반투과형 PVA 액정 소자의 광 특성 향상을 위한 전극 구조

Electrode Structure for Enhanced Light Efficiency in a Transflective PVA liquid crystal device

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Lately, a transflective LCD with periodically patterned electrodes was proposed.[1] Using the periodicity of the fringe field distribution in the patterned vertical alignment (PVA) mode, we can realize a single cellgap transflective LCD with high performances. The initial vertical alignment of liquid crystal (LC) molecules guarantees the high contrast ratio (CR) in the reflective as well as the transmissive parts, which is a very important factor fortransflective applications. By optimizing the electrode width and distance, we can drive the reflective part and the transmissive part with a single voltage. The wide viewing angle property is also obtained by using a C-plate compensating the dark states of the vertical alignment. Figure 1 shows the conventional transflective PVA cell structure. The patterned bottom electrodes induce the distorted electric field distributions so that the retardation is distributed periodically. We can use the high retardation (about λ/2) regions on top of transparent electrodes as the transmissive part, while the low retardation (about λ/4) regions between patterned bottom electrode as the reflective part with insulated mirrors. The initial vertical alignment provides a superior black level so that we can realize high CR at normal direction. We can also obtain the wide viewing angle property by adding a negative C-plate for the dark state compensation of the vertical alignment.

Although this structure has high potential for the transflective LCD mode as mentioned above, the conventional 2-domain PVA structure introduces disclination lines at the center of each part, the reflective and the transmissive ones. Because the gap between bottom electrodes is relatively narrower than their widths, the fringe field effect is more dominant in the reflective part while the vertical field distribution is dominant in the transmissive part. So the director in the center of reflective part does not align parallel to the substrates even a high voltage is applied.The degradation of the light efficiency is more serious in the reflective part. We have studied this problem with patterned top electrodes. A commercial software 'TechWiz LCD' was used for numerical calculation.

Figure 2 shows the top view of a conventional transflective PVA cell in the bright state obtained by using a numerical simulator 'TechWiz LCD.' Centers of both the transmissive part and the reflective part remain dark even under the field-on state (5V), which result from the symmetric 2-domain structure as mentioned above. In the bright state, the reflective part shows black stripe pattern, which is the dead zone while the transmissive part shows dark spots. Because large portion of pixel areas are usually used as the transmissive part in the transflective PVA mode, the dead zone of the reflective part resulting from the disclination between the domain boundaries is a serious problem. It may lowers the reflectance.

To increase the reflectance, we studied the formation of the multi-domain structure by patterned electrodes. Because the field distribution is 2-dimensional in the previous PVA structure, the disclination forms the line shape. If 3-dimentional field distribution can be obtained, the disclination may gather around a specific point. Actually, the dark spots may affect the light efficiency less than the dead lines. For the 3-dimensional field distribution, we propose the electrode structure shown in Fig. 3. In addition to the previous patterned bottom electrode, the top electrode is also stripe patterned along the direction perpendicular to the bottom pattern. If the vertically aligned negative LC is sandwiched between these electrode structures, the director distribution becomes 3-dimensional so that the intrinsic 4-domain distribution can be obtained.

To verify the performance of the proposed structure, we executed numerical simulation with a commercial 3-dimensional simulator, 'TechWiz LCD.' We used the LC parameter of MDA-01-2306 (Merck, Δn: 0.1204, $\Delta\varepsilon$: -5). The cellgap, the width of the bottom electrode, and the width of insulated mirror were 3 m, 10 m and 5 m, respectively. This condition is obtained by our previous optimization for high resolution mobile display using the transflective PVA mode.[2] We started with the top electrode structure the same as the bottom electrode structure the width of top electrode and the width of top insulator (glass) are 10 m and 5 m, respectively. In this condition, although the dead zone gathers to a circle, the reflectance is rather decreased. So the overall light efficiency is decreased. To find the optimized condition, we varied parameters such as the period of top electrode, the optical anisotropy of LC, the widths of the top electrode,and the gap between top electrodes.

Figure 4 shows the top-view image of the optimized structure. The bottom electrode structure is remained the same, while the top structure is optimized. The widths of top electrodes and insulators are shown in Fig. 4. The electro-optic characteristics are shown in Fig. 5. While the transmittance in our structure is somewhat decreased because we focused on the maximum reflectance, it can be modified and enhanced if the electrode condition, cell-gap, and LC parameters are optimized.

The remarkable point in our result is that even if the transmissive and reflective area ratio is fixed and the reflective part is smaller than the transmissive one, the light efficiency can be increased by 2-dimensional fringe field formation with crossed patterned electrodes in the transflective PVA mode. Moreover, the reflectance and the transmittance are saturated while the previous line shape patterned PVA mode shows peak luminances in both parts. This may help to easily drive the cell. To ensure the wide viewing angle characteristics, anegative C-plate is added. Its optimized parameters are n_x = 1,5, n_y = 1.5, $(n_x-n_y)\cdot D$ = 250 nm, where $D$is the thickness of the C-plate. Iso-contrast contour diagrams with this film are shown in Fig. 6.

References

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2. J. I. Baek, S. J. Park, C. G. Jhun, J. C. Kim, and T.-H. Yoon, Proc. IMID '05, p. 403, 2005.

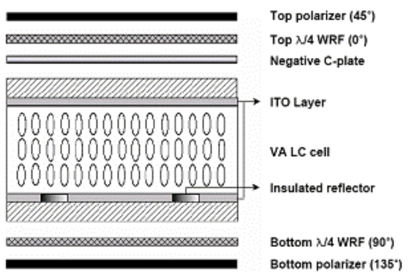

Fig. 1. Conventional PVA cell structure.

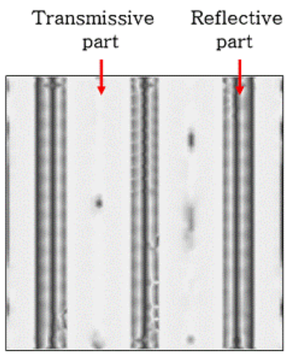

Fig. 2. Calculated top-view image of the conventional PVA structure in the bright state.

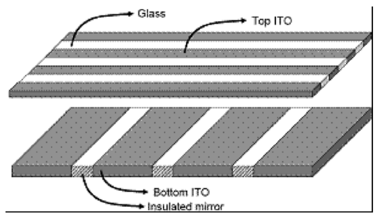

Fig. 3.Proposed electrode structure for the transflective PVA mode.

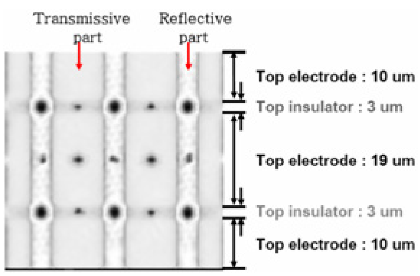

Fig. 4. Calculated top-view image of the proposed electrode structure in the bright state.

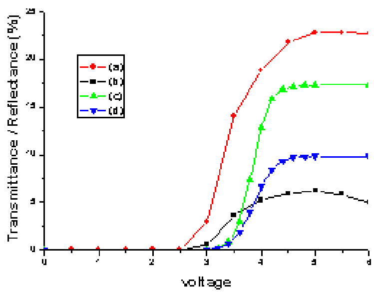

Fig. 5 Calculated electro-optic characteristics. (a) transmittance of the conventional structure, (b) reflectance of the conventional structure, (c) transmittance of the proposed structure, (d) reflectance of the proposed structure.

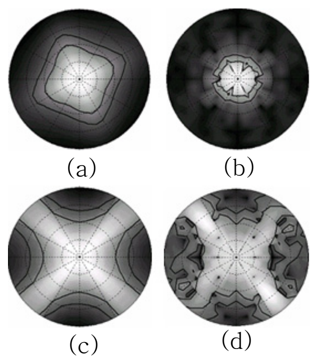

Fig. 6.Viewing angle characteristics of the proposed electrode structure. Inner and outer lines correspond to CR of 30 and 10, respectively.(a) the transmissive part before compensation, (b) the reflective part before compensation, (c) the transmissive part after compensation, (d) the reflective part after compensation.