Optical Performance of Bent Polymer Network Liquid Crystal Films Using Plastic Substrates

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Abstract

We have studied the optical performance of flexible polymer network liquid crystal (PNLC) films at various bending states. Different measurement setups, wide and narrow opening angles of detector, were used to collect scatting light of PNLC films. The optical and dynamic properties of bent PNLC implied the change of LC domains.

1. Introduction

Recently, flexible liquid crystal (LC) display technology has been paid much attention to its unique properties, such as light-weight, curved, and roll-up portable products. For various LC technologies, polymer network liquid crystal (PNLC) is suitable for developing flexible displays because it requires no polarisers and has a high tolerance for the non-uniform birefringence of plastic substrates[1]. However, scattering characteristics of flexible PNLC films under bending is needed to be studied to develop flexible displays. In this work, we measured and analysed the electro-optical properties of bent flexible PNLC films.

2. Results

The schematic structure of PNLC film is shown in Figure1. 125-μm-thick films of Indium Tin Oxides (ITO) coated Polyester (PET) films were used as substrates. The spacers with 8 μm height were formed by roll-to-roll screen printing process, then, LCs and monomer composite materials were coated between two substrates. After UV exposure, the PNLC film was fabricated due to polymerization-induced phase separation mechanism. Because of none alignment layers inside, both the LCs and polymer had random orientations so as to induce scattering effect. The total thickness of the PNLC film was about 260 μm.

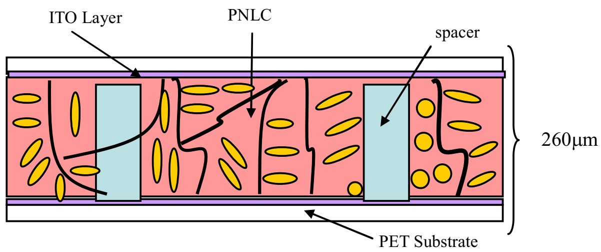

Fig. 1. Cross-sectional view of PNLC films

Otsuka LCD5100 was used to measure the optical performances of PNLC films in this experiment. Here two opening angles of the detector, 15.3° and 3.5°, were chosen as shown in figure 2. The 2 mm^2 measured area on PNLC film was defined by two pieces of opaque instruments. Figure 3(a) and 3(b) show the transmittance versus voltages (T-V) curves detected by different opening angles of detector. The PNLC film was bent at various curvature radius R in order, *e.g* flat state, R = 7.5 cm, R = 5 cm, returned to flat state again. The threshold voltages of PNLC films were low and didn't change when bending. In addition, comparing the T-V curves of flat PNLC films before and after bending, there is no obviously difference between them. For narrow opening angles (3.5°) measurement as Figure 3(a), bending effect made the transmittance of PNLC films to enhance from 45 % to 52 % at 5 V_{rms}. However, the enhancement of T-V curves wasn't observed from wide opening angles (15.3°) measurement as Figure

3(b). Table 1 shows the response time of bent PNLC films. After bending, the 13 % decrease of rising time was observed but the falling time was always kept approximately 230 ms at 10 V_{rms} regardless the bending states.

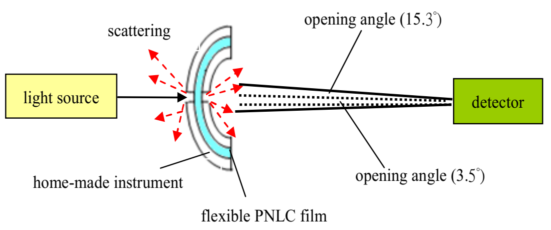

Fig. 2. Measurement system with different opening angles

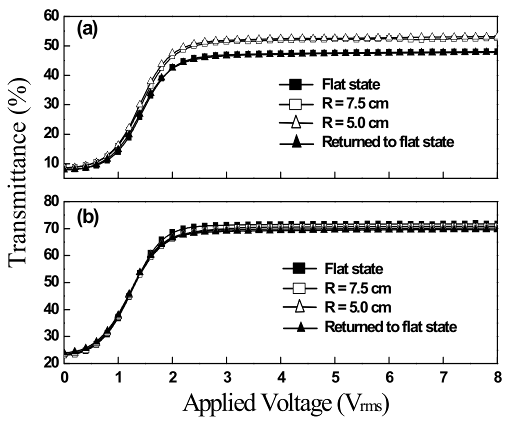

Fig. 3. T-V curves of PNLC films under different bending measured by (a) 3.5° and (b) 15.3° opening angles.

Table 1. Response time of PNLC films under various bending

Curvatures R (cm)	Flat	7.5	5	Flat
Falling time (ms)	230.49	236.64	234.21	228.55
Rising time (ms)	3.14	3.08	2.62	2.72

3. Discussion

The T-V characteristics imply that the polymer structures help LCs to recover their initial orientations while releasing the bending stress inside PNLC. From the results of different opening angles measurements, we can suppose that the light distribution of bent PNLC film isn't the same as flat one. The bent PNLC films become more transparent within 3.5° opening angle. Figure 4 shows the schematic diagram of transmittance distribution throughout the PNLC film. Combining the results of T-V curves and reduced rising time, it gives us a hint that LC domains divided by polymer are still compressed even eliminating the bending stress. Nevertheless, the compressed LC domains don't show sensible change in T-V characteristics for wide opening measurement. Finally, the slow falling time and low threshold characteristics of our devices might result from weak anchoring force between LCs and polymer networks[2]. Hence, the plastic PNLC films are suitable for developing the produces which need easy manufacturing process and usually used with flat type, *e.g.* price tags.

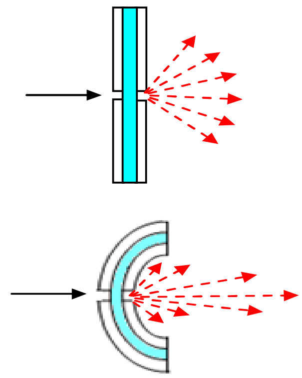

Fig. 4. Schematic diagram of transmittance distribution throughout PNLC film.

4. Acknowledgements

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5. References

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