Flexible Bistable Chiral Splay Nematic Display Mode with Enhanced Memory Characteristics by Surface Treatment

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ABSTRACT

We propose a flexible bistable chiral splay nematic (BCSN) display device with excellent memory characteristics. The strong azimuthal anchoring energy enhanced by the surface treatment for the higher energy barrier between a splay state and π-twisted state. Finally, a memory retention time is significantly improved in the flexible BCSN device.

1. INTRODUCTION

The individual mobile display has attracted great interest since the rapid spread of the digital information. The various display technologies have being developed for mobile applications. A concept of the dual mode liquid crystal displays (LCDs), mentioned to bistable chiral splay nematic liquid crystal (BCSN) mode, comes into the spotlight due to their viable functionality [1, 2]. The BCSN-LC mode can be switchable between dynamic mode by the optically compensated bend (OCB) switching and memory mode obtained by the bistability of the bounded LC cell with a chirality [3, 4]. In this dual LC mode, the memory mode has been focused due to the low power consumption. Various endeavors were attempted to increase the memory retention time which is limited by the stability of π-twisted arrangement of the LC molecules [5, 6]. This approach was rather limited because the fabrication process was incorrigible in comparison with that for conventional LC cell. Actually, it is hard to achieve the permanent memory retention time in BCSN mode. Especially, in the condition of the BCSN LC device fabricated on the flexible substrate, its memory characteristic is declined further when the external deformation is applied.

In this work, we propose the flexible BCSN mode with an improved retention time in memory mode by polymerizing reactive mesogen (RM) on alignment layer. The RM networks on alignment layer could be enhanced the azimuthal surface anchoring energy [7]. The polymer networks act as leading powers that disrupts the return to the initial splay state by increasing the energy barrier between bistable states despite the external bend deformation. Eventually, we could obtain flexible BCSN device with the improved memory retention time.

2. EXPERIMENT

Figure 1 shows the schematic diagram of flexible BCSN cell structure in crossed section by using the RM network structure. The polyimide (PI) alignment layer (AL22620, JSR Inc.) for LC alignment parallel to the plastic (polycarbonate) substrates was spin-coated on substrates evaporated indium tin oxide (ITO) and soft-baked to evaporate solvent under 100 °C for 10 min followed by hard-baked to polymerize under 220°C for 1 h. The alignment layer was rubbed for a unidirectional alignment of the LC molecules. The RMs (E. Merck Co.) of 0.5 wt.% and photo-initiator (Irgacure651, Ciba Chemicals) of 0.1 wt.% were dissolved in propylene glycol monomethyl ether acetate (PGMEA). It was baked at 60 °C for 90 s to evaporate the solvent after spin-coating on the rubbed homogeneous alignment layer. Eventually, UV light was irradiated for 30 min to polymerize the RM monomers on the surface of the homogeneous alignment layer. The rubbed plastic substrates were assembled with maintaining cell gap of 5 μm in the same rubbing direction of both substrates.

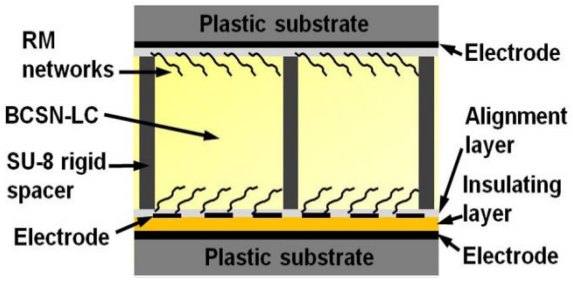

Fig. 1 Schematic diagram of the cross section of a flexible BCSN-LC cell structure proposed in this work

In this work, nematic LCs (ZKC-5085XX, Chisso) and chiral dopant (R-811, E. Merck Co.) with the right-handed helical molecular sense were mixed to get tendency of twist formation on LC molecules. The proportion of cell gap to pitch (*d/p*)

is 0.2 which is more stable in splay state than in energy boundary condition in which *d/p* is 0.25 between splay and π-twisted state. By capillary action in the isotropic phase, the BCSN-LC mixture was injected between assembled substrates with parallel rubbed homogeneous alignment layer. Below the nematic-isotropic transition temperature, the LC molecules are aligned in the splay state by the parallel rubbed surface condition. Finally, we could obtain the flexible BCSN-LC cell proposed in this work.

3. RESULT

Figure 2 shows the measured retention time in memory mode of fabricated flexible BCSN cells with/without the functional alignment layer treated by RM. The retention time was determined through measuring the transmittance of the π-twisted state as a function of the elapsed time after forming the π-twisted state (no applied voltage). In the initial splay state with the rubbing direction coincided with the transmission axis of the crossed polarizers, both BCSN cells on the alignment layer with/without the RM polymer networks exhibit dark state. By the regulation of the external voltage (dropping voltage after applying voltage for the high bend state with topologically same phase with the π-twisted state), the π-twisted state (bright state) could be achieved.

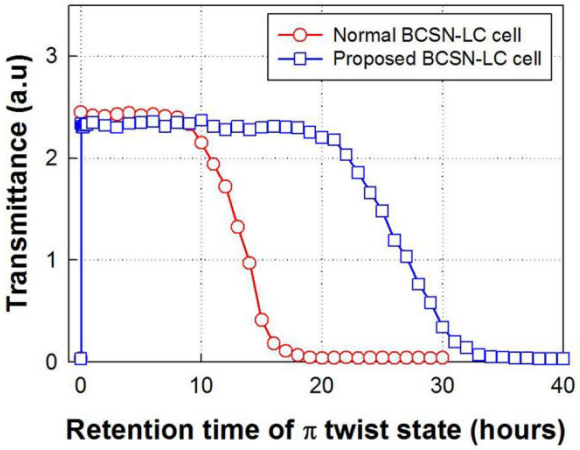

Fig. 2 Measured retention time of π twist state in flexible BCSN cell with/without the functional alignment layer treated by RMs

We measured the time conserving the uniform transmittance of the π-twisted state. In the BCSN cell on the alignment layer with the polymerized RM network structure, the retention time was significantly improved rather than that of the conventional BCSN cell with the conventional alignment layer.

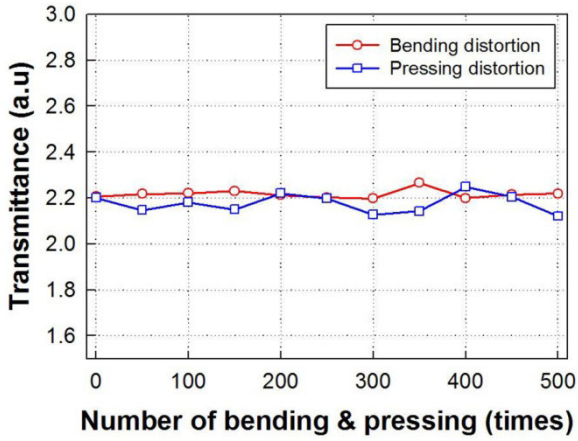

Fig. 3 Measured transmittance in memory mode of flexible BCSN cell under the repeated bending and pressing distortions

Commonly, when the flexible LC device undergoes external distortion such as bending and pressing, it is hard to retain its electro-optic (EO) characteristics due to the change in the cell gap. That is, the LC molecules are severely distorted, and the EO characteristics, like the transmittance of the LC device, are dramatically changed by the dependence on a degree of external distortion. Figure 3 shows the results about the transmittance changes at the memory state that were measured with the 500-time bending distortion of R=2.5cm (R is the radius of the bending curvature) and with the 500-time pressing distortion of 4N/cm^2 pressure. The initial transmittance in the memory mode could be maintained against the repeated bending deformation within 2%, as shown in Fig. 3.

4. CONCLUSION

A flexible BCSN-LC device with the enhanced memory characteristic by the surface treatment was demonstrated in this work. The flexible BCSN mode proposed here could be operated in more stable memory mode through the increased energy barrier between splay and π-twist state by the RM networks on the surface alignment layers. Besides, this characteristic could be retained even though the external deformation was applied. The novel technology improving the memory retention time in flexible BCSN mode could be useful to overcome the limitation of parameters such as *d*/*p*, cell gap, and elastic constant of LCs considering the driving properties in both dynamic and memory modes. It should be expected that the flexible BCSN mode proposed in this work could be could be applicable

to the next generation mobile display with the high achieved.

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