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The Response Time of Vertical Aligned LC mode by stacking Alignment Layer

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We study on the effect of stacked alignment layer on the response time of vertical alignment (VA) mode. The response time characteristic of the rubbed VA mode is dramatically improved by adopting the stacked alignment system in high field region due to the enhanced azimuthal anchoring energy.

1. Introduction

The liquid crystal Display (LCD)'s electro-optical characteristics are important to realize the high quality images. However, LC molecule's response time is one of the significant characteristics in LCD. There are lots of researches to improve the response time of the vertical alignment (VA) mode such as pre-charging method [1], over-driving method [2] and guest-host system with reactive mesogen [3]. Those kinds of method have several disadvantages. Therefore we focused on the surface modification to improve the response time of VA mode. In this paper, we study on the effects of stacked alignment layer to the response time of VA mode. By comparing the anchoring energy of the surface and response time of the LC, we will explain the change of the response time.

2. Experimental

To fabricate the LC cell, the various conditions to control the thickness of the vertical alignment layer was chosen. As a planar layer, we spin coated the SE7492 (Nissan Chem.) onto cleaned indium-tin-oxide (ITO) glass substrate. Then we spin coated the diluted vertical alignment material with various conditions (5, 7, 10, 20 wt.% with solvent) onto the substrate as a second layer. The top and bottom substrates were rubbed and assembled in anti-parallel direction. The 3μm glass spacers were used to maintain the cell gap.

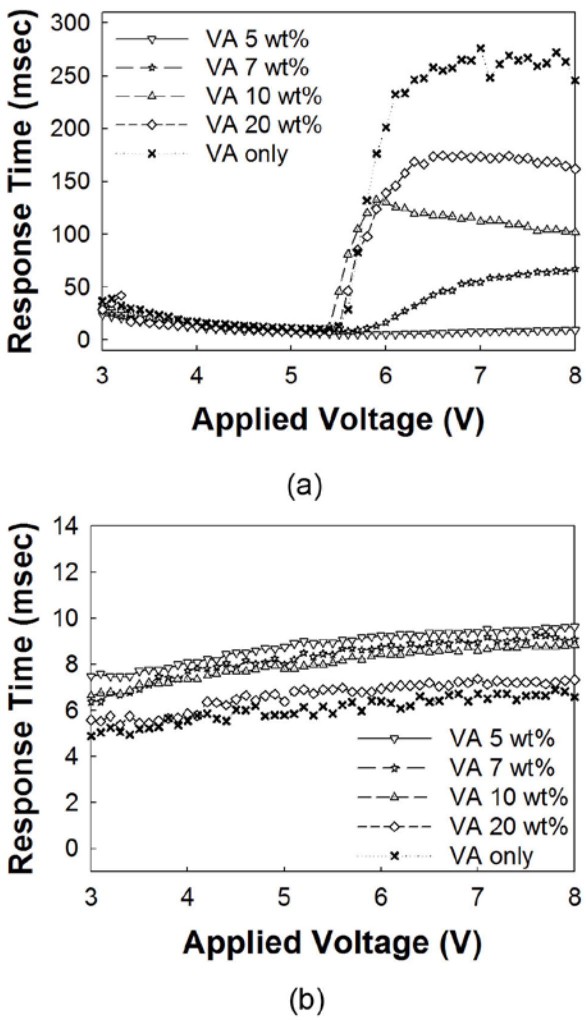

Figure 1. The response time characteristics of the stacked VA mode by changing the thickness of the vertical alignment layer

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3. Results

We measured the response time as a function of the applied voltage. Then we divided the vertical alignment layer as shown in figure. 1 into various stacked alignments layers with different thicknesses. In relatively low electric field region, since the electric field is relatively weak the response times of the rising process are almost same in all conditions. However, in relatively high field region, the response time is increased dramatically except for VA 5 wt% case because of the reorientation process of LCs with high field. Conventionally, the LC molecules cannot define the azimuthal direction directly due to the weak azimuthal anchoring energy when the high electric field induced to the VA mode. Therefore, it takes long time to obtain the stable LC molecules at the high field region (> 5.5 V). The rising process was mostly governed by the azimuthal anchoring energy in the stacked alignment layer system [4, 5]. Therefore, the thickness of the VA layer getting thinner, the layer generates stronger azimuthal anchoring energy because of the planar alignment layer.

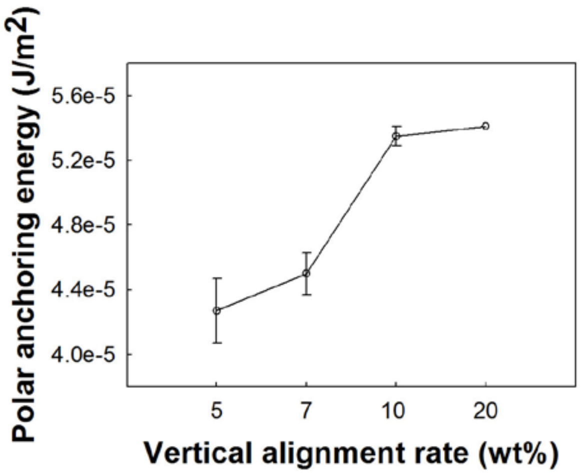

Figure 2. Measured polar anchoring energy of the stacked VA mode by changing the thickness of the vertical alignment layer

In the falling process, the response time is gradually decreases with increase of the concentration of the VA material. Here, the polar anchoring energy contributes to the falling time. We measured the polar anchoring energy of the surface to investigate the effect of the thickness of VA in the stacked alignment layers on the falling response. We used the modified high field method by measuring capacitance change in high field region, to measure the polar anchoring energy. The relation between falling time of the LC molecules and the polar anchoring energy are expressed. [6]

$$W \approx \frac{4\gamma_1 d}{\tau_0 \pi^2}$$

Where W is the polar anchoring energy of the surface, γ_1 is rotational viscosity, d is the cell gap, and τ_0 is the falling time.

As we expected, by increasing the thickness of the vertical alignment layer as shown in Figure. 2 the polar anchoring energy of the surface is increased. Therefore, the restoring force can be decreased in case of the lower wt.%. We can also obtain that the tendency of the falling time is perfectly matched with in 10 % error boundary by calculating the falling time by the above equation.

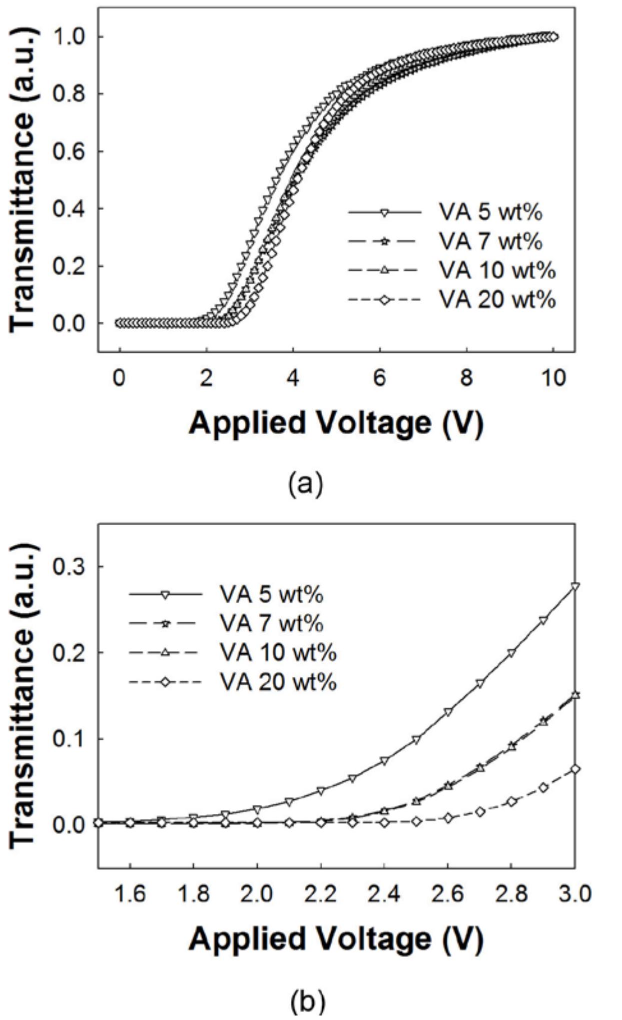

Figure 3. Measured (a) voltage transmittance characteristics of the various fabricate conditions

Figure 3 shows the voltage transmittance characteristics of the fabricated sample. The pretilt angle and polar anchoring energy strongly influence the voltage transmittance curves. The pretilt angle of the each condition is almost same about 87°. Therefore, sample condition with relatively weak polar anchoring energy exhibits the lower threshold voltage as shown in fig. 3(a). Figure 3(b) shows the expanded voltage transmittance curves of the fig. 3(a). The inverted triangle symbol case (5 wt.%) shows the threshold voltage about 1.6 V and diamond symbol shows the threshold voltage about 2.2 V.

4. Conclusion

We studied the effect of stacked alignment layer on the response time of the VA mode. The response time characteristics are improved in rising time due to increased azimuthal anchoring energy. The falling times are little bit increased due to the reduced polar anchoring energy. We can improve the response time characteristics by adopting this method to the rubbingless or photo-aligned VA mode.

5. Acknowledgements

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