Square-cross-patterned Vertical Alignment Liquid Crystal Mode with High Brightness Characteristics

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Abstract

We propose a vertical alignment (VA) liquid crystal (LC) mode with square-cross-pattern, so called SXVA mode, for high transmittance characteristics. A common electrode has cross shaped slits with wings along with polarizer direction, which make a lattice structure. The slits make a diagonal direction of electric field and uniform alignments of LC molecules for high transmittance characteristics in SXVA mode.

Author Keywords

Square-cross-pattern; Vertical alignment; High brightness; SXVA

1. Introduction

Liquid crystal displays (LCDs) have attracted much attention because of their superior device performances and as low power consumption characteristics. Many kinds of LC modes such as twisted nematic (TN), in-plane switching (IPS), fringe-field switching (FFS) and patterned vertical alignment (PVA) were developed for various purposed and applications [1-5]. Among them, a PVA mode is at the important position due to their high contrast ratio and wide viewing angle characteristics with chevron type electrode structure for generating the multi-domain. For PVA mode, there is no need an alignment process such as rubbing and UV exposure. Instead, it needs slits within pixel and common electrodes for producing oblique electric fields which can make designate the falling direction of LC molecules under electric field. However, the slits cause a low transmittance characteristic. If the widths of the slit are too narrow, it is difficult to decide the falling direction. And, if the widths between slits are increased, a response time characteristics would be slow. So, the number of slits should be minimized for high transmittance characteristics

and surface treatment is needed for fast response time characteristics.

In this paper, we propose a vertical alignment LC mode with square-cross slit structure, so called square-cross-patterned vertical alignment (SXVA) LC mode, for high transmittance characteristics. In this mode, pixel electrodes have a square structure without any pattern. A common electrode has cross shaped slits along with polarizer directions, which make a lattice structure. Because of the diagonal electric field direction, the LC cell shows white stat under electric field. And also, we additionally designed the slit structure with wings for uniform alignment of LC molecules over whole pixel area. As a result, we could realize high transmittance characteristics in SXVA mode.

2. Method and Result

Figure 1 shows electrode configurations for a simple SXVA LC mode. For designing and characterizing the electro-optic properties, we used a commercial LCD simulator (Techwiz 3D-LCD, Sanayi system co., Korea). The pixel size was 125 × 125 μm, and the one of the pixel electrode was 105 × 105 μm without any pattern within the electrode. The common electrode has cross shaped slits for generating the electric field with diagonal direction. The slit width was 5 μm.

Figure 2(a) shows the LC director distribution according to the position of a pixel when 10 V is applied. According to the electric field direction, the LC molecules lay down with 45° to polarizers. However, the LC molecules near of the edge of pixel electrode, the LC molecules aligned along polarizer and/or analyzer. These LC director distributions cause a low transmittance characteristic. These results are reflected to the transmittance characteristics
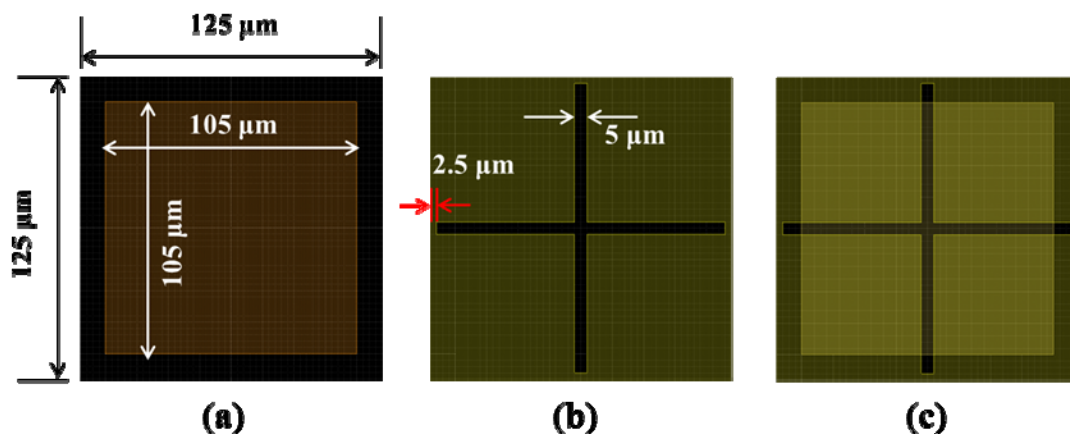

Figure 1. Electrode configurations of the simple SXVA LC mode. (a) A pixel electrode, (b) common electrode, and (c) pixel overlapped two electrodes
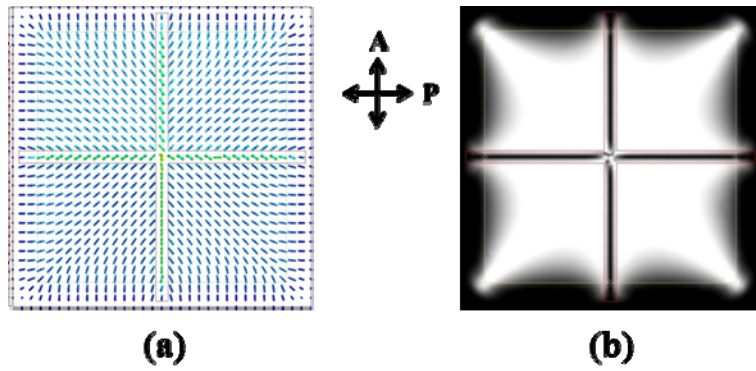
Figure 2. (a) LC direction distribution and (b) transmittance according to the position of a pixel when 10 V is applied to the simple SXVA LC mode.
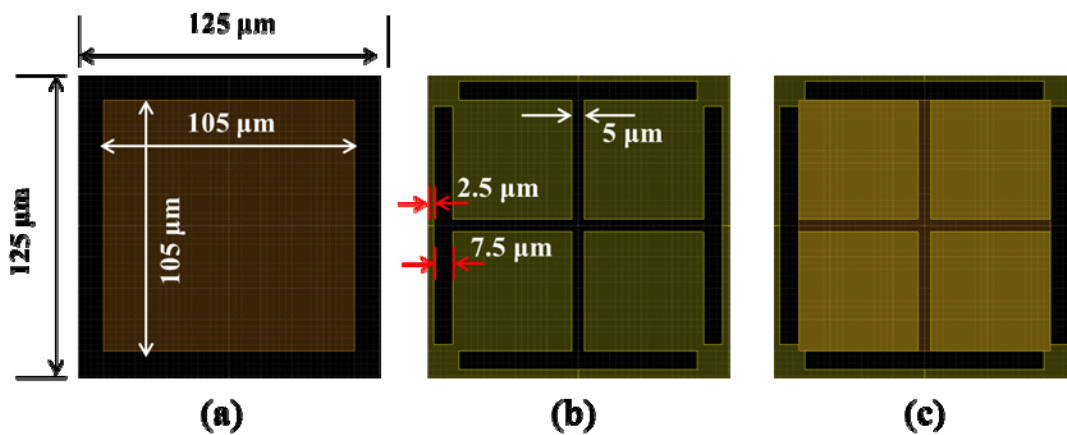

Figure 3. Electrode configurations of the advanced SXVA mode. (a) A pixel electrode, (b) common electrode, and (c) pixel overlapped two electrodes.

within pixel area, as shown in Fig. 2(a). At the center of the pixel, the electric field direction was 45° to polarizer due to the slits. However, at the edge of the electrode, the electric field lay along to polarizer because there is no effect of slits. So, the transmittance at the edge of the pixel should be improved, in spite of merits such as simple electrode structure and large process margin for alignment between top and bottom substrates.

To overcoming the problem, we designed the slit structure with extended wings on the common electrode. The electrode configuration of an advanced SXVA LC mode was shown in Fig. 3. All layout of the electrode structure was same to the simple SXVA mode except slit structure. The slits have wings at the end of it, which perform a role of slits at the middle of the pixel. Wing of slit width was 7.5 μm and does not overlap with common electrode.

Figure 4(a) shows the LC director distribution according to the position of a pixel when 10 V is applied to the advanced SXVA cell. In contrast with the simple SXVA mode, the extended wings at the slits induce director of electric field to 45° to polarizers at the edge of the electrode. As a result,

the LC molecules lay down along the direction of the electric field. As a result, we could get white state over whole lattice area, as shown in Fig. 4(b).

Figure 5 shows the time-resolved transmittance characteristics for the proposed SXVA cells. After 2 seconds, the saturated maximum transmittance for the simple and advanced SXVA cells was 0.19 and 0.27, respectively. The transmittance of the advanced SXVA cell was increased about 42%. This property need exact alignment between pixel and common electrodes. However, even if there is miss-alignment of 2.5 μm to right/left and up/down directions, the transmittance was 0.23 and it is still 21% higher than the simple SXVA cell.

For stabilizing the director of LC molecules, it needs very long time, about 2 seconds. However, we could get over by controlling of the pretilt angle of the alignment surface with reactive mesogen (RM). In previous our work, we reported that we can memorize falling directions of LC molecules by polymerized RM within alignment layers after UV exposure process [6-7]. By adopting the polymerized RM within alignment layers, we can get fast response time characteristics for SXVA mode.
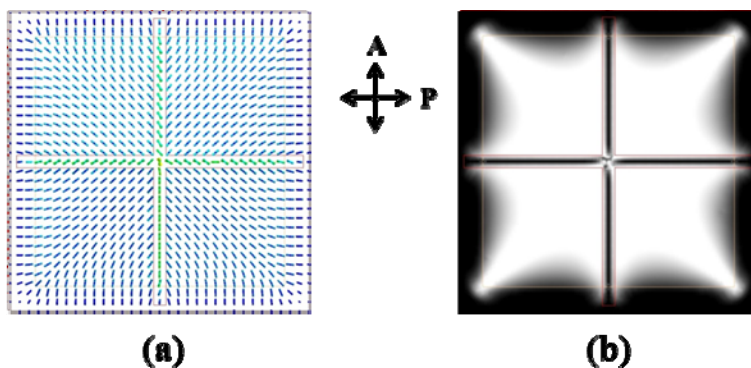
Figure 4. (a) LC direction distribution and (b) transmittance according to the position of a pixel when 10 V is applied to the advanced SXVA LC mode.
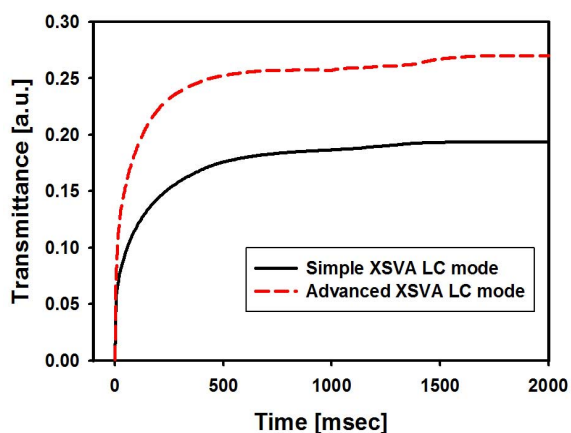

Figure 5. Time-transmittance characteristics when 10 V is applied to two SXVA cells.

3. Conclusion

We proposed the SXVA LC mode for high transmittance characteristics. By adopting cross shaped slits on the common electrode, we could get the lattice structure with minimized slit area. And also we designed the slit patterns with wing structure at the end of the slits. The advanced slit structure made uniform alignment over whole pixel. As a result, we could get high transmittance characteristics. The SXVA mode is expected to become a viable technology to produce the large-sized LCDs with the excellent display performances.

5. References

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