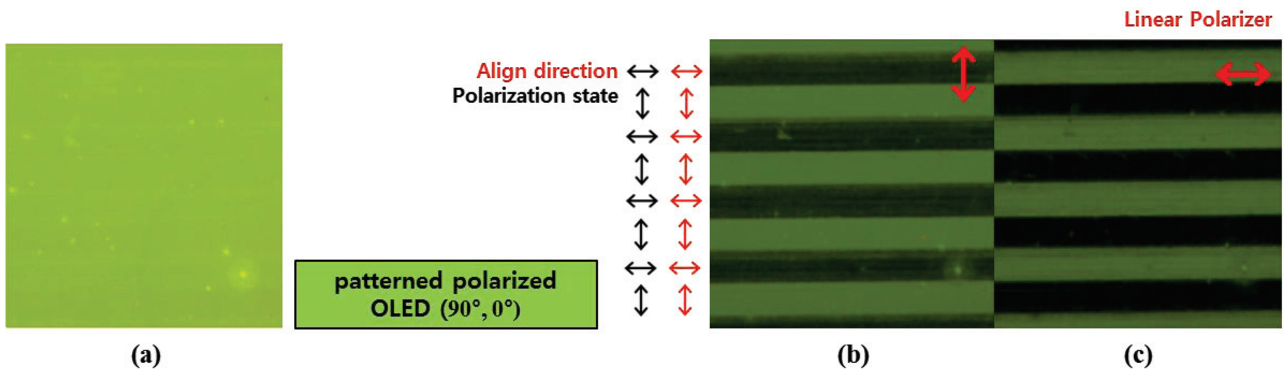

Fig. 3 PL images of patterned *p*OLED (a) without a linear polarizer and with a linear polarizer by (b) 0° and (c) 90°.

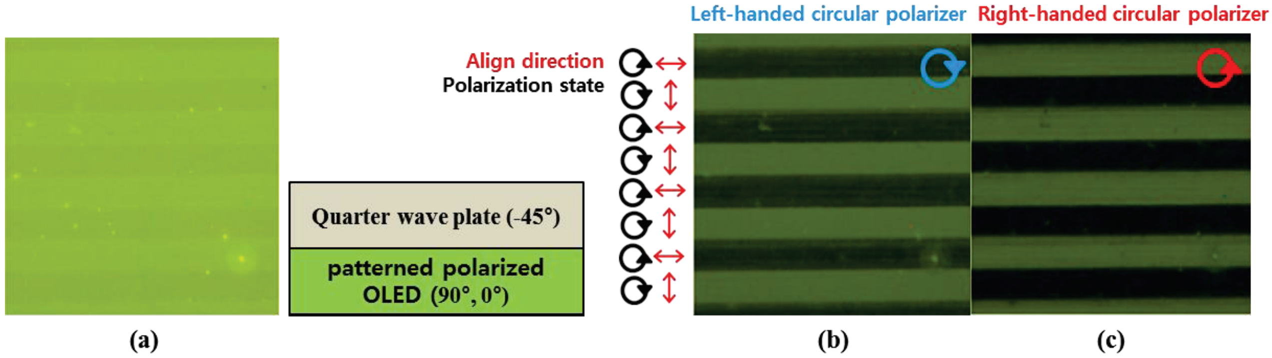

Fig. 4 PL images of patterned *p*OLED with QWP (a) without a circular polarizer and with (b) right- and (c) left-handed circular polarizers.