Spacing Method Suitable for Flexible Cholesteric LCDs

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Abstract

In order to find out LC cell spacing method suitable for flexible cholesteric LCDs with high mechanical stability, we carried out bending and mechanical shock tests by using various spacing techniques: bead spacer, photo spacer, polymer wall with bead spacer and polymer wall with photo spacer. As a result, it was found that the spacing method using polymer wall incorporated with photo spacer is the best for flexible cholesteric LCDs in terms of mechanical stability. The investigation is discussed in detail.

1. Introduction

Flexible plastic LCDs have attracted much attention because of their advantages in comparison with conventional glass LCDs; thinner, lighter, non-breakable, conformable and contourable features.

Recently, flexible LCDs, highly bendable or rollable flexible LCDs are required for paper-like displays. Flexible bistable cholesteric LCD is one of the strong candidates for paper like displays because of its ultra low power consumption and polarizer free structure features.

However, the LC alignment of the flexible cholesteric LCDs in general is deformed when it is strongly bent or pressed. In order to avoid the deformation, we need to find out very stable spacing technology, which prevent mechanical stress exerted to liquid crystal layer while bent or pressed.

Polymer wall[1-2] and photo spacer[3] spacing technology was developed for mechanically stable flexible LCDs. We investigated the influence of spacing technologies including them on the mechanical stability of flexible cholesteric LCDs. To form polymer wall, we used phase separation process by applying patterned electrode field and polymerization process by UV irradiation [4]

2. Experimental

We fabricated 20mm x 30mm cholesteric LCDs with four kinds of spacers such as bead spacer, photo spacer, polymer walls with bead spacer and polymer walls with photo spacer.

We used polycarbonate film as a plastic substrate and cholesteric liquid crystal, MDA-00-1824 with 20% BL-187(Merck).

Figure 1 shows the schematic diagram for the structure of four kinds of spacers used in this experiment.

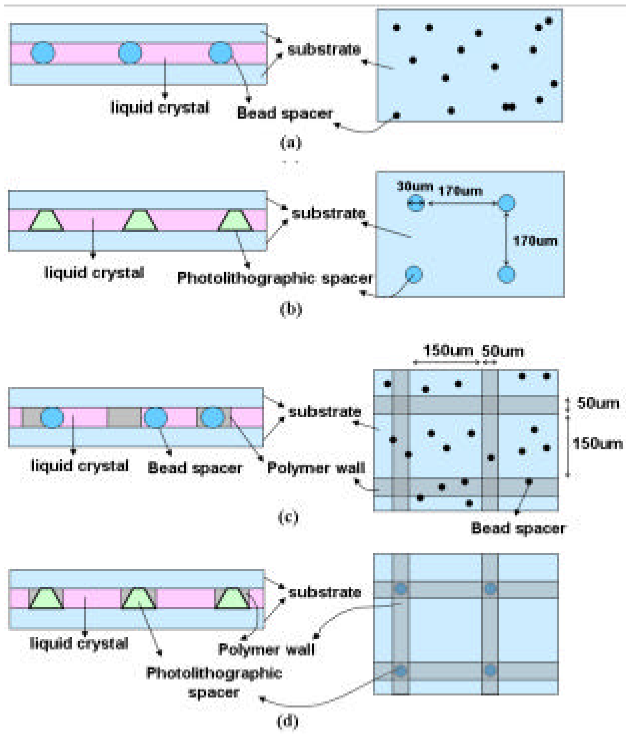

Figure 1. Schematic diagram of the cell structure of various spacers; (a) Bead spacer, (b) Photo spacer, (c) Polymer wall with bead spacer, (d) Polymer wall with photo spacer

We used 4.0μm bead spacer. The density of bead spacers was 300~400 each per mm^2. A negative PR(Dong-Jin Semichem Co.) was used as a photo spacer. The column shape photo spacer was formed on bottom substrate by photolithographic process. The pitch and diameter of photo spacers were 200µm and 30µm.

Mixture of Cholesteric LC and polymerizable monomer, Isobornyl-methacrylate with a ratio of 75:25 was injected into the cell at isotropic temperature. The phase separation of liquid crystals and monomers was done by applying electric field to patterned row and column electrodes. The monomer with lower dielectric constant than that of liquid crystal moved in no electrode region and liquid crystal moved in electrode region.

The phase separation process condition is shown in Figure 2 After filling the mixture at isotropic temperature, we applied 50V_{rms} and cool down 1°C/min. Then we irradiated UV light for 1hour without photo-mask. We formed polymer wall as a matrix structure with 50µm width and 200µm pixel pitch.

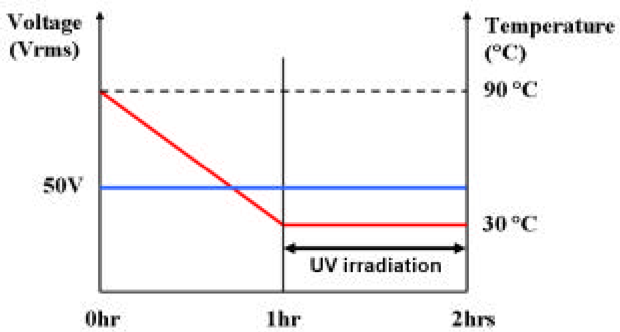

Figure 2. Profile of phase separation & polymerization process

3. Results & Discussions

In order to examine the mechanical stability of flexible cholesteric LCDs with different kinds of spacers, we measured transmission spectrum of the cholesteric LCDs with change of bending stress.

Figure 3 shows the transmission spectrum for un-bent cell and highly bent cells with different kinds of spacers. No significant change of transmission spectrum occurred even for highly bent cells with all type of spacers. These results mean that cholesteric LCDs for all kinds of spacers have good LC alignment stability against bending stress.

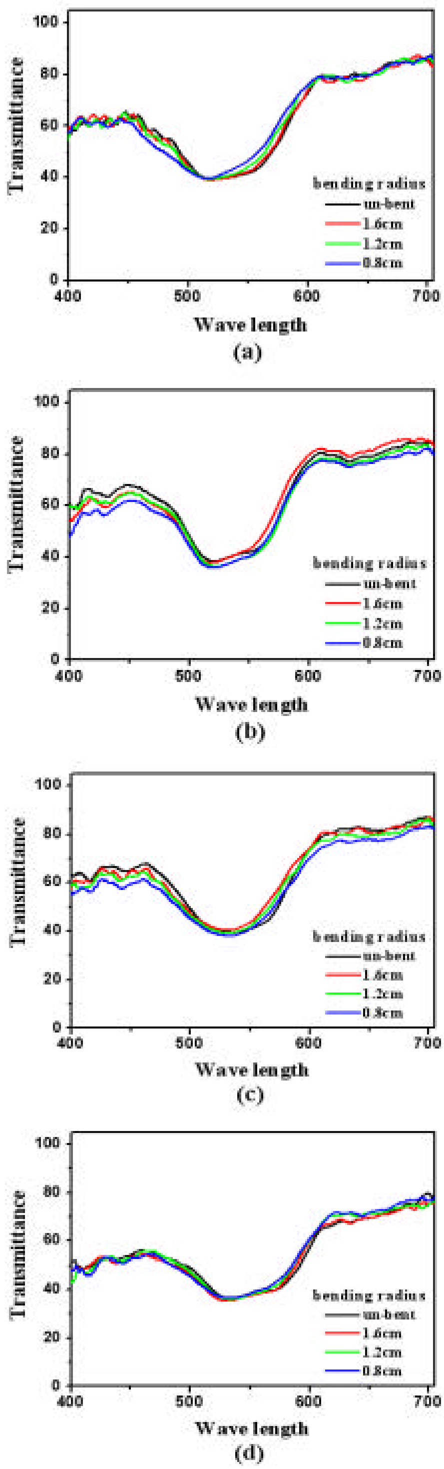

Figure 3. Transmission spectrum of cholesteric LCDs with the parameter of bending radius; (a) bead spacer, (b) photo spacer, (c) polymer wall spacer with bead spacer, (d) polymer wall spacer with photo spacer

Figure 4 shows the polarizing microscopic images of flexible cholesteric LCDs with different spacers before and after mechanical shock was applied by dropping sharp tip on the cells. It is shown that the cholesteric LCDs only with bead spacer or photo spacer were damaged by the mechanical shock. The bead spacer used cholesteric cell was easily damaged than photo spacer used cholesteric cell. On the other hand, the cholesteric LCDs with polymer wall was not damaged by mechanical shock regardless of spacer type.

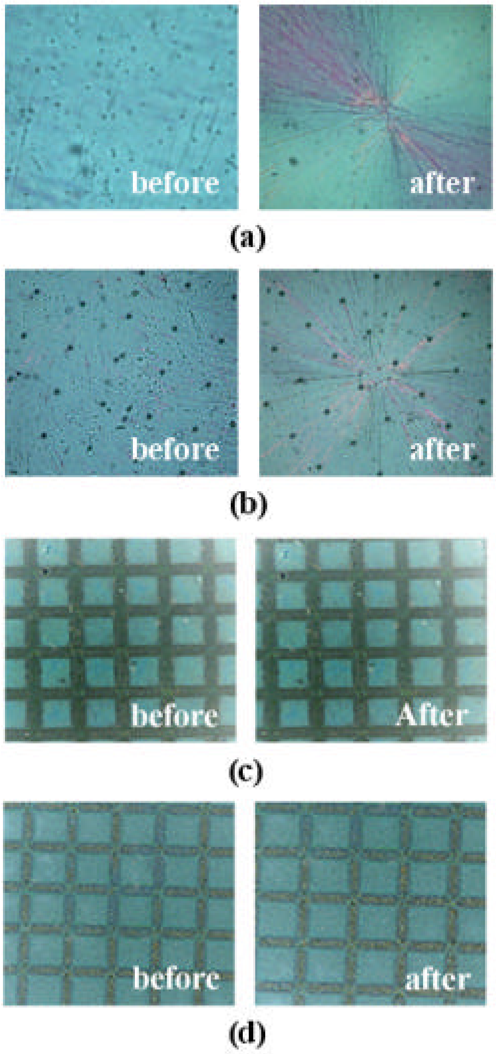

Figure 4. Microscopic images before and after mechanical shock; (a) bead spacer, (b) photo spacer, (c) polymer wall spacer with bead spacer, (d) polymer wall spacer with photo spacer

Figure 5 shows the alignment defect caused by the movement of bead spacer when the cholesteric LCDs was stressed.

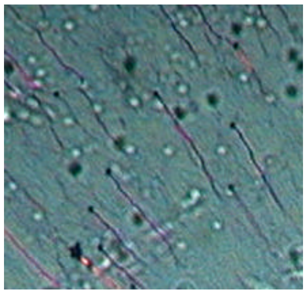

Figure 5. Scratch tails of bead spacer when it is stressed

Polymer wall spacer with bead spacer and photo spacer has no mechanical shock damages in investigation using microscopic images. But, polymer wall spacer with bead spacer has scratch tails as shown in Figure 5.

This scratched defect, even though it is rare, occurred in the cholesteric LCDs with polymer wall incorporated with bead spacer. In case of photo spacer used cholesteric LCDs, the damage by mechanical shock is supposed to be reduced if the spacer density increases. In view of bending stress, mechanical shock and moving spacer damages of cholesteric LCDs, polymer walls with photo spacer is the most suitable spacing structure for flexible cholesteric LCDs.

The further studies on the photo spacer density dependence of mechanical stabilities and on dynamic characteristics are needed.

4. Conclusions

We investigated the mechanical stability of flexible cholesteric LCDs with different spacer structure such as bead spacer, photo spacer, polymer wall with bead spacer and polymer wall with photo spacer. The flexible cholesteric LCDs revealed acceptable LC alignment stability for all spacer types when they were bent, but they were damaged by mechanical shock in case that only bead spacers or only photo spacer (low density of photo spacer) were used.

It is believed that polymer wall with photo spacer is the most suitable spacing technology for flexible cholesteric LCDs.

5. References

[1] Jong-Wook Jung et al., SID 04 Digest p. 606 (2004)

[2] P. Slikerveer et al., SID 04 Digest p. 770 (2004)

[3] Joost P.A.Vogels et al., SID 04 Digest p. 767 (2004)

[4] John L. West ea al, US Patents 5929630 (1999)