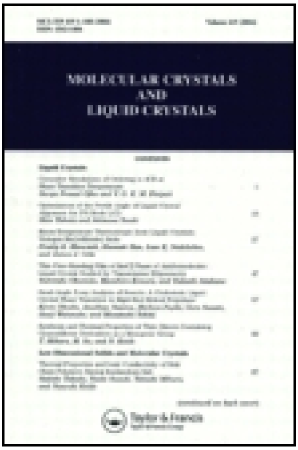

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Laser Etchings on Polyimide Alignment Layers in Multi-Domain VA Mode

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Laser Etchings on Polyimide Alignment Layers in Multi-Domain VA Mode

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We used a homeotropic and homogeneous hybrid double layer with micro-domains as a vertically aligned (VA) mode for wide viewing angle. Multi-domains of homogeneous polyimide on homeotropic polyimide (PI) layer were obtained using a noncontact method based on laser ablation. Nonpolarized light from a KrF excimer laser at 248 nm was illuminated through a phase mask to etch gratings of various patterns onto homeotropic PI layer. The contrast of LC cells, made with the hybrid double layer, along the direction of 45° to one the polarizers, was about 10:1 up to ± 30° without any compensation film.

Keywords: Wide viewing angle; Multi-domain; Excimer laser; Laser etching; Homeotropic-Homogeneous alignment layer

INTRODUCTION

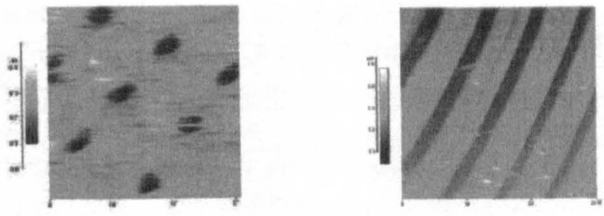
Hybrid alignment of a liquid crystal (LC) on multi-domains (MD) is one of the techniques improving viewing characteristics by dividing each pixel into sub-pixels in which the optical characteristics of LC compensate each other [1]. Also, there has been interest in noncontact alignment methods for LCDs to replace the rubbing of polymer alignment layers, which limits the yield of active matrix displays. Berreman first examined micro-groove alignment of LC and concluded that alignment along the groove direction was due to the minimization of the elastic strain energy of the LC. Since then excimer laser etching has been tried to make patterns on alignment layers [2]. Excimer laser provides a more convenient and controllable way to etch gratings into polymer layers through phase masks. The ablation is a one step process and large areas can be patterned. In this work we report on the enhanced viewing angle characteristics of LCDs by embedding homogeneous micro-domains in homeotropic alignment layer with laser etching process.

EXPERIMENTAL

In order to prepare a homeotropic-homogeneous hybrid layer with micro-domains, homogeneous polyimide (PI, AL 3046, JSR Co.) was spin-coated on indium-tin-oxide glass plates and then cured to yield homogeneous layers, on which solution of homeotropic PI (JALS 2021-R1, JSR Co.) was coated. After curing, nonpolarized light from a KrF excimer laser at 248 nm is exposed through a phase mask to etch gratings of micro-domains onto homeotropic polyimide layer. LCD cells were assembled with rubbed hybrid layer and then a commercial liquid crystal (EN-40, Chisso Co.) was filled. The gap of each cell was 5 μm. Surface morphology of the homeotropic-homogeneous double layer with micro-domains was observed with an atomic force microscope (AFM) and an optical polarizing microscope. The viewing angle characteristics of the LCD cell were obtained using Autocronic DMS 501.

RESULTS AND DISCUSSION

The AFM images of the surface-treated alignment layer are shown in Figure 1.

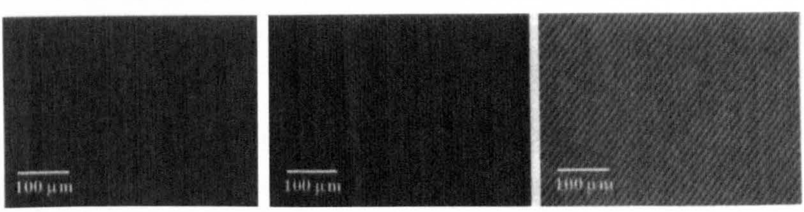


(a) (b)

FIGURE 1. The AFM images of homeotropic-homogeneous micro-domains: (a) rectangle and (b) groove (homogeneous : homeotropic=3:7, scanning size: 30 μm × 30 μm).

Uniform domains are clearly seen in Figure 1.

In order to investigate the LC orientation, an optical polarizing microscope was used.

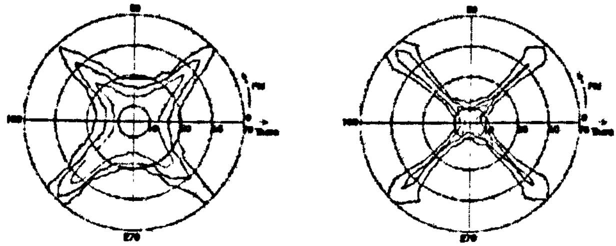


(a) (b) (c)

FIGURE 2. The microscopic textures of the LCD cells: (a) vertically aligned, (b) homogeneous:homeotropic=3:7 (rectangle), and (c) 3:7 (bar) (magnification:× 200).

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 (c), the observed white spots of 3 micrometers are the homogeneous micro-domains embedded in the homeotropic layer. This implies that homeotropic layer was successfully etched by excimer laser without doing damage to the homogeneous layer.

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, along the direction of 45° to one of the polarizer, was about 10:1 up to ±30° without any compensation film. On the other hand, the viewing characteristic of VA mode indicates that along the rubbing direction of 45° to the polarizer, the contrast ratio of 10:1 was obtained up to ±10° as shown in Figure 3(b).



(a) (b)

FIGURE 3. Viewing characteristics of LCD cells: (a) VA mode cell, (b) Homogeneous-Homeotropic double layer cell (3:7).

The reason why the cell made with the hybrid double layer showed better viewing characteristics than VA mode one is that LC orientation was influenced by uniform micro-domains and compensated for the difference of optical characteristics.

Acknowledgment

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