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Bistable Chiral Splay Nematic Liquid Crystal Display with Enhanced Memory Characteristic by Surface Treatment on the Plastic Substrate

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We propose a bistable chiral splay nematic liquid crystal (BCSN-LC) display on the plastic substrate with enhanced memory characteristic. The strong azimuthal anchoring energy enhanced by the surface treatment by using RMs derives the higher energy barrier between a splay state and π-twisted state. Finally, by the disturbance of transition between two states, a memory characteristic could be significantly improved in our flexible BCSN-LC cell.

1. Introduction

Recently, individual mobile displays have attracted great interests since the rapid spread of the digital information. Various display technologies have being developed for mobile applications. Among them, a concept of the dual mode liquid crystal displays (LCDs), mentioned to bistable chiral splay nematic liquid crystal (BCSN-LC) display, comes into the spotlight due to their viable functionalities [1, 2]. The BCSN-LC display 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 dual LC modes, the memory mode has been focused due to 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]. However, previous approaches were rather limited because their fabrication processes were incorrigible in comparison with one for conventional LC cell. It is hard to achieve the permanent memory retention time in BCSN-LC display. Besides, the memory characteristic of BCSN-LC display fabricated on the flexible substrate is declined further when the external deformation is applied to the display.

In this paper, we propose a flexible BCSN-LC mode with enhanced memory retention time by polymerizing reactive mesogen (RM) on both alignment layers of plastic substrates. The RM structure on alignment layers could be enhanced the azimuthal surface anchoring energy [7]. It acts as leading powers that disrupts the return to the initial splay state by increasing the energy barrier between bistable states. This excellent characteristic could be maintained well despite the external bend distortion. Finally, a flexible BCSN-LC display with the enhanced memory characteristic could be obtained.

2. Experiments

The schematic diagram of a flexible BCSN-LC cell with RM structure is shown in Fig. 1. The polyimide (PI) alignment layer (AL22620, JSR Inc.) for parallel alignment was spin-coated on the plastic (polycarbonate) evaporated indium tin oxide (ITO). And then, it was soft-baked to evaporate solvent under 100 °C for 10 min. followed by hard-baked to polymerize near 200°C for 1 h. For maintaining the cell gap, photo resist walls (SU8 2005, MicroChem) were formed on only one substrate by the conventional photolithography process. Alignment layers were rubbed for a unidirectional alignment of the LC molecules. The RM (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. After that, UV light was irradiated for 30 min. to polymerize RM monomers on the surface of homogeneous alignment layer.

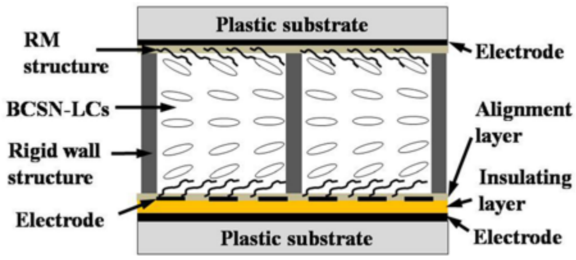

Figure 1. Schematic diagram of our flexible BCSN-LC cell.

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The worked plastic substrates were assembled by thermal pressing process in the same rubbing direction. 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 energy boundary condition in splay state than it in π twist state. By capillary action in the isotropic phase, BCSN-LC mixture was injected in the empty space between assembled substrates. Below the nematic-isotropic transition temperature, 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. Results and Discussion

We manufactured two kinds of experimental BCSN-LC cells as a conventional type without RM structure and proposed type with it. Figure 2 shows the measured retention time in memory mode of fabricated two BCSN-LC cells. Memory retention time was determined through measuring the transmittance of the π-twist state as a function of the elapsed time after forming the π-twisted state. In the initial splay state with the rubbing direction coincided with the transmission axis of the crossed polarizers, both BCSN-LC cells on the alignment layer with/without the RM structure exhibit dark

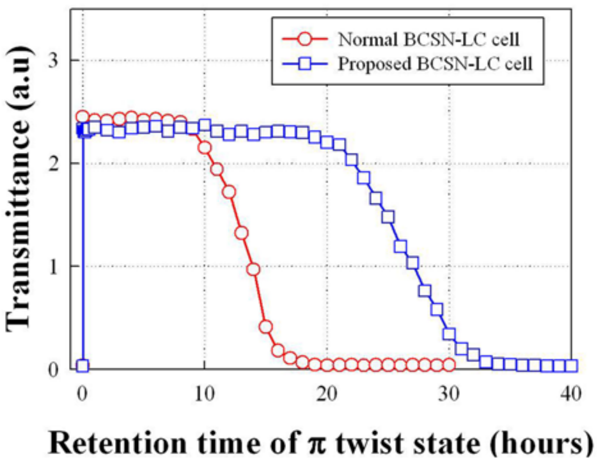

Figure 2. Measured retention time of π-twist state in flexible BCSN-LC cells with/without RM structure.

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-twist state (bright state) could be obtained. We measured the time conserving the uniform transmittance of the π-twist state. In our proposed cell, the memory retention time was significantly improved rather than that of the conventional one.

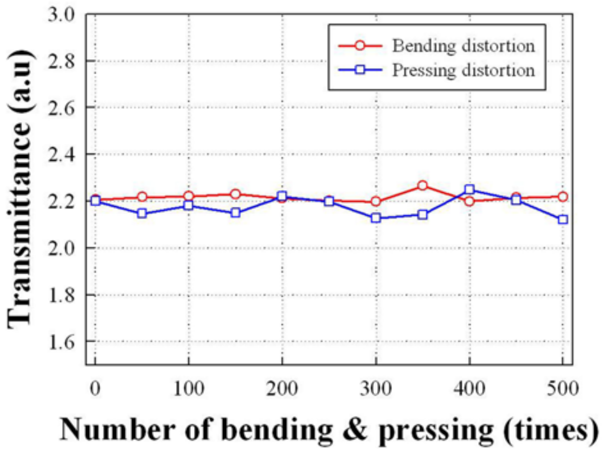

Figure 3. Measured transmittance in memory mode of flexible BCSN-LC cells under repeated bending and pressing distortions.

Generally, when flexible LCDs undergo the external force such as bending and pressing deformations, it is hard to retain their electro-optic (EO) characteristics due to the change of the LC cell gap. That is, LC alignment is 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. In contrast, our flexible BCSN-LC cell could retain the enhanced memory characteristic by the internal rigid wall structure. Figure 3 shows the results about the transmittance changes in the memory state that were measured with the 500-times bending distortion of R = 2.5 cm (R is the radius of the bending curvature) and with the 500-times pressing distortion of 4 N/cm^2 pressure. The initial transmittance of the memory mode could be maintained against the repeated bending deformation within 2 %, as shown in Fig. 3.

4. Conclusion

In this work, a flexible BCSN-LC display with the enhanced memory characteristic by the surface treatment was demonstrated. It could be operated in more stable memory mode through the increased energy barrier between splay and π-twist state by the RM structure 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 also expected that our flexible BCSN-LC display could be helpfully applicable to the next generation mobile display.

5. Acknowledgements

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