Development of Fast Response Time 4.3-inch WVGA Fringe Field Switching Liquid Crystal Mode through Reactive Mesogen†

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Abstract

We fabricated 4.3-inch WVGA fringe-field switching mode with fast response time using reactive mesogen (RM) mixed in planar alignment layer. The RM-mixed alignment layer gave rise to improvement of the response time by an enhancement of azimuthal anchoring energy. In addition, due to low pretilt angle of the RM-mixed alignment layer, no gray inversion was observed.

Author Keywords

Reactive mesogen; Azimuthal anchoring energy; Fringe field switching; Response time

1. Introduction

The fringe field switching (FFS) liquid crystal display (LCD) mode in mobile display have been one of important modes because of its various merits such as high transmittance, wide viewing angle, and high resolution [1, 2]. However, the response time characteristic of FFS mode was not enough to realize moving pictures perfectly. So many efforts have been to improve the response time such as FFS electrode configuration, the rubbing angle, and LC material parameters. But, there have inevitable optimizing difficult of processes and material parameters [3, 4]. Recently, UV curable reactive mesogen (RM) was introduced to improve the response time characteristics by enhancement of the azimuthal anchoring energy. Escuti *et al*. [5] and Lim *et al*. [6] proposed fast response time in plane switching (IPS) mode and FFS mode using RM mixed in LC layer. Also we reported fast response time FFS mode using RM coated on planar alignment layer [7]. However, in case of mixing in LC system, residual RMs in LC would have influenced on reliability problems of display. In case of RM coating onto the planar alignment layer system, additional RM coating process is necessary after obtaining the alignment layer.

In this paper, we proposed fast response time FFS mode using RM mixed alignment layer for strong azimuthal anchoring energy and low pretilt angle. To confirm the electro optical characteristics, we fabricated the 4.3-inch WVGA (480×RGB×800) FFS mode panel for the first time in our knowledge and we could achieved not only the improvement of response time characteristic but also no gray inversion at all directions

2. Method and Result

For fabrication of the LC cell, the planar alignment material (AL16470, JSR) was mixed with RM (RM257, Merck) 1.0 wt.% and photo-initiator (IRGACURE 651, Chiba Chem.) 20 wt.% of the RM. The RM mixed alignment materials were coated on TFT and CF glass (370×470 mm) and then were cured. Then the surface was rubbed in antiparallel direction at 7° with respect to electrode and the cell was filled with LC material (MLC-0643, Merck, $\Delta\varepsilon = 6.9$, $\Delta n = 0.1023$) and the cell gap was maintained about 3.4 μm. After fabricating cell, the LC cell was exposed to the UV to polymerize the RM inside the alignment layer.

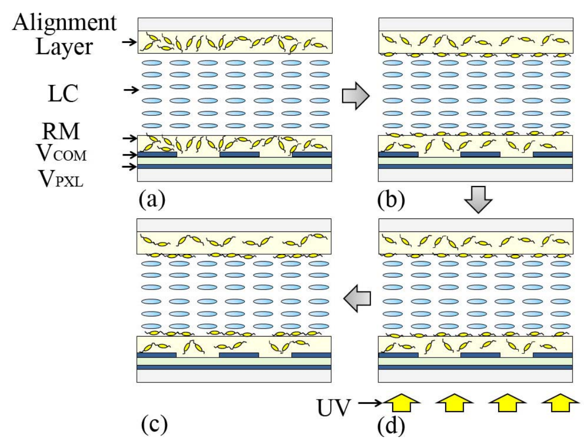
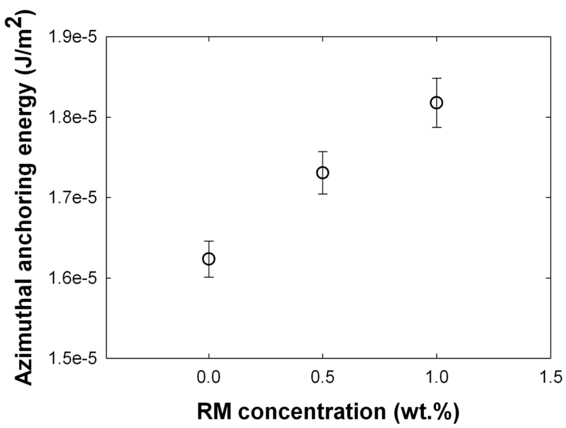


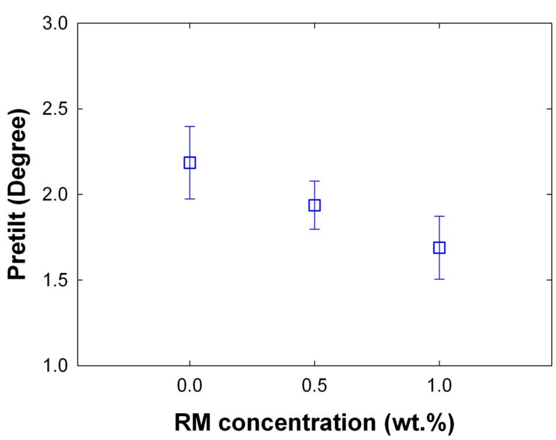
Figure 1. The schematic diagram of fabrication process of LC cell

Figure 1 shows the schematic diagram of fabrication process of LC cell. At an initial state, the LC molecules were aligned parallel to the rubbing direction and RMs were distributed randomly in the alignment layer as shown in Fig. 1(a) and then RMs were re-oriented along LC molecules in Fig. 1(b) because RMs were dissolved in the LC and movable due to the liquid crystalline property of RM. Then, the LC cell was exposed to the UV light (UV intensity: 9.9 J/cm^2, λ = 365 nm) [Fig. 1(c)], RMs were polymerized on surface and in bulk of alignment layer in Fig. 1(d). The size of the fabricated panel was 4.3 inch and size of the sub-pixel was 39 μm × 117 μm, and color gamut was 72 %.

It is well known that the strong azimuthal anchoring energy was contributed to fast response time and also low pretilt angle [8, 9]. To indicate the anchoring energy properties of the RM mixed alignment layer system, we measured the azimuthal anchoring energy of the surface by varying the concentration of RM. The azimuthal anchoring energy was enhanced as a function of RM concentration mixed in alignment layer as shown in fig. 2(a). The azimuthal anchoring energy was increased to 1.73×10^{-5} J/m^2 (RM 0.5 wt.%) and 1.82×10^{-5} J/m^2 (RM 1.0 wt.%) as compared to 1.62×10^{-5} J/m^2 (without RM). We think that azimuthal anchoring energy is enhanced since the interaction between LC and RM is stronger than that of LC and PI. And pretilt angle also was remarkable reduced from 2.25° (without RM) to 1.90° (RM 0.5 wt.%) and 1.58° (RM 1.0 wt.%) as shown in Fig. 2(b).



(a)

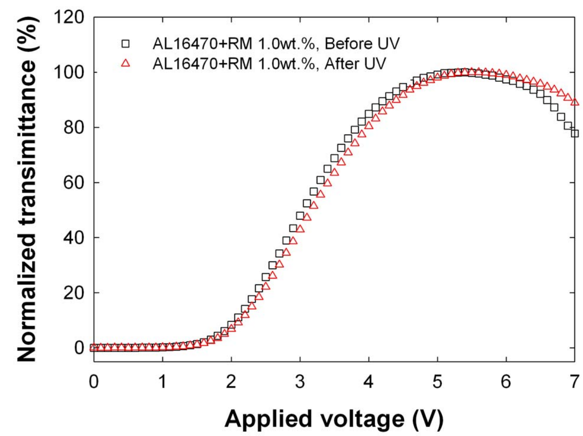


(b)

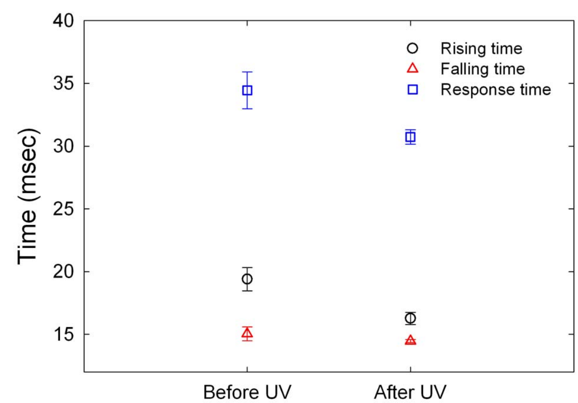
Figure 2. (a) Measured azimuthal anchoring energy and (b) pretilt angle as a function of RM concentration mixed in planar alignment layer

Figure 3 shows the measured voltage-transmittance (*V-T*) characteristic [Fig. 3(a)] and on/off response time characteristic [Fig. 3(b)] of fabricated 4.3-inch WVGA FFS mode panel comparing to before and after RM UV curing. After UV curing of the RMs, *V-T* curve shifted to right and threshold voltage (V_{th}) was increased.

This phenomenon indicated that azimuthal anchoring energy was enhanced during RM UV curing process as shown Fig. 3(a). And both rising time and falling time after RM UV curing were faster than that before RM UV curing. Response time could be improved about 11% compare to before RM UV curing as shown in Fig. 3(b). We think that improvement of falling time was dependent on enhancement of azimuthal anchoring energy and rising time was dependent on LC ordering stabilization induced strong azimuthal anchoring energy.



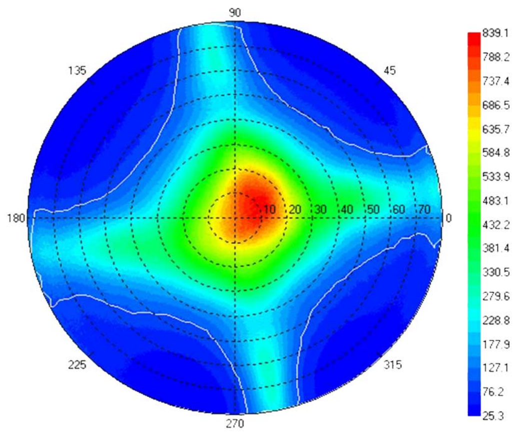
(a)



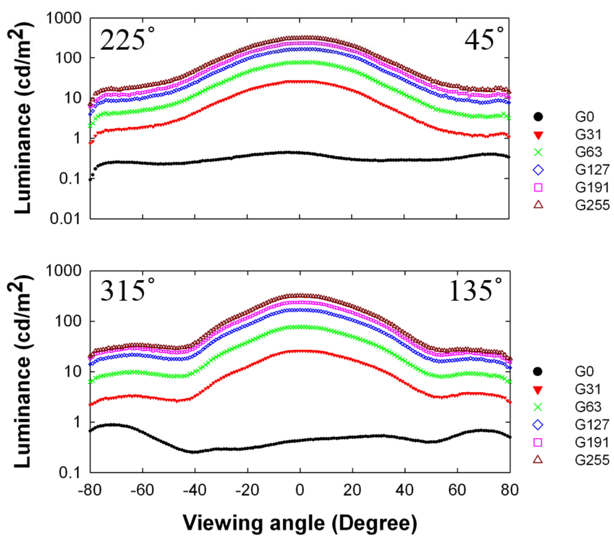
(b)

Figure 3. (a) Measured voltage-transmittance characteristic and (b) on/off response time of 4.3-inch WVGA FFS mode panel before and after UV curing respectively

Figure 4 shows the measured viewing angle characteristic of fabricated 4.3-inch WVGA FFS mode panel with optical compensation film. The viewing angles (CR=100:1) were 80°/80°/80°/62° (right/left/up/down) as shown in Fig. 4(a). However, considering rubbing direction, view angle of down was above 80°. Especially, low gray inversion could not be observed at the off axis due to low pretilt as shown in Fig. 4(b).



(a)



(b)

Figure 4. Viewing angle characteristics of fabricated 4.3-inch FFS mode panel using RM mixed alignment layer: (a) iso-contrast (white line was 100:1 of CR), (b) cross sectional luminance of each gray at the off axis, respectively

3. Conclusion

We fabricated the real panel of 4.3-inch WVGA FFS mode using RM mixed alignment layer for the first time as shown in fig. 5. By achieving strong azimuthal anchoring energy and low pretilt using RM, we made proto-type mobile display FFS panel with fast response time and no gray inversion at any direction without any other properties reduction. We expect that our proposed alignment method is simple and available in real devices.

(a)

Item	Specification	Remark
Size(Active area)	4.3 inch (56.16mm X 93.60 mm)	
Resolution	480 X RGB X 800	217PPI
Dot size	0.039mm X 0.117mm	217PPI
View angle(U/D/L/R)	80/80/80/80	CR ≥ 10:1
Color gamut	72%	CF only

(b)

Figure 5. (a) Picture and (b) specification of the 4.3-inch WVGA FFS sample using RM mixed alignment layer

4. Acknowledgements

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5. References

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