Enhancement of Polarization Ratio on Polarized Organic Light-Emitting Diodes using Anisotropic Micro Lens Arrays

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ABSTRACT

We proposed an anisotropic micro lens structure to compensate the polarization ratio of the polarized organic light emitting diodes (OLEDs). Using micro lens structure, light path could be modified and enhancement of polarization ratio is studied.

1. INTRODUCTION

The organic electroluminescence devices enable the realization of polarized light sources including the advantages of low driving voltage, high brightness, simple fabrication processes, good color performance and low cost[1-2]. Therefore, there are lots of interests in the application of the organic light-emitting diodes (OLEDs) as a light-source in the backlight unit on the liquid crystal display (LCD) applications. Recently, many approaches to design the LEDs that emit linearly polarized light were researched by obtaining the mono-domain alignment of organic emission layers such as stretching, Langmuir-Blodgett (LB) deposition and direct rubbing methods. However, polarization ratio of the polarized OLED is limited due to the alignment of the organic molecules [3-5].

Therefore, we propose an anisotropic micro lens structure to compensate the polarization ratio of the polarized OLED. And also, we could improve an out coupling efficiency of the OLEDs by optimization of the micro lens structure.

2. EXPERIMENTS

Figure 1 shows the schematic diagrams of the proposed structure. At first, micro lens structure was fabricated with optical adhesive material (NOA65) using replication method. Reflective index of the optical adhesive material is 1.524. The diameter and depth of the micro lens are 180 μm and 40 μm, respectively. We used the commercial polyimide alignment material (RN1199, Nissan) as a layer to align LCP which ordinary and extraordinary reflective index are 1.524 and 1.680. Then, we coated the LCP on the rubbed polyimide layer and LCP was exposed to the UV for polymerization of LCP.

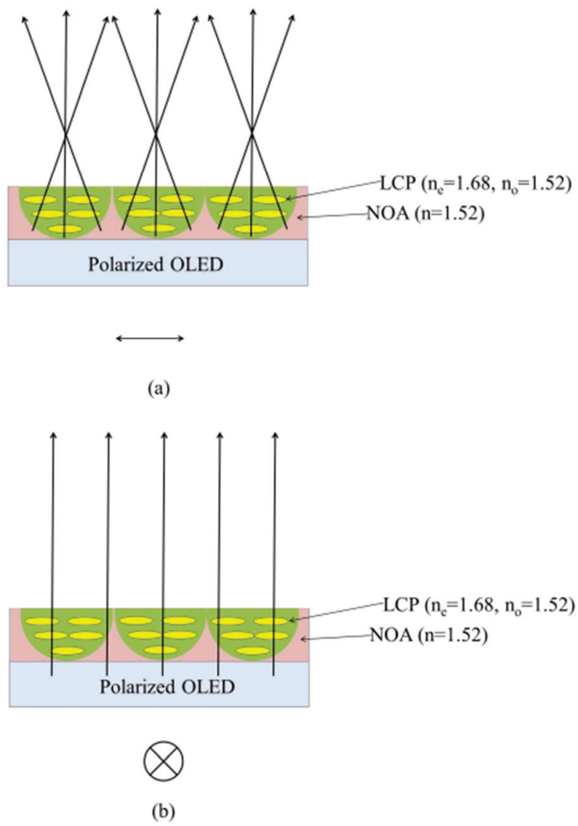

Figure 1. Schematic diagrams of the proposed structure (a) extraordinary axis and (b) ordinary axis of the LCP

For fabrication of polarized OLED cell, we spin-coated an alignment layer (SE-7492, Nissan, diluted in solvent about 20 wt.%) on ITO substrate. After thermal annealing process on a hot plate, the alignment layer was rubbed by cotton cloth to define an polarization direction of emitting material. Then, emitting Layer (poly [(9,9-di-*n*-octylfluorenyl-2,7-diyl)-*alt*-(benzo[2,1,3]thiadiazol-4,8-diyl)], F8BT, American dye Source) layer was spin-coated on the alignment layer. For unidirectional alignment of emitting layer, sample was baked at nematic phase of F8BT. After that aluminum (Al) were deposited by thermal evaporation as a cathode. All processes were fabricated in glove box to avoid humidity and oxygen. In addition F8BT's wavelength was 515nm~535nm. Therefore, when OLED turned on, emitting color represents green-yellow.

In polarized OLEDs, two different polarization components are emitted at emission layers. Most of the light is linearly polarized state which is parallel to the orientation of OLED molecules and the other is perpendicular to molecules. Next, rubbing direction of LCPs and OLED align perpendicularly. When polarization state of the light are parallel to the extraordinary and ordinary axis of the LCPs, lights from the OLED are spread and straightly passing through, respectively.

3. RESULTS

To analyze a light path after microlens, we simulated emitting light using MATLAB. Simulation conditions are as follow, LCP which ordinary reflective index is 1.524 and extraordinary reflective index is 1.680. And diameter and depth of the micro lens are 180 μm and 40 μm, respectively.

Figure 2 shows the simulated result of the light using ray optics analysis. When polarization state of the light are parallel to the extraordinary axis of LCPs, numbers of light ray are reduced 73.6% passing though micro lens. Then light from the OLED are spread. And polarization state of the light are parallel to the ordinary axis of the LCPs, numbers of light ray are maintained 99.9% passing though micro lens. Then light from the OLED are straightly passing through. Therefore, we could enhance the polarization ratio by reducing the residual polarization component using anisotropic micro lens structure. The minor component of the light is spread when light pass the anisotropic micro lens.

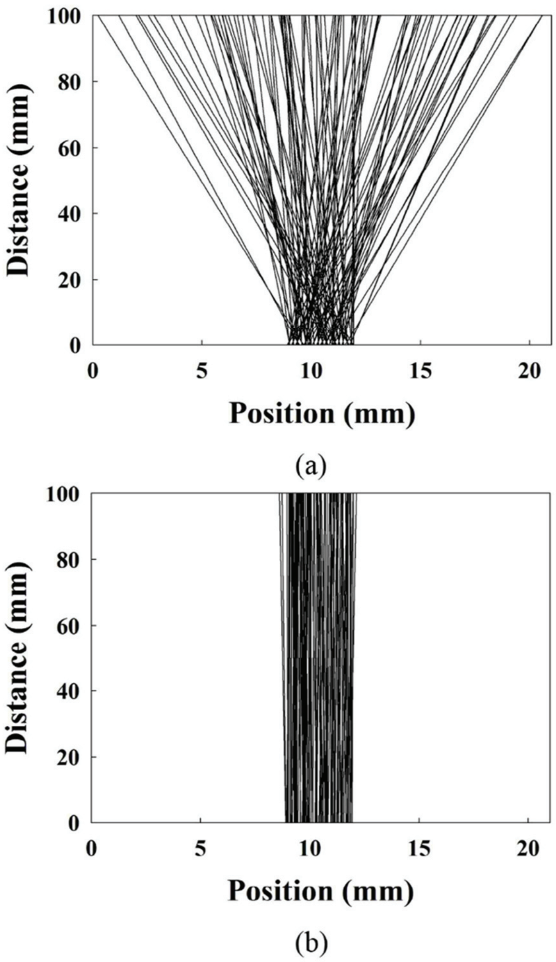

Figure 2. Ray optics analysis of the emitted light parallel to the (a) extraordinary axis and (b) ordinary axis of the LCPs.

Figure 3 shows comparison of the polarization ratio using sheet polarizer and anisotropic micro lens array. In case of sample without micro lens, polarization ratio of polarized OLED is 12 : 1. And sample with micro lens, parallel term to the ordinary axis of LCPs is reduced about 9% of light brightness. However, parallel term to the ordinary axis of LCPs is reduced about 38% of light brightness. Polarization ratio of polarized OLED is 17.4 : 1. And we could demonstrate minor component of the light to spread and major component of the light to straight. Therefore, using anisotropic micro lens structure is enhanced 45% of polarization ratio.

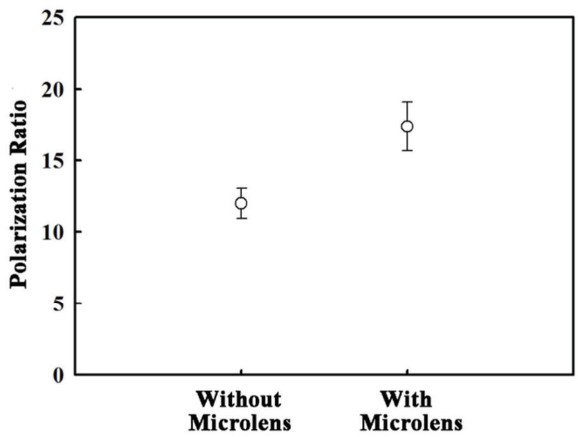

Figure 3. Comparison of polarization ratio with and without microlens arrays.

4. CONCLUSION

We demonstrated polarization ratio enhancement of the polarized organic light-emitting diodes using anisotropic micro lens arrays. The anisotropic micro lens array led minor component of the light to spread and major component of the light to straight. Major component of the light was preserved when the light passed through micro lens. Also minor component of the light was decreased when the light passed through micro lens. Therefore, 45% enhancement of polarization ratio could be achieved using anisotropic micro lens.

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