Mechanical Stability of Plastic LCDs with Bistable Chiral-Splay Nematic LC Mode

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Abstract

We made plastic LCDs with Bistable Chiral-Splay Nematic (BCSN) LC mode for several types of spacers and investigated mechanical stability of them. The plastic BCSN LCDs used adhesive bead spacers have sufficient LC alignment stability against the mechanical shock and bending stress.

1. Introduction

In order to achieve extremely low power consumption LCDs, various bistable liquid crystal modes such as bistable nematic, bistable cholesteric and bistable FLC have been proposed.

Recently developed BCSN LC mode has two stable states: splay and twist state as shown in Figure 1 [1-2]. It seems to be a promising candidate for the application to future flexible displays which require both fast response and memory states.

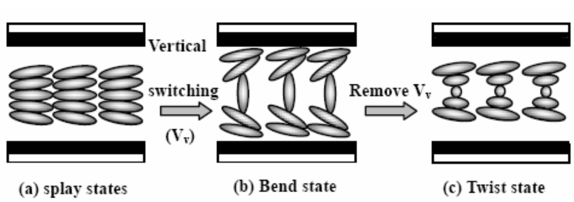


Figure1. Transition from splay state to twist state via bend state with voltage turn-on and turn-off

The study for the BCSN LCDs with plastic substrates has not been reported yet.

In this paper, we discuss on the mechanical stability of the plastic BCSN LCDs with different spacers such as non-adhesive bead spacer, adhesive bead spacer and photo spacer, where the plastic BCSN LCDs were fabricated at low process temperature.

2. Experiments

The test LC cells that we made using BCSN mode have two-terminal electrode containing top and bottom electrodes. We used ITO coated PolyCarbonate film as a plastic substrate and a nematic LC mixture with chiral dopant, where the ratio of cell gap to chiral pitch is 0.2 to achieve good twist memory state. The PI alignment layers coated on the top and bottom substrate were cured at 180°C. The rubbing directions of PI coated top and bottom substrate are parallel and cross polarizers were attached as shown in Figure2.

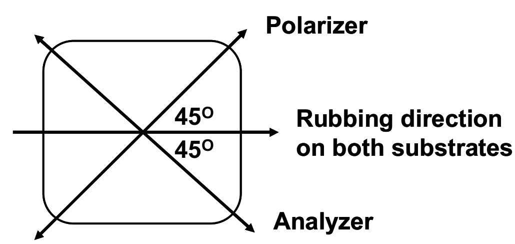


Figure2. Transmission spectrum measurement geometry

We made BCSN LC cells with three different spacers: non-adhesive bead spacer, adhesive bead spacer and photo spacer. The diameters of non-adhesive and adhesive spacers were 5um.

Photo spacers were formed through photolithographic process. (Figure3) Their width and thickness are about 20µm and 4.9µm.

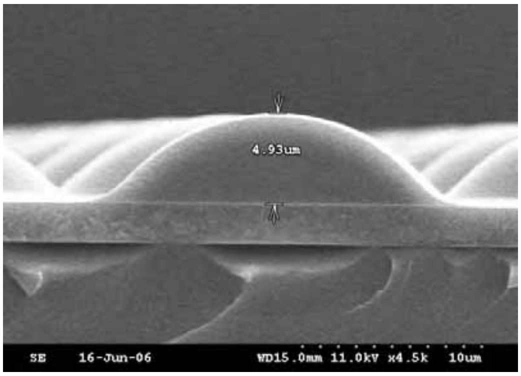


Figure3. SEM image of photo spacer

We measured the transmission spectra of plastic BCSN LC cells at the splay, bend and twist state and compared with those of glass BCSN LC cells. Figure4 shows the transmission spectra. The plastic BCSN LC cells show almost the same spectra as those of glass BCSN LC cells. The slight difference of intensity and shift of wavelength are within the cell fabrication process margin.

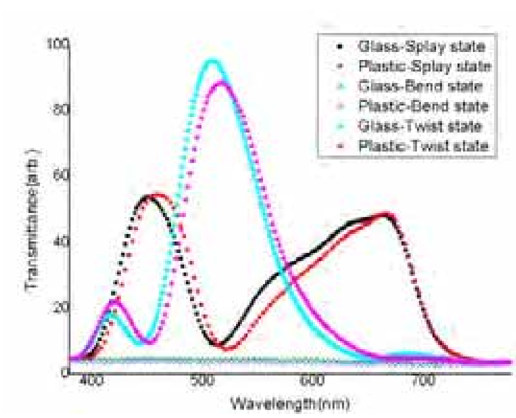


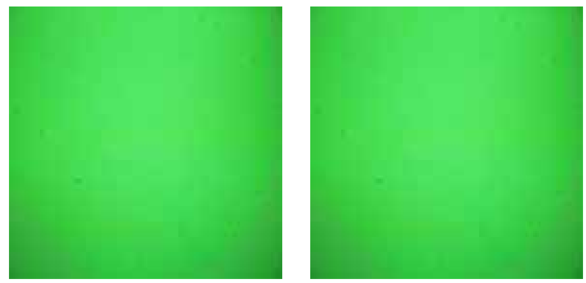
Figure4. The transmission spectra of the glass substrate- and plastic substrate-based BCSN LCDs at three kinds of LC alignment states.

3. Results

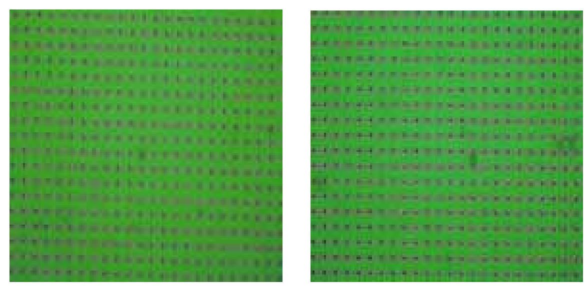
3-1. Mechanical Impact Test

In order to investigate the mechanical stability of plastic BCSN LC cells, we performed impact test. We dropped 100g round shape metal bar with changing the height. When the height is 20cm, there was no impact damage in three types of spacer's plastic BCSN LC cells. The result is shown in Figure5.

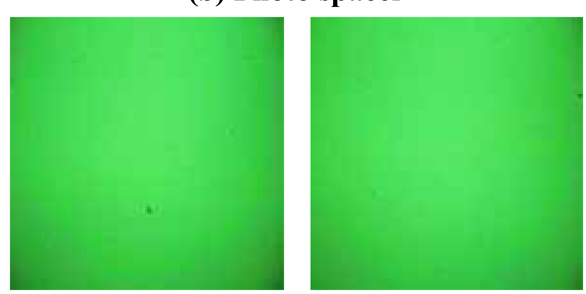
In case of BCSN LC cells with photo spacer, when it is changed from splay to twist electrically, LC alignment defects around the surface of photo spacers appear.



(a) Non-adhesive bead spacer



(b) Photo spacer



(c) Adhesive bead spacer

Figure5. Polarizing microscopic images of plastic BCSN LC cells with three types of spacers before and after mechanical shock

3-2. Bending Stress Test

In this experiment, the central area of the bent BCSN LC cells were observed with a polarizing microscope with spectrometer to measure the distortion of LC alignment caused by bending stress. (Figure6)

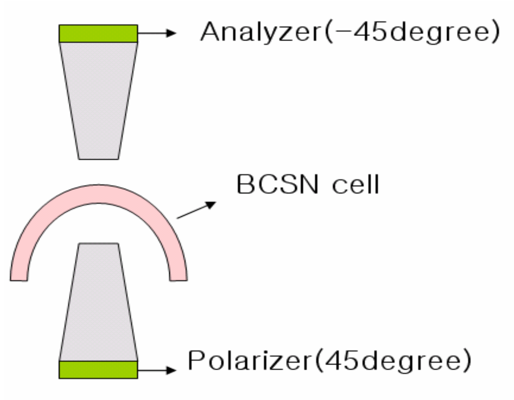
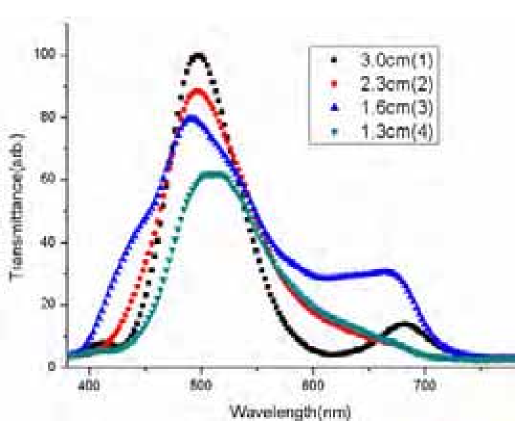


Figure6. Transmission spectrum measurement system

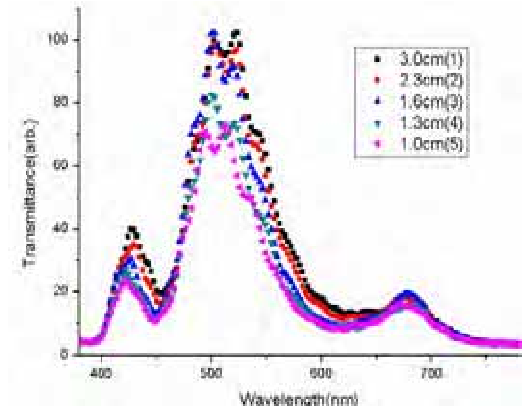
We measured the spectra and microscopic images with the change of bending radius from infinite to 1.0cm in twist state.

Figure7(a) and Figure8(a) show that BCSN LC cells with non-adhesive spacer has unstable spectrum when it is bent. The big change of LC alignment after bending stress seems to be caused by the change of cell gap.

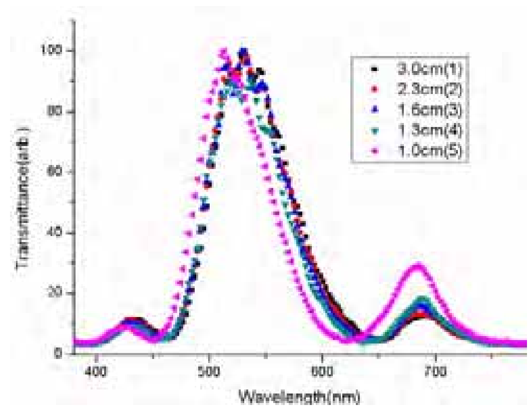
Figure7(b) and Figure8(b) show the data of BCSN LC cells with photo spacer. BCSN LC cells changed from twist state to splay state as time elapsed because photo spacers play a role as defect source. Its memory time is much shorter than that of adhesive spacer ones.



(a) Non-adhesive bead spacer



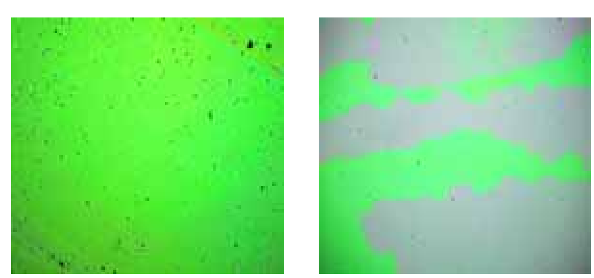
(b) Photo spacer



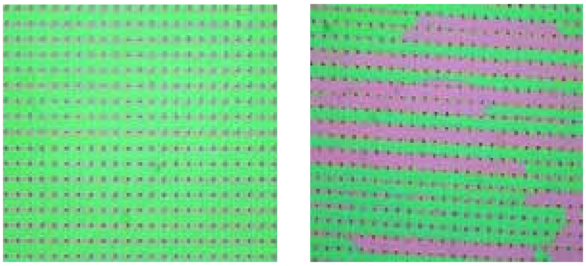
(c) Adhesive bead spacer

Figure7. Transmission plastic BCSN cells with spectra of three types of spacer

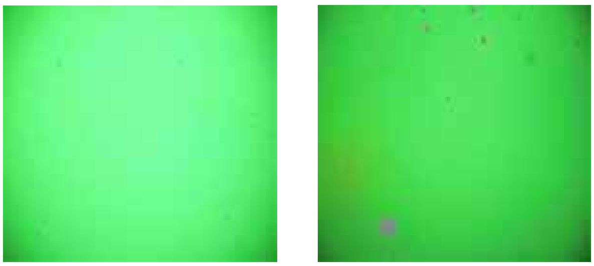
On the other hand, the LC alignment state of BCSN LC cells with adhesive spacer did not be significantly changed when it was bent as shown in Figure7(c) and Figure8(c), since the cell gap was not changed and the adhesive bead spacer was not defect source which changed from twist to splay.



(a) Non-adhesive bead spacer



(b) Photo spacer



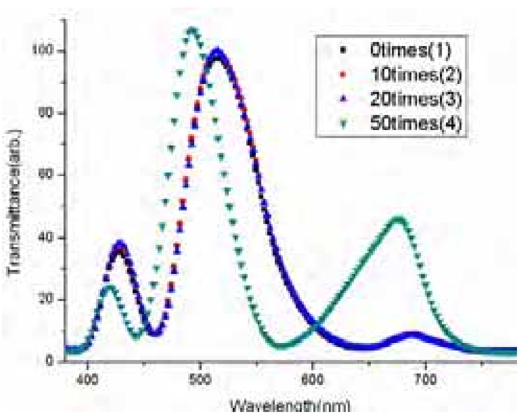
(c) Adhesive bead spacer

Figure8. Polarizing microscopic images of plastic BCSN LC cells with different spacers.

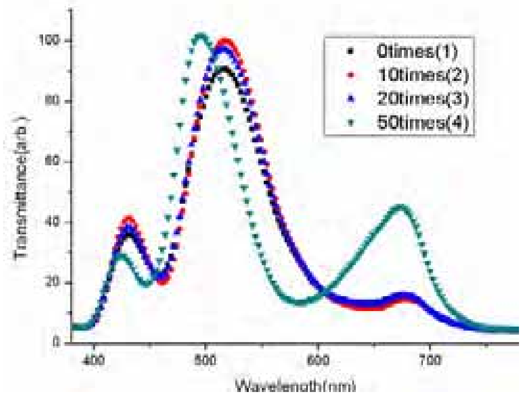
3-3. Reliability test

Figure9 shows the data for reliability test of the plastic BCSN LC cells with adhesive and photo spacers. The bending radius is fixed 1.1cm when the test was carried out. The numbers of bending times were varied in the range of 10 ~ 50.

There was no significant change in case of bending less than 50 times, but twist state became broken to splay state partially in case of bending greater than 50 times.



(a) Adhesive bead spacer



(b) Photo spacer

Figure 9. Spectra for reliability test

4. Conclusions

We investigated LC alignment stability of BCSN LC cells with different spacers against mechanical impact and bending stress. It was found that the mechanical stability of BCSN LC cells were much higher in using adhesive spacers than non-adhesive spacers and photo spacers. Adhesive spacers are not defects which cause the change from twist state to splay state such as photo spacers.

5. Acknowledgements

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6. References

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[2] S. H. Kang, C. G. Jhun, S. R. Lee, J. C. Kim,and T.H. Yoon, Proc. Asia Display / IMID '**041173** (2004).