Effects of Fine-slits for High Transmittance in MVA-mode LCD

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Abstract

In this paper, we propose an MVA mode cell structure with improved optical characteristics. Our MVA cell has an electrode with fine-slits. Optical characteristics of our proposed structure were compared with those without fine-slits. Moreover, we varied the interval as well as the widths of fine-slits in order to appreciate the effect of fine-slits. Optical characteristics of these cells were calculated with 3D FEM solver, TechWiz LCD. It was confirmed that the transmittance can be improved by more than 7% with fine-slits.

1. Introduction

MVA-LCD is one of the technologies which are widely used in the LCD manufacturing companies around the world. A MVA-LCD with fine-slits of different size has been proposed in an effort to improve the optical characteristics such as transmittance and viewing angle. A MVA-LCD is composed of a patterned common electrode on color filter (CF) substrate and slits on TFT substrate for controlling the liquid crystal (LC) molecular alignment. Particularly, design of the slits on TFT substrates is important for optimization of the high performance. By using numerical simulator, we obtained the optical results of a MVA-LCD with fine-slits and without fine-slits.

In this study, two kinds of numerical methods are used to analyze the optical characteristics. They are extended-Jones method, and FEM(finite element method) which has been used for providing a flexible design capability of the liquid crystal cell. By using numerical simulator(TechWiz LCD), we obtained the optical results of a new MVA-LCD with fine-slits and compared the simulation results with experimental reports.

2. Simulation Results and Discussion

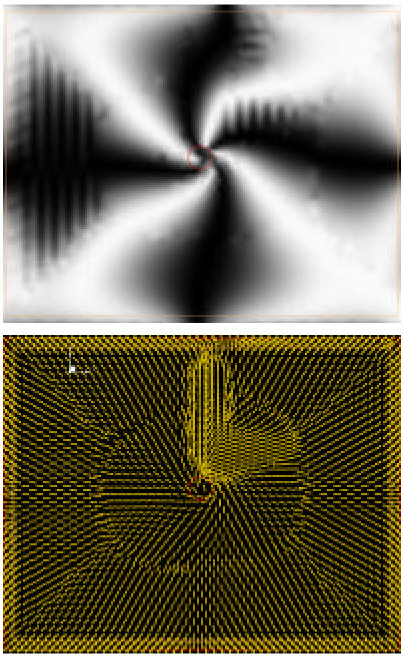

Figure 1. Transmission, layout and director distribution of case 1: (a) transmission and layout with simple pixel and common round shape pattern and (b) director distribution

Figure 1 shows the schematic view of the structures of common and pixel electrodes simulated in this study. To simulate the optical characteristics of three cases pixel electrodes designed (Case 1: simple pixel without fine-slits; Case 2: fine-slits of 3um which are located over whole area; Case 3: fine-slits of 2um which are located over whole area). Common electrode has designed same structure. As a voltage condition, we fixed 0V of common electrode and 6V of pixel electrode. As an LC material, MLC-6608 is selected. Cell gap has 4um, and size of the structure has 47um x 37um.

In cell structure, finite element method has been use for solving potential and director distribution. Numerical method for optical calculation was performed by using extended Jones method.

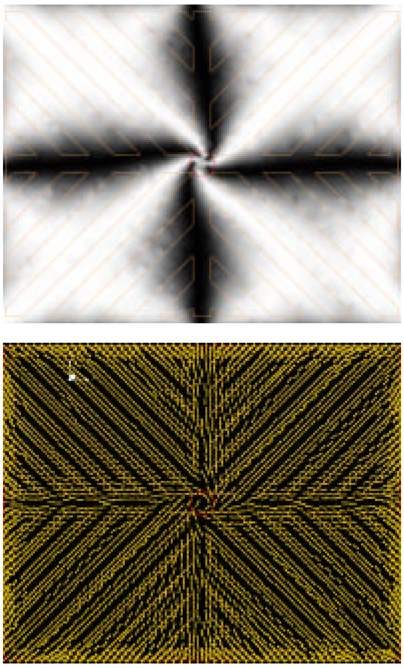

Figure 2. Transmission, layout and director distribution case 2: (a) transmission and layout with a pixel which has a slits of 3um width and 3um interval and common round shape pattern and (b) director distribution

Three different cases of pixel structures are shown in figure 1(a), figure 2(a) and figure 3(a). Case 1(figure 1(a)) has a simple pixel and common which has a round shape pattern in center. The director distribution is shown in figure 1(b). The LC molecules are inclined vertically to electric field direction which tends to tilt along the circumference of round shape pattern in common. Therefore, the director is spread out all side direction from center.

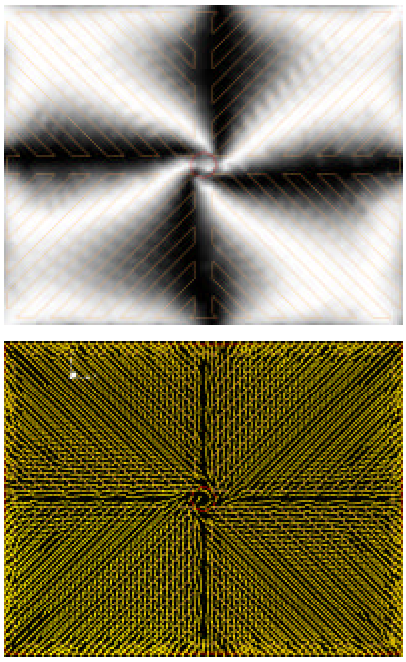

Figure 3. Transmission, layout and director distribution of case 3: (a) transmission and layout with a pixel which has a slits of 2um width and 2um interval and common round shape pattern and (b) director distribution

Figure 1(a) shows the transmission of case 1. The dark region is shown along the regions dividing the pixel into four parts and bright region is shown along diagonal regions. Two polarizers are polarized in the vertical and horizontal direction in cell. Therefore, maximum transmittance is appeared at diagonal directions of the cell. Dark regions are caused by the directors appeared in parallel to vertical and horizontal direction. In order to decrease these dark regions and appear the directors in diagonal direction of cell, we used fine-slit technology [2]. If fine-slits are designed, LC molecules will tend to inclined in the azimuth parallel to the fine-slits [1].

Figure 2(a) shows the pixel electrode with fine-slits with 3um width and 3um interval; it is case 2, the directors are inclined parallel to the fine-slits, toward the round shape pattern in common (Figure 2(b)). When we compared case 1 with case 2, we found that dark region was decreased.

In order to increase transmittance, we extended the area of fine-slits through controlling the width and interval of slits. In the case 3, we designed the width and interval of the fine-slits to 2um, respectively. In figure 3(a), (b), transmittance is decreased rather than case 2. Dark regions are notably decreased in horizontal and vertical direction of the cell. Case 2 has the best transmission among the three cases of pixels. Figure 2(a) shows the transmittance of case 2. Therefore, we found that we could change transmittance by designing pixels with the fine-slits.

Figure 4 shows the transmission graph of the three cases of pixel structure. In the case of the structure with fine-slits have higher transmittance than a case without fine-slits, and the pixel which have slits of 3um width and 3um interval(Case 2) have better transmittance than transmittance of the case of 2um(Case 3).

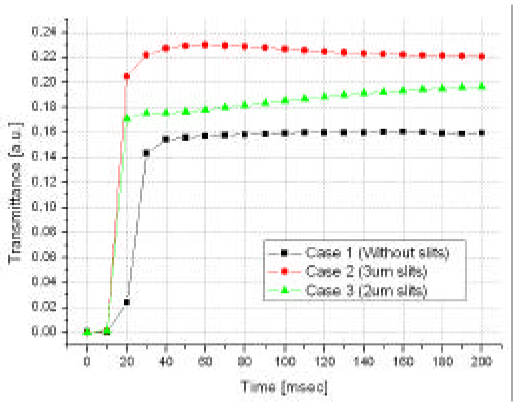

Figure 4. Transmittance of three different cases of pixel structure: In the case of 3um slits, the transmission is the highest among the others.

3. Conclusion

In this work, we induced a cell with fine-slits to form multi-domain of liquid crystal molecules. The electrode structure with fine-slits has high transmittance in comparison with simple electrode without fine-slits. The simulation results well reflected our intention which the fine-slits to form multi-domain can improve transmittance. However, we confirmed that interval and width of fine-slits should be well fixed because many fine-slits were decreased transmittance. Therefore, we obtained that a suitable design of electrode with fine-slits can improve optical characteristics.

4. Acknowledgements

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5. References

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