Enhancement of Memory Characteristics of Bistable Chiral Splay Nematic Liquid Crystal

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Abstract

We report the enhanced memory characteristics in a surface-controlled bistable chiral splay nematic (BCSN) display. The reactive mesogen stacked on the alignment layer improves the azimuthal anchoring energy in BCSN cell. The strong anchoring energy gives rise to a large energy barrier between splay and π-twisted states. As a result, a memory retention time of the π-twisted state is significantly improved.

1. Introduction

The significance of the individual mobile display has being emphasized in the rapidly changing digital era. Among several display technologies for portable mobile applications such as multifunctional smart phone, subcompact laptop, and multimedia player with other functionality, bistable chiral splay nematic liquid crystal (BCSN-LC) mode which can be driven in dual mode comes into the spotlight due to their functionality [1-3]. BCSN-LC mode can switch between dynamic mode with a fast switching time by dynamic operation of the optically compensated bend (OCB) mode and memory mode with a suitable retention time in a pixel in given situations by chirality with suitable pitch [4, 5]. In this dual LC mode, memory mode has significance because it is responsible for displaying the texture or still image pictures using low power consumption, which is expected to be fully contented with the requirements of mobile display devices.

However, until now, the memory retention time by the stability of π-twisted energy state is limited by troublesome problems considering the operation in dual modes despite of the utmost efforts [6]. Novel technology like the multidimensional alignment method was attempted to increase the π twisted alignment state as the memory retention time of BCSN-LC mode. However, application of this method was rather limited because the fabrication process was incorrigible in comparison with that for conventional LC cell [7, 8]. Actually, it is hard to achieve the permanent memory retention time in BCSN-LC mode for the low power

In this work, we propose the BCSN mode with an improved retention time in memory mode by surface treatment with a reactive mesogen (RM). After forming the conventional homogeneous alignment layer, the RM network was stacked on it by ultraviolet (UV) irradiation. The azimuthal surface anchoring energy of the stacked functional alignment layer was enhanced compared with the conventional homogeneous alignment layer without network structure [9]. Polymer networks act as leading powers that disrupts the return to the initial splay state by increase the energy barrier between bistable states. Eventually, we could obtain BCSN device with the improved memory retention time.

2. Experiment

Figure 1 is the schematic diagram of BCSN cell structure in crossed section by using the RM network structure. Polyimide (PI) alignment layer (AL22620, JSR) for LC alignment parallel to the 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. We rubbed the alignment layer for a unidirectional alignment of the LC molecules. The RM (E. Merck) and Photo-initiator (Irgacure651, Ciba Specialty Chemicals) were dissolved in propylene glycol monomethyl ether acetate (PGMEA). It was baked at 60 °C for 90 sec to evaporate the solvent after spin-coating on the rubbed homogeneous alignment layer.

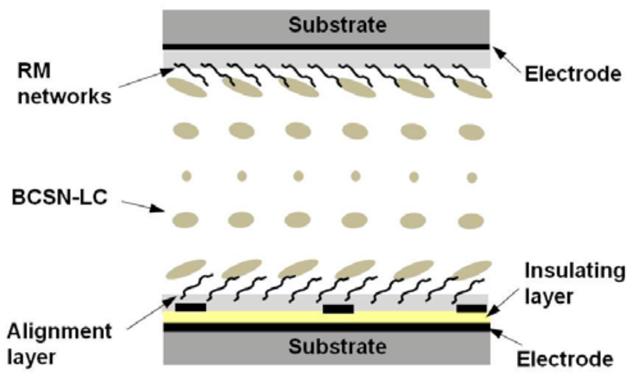

Fig. 1. The schematic diagram of the cross section of the BCSN-LC cell structure by the surface treatment proposed in this work.

Finally, UV light was irradiated for 30 min. to polymerize the RM monomers on the surface of the homogeneous

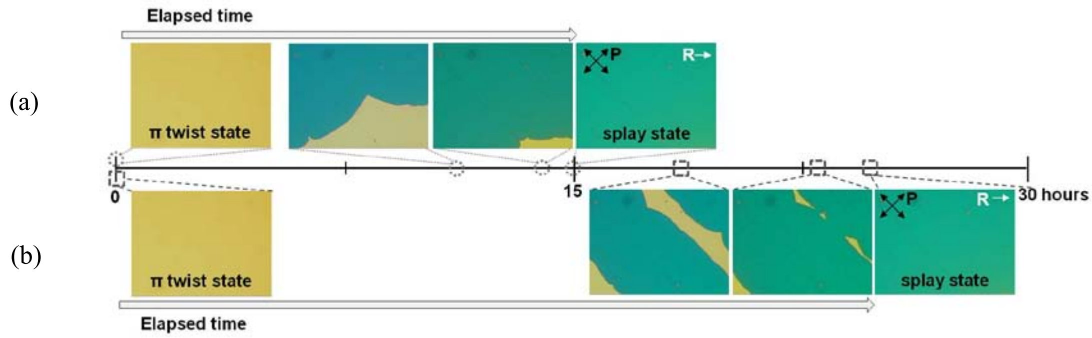

Fig. 2. The changed transmittance as the elapsed time of π twist state in designated pixel area measured by POM: (a) conventional BCSN LC cell and (b) BCSN LC cell by the surface treatment.

alignment layer. For an initial splay state, two rubbed substrates were assembled parallel with the cell gap uniformity using by 5 μm ball spacers. Nematic LCs (ZKC-5085XX, Chisso) and chiral dopant (R-811, E. Merck Co.) with the right-handed helical 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 states. By capillary action at the isotropic phase, the BCSN-LC mixture was injected between both substrates with parallel rubbed homogeneous alignment layer maintaining 5μm cell gap. Under the nematic-isotropic transition temperature, LC molecules are aligned in the splay state by the parallel rubbed surface condition. Following this process, BCSN-LC cell with our concept could be obtained.

3. Result and Discussion

The retention time in memory mode of fabricated BCSN cells with/without polymerized RMs network structure are shown in Fig. 2. The retention time was determined through measuring the changed transmittance of the π-twisted state in designated pixel area as the elapsed time by polarized optical microscope (POM) 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 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. We measured the time conserving the uniform transmittance of the π-twisted state through the POM images. In the BCSN cell with the polymerized RM structure stacked on homogeneous alignment layers (in Fig. 2 (a)), the retention time was significantly improved rather than that of the conventional BCSN cell without RMs (in Fig. 2 (b)). Eventually, azimuthal anchoring energy enhanced by polymer networks increases the energy barrier between bistable states and the memory retention time of our BCSN-LC cell could be remarkably improved.

4. Conclusion

In this work, we presented the enhancement of memory characteristics of a BCSN mode by the surface treatment. The BCSN mode proposed here could be operated in more stable memory mode through the increased energy barrier between splay and π-twisted states by the RM networks on the surface alignment layers and thus shown the enhanced retention time of the memory mode. The novel technology improving the memory retention time in BCSN mode could be useful to overcome the limitation of parameters such as *d*/*p*, cell gap, and ela stic constant of LCs considering the driving properties in both dynamic and memory modes.

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