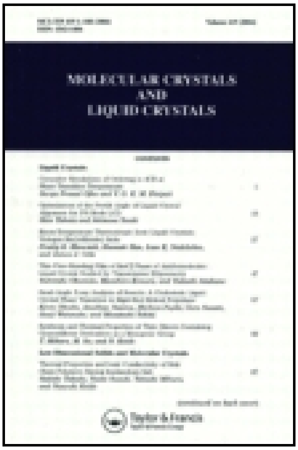

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Homeotropic and Homogeneous Hybrid Alignment Layer for Wide Viewing Angle LCDs

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Homeotropic and Homogeneous Hybrid Alignment Layer for Wide Viewing Angle LCDs

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We introduce a homeotropic and homogeneous 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; viewing characteristics

INTRODUCTION

Hybrid alignment technique for multi-domains (MD) liquid crystal (LC) alignment (usually 2 or 4 domains) have been developed in order to improve viewing angle characteristics [1,2]. One of the techniques improving viewing characteristics by dividing each pixel into sub-pixels in which the optical characteristics of LC compensate each other. However, photolithography and multiple rubbing process of the conventional MD techniques have limited commercial production of liquid crystal displays (LCDs) using this method [3]. 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.

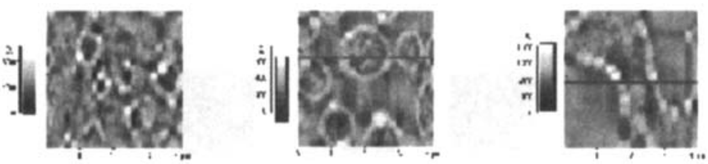
EXPERIMENTAL

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 that acts as a good solvent for PVCi but poor one for PI 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.) which has negative dielectric anisotropy was filled. The gap of each cell was nominally 5 μm. Surface morphology of the homeotropic-homogeneous hybrid layer with micro-domains was observed with atomic force microscope (AFM) and an optical polarizing microscope.

The viewing angle characteristics of a LCD cell were determined from the measured iso-contrast map 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.



(a) (b) (c)

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

In order to investigate the LC orientation, an optical polarizing microscope was used. It is clear from Figure 2 (a) that no light can pass through the cell under crossed polarizers because all LC directors are vertically aligned. In Figures 2(b) and 2(c), the observed white spots of less than 10 micrometers are the homogeneous micro-domains embedded in the homeotropic layer. This tells us that PVCi was successfully removed by surface treatment without doing damage to the homeotropic layer.

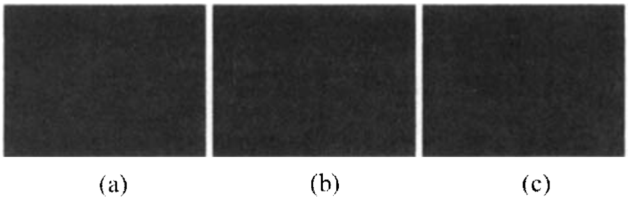


FIGURE 2 The microscopic textures of the LCD cells: (a) 10:3, (b) 10:5, and (c) 10:7 (x200).

The AFM images of hybrid alignment layer was also influenced by the solvent of PVCi as shown in Figure 3. 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.

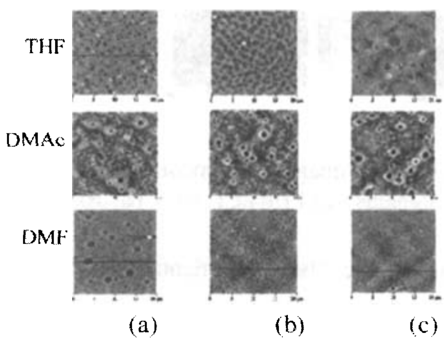


FIGURE 3 AFM images of hybrid alignment layer:(a) PI:PVCi=10:3, (b) 10:5 and (c) 10:7 (scanning size: 20 ㎛ × 20 ㎛).

The size of the homogeneous domain was also influenced by the solvent of PVCi as shown in Figure 4.

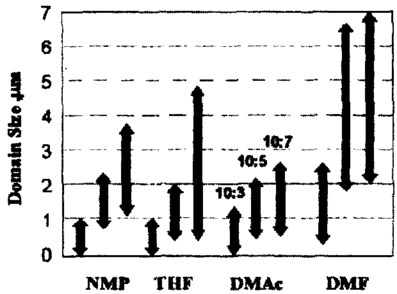


FIGURE 4 Homogeneous domain size for different solvents.

Viewing characteristics of the LCD cells assembled with the hybrid substrate are shown in Figure 5. The rubbing directions were anti-parallel and polarizers were positioned along the direction of 45° to the rubbing direction. Figure 5(a) and (b) shows that the contrast ratio of the hybrid LCD cell, along the direction of 45° to one of the polarizer, was about 10:1 up to ±30° without any compensation film.

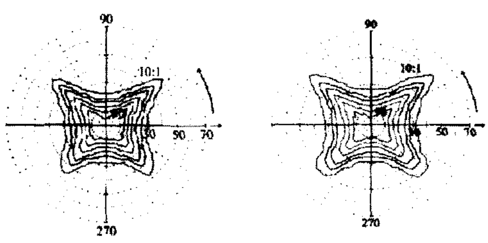


FIGURE 5 Viewing characteristics of LCD cells: (a) PI:PVCi=10:3 and (b) 10:5

On the other hand, the simulation of vertically aligned (VA) mode indicated that along the direction of 45° to one of the polarizer, the contrast ratio of 10:1 was obtained up to ±22° as shown in Figure 6(a). the simulation of VA mode cell with uniaxial compensation film indicated that along the direction of 45° to one of the polarizer, the contrast ratio of 10:1 was obtained up to ±40 ~ 45° as shown in figure 6(b).

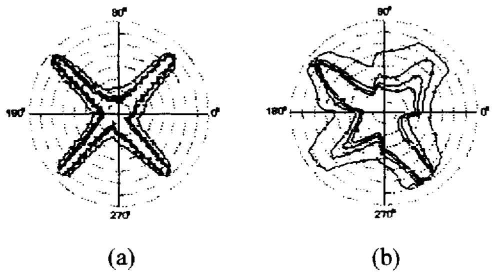


FIGURE 6 Viewing characteristics simulations of VA mode cell:
(a) Simulation results of VA mode.
(b) Simulation results of VA mode with compensation film.

This value is close to other simulation results [4]. 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.

CONCLUSION

A new and simple type of alignment layer for wide viewing angle LCDs was introduced. By spin coating PI/PVCi blend onto the homogeneous layer and then by surface treatment, we could make a homeotropic-homogeneous hybrid alignment layer. The homogeneous micro-domains embedded in homeotropic alignment were observed by the measurement of AFM and optical polarizing microscope. The domain size was ranged from 1 μm to 10 μm and it could be controllable by changing PVCi weight ratio. Viewing characteristics of LCD cells made with this technique were improved to some extent.

ACKNOWLEDGEMENT

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