Pixel design for Improving Transmittance in OCB LCD

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ABSTRACT

Two new cell structures for optical compensated bend were proposed. There are two groups of slit electrodes, which are driven by two different signals corresponding to the entire electrode as common electrode. The transmittance was enhanced without increasing the response time and light leakage. Compared with the traditional OCB mode, the increment of the transmittance of each kind is about 90% and 30%.

1. Introduction

In the last twenty years, liquid crystal display has been used in many applications, including notebook, PC, cell phone and TV etc. The OCB mode (Optical Compensated Bend) was considered as a fast response mode for high quality display mode. However, there are some disadvantages as well, such as splay to bend transition[1-2], viewing angle[3-4] and low transmittance. In this paper, we simulate two new structures of OCB mode LCD which could enhance the transmittance by the software "TechWiz".

2. Structure Design

First structure

The pixel electrode that corresponds to the common electrode was designed as two groups of slit electrode, which are separated and driven by different signal as well. The first group is driven by the normal driving signal; the second group is always driven by high voltage while the display is in the dark state. On the other hand, the rubbing direction was parallel to the slit electrodes, as shown in Fig. (1). When the pixel is in the bright state, the first group electrode was driven by the lower voltage while the second group electrode was still driven by high voltage. This design will induce the transverse fringe field, whose direction is vertical to the slit electrodes, so that the liquid crystal molecule would be not only bended but also twisted, followed by higher retardation and higher transmittance as well.

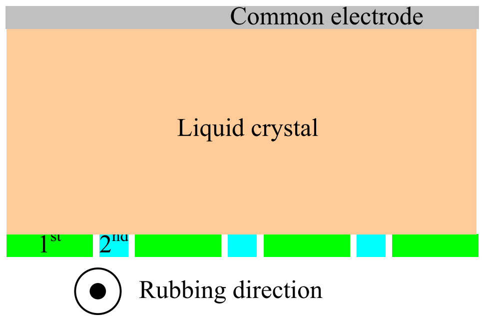

Fig. 1 Pixel design of the first structure

Second structure

The other pixel design is similar to the first design, but the first group electrodes driven by the normal driving signal became entire electrode located on the substrate first, covered by dielectric layer and the second slit electrode driven by the high voltage which is the same as the first structure. The rubbing direction is also the same as the first structure, which is parallel to the slit electrode, as shown in Fig.2. Because of the same reason, the liquid crystal will also be extra twisted; the transmittance will be enhanced as well.

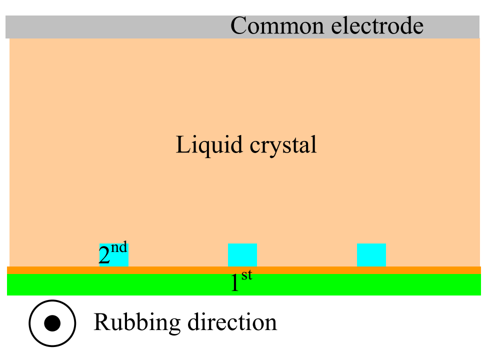

Fig.2 Pixel design of the second structure

In this simulation, except for the structure design of the electrode, the other simulation is set up as below: pretilt angle is 4° ; cell gap is 4µm; liquid crystal is MJ05128.

3. Result

Traditional OCB structure

In the traditional OCB structure, the pixel and common electrode are both entire electrode without patterning, as shown in Fig. 3.

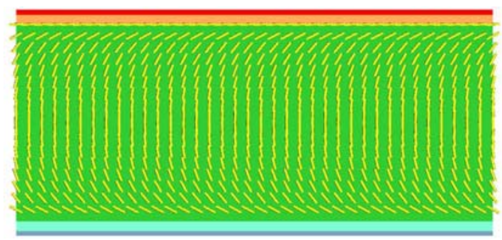

Fig. 3 The distribution of liquid crystal molecule of traditional OCB structure.

The CR of traditional OCB structure is shown as Fig. 4, as we mentioned before, because of the transmittance is not high enough, the CR is not high as well.

First structure

In this OCB structure, as mentioned before, the liquid crystal molecule was twisted near the edge between two slit electrodes when driven as bright state, as shown in Fig. 5. The structure in this simulation includes the first electrode, which was driven by normal signal with 6µm width, the second electrode driven by high voltage with 2µm width and these two electrodes were separated by 0.5µm. In the dark state, the two groups of slit electrodes were both driven by high voltage, just like the entire electrode in the traditional OCB mode. Therefore, the transmittance at the dark state was the same as the traditional OCB mode. Therefore the CR of first design will be higher than the traditional design. The maximum CR of the traditional OCB is about 30, as shown in Fig. 4, and that of the first design is about 65, as shown in Fig. 6, which is enhanced by about 90%.

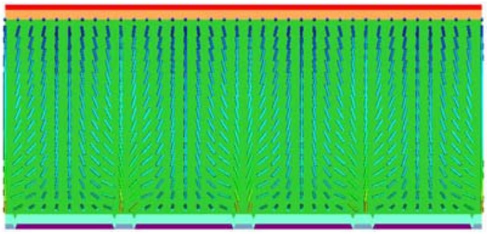

Fig. 5 The distribution of liquid crystal molecule of the first structure.

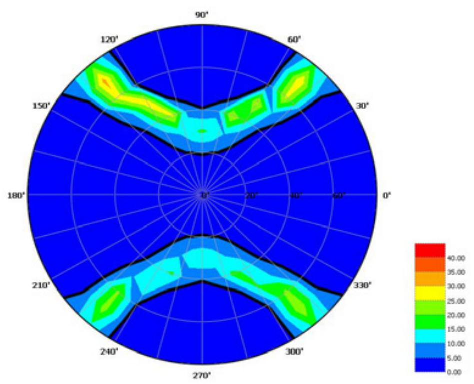

Fig. 4 The contrast ratio of the traditional OCB mode.

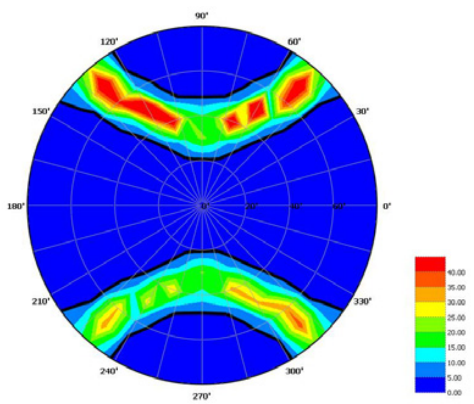

Fig. 6 The contrast ratio of the proposed OCB mode.

The optical performance of contrast ratio depends on the ratio of width between these two groups of electrodes was also investigated. We set the width of the electrode driven by high voltage 2μm. Then we find the width of the other group electrode, as shown in Fig. 7. It reveals that when the group of electrode is 6μm, the CR will be highest.

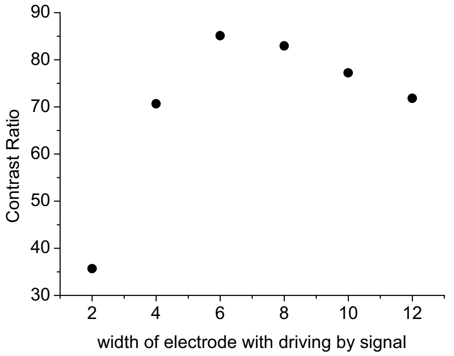

Fig. 7 the relation between the width of the slit electrode and the CR.

Final, we simulate to find the best width of the separation between the electrodes. The simulation result is shown in Fig. 8, it reveals that the CR will be the highest as the width of the separation is 0.5 μm.

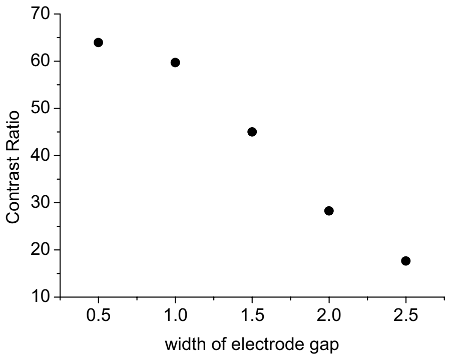

Fig. 8 the relation between the separation and the CR

Second Design

As we mentioned above, the liquid crystal of this design will also be extra twisted. In this simulation, we set the width of the electrode gap as 10 μm, and the liquid crystal molecule distribution is shown as shown in Fig. 9.

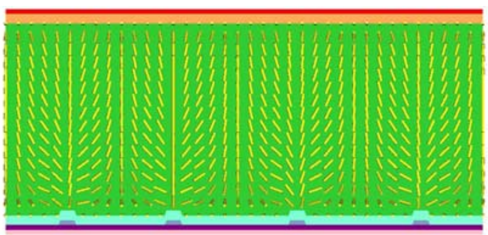

Fig. 9 The distribution of liquid crystal in the second structure.

The CR of the second structure is also enhanced, as shown in Fig. 10. The maximum CR of this structure is about 38, which is enhanced by about 30%.

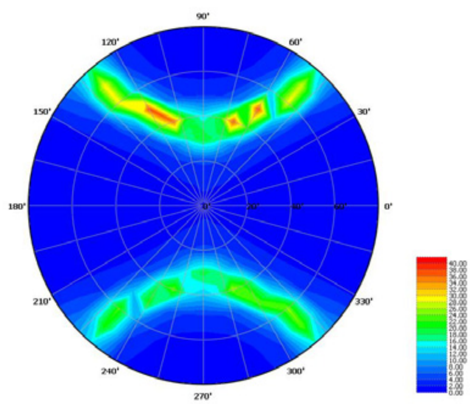

Fig. 10 The CR of the second structure.

Then we simulation the best electrode gap with highest CR., we set the width of the electrode as 2μm, and change the width of the electrode gap to find the high CR. The result showed the best electrode gap is 10μm, as shown in Fig. 11.

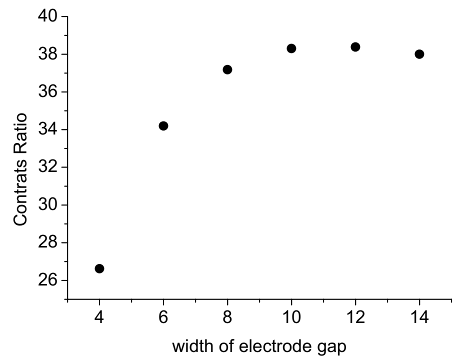

Fig. 11 the relation between the separation and the CR

4. Conclusion

We have simulated the optical performance of new electrode structures for OCB mode, and proposed two new structures. In these two structures, the transmittance was increased and the contrast ration was enhanced as well.

5. References

1. Jun Ho Park, Duk Woon Choi, Kyung Ho Choi, Tae Soo Kim, Kee Doo Kim. SID'06, P.709, 2006.
2. Kenji Nakao, Daiichi Suzuki, Tetsuya Kojima, Midori Tsukane, Hirofumi Wakemoto. SID'04, P.1416, 2004.
3. Mi Jun Jung, Chul Gyu Jhun, Jae Chang Kim, and Tae-Hoon Yoon. IDW'04, P.121, 2004.
4. Seong-Ryong Lee*, Tae-Hoon Yoon, and Jae Chang Kim. IMID'06, P.167, 2006.