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Polarized Organic Light Emitting Diode Backlight Unit for High Transmittance Liquid Crystal Display

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We studied about the surface anchoring energy induced by the rubbing strength and polarization ratio of the electroluminescence devices. For high polarization ratio, we optimized the rubbing condition for high azimuthal anchoring energy. And we adopted the polarized OLED to the twisted nematic (TN) LCD as a light source for high electro-optical characteristics.

1. Introduction

In liquid crystal displays (LCDs), polarized light required owing to its switching characteristics. In early studies, these devices usually used the linearly polarized light which is made from unpolarized light source with a sheet polarizer. However, a sheet polarizer absorbs about 50% of the incident light from the backlight, which leads to a high power consumption for high transmittance.

Organic light-emitting diodes (OLEDs) have been focused as a light source because of the advantages of low driving voltage, high brightness, simple fabrication processes, and so on. Many researchers have reported bout the linearly polarized OLED as a light source in the backlight unit on the liquid crystal display (LCD) applications by obtaining the mono-domain alignment of organic emission layers such as stretching Langmuir-Blodgett (LB) deposition and direct rubbing methods [1-3]. The LB deposition method was first applied to the alignment of emission layers of conjugated light-emitting polymers by Neher, but fabrication processes of these devices are time consuming and incompatible in large size application [4]. And the stretching of the films has a critical limitation of the drawing ratio of the polymer backbone and they also show the low polarization ratio. Therefore, direct rubbing with alignment layer method is compatible at the point of the simple fabrication process and large size application. In direct rubbing method, they used the liquid crystalline fluorescent materials can be aligned on suitable alignment layers [5]. And this method shows the highest polarization ratio due to the re-orientation properties of the nematic liquid crystalline materials.

In this paper, we studied about the surface anchoring energy induced by the rubbing strength and polarization ratio of the electroluminescence devices. For high polarization ratio, we optimized the rubbing condition for high azimuthal anchoring energy. And we adopted the polarized OLED to the twisted nematic (TN) LCD as a light source for high electro-optical characteristics.to achieve the high performances.

2. Experiments

To make the OLED cell, we used the ITO substrate as an anode electrode. As an alignment layer, polyimide (PI) material (AL22620 from JSR) was prepared and that was spin-coated onto the ITO substrates. The thickness of the PI layer was about 20 nm. After imidization with heating process, the PI layer was rubbed using the cotton roller with different times to control the azimuthal anchoring energy of the surface. The emission material (ADS-133YE from American Dye Sources) mixed with solvent (toluene) was spin-coated onto the rubbed PI layer and the thickness was about 60 nm. At this state, emission molecules are randomly distributed in azimuthal directions as shown in Fig. 1(d). Mono-domain alignment was induced by annealing the polymer film at nematic temperature onto the hot plate about 60 min (fig. 1(e)). And then the Ca/Al layer was deposited using the thermal evaporation method about 5 nm and 90 nm, respectively (fig. 1(f)).

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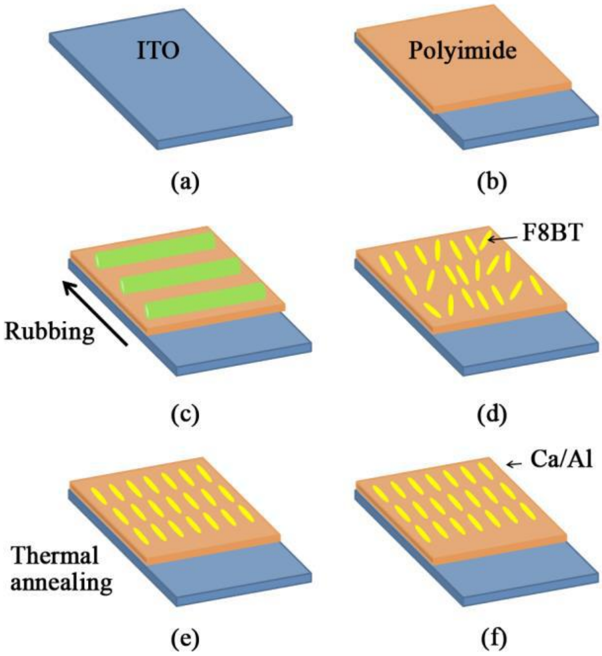

Figure 1. Schematic diagram of fabrication process for the polarized OLED. (a) ITO substrate as anode, (b) polyimide alignment layer, (c) rubbing process, (d) emission layer coating, (e) thermal annealing of the emission layer, (f) deposition of cathode.

3. Results and Discussion

In LCD, the surface azimuthal anchoring energy of nematic LC is proportional to the rubbing strength. The strong rubbing strength affected to the chain distribution of alignment polymer, and the high ordered polymer chain make highly ordered alignment of nematic LC molecules due to high azimuthal anchoring energy. In our study, when we increase the rubbing strength by increasing the rubbing times, the azimuthal anchoring energy was gradually increased to 2.4 X 10^{-4} J/m^2 till 6-times rubbing processing using torque balance method. After that, the azimuthal anchoring energy was saturated even increase the rubbing times because alignment of the polymer chains of alignment layer was saturated. Even though we measured the azimuthal anchoring energy using nematic LCs, we can analogize the anisotropic alignment of emitting materials from the azimuthal anchoring energy of the alignment layer because the used emitting material in this study has liquid crystalline characteristics in proper temperature range. After coating the emitting material on the alignment layer, the emitting layer has mono-domain alignment during annealing process at the nematic temperature range of the emitting material. The unidirectional alignment of emitting material could make the polarized emitting light.

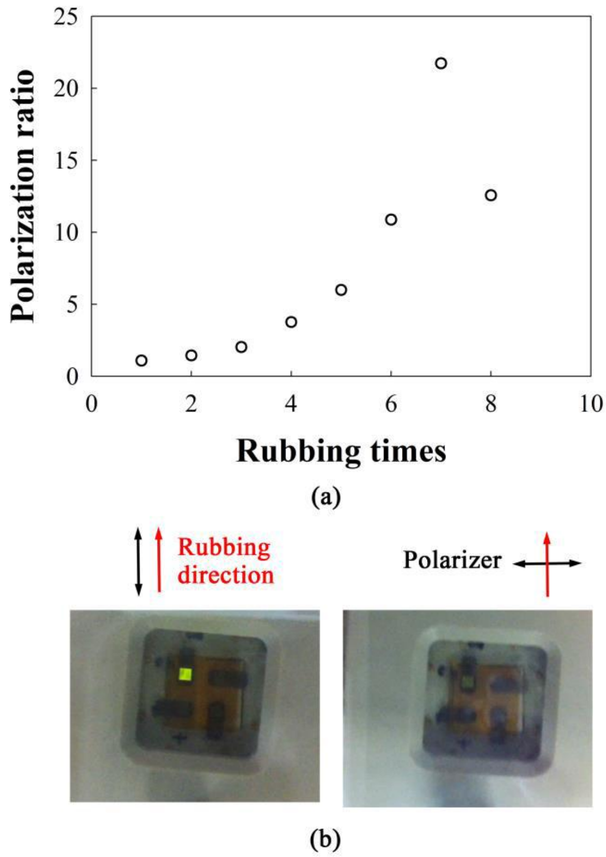

Figure 2. The measured (a) polarization ratio of the EL by varying the rubbing strength and EL characteristics for 7 times rubbing devices by adopting the different polarizer direction.

Figure 3 shows the camera textures of the TN LC cell and voltage-transmittance characteristics of TN cell with polarized/non-polarized OLEDs. The cell configuration is same as the calculated cell conditions. The cell size was 2.5 cm X 2.5 cm, and we could get the uniform texture of whole cell area. At initial state, the TN cell shows the bright state because the incident polarized lights are guided along the TN structure, and the polarization direction is changed to parallel to the analyzer. When we applied voltage, the LC molecules are rise up to a substrate and the incident polarization direction is not changed. As a result, we could get the dark state. The texture shows the green light because we used the emission material which emits green lights.

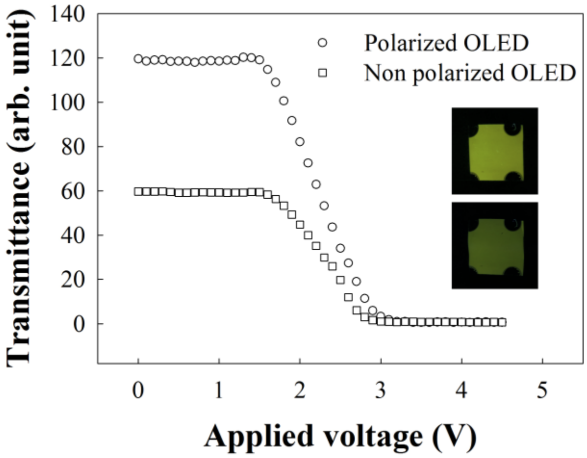

Figure 3. The measured (a) polarization ratio of the EL by varying the rubbing strength and EL characteristics for 7 times rubbing devices by adopting the different polarizer direction.

4. Conclusion

We studied about the relationship between surface anchoring energy induced by the rubbing strength and polarization ratio of the electroluminescence devices. By increasing the rubbing times, the azimuthal anchoring energy is increased rapidly then saturated. The high azimuthal anchoring energy makes unidirectional alignment of emitting materials. Therefore, the polarization ratio is changed according to the rubbing condition and we could achieve the highly polarized (~22 : 1) OLED devices. And also, we adapted the polarized OLED to the TN LC cell as a backlight unit for high transmittance characteristics. We believe that the polarized OLED is a leading candidate as a light source for the optical devices using LCs.

5. Acknowledgements

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