Effect of Stacked Alignment Layer to the Response Time of Vertical Aligned LC Mode

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ABSTRACT

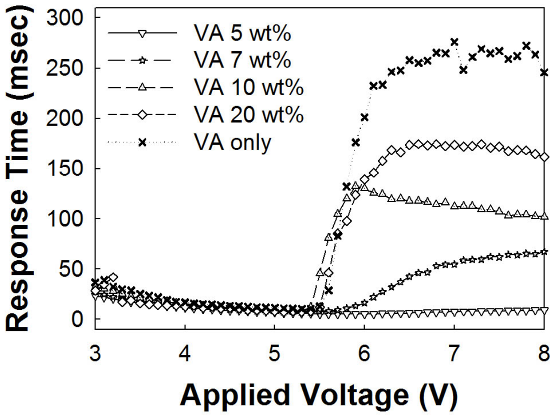
We study on the effect of stacked alignment layer on the response time of vertical alignment (VA) mode. The response time characteristic of the rubbed VA mode is dramatically improved by adopting the stacked alignment system in high field region due to the enhanced azimuthal anchoring energy.

1. INTRODUCTION

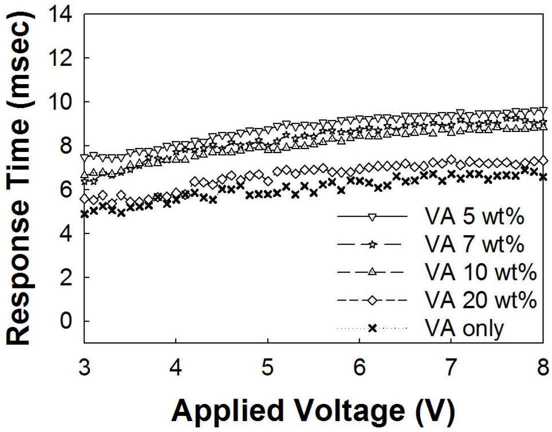
The electro-optical characteristics of the liquid crystal display (LCD) play an important role to represent the high quality images. Among them, the response time of the LC molecule is one of the important characteristics to represent the moving pictures or 3-D applications. There are many researches to improve the response time characteristics 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 some disadvantages about complex driving scheme and image sticking due to the residual reactive mesogens in bulk area. We can expect that the best way to improve the response time of the VA mode is the surface modification. In this paper, we study on the effect of the stacked alignment on the response time of the VA mode. By comparison of the measured 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, we choose the various conditions to control the thickness of the vertical alignment layer. We spin coated the SE7492 (Nissan Chem.) as a planar layer onto cleaned indium-tin-oxide (ITO) glass substrate. The diluted vertical alignment material with various conditions (5, 7, 10, 20 wt.% with solvent) were spin coated onto the substrate as a second layer. The top and bottom substrates were rubbed and assembled in anti-parallel direction. The cell gap was maintained 3 μm with the glass spacers.



(a)



(b)

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

3. RESULT

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

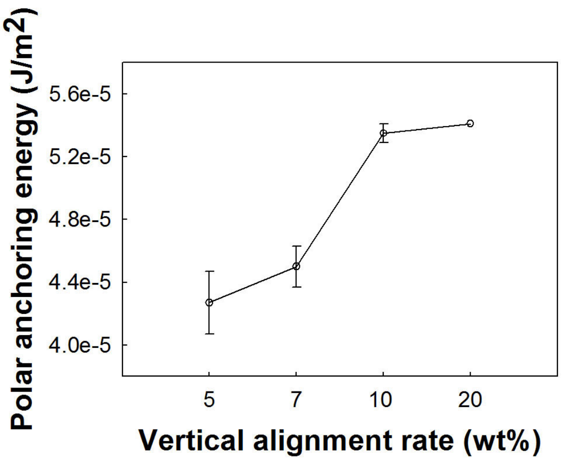


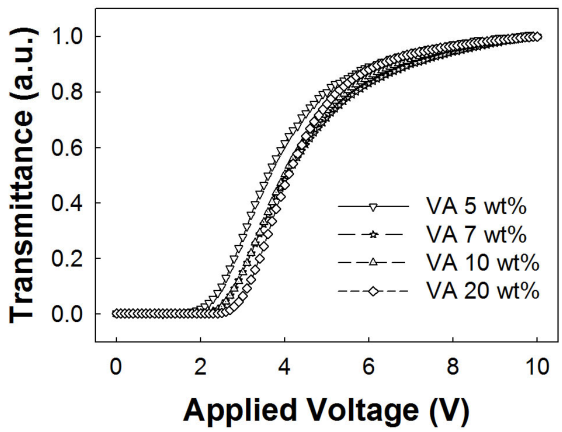
Fig. 2 Measured polar anchoring energy of the stacked VA mode by changing the thickness of the vertical alignment layer

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

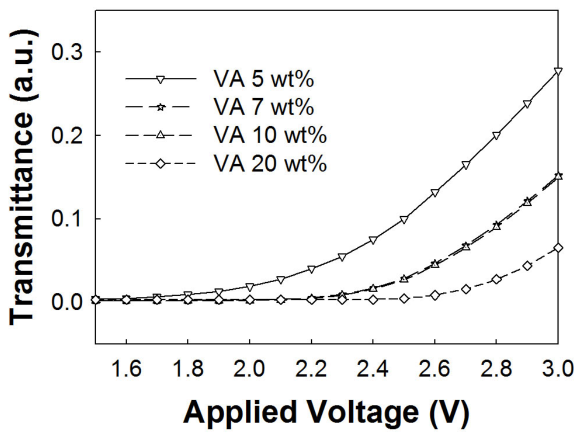
$$W \approx \frac{4\gamma_1 d}{\tau_0 \pi^2}$$

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



(a)



(b)

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

Figure 3 shows the voltage transmittance characteristics of the fabricated sample. The voltage transmittance curves are strongly influenced by the pretilt angle and polar anchoring energy. The pretilt angle of the each case 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 round symbol case (5 wt.%) shows the threshold voltage about 1.6 V and hexagon symbol shows the threshold voltage about 2.2 V.

4. CONCLUSIONS

We investigated 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 and falling times are little bit increased due to the reduced polar anchoring energy. We expect that we can adopt this method to the rubbingless or photo-aligned VA mode for improving response time characteristics.

5. ACKNOWLEDGE

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