Fast Switching Four-Domain Twisted Nematic Mode Using Reactive Mesogen

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Abstract

We proposed a method to improve the response time of the four-domain twisted nematic (TN) structure through surface modification using photo-curable reactive mesogen. In our structure, we improved a response time characteristic of the four-domain TN structure dramatically, especially in falling time.

1. Introduction

Nowadays liquid crystal displays (LCDs) have been widely used in practical applications. Many kinds of LCD modes have been reported such as the twisted nematic mode (TN)[1], fringe field switching mode (FFS)[2], optically compensated bend mode (OCB)[3], in-plane switching mode (IPS)[4] and patterned vertical alignment mode (PVA)[5] to improve the properties of LCDs. Among these various LCD modes, particularly, the TN mode is widely used due to its very stable structure, low operation voltage, simple fabrication process and wide process margin and so on. However, it is hardly used in the large size or high performance required displays because TN mode has a drawback such as narrow viewing angle characteristic. To overcome this obstacle, four-domain TN structure was suggested and the improvement of the viewing angle characteristic is explicitly visible[6-7]. However, its response time is very slow than conventional one domain TN mode because this structure has different twist sense in one pixel without chiral dopant. Thus, the four-domain TN structure is not suitable for realizing high quality moving picture although it has superior viewing angle characteristics.

In this paper, we proposed the method for improving response time of the four-domain TN structure through surface modification using photo-curable reactive mesogen (RM). The polymerized RMs strengthen the anchoring energy of the four-domain TN structure. As a result, we could get a fast response time characteristic compared with the conventional four-domain TN cell.

2. Experimental

Figure 1 shows the layer structure of the proposed four-domain TN mode base on the surface modification using RM. It needs high pre-tilt angle to obtain stable four-domain TN structure[6] and we realized the high pre-tilt angle by using stacked alignment layer[8] and we mixed RM monomers in the diluted vertical alignment layer to improve response time.

We spin coated planar alignment layer (SE-7492 from Nissan) on the ITO coated glass and then spin coated the diluted vertical alignment layer which consists of 3.17 wt% vertical alignment layer (AL-1H659 from JSR), 95.83 wt% solvent (n-methyl-pyrrolidone : buthyrolactone : butoxyethanol = 3:4:3) and 1 wt% RM monomers on the unrubbed planar alignment layer. After polyimide (PI) coating step, we carried out reverse rubbing process to obtain four-domain TN structure by using rubbing mask (SUS, 150 μm spacing, 30 μm thickness) and then substrates assembled perpendicular to each other. This structure has two right handed and two left handed sub-pixels[6]. This structure could bring optical compensation and provides good viewing angle characteristics.

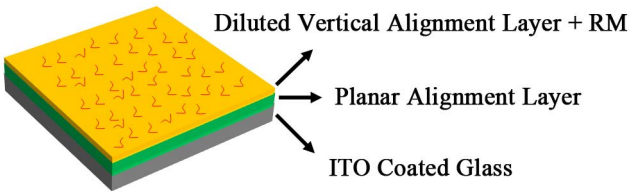


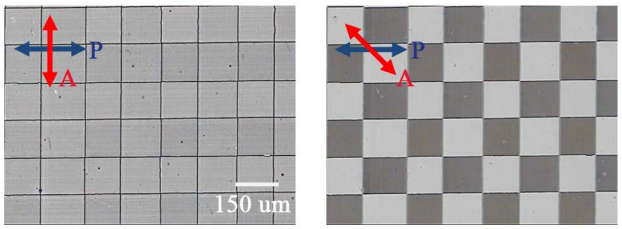
Fig.1. The schematic diagram of the proposed stacked alignment layer using RM

For electro-optical performance measurement, test cells of the thickness 5μm were filled with nematic LC (from

Merck, Δε = 7.8, Δn = 0.1114). The cell configuration satisfies the first maximum conditions given by Gooch - Tarry equation. Then, we conducted UV cure process under critical applied voltage to polymerize the RM monomers.

3. Results and discussion

According to theoretical model[6], the minimum pre-tilt angle to obtain stable four-domain TN structure is 18.6° in our cell parameters (cell gap = 5 μm, sub-pixel length = 150 μm). The used pre-tilt angle in our stacked alignment system is 21° and it is sufficient to obtain stable four-domain TN structure. Figure 2 shows the microscopic images of the four-domain TN structure using RM. This structure is stable at even 0V. As shown in Fig. 2(b), the four-domain TN structure has two right handed sub-pixels and two left handed sub-pixels.



(a) (b)

Fig.2. Microscopic images of the four-domain TN cell using RM under (a) 90 ° crossed polarizer and analyzer, (b) 45 ° crossed polarizer and analyzer

Figure 3 compares the response time of the stable four-domain TN cell with RM. Because the conventional four-domain TN structure has two kinds of twist sense in sub-pixels, its response time is very slow than conventional one-domain TN, especially in falling time. The RM monomers in the diluted vertical PI are polymerized along the LC directors by processing UV exposure under critical applied voltage[9]. The result explicitly indicates that RM affect the response time of the four-domain TN cell. In fact, the falling time of RM free cell is 47.77 ms and that of RM adding cell is 26.04 ms at 10 V.

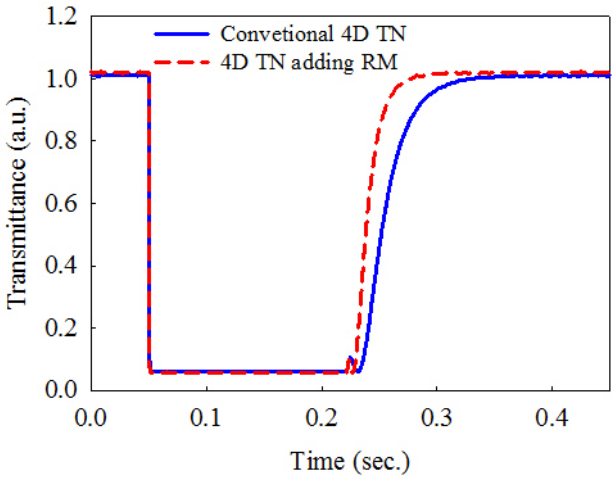


Fig.3. Response time of the four-domain TN cell

4. Summary

In this paper, we proposed a fast switching four-domain TN structure by using photo-curable reactive mesogen (RM). The polymerized RMs strengthen the anchoring energy of the four-domain TN cell. As a result, the falling time of the four-domain TN with RM is faster than that of conventional four-domain TN cell.

5. References

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