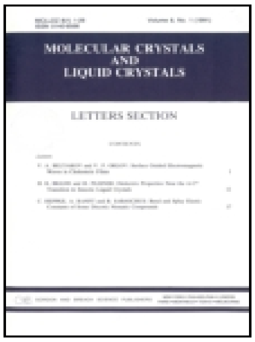

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Non-Ideal Optical Isotropy of Blue Phase Liquid Crystal and their Self-Assembly on Electrode Surface

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In this paper, we reported blue phase liquid crystal (BPLC) is not only a non-ideal optical isotropic, but also self-assembly along with electrode. The self-assembly was carefully verified by luminescent colorimeter system. Result showed that BPLC self-assembly along with electrode of in-panel switching cell. We believe this findings will inspire the improvement of light leakage of BPLC.

Keywords Blue phase liquid crystal; self-assembly; non-ideal optical isotropy

Introduction

Polymer-stabilized blue phase liquid crystal (BPLC) is well defined as three-dimension nanostructures and has three thermodynamic lattices, blue phase I, blue phase II and blue phase III[1–2]. Nanostructures of BPLC have excellent optoelectric properties. For example, optical isotropy leads alignment free and voltage-off state. Short coherent length contributes to microsecond response time[3–4]. Consideration above advantages, BPLC is regarded as next-generation display. Initially, BPLC display has serious issues such as high driving voltage, large hysteresis and poor charging behavior. However, all of these issues have been overcome. Driving voltage of 8.4 V_{rms} was achieved by electrode design[v] and new BPLC material [6] Hysteresis free was obtained by vertical-field switching, [7] dual-frequency driving, [8] and compensation effect[9]. Full charging BPLC was proposed by bootstrapping method[10]. In 2013, BPLC display is demonstrated by using groove cell.[11] So far, contrast ratio (CR) of BPLC display has poor CR ($<$1000) due to severe light leakage[12, 13]. Previously, we found BPLC revealed polarization rotatory and lead to serious light leakage[14]. In this report, we found BPLC is non-ideal optical isotropic and shows strong interaction with electrode. Subsequently, BPLC rendered self-assembly and aligned along electrode axis.

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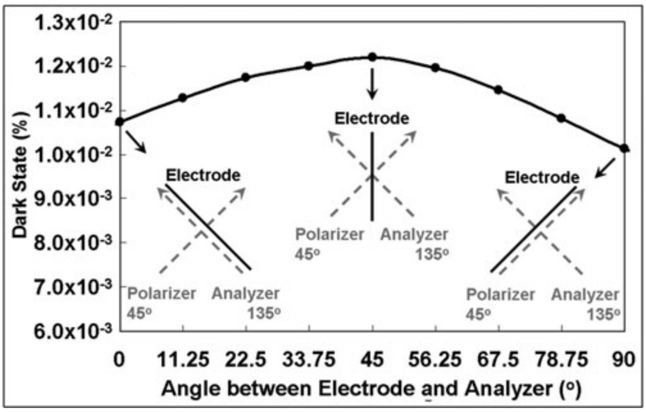

Figure 1. Light leakage measurement of BPLC in IPS cell.

Experimental

BPLC was consisted of 86.9 wt% host liquid crystal (HTG135200-100) and 5.2 wt% chiral dopant (R5011). Host and dopant were obtained from Jiangsu Hecheng Chemical Materials Co., Ltd. BPLC was stabilized by polymer which was consisted of 2.9 wt% monomer (dodecyl acrylate, technical grade, purity 90%, obtained from Sigma Aldrich), 5 wt% reactive mesogen (diacrylate monomer, RM257, obtained from Merck KGaA), and photo initiator (2,2-dimethoxy-2-phenyl acetophenone, obtained from Sigma Aldrich). BPLC Mixtures were injected into in-plane switching (IPS, cell gap 8 μm). Polymer stabilization was isothermally curing by ultra-violet exposure (365 nm, intensity 8 mW/cm^2, 10 min). Light leakage of dark state is analyzed by luminance colorimeter system (Topcon, BM5A, Nit resolution: $\pm$4%). Detail of colorimeter setup was described in literature[15].

Results and Discussion

BPLC has lattice nanostructures which were self-assembled by double twist cylinder (DTC).[8] Generally, DTC is constructed by twist-nematic liquid crystal (TNLC) and has similar polarization behavior to TNLC, but only performs in BPLC nanostructures. Previously, we found BPLC revealed optical rotatory power and explained by nanoscale TNLC model.[14] In this report, non-ideal optical isotropic BPLC was investigated by luminance colorimeter system. In-plane-switching (IPS) test cell was selected for studied. IPS test cell was rotated from 0°∼90°, while maintained polarizer crossed to analyzer. In other word, electrode axis of IPS cell changed corresponding to transmitted axis of analyzer. During rotation of IPS cell, darkness was record by luminance colorimeter system. As shown in Figure 1, BPLC revealed different manner in dark state of IPS cell. Result showed large dark state of 1.20×10^{-2}% at 45° and small dark state of 1.07×10^{-2}% and 1.01×10^{-2}% at 0° and 90°, respectively.

Consideration to interaction between electrode and BPLC, an explanation of BPLC self-assembly and alignment were proposed (Fig. 2). BPLC was regarded as non-ideal optical isotropic material and revealed severe light leakage due to optical rotatory of TNLC nanostructures.[14] Generally, TNLC renders alignment in electrode surface due to strong anchoring force between TNLC and electrode. BPLC revealed similar behavior as

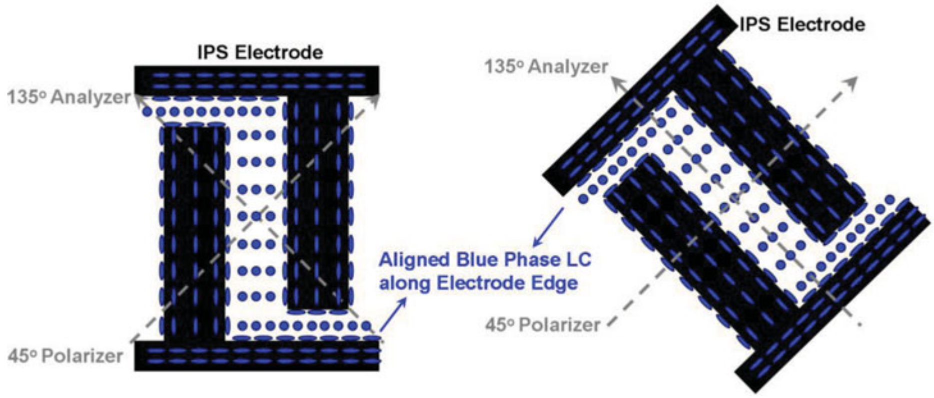

Figure 2. Conceptual diagram of BPLC self-assembly and alignment along with the axis of electrode surface.

TNLC and rendered alignment on electrode surface, but only construction in nanoscale. Consequently, nanoscale-aligned BPLC resulted in light leakage.

Conclusions

Blue phase liquid crystal was regarded as non-ideal optical isotropy and revealed self-assembly and alignment along with electrode axis. Alignment of BPLC rendered cell structure dependent and showed directionally aligned along with electrode axis in IPS cell. Based on TNLC model, mechanism of BPLC nanoscale-alignment was proposed. This new finding of non-ideal optical isotropic BPLC will impact application of BPLC devices.

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