

Improvement of Off-axis Gamma Distortion in Vertical Alignment Liquid Crystal Mode Using Hybrid Pixel Electrode Structure

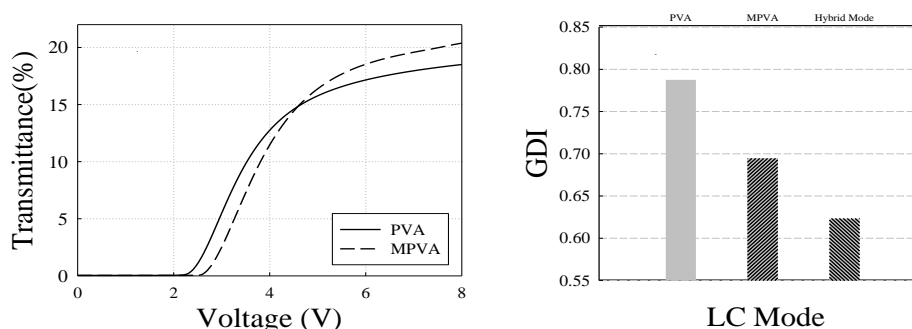
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The vertical alignment (VA) liquid crystal (LC) mode has the superior dark state, providing the highest contrast ratio because the LCs are aligned vertically against the substrate in the off state. However, the VA mode of single domain has poor image quality and color shift in the off-axis. To improve these problems, multi-domain VA mode have been suggested. Recently, several technologies for 8-domain alignment have been proposed to decrease the color shift at an oblique viewing angle. However these LC technologies faced with issue at additional driving circuit, complicated fabrication process, low aperture ratio, and degradation of maximum luminance¹.

In this study, we propose a new VA LC mode with hybrid electrode structures to reduce an off-axis color shift. In our LC mode, the main-region is formed like the micro-patterned vertical alignment (MPVA) mode and the sub-region is composed of the conventional patterned vertical alignment (PVA) mode, where the threshold voltage of the MPVA mode is 2.57V, and the CPVA mode is 2.22V which is shown in Figure 1(a).



**Fig. 1. (a) Transmittance-Voltage curves of MPVA and PVA at normal(0°) angle
(b) Gamma Distortion Index versus LC mode.**

The difference of threshold voltage between two modes can be explained as the difference in the electric field strength caused by the area ratio of electrode each LC mode. For such a reason, the proposed electrode structure consist of two regions with different electric field leading to different LC director distribution in these two areas. The difference of these LC performance improves reducing color shift defined an off-axis Gamma Distortion Index² (GDI) as

$$GDI(\theta, \phi) = \left\langle \frac{|\Delta B_{i,j(on-axis)} - \Delta B_{i,j(off-axis)}|}{\Delta B_{i,j(on-axis)}} \right\rangle_{i,j=0-255}$$

Reference of MPVA mode has a GDI value of 0.6944 at $(\theta, \Phi) = (60^\circ, 0^\circ)$, and the GDI value of our LC mode is 0.6234 at $(\theta, \Phi) = (60^\circ, 0^\circ)$ viewing direction which is improved to 6.32% over the conventional four-domain MPVA LC mode which is shown in Figure 1(b). Also we designed pixel electrode with no disclination line and without decreasing maximum luminance. The hybrid electrode structure imposes different threshold voltage (V_{th}) at two region divided by electrode area with no additional driving circuits and no decrease of contrast ratio. This indicates that a proposed LC mode with multi-domain alignment reduces the color shift at off-axis viewing angle. The GDI value can be further reduced by optimizing the area ratio of MPVA/PVA.

References

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2. Ji. Ma, Young-Cheol Yang, Zhigang Zheng, Jianru Shi and Wenyi Cao, *Displays*, 30, 185-189 (2009)