Orientational deformation of ferroelectric liquid crystal molecules by bending performance of plastic substrate

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Abstract

We have examined the aspects of the orientational ordering deformation of ferroelectric liquid crystal during bending performance of plastic substrate by analyzing the polarizing optical microscope texture and the birefringence of the cell. Striped texture becomes more prominent as the radius of curvature of substrate gets smaller. The optic axis of the adjacent stripes domain was not same and the relative angle between them becomes larger as the radius of curvature gets smaller. Especially, the optic axis rotation angle of one domain was lager than the other and the liquid crystal molecules in each domain became more coherent. In addition, the birefringence data with obliquely incident light shows the polar direction shift of liquid crystal molecule by bending performance.

1. Introduction

In recent years, the flexible display using organic substrate has been studied actively because of the portability, low cost and easy approach procedure [1-3]. However the tolerance of the liquid crystal fluid against external torsion is a serious problem to gain a sufficient reliability [4-5]. Especially for the ferroelectric liquid crystal which has high viscosity and weak mechanical tolerance, it is an inevitable obstacle obviously for the purpose of display application.

We have examined the detailed aspects of the ferroelectric liquid crystal deformation against the bending performance of the substrate by the polarizing optical microscope and the birefringence data.

2. Experiment

Indium-tin-oxide (ITO) deposited PES (Poly-ether-sulfone) substrate with 120 ㎛ thickness was used as substrate. Polyimide solution AL-3046 (JSR) was spun on and baked at 180 ℃ for 2 hours. Rubbing direction were antiparallel and the gap was 2 ㎛. The commercial FLC FELIX 018/100 (Clariant) was used.

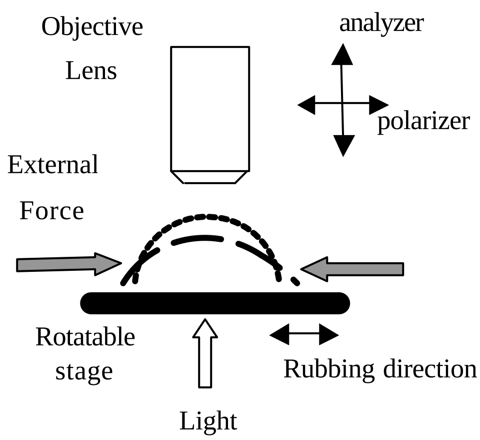

Figure 1: Schematic illustration of the experimental setup for measuring the microscopic textures of the cell at each radius of curvature of the substrate.

Microscopic texture was observed by polarizing optical microscope (POM) at each radius of curvature of the substrate as suggested in figure 1. External force was applied in the rubbing direction to bend the substrate. Birefringence of the sample was measured for the 632 ㎚ laser beam as a function of the rotation angle of crossed polarizers.

3. Results and Discussion

Figure 2 shows the POM texture of the FLC cell at each bent states. It can be easily recognized that the sample with initially striped texture becomes more prominent stripe domains as the radius of curvature of the substrate get shortened. The width of each striped domain and the contrast between adjacent domains was increased.

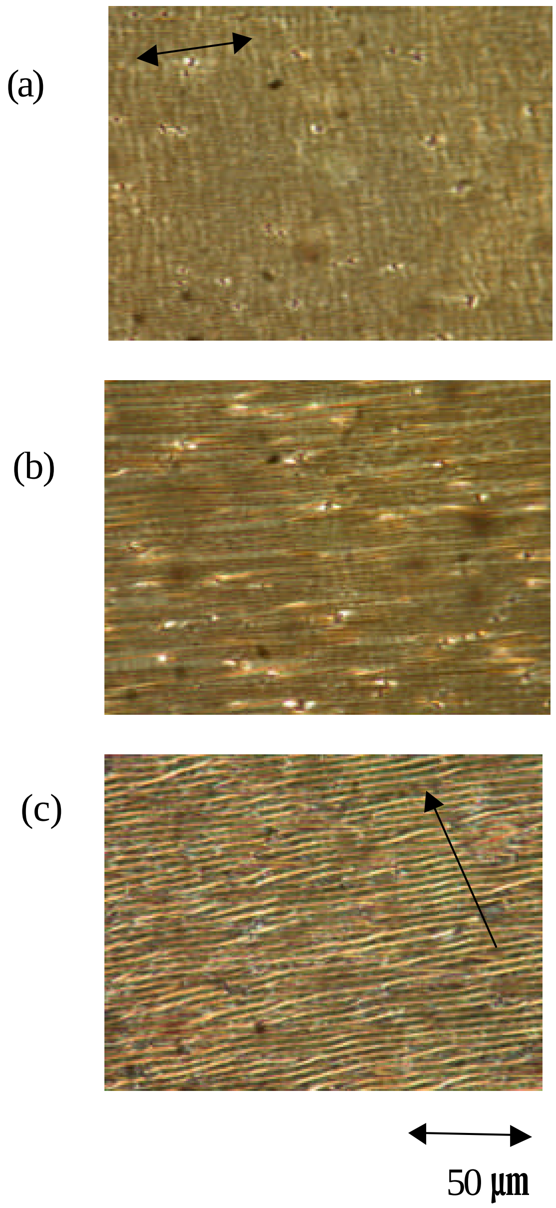

Figure 2: POM textures of the cell at initial state (a), bent state with the radius of curvature of 42 μm (b), and that of 30 μm (c).

The optic axis of neighboring black and white domains in figure 1 was measured at each bent states [Fig. 3]. The zero degree in y axis means rubbing direction of the cell. The optic axis of adjacent domains gets widen and one domain rotates more than another one.

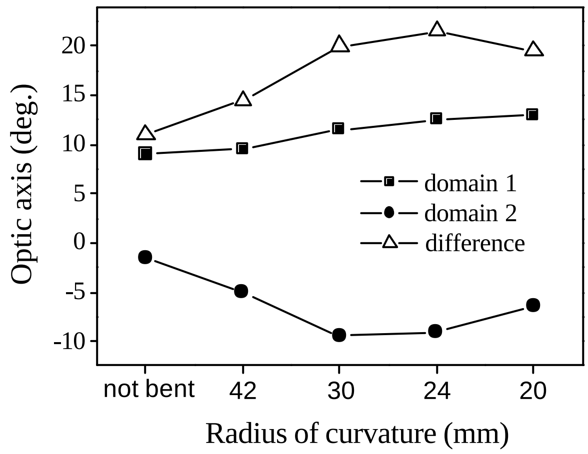

Figure 3: Optic axis of adjacent striped domains and the difference between them as a function of the radius of curvature of the plastic substrate.

Intensity to the stripe normal direction obtained from the optical textures of the cell is shown in figure 4. The contrast between adjacent domains increased as the radius of curvature was shortened. This means that the liquid crystal molecules in each domain became more coherent by bending of the substrate. In addition, the intensity of full width at half maximum (FWHM) at each radius of curvature increased and this means that the width of striped domain was also increased.

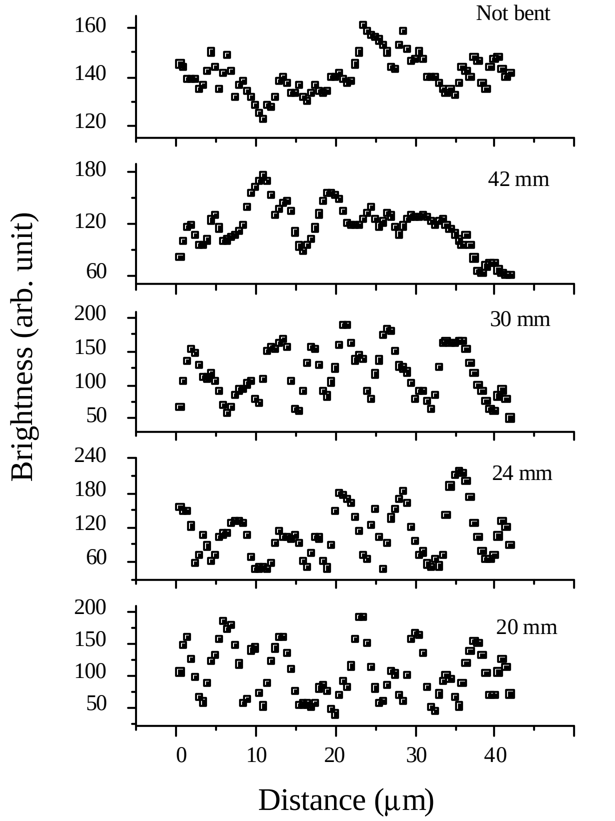

Figure 4: Brightness of the adjacent striped domains at each bent state.

We have also examined the birefringence of the cell at each bent state [Fig. 5 (a)]. As the radius of curvature gets shortened, the maximum transmittance decreases but the minimum transmittance does not change. This result means that the maximum optical anisotropy decreases but the minimum one does not. If the half number of LC molecules rotates in some direction and the last half ones rotates in opposite direction as suggested in figure 3, the maximum value of optical anisotropy should be decreased but the minimum one does not change. Therefore the birefringence data confirms the results of the POM texture observation. Moreover, if the rotation angle of each half one is not same, the average optic axis will rotate in one direction. As is seen in figure 5, the optic axis of the sample rotates in one direction. Therefore, it is confirmed that the wideness of the optic axis and the asymmetric optic axis rotation of adjacent striped domains.

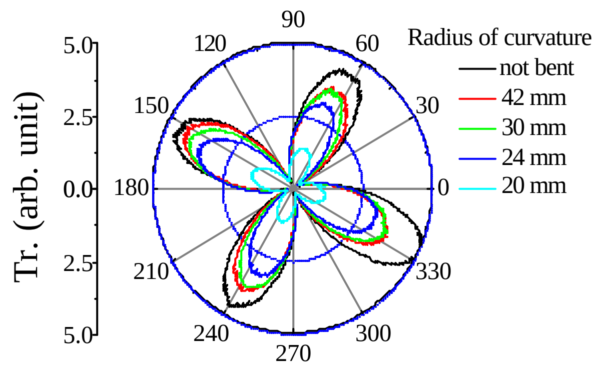

Figure 5: Birefringence at each bent state.

Next, we examined the change of the optic axis in polar direction by measuring the birefringence for the obliquely incident light. As suggested in figure 6 (a), the angle where the maximum optical anisotropy is shown at the zero incident angle, i.e. normal incidence. On the other hand, for the cell which was fully bent, that was found at the 30 degree of incident angle. This means that the polar angle of the optic axis of liquid crystal molecules increase as the substrate was bent.

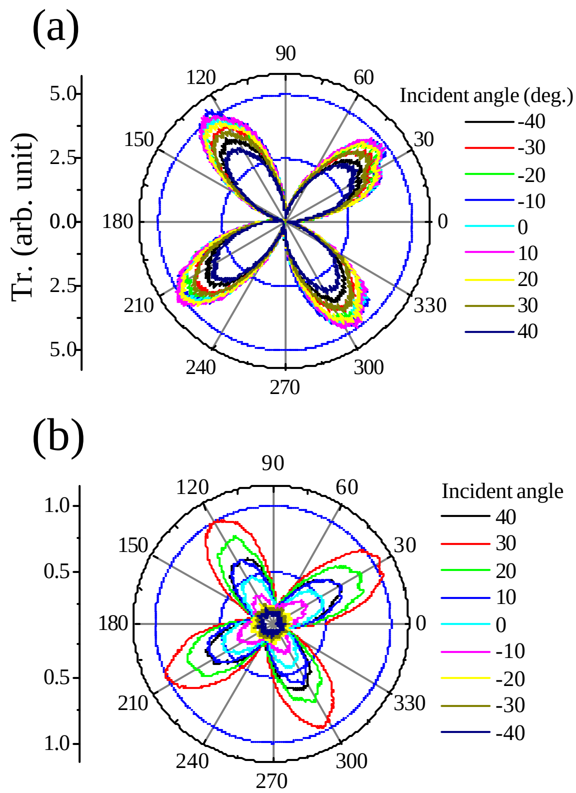

Figure 6: Birefringence for the obliquely incident light at each incident angle before bending (a) and after bending (b).

4. Conclusion

Detailed aspects of the ferroelectric liquid crystal deformation while the flexible substrate was being bent were demonstrated by polarizing optical microscope texture and off-axis birefringence data. It can help further study of liquid crystal display conducting plastic substrate. The exact mechanism between the director deformation and external perturbation can be explained by comparing the macroscopic fluid flow and microscopic molecular shape. The process to interpret the exact relation between them is undergoing. These results can be used as a precedent data for the flexible display application.

5. References

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