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Hybrid Alignment Technique for Wide-Viewing Liquid Crystal Displays with Multi-Domains

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Hybrid Alignment Technique for Wide-Viewing Liquid Crystal Displays with Multi-Domains

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We introduce a hybrid double layer for liquid crystal (LC) alignment into a multi-domain vertically aligned mode. A blend of polyimide (PI) and poly(vinyl cinnamate) (PVCi) was cast onto a preformed PI layer. After curing, PVCi was extracted by washing to yield a LC alignment layer with homogeneous micro-domains uniformly distributed over the homeotropic layer. The size of homogeneous domains was strongly influenced by the weight content of PVCi as well as the solvent of PVCi. The viewing angle of ±30° with contrast ratio of 10:1 along the direction of 45° to a polarizer was obtained from hybrid double layer LC cells with no compensation film.

Keywords wide-viewing angle; multi-domain; homeotropic-homogeneous alignment layer

INTRODUCTION

Hybrid alignment of a liquid crystal (LC) on multi-domains (MD) is one of the techniques improving viewing characteristics by dividing each pixel into sub-pixels in which the optical characteristics of LC compensate each other [1]. However, photolithography and multiple rubbing process of the conventional MD techniques have limited

commercial production of liquid crystal displays (LCDs) using this method [2]. In this work we report on the enhanced viewing angle characteristics of LCDs by embedding homogeneous micro-domains in homeotropic alignment layer with no photolithography or multiple rubbing process.

EXPERIMENTAL

Solution of polyimide (PI, AL 3046, JSR Co.) was spin-coated on indium-tin-oxide glass plates using N-methyl-2-pyrrolidinone (NMP) and then cured to yield homogeneous layers, on which a blend solution of another kind of PI (JALS-204, JSR Co.) and poly(vinyl cinnamate) (PVCi) was subsequently coated. Several solvents were used to study the effect on the domain sizes of PVCi: NMP, tetrahydrofuran (THF), dimethylacetamide (DMAc), or N,N-dimethyl foramide (DMF). After curing, a mixture of monochlorobenzene and dichloroethane was used to wash out PVCi from the hybrid substrates. LCD cells were assembled with rubbed hybrid substrates and a commercial liquid crystal (EN-40, Chisso Co.) was filled. Surface morphology of a hybrid layer was observed with atomic force microscope (AFM). Viewing angle characteristics of a LCD cell were obtained using Autocronic DMS 501.

RESULTS AND DISCUSSION

Figure 1 shows the homogeneous multi-domains embedded in the homeotropic layer, which resulted from the aggregation of PVCi during curing process. The domain size of the homogeneous layer increased

with increasing the weight content of the incorporated PVCi, indicating that the higher content of PVCi yielded the larger PVCi agglomerates during curing process. However, too high weight content of PVCi (PI:PVCi = 10:7) failed to form homogeneous micro-domains because of the excessive aggregation of PVCi.

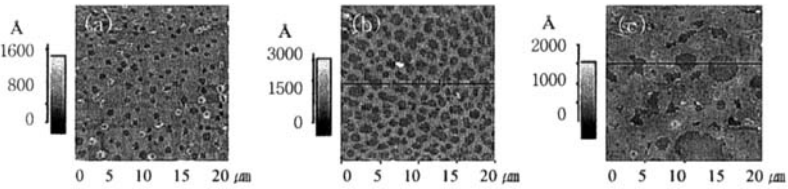


FIGURE 1 The AFM images of homeotropic-homogeneous micro-domains: (a) PI:PVCi=10:3, (b) 10:5, and (c) 10:7.

The size of the homogeneous domain was also influenced by the solvent of PVCi as shown in Figure 2. For all solvents used, the increase in PVCi content resulted in the size increment of homogeneous domains. It is suggested that the homogeneous alignment domain size is affected by the difference of the solubility parameter between the solvent and the PVCi.

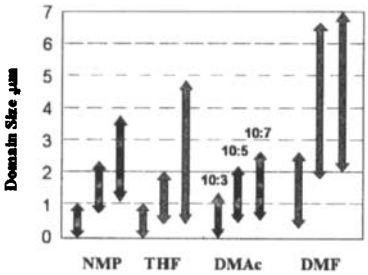
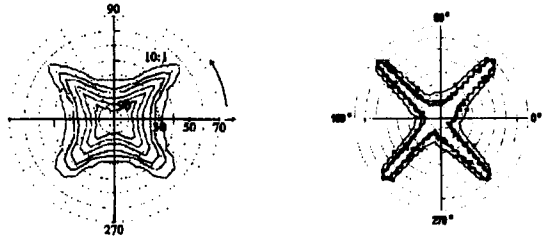


FIGURE 2 Homogeneous domain size for different solvents.

Viewing characteristics of the LCD cells assembled with the hybrid

substrate are shown in Figure 3. The rubbing directions were anti-parallel and polarizers were positioned along the direction of 45° to the rubbing direction. Figure 3(a) shows that the contrast ratio of the hybrid LCD cell was about 10:1 up to ±30° without any compensation film. On the other hand, the simulation of vertically aligned mode indicated that the contrast ratio of 10:1 was obtained up to ±22° as shown in Figure 3(b). It indicates that orientation of LC was strongly influenced by homogeneous micro-domains to compensate for the difference of optical characteristics resulting in the enhanced viewing angle characteristics.



(a) (b)

FIGURE 3 Viewing characteristics of test cells: (a) PI:PVCi=10:5 and (b) simulation results of the VA mode cell.

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