Emiflective display with high brightness characteristics

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ABSTRACT

We propose a high brightness emiflective display operated in a whole pixel configuration consisting of the OLED and TN LC cell which are used for backlight and reflector, and switching device, respectively. Emission and reflection mode acts simultaneously under dim environment without any optical path difference giving higher brightness characteristics.

1. INTRODUCTION

Transflective liquid crystal displays (LCDs) have attracted much attention for mobile applications since their superior device performances can be achieved under both bright and dim or dark environments, as well as low power consumption [1,2]. Under bright illumination, the display acts mainly as a reflective display. Only dim and dark ambient situations needed a transmissive display with a backlight. Recently, many approaches to design the tranflective LCDs were researched such as the LC structures with multi-cell gap in a single cell gap, single cell gap in two kinds of LC modes, and the two sub-pixels are divided as areas. However, these methods have a problem such as complex fabrication process, non-uniform deformations of LC molecules at the interface of the two parts, different LC response to the applied voltage, and difference threshold voltage.

Therefore we propose a high brightness emiflective display operated in a whole pixel configuration consisting of the OLED and TN LC cell which are used for a backlight and reflector, and switching device, respectively. Because the emission and reflection mode acts simultaneously under dim environment without any optical path difference, we can get higher brightness characteristics.

2. RESULT & DISCCUSION

Figure 1 show the schematic diagrams of the emiflective display. The system consists of TN LC mode with crossed two polarizers and white OLED which has a cathode made of metal (i.e. aluminum). Under bright environment such as daylight, the ambient light is stronger than a backlight. So, a reflective mode is appropriate for high brightness characteristics. In the reflective mode at the field-off state, the linearly polarized light becomes linear light by rotating 90° through LC layer due to wave guiding effect of TN LC mode and pass through the analyzer without any loss of light intensity. After reflection by the cathode layer of the OLED as a reflector, the polarization of light still sustains and passes through with analyzer which has same optical axis. After passing through the LC layer, the light becomes a linearly polarized light by rotating 90° which is parallel to the optical axis of top polarizer. As a result, we get the bright state. Although the light passes through LC layer twice, the intensity of incident light is almost same to LC mode which has only one optical pass of LC layer. For the field-on state, the LC molecules align parallel to electric field and there is no optical retardation. So, the linearly polarized light after polarizer keeps their polarization state after passing through a LC layer. Since this light is blocked by analyzer, we can get the black state.

Under dim or dark environment, we need an additional light source such as a backlight in LCD. In our system, we used the bottom emission type OLED for light source and LC layer acted as same to conventional normally white TN LC mode. Thus, the emissive and reflective

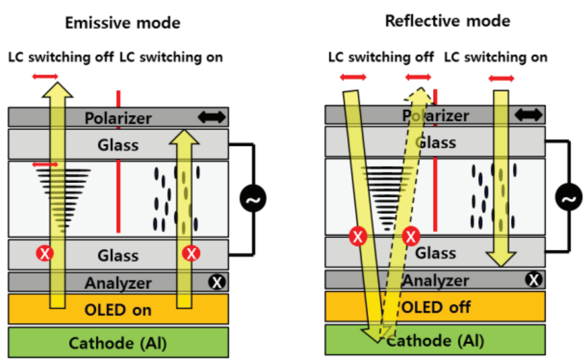
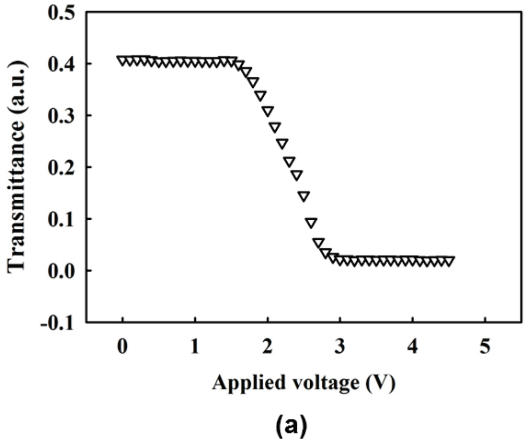


Fig. 1. The schematic diagrams of the emiflective display



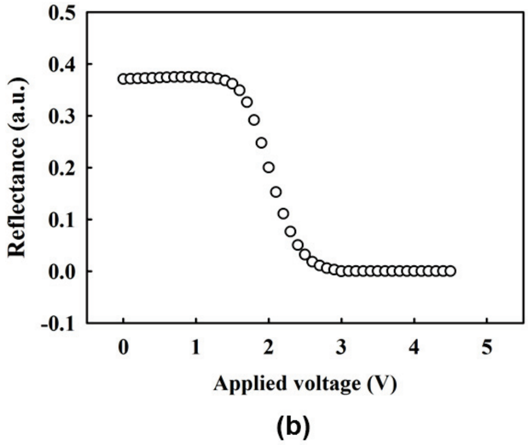


Fig. 2. Measured electro-optical characteristics of the fabricated sample (a) voltage-electroluminance, (b) voltage-reflection characteristics.

M odes in our emissive display have the same optical state in both the field-on and –off state. However, the reflected light also exists if the ambient light has any intensity though emission mode. Thus, the total brightness is increased because that is the sum of the intensities of the emitted light and reflected light.

Figure 2 shows the electro-optic (EO) characteristics. After normalizing the input light intensity (i.e. OLED electro-luminance and ambient light intensities), the brightness was measured. The EO characteristics well agree with each other over the whole gray level as well as threshold voltage, as shown in Fig. 2. If the light intensities between OLED and ambient light are same, the brightness of our emiflective display is increased 200% than each mode.

Because we used unit cell without any electrode pattern, the brightness was almost 0.4, as conventional normally white TN LC mode does, which are caused by absorption of a polarizer in front of light source. In our previous work, we reported the polarized OLED. That shows the almost same electro-luminance and polarization ratio. If we use the polarized OLED which optical axis is parallel to analyzer in our system, we can increase the light efficiency without any light loss. The light intensity of the emissive mode will be increased 100%, and, as a result, the total light intensity of emiflective display with polarized OLED is more 150% than that with non-polarized OLED and more 300% than a conventional OLED or reflective TN LC mode.

3. CONCLUSION

We proposed the emiflective display for high brightness. Our system is consisted of TN LC mode with two crossed polarizers and OLED. The LC layer displays the information and the OLED acts as a backlight and reflector. In bright environment, we can get a picture through the reflection mode over the whole pixel area. Under dim or dark environment, the emission mode and reflection mode operates simultaneously with same optical paths between two modes, as a result, we can get higher brightness characteristics. In addition, the brightness of our emiflective display can increase the brightness with polarized OLED.

4. ACKNOWLEDGEMENTS

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