Effect of the polymer wall boundary condition on the dynamic and memory behavior of the ferroelectric liquid crystal

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Abstract

In this research, we examined the correlation between the polymer wall boundary condition and the dynamic/ memory behavior of the ferroelectric liquid crystal (FLC) molecules. It was shown that the polymer wall perpendicular to the rubbing direction induces asymmetric switching to the rubbing direction and induce smaller cone angle angle of LC. On the contrary, in the cell with polymer wall parallel to the rubbing direction, the FLC molecules are oriented in the rubbing direction and shows symmetric switching and has larger cone angle. Memory behavior of each cell has strong correlation with the dynamic state of the FLC molecules. Response time of each cell was also examined.

1. Introduction

Studying the microscopic behavior of liquid crystal molecules under micron-sized boundary condition is very important and interesting physical problem. Especially, in the flexible liquid crystal display area, the polymer wall fabrication method to enhance the mechanical stability of display draws much attention. Hence, the correlation between the polymer wall boundary condition and the switching behavior of liquid crystal molecules becomes important issue to be identified.

In this report, we examined the effect of the polymer wall boundary condition on the dynamic and memory behavior of the FLC molecules. We measured birefringence, tilt angle and the conic angle of the cell to understand the microscopic picture of the dynamic and memory operation of FLC. Response time of each cell was also measured.

2. Results

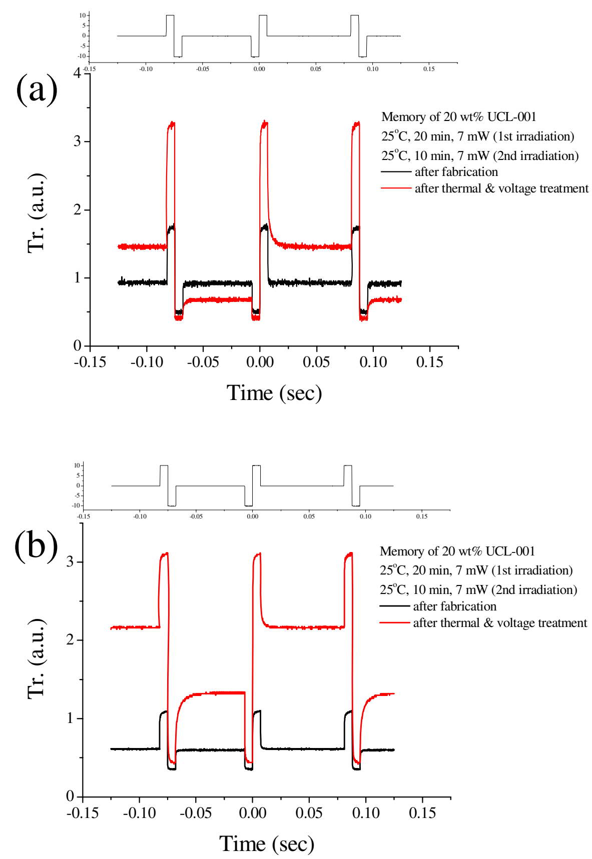

Figure 1. Electro-optical response of the cell with polymer wall perpendicular (a) or parallel (b) to the rubbing direction.

Figure 1 shows the dynamic and memory behavior of the cell with polymer wall perpendicular [Fig. 1 (a)] or parallel [Fig. 1 (b)] to the rubbing direction. Notice that the bi-stable memory state of the optical transmittance of former cell is lower than that of the latter one. The polarizer was set to be parallel to the optic axis of the cell at negative maximum voltage (-10V) applied state. Therefore, this result means that the optic axis of the former sample at memory state is more tilted to the rubbing direction. On the contrary, the memory state transmittance of the sample with polymer wall parallel to the rubbing direction is shown at the intermediate value of maximum transmittance. This means that the optic axis of the sample at memory state is oriented at near the rubbing direction.

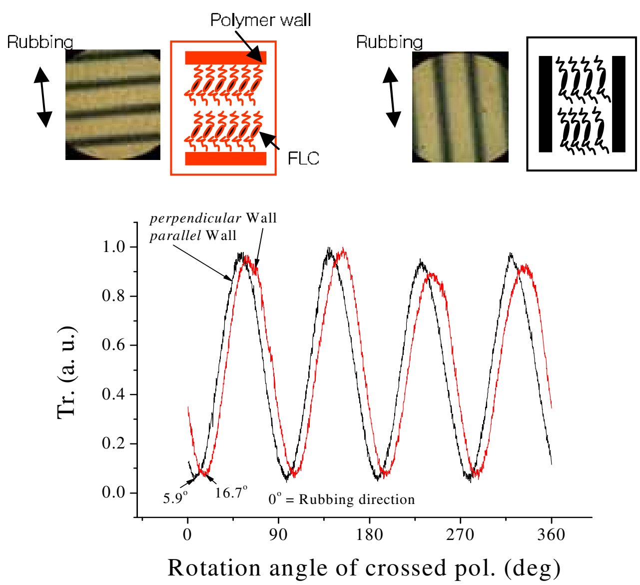

Figure 2. Optical birefringence of the cell with polymer wall perpendicular or parallel to the rubbing direction at field off state.

Figure 2 shows the optical birefringence of the cell after fabrication. The optic axis of the sample with polymer wall perpendicular to the rubbing direction is 16.5° and that of the sample with parallel wall is 5.9°. This result means that the former sample is more tilted initially than the latter one [see the schematic illustration of the cell in Fig. 2]. This may be due to the stronger anchoring of the wall boundary to the FLC molecules in the cell with parallel wall than the one with perpendicular wall. This result is reasonable if one consider the fact that anchoring to the rigid core body of FLC is stronger than that to the flexible aliphatic chains.

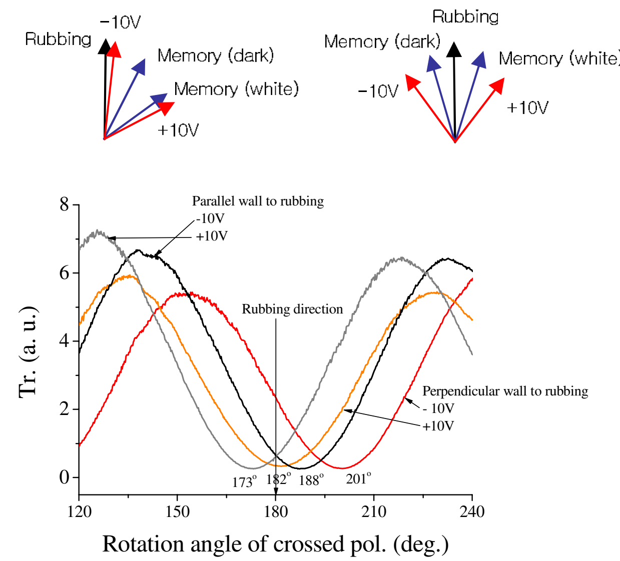

Figure 3. Optical birefringence of the cell with polymer wall perpendicular or parallel to the rubbing direction at field on state.

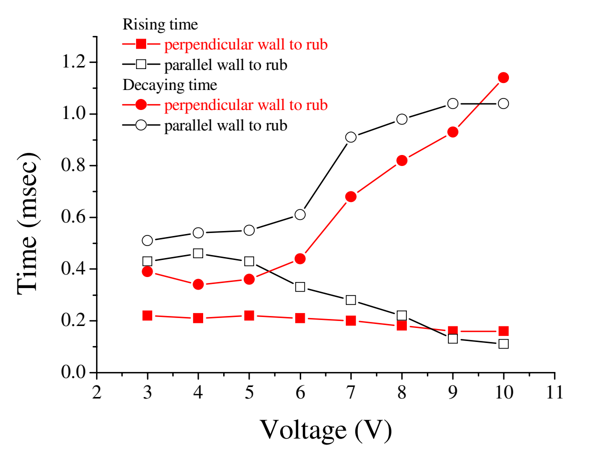

Figure 4. Rising and decaying time of the cell with polymer wall perpendicular or parallel to the rubbing direction.

We have also examined the orientation of the FLC molecules of each sample with field on state. Figure 3 shows the birefringence of the sample under each dc electric field. It is shown that the optic axis of the field-induced bi-stable state is clearly different between them. The cell with perpendicular wall switches asymmetrically to the rubbing direction with relatively small conic angle. On the other hand, the cell with parallel wall switches symmetrically to the rubbing direction with relatively large cone angle [see the schematic illustration of FLC orientation in Fig. 3]

We have also examined the response time of each cell. In the regime of the applied voltage less than 10V, the cell with perpendicular wall showed faster rising and decaying time. It may be due to the different anchoring strength of the polymer wall with different direction.

3. Conclusion

This report shows that the correlation between the polymer wall boundary condition and dynamic/memory behavior of the FLC molecules. This result could suggest a helpful advice on the way of the dynamic or memory application of FLC display devices and also help to understand microscopic behavior of liquid crystal molecules under specific morphology of micron-sized boundary conditions.

4. Acknowledgements

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5. References

[1] H. Sato, H. Fujikake, H. Kikuchi and T. Kurita, Jpn. J. Appl. Phys. **42** L476 (2003)

[2] J. H. Lee, O. S. Son, C. W. Jang and T. K. Lim, Jpn. J. Appl. Phys. **44** 7528 (2005)

[3] J. H. Lee, T. K. Lim, Y. W. Kwon and J. I. Jin, J. Appl. Phys. **97** 084907 (2005)

[4] J. H. Lee, T. K. Lim, Y. W. Kwon, J. I. Jin, S. B. Kwon and S. T. Shin, Jpn. J. Appl. Phys. *in press* (2006)