Publication information

Title	Electrooptic response of FLC: Effect of alignment materials
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Source	SID Symposium Digest of Technical Papers , v. 42, (1), June 2011, p. 1648-1649
Version	Published version
DOI	https://doi.org/10.1889/1.3621190
Publisher	The Wiley - The Society for Information Display (SID)

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P-144: Electrooptic Response of FLC: Effect of Alignment Materials

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Abstract

In this paper, parameters of ferroelectric liquid crystals (FLC) with different alignment materials, which include Nylon 6 with rubbing method, photoaligned azo-dye layer SD1 and new photosensitive material from DIC, were investigated. The effects of alignment layer on contrast ratio, response time and switching of FLC are provided. Asymmetric boundary conditions, with only one of ITO surfaces is covered with the aligning layer while the other one is not, have been used for providing both high contrast ratio and defect free orientation. It is indicated that SD1 is suitable for FLC alignment, with which switching time of 65 μ s and contrast of 500:1 are obtained at room temperature, and switching time decreases with higher temperature.

1. Introduction

Recently, as the fast response and blur-free image become more demanding in the liquid crystal display (LCD) TV market, the ferroelectric liquid crystal display (FLCD) becomes a promising candidate to meet such a requirement [1]. Field sequential color (FSC) display is a method based on the temporal additive color formation. Compared to conventional color LCDs, which use color filters, the FSC-LCDs have the following potential advantages, such as high luminance, low power consumption, high resolution, and simplicity in the fabrication since no color filters are used and also simplicity in the driving circuit [2, 3]. The target LC cell response time for a field sequential color displays should be less than 1 ms (240 Hz frame frequency). Fast switching FLC display is a good candidate for the new generation of FSC-LCD, which is proved to be better in response time, than usually used nematic LC. One of the most crucial problems, which is usually faced in ferroelectric LCD such as quality of FLC alignment on sufficiently large surface area etc., can be effectively solved by a photo-alignment technology [4].

FLC were aligned with ordinary rubbing technique for many years [5]. However, due to its sensitivity to dust particles induced by rubbing, defects appears making difficult to get the good alignment quality and high contrast ratio [6]. In this study, in order to improve FLC alignment quality various kinds of aligning surface, rubbed film as well as photo-sensitive materials with different photo-alignment mechanisms were used.

2. Experiment

Asymmetric boundary conditions were used for modeling and manufacturing FLCs [7], shown in Figure 1. In this approach, only one indium tin oxide (ITO) surface of an FLC cell was covered with a photoaligning substance, while the other one was covered with 1.5 μ m spacers. FLC material of FD4004N (from DIC) was used. Electrooptical measurements were carried out using a conventional electrooptical setup based on He-Ne laser. A programmed generator was used for experimental simulating the multiplex operation.

Substrate
ITO
Alignment layer
FLC
ITO
Substrate

Figure 1 Schematic Drawing of an FLC cell with asymmetric boundaries

The following mechanisms of the photo-alignment are known [8]: (i) photochemical reversible cis-trans-isomerization in azo-dye containing polymers, monolayers and pure dye films; (ii) pure reorientation of the azo-dye chromophore molecules or azo-dye molecular solvates due to the diffusion under the action of polarized light; (iii) photo-crosslinking chemical reaction in side-chain polymers; (iv) photodegradation in polyimide materials. Photo-aligning ROLIC-like material from DIC is used in experiment. When the azo-dye molecules are optically pumped by a polarized light beam, the probability for the absorption is proportional to $\cos^2\theta$, where θ is the angle between the absorption oscillator of the azo-dye molecules and the polarization direction of the light (Figure 2).

Figure 2 Photo-induced order in photochemical stable azo-dye films. Above: the geometry of the effect; (b) Below: azo-dye molecule, having the absorption oscillator (chromophore) perpendicular to the long molecular axis

3. Result and Discussion

In order to obtain a good alignment quality, sufficiently strong azimuthal anchoring energy of the aligned layer should be obtained [9]. Figure 3 shows the relationship between temperature and contrast ratio of FLC with three different alignment layers. At room temperature, a contrast of 500:1 is obtained by SD1, while the contrast ratio for DIC material is less than 100, which is due to its poor anchoring energy.

Figure 3 Contrast ratio vs. temperature

From Figure 4, we can see that the response time of FD4004N tends to decrease with temperature increasing. Fast switching with less than 65 μ s response time is obtained with low voltage as 5 Volt. Figure 5 shows the relationship between switching angle of FLC driving voltage with different alignment methods. It is indicated that SD1 is more suitable for aligning FLC molecules because of its strong anchoring energy which is comparable to rubbing method, also it can avoid dust particle which is induced by rubbing.

Figure 4 Response time vs. temperature on fixed voltage

Figure 5 switching angle vs. voltage

4. Conclusion

In summary, parameters of FLC material FD4004N aligned with different method are provided. Photo-alignment technology can be used to provide low voltage fast response with this FLC material. The switching time of 65 μ s and contrast of 500:1 are obtained with azo dye photo-alignment material SD1 at room temperature, and switching time decreases with higher temperature.

5. Acknowledgements

This work is supported by financial support under grant CERG 612310 CERG 612 409 and CERG 612208.

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