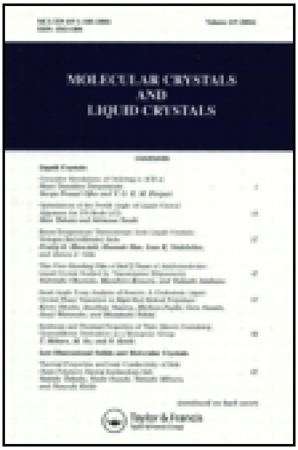

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Axially Symmetric Vertically-Aligned (ASVA) Liquid Crystal Display Using Surface Relief Gratings on a Polymer Layer

Jae-Hong Park [a], Ju-Hyun Lee [a], Doo-Hwan You [a] & Sin-Doo Lee [a]

[a] School of Electrical Engineering #032, Seoul National University, Kwanak P.O. Box 34, Seoul, 151-742, Korea

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Axially Symmetric Vertically-Aligned (ASVA) Liquid Crystal Display Using Surface Relief Gratings on a Polymer Layer

JAE-HONG PARK, JU-HYUN LEE, DOO-HWAN YOU and SIN-DOO LEE*

School of Electrical Engineering #032, Seoul National University, Kwanak P.O. Box 34, Seoul 151-742, Korea

A new method of fabricating a vertically aligned (VA) LCD with axially symmetric multi-domains is presented here. Multi-domain structure is created by 2-dimensional grating surfaces treated to induce homeotropic alignment. The LCD configuration presented here has an axially multi-domain structure along the surface relief and excellent viewing characteristics.

Keywords: liquid crystal display; wide-viewing; surface relief grating

INTRODUCTION

For eliminating asymmetric viewing properties of a twisted nematic (TN) mode, various multi-domain methods are presented. Especially, a vertically aligned (VA) multi-domain mode[1] is promising one due to its good contrast and wide viewing characteristics. However, its fabrication involves complex processes such as multiple rubbings, elaborate evaporation. Recently, an easy method of controlling the surface morphology has been extensively studied for making microlens arrays[2]. This method is based on the contraction effect of ultra-violet (UV) curable photopolymer. We adopt this technique for producing the multi-domain homeotropic alignment structure which has the surface morphology with precise domain size and surface inclination.

In this paper, we propose a wide-viewing LCD mode realized in an axially symmetric vertical alignment (ASVA) configuration. In order to obtain this configuration, we make surface relief gratings on an UV curable photo-polymer and coat it with a homeotropic alignment polyimide.

EXPERIMENTAL

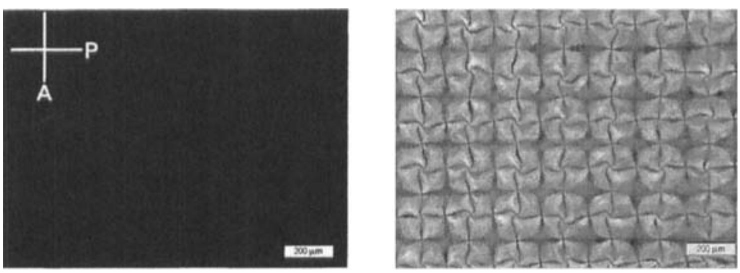
The UV curable optical adhesive (NOA60, Norland Products Inc.) was spin-coated on the ITO glass under the condition of 4000 r.p.m for 100 seconds. This photopolymer layer was irradiated by UV light from Xe-Hg lamp with 50 mW/cm^2 in about 1 second through a chromium photomask with 100 μm circular apertures which is arranged with 200 μm period, and was subsequently illuminated with the same power in 15 minutes without the photomask. The homeotropic polyimide, JALS204 (Japan Synthetic Rubber), was spin-coated onto this surface. The cell was assembled with the above substrate and another one with only JALS204. We used 5 μm glass spacers to maintain the cell gap. Our cell was filled with a nematic liquid crystal, EN40 (Merck Co.), which has negative dielectric anisotropy.

We observed the cell texture as a function of the applied voltage of a bipolar square waveform at the frequency of 1 kHz under an optical microscope. The iso-contrast map was measured to determine the viewing characteristics.

RESULTS AND DISCUSSION

When the polymer is illuminated through the photomask, the photopolymerized process begins at positions corresponding to the apertures. Then, the difference in density between the illuminated areas and unilluminated ones causes the contraction effect to move the polymer into the illuminated region during the polymerization process so that micro-groove array is formed. This micro-groove induces pretilt angle variations along which directions are axially distributed. The maximum height of the micro-groove is about 600 nm under the above condition.

Figure 1 shows the texture of the cell under crossed polarizers. In the case of no applied field, the liquid crystal is homeotropically aligned so that a dark state similar to a normal VA mode is obtained. In the ON state, the axial symmetrical structure can be observed along the micro-groove array.



(a) (b)

FIGURE 1 Polarized microscopic texture : (a) OFF state (b) ON state

As mentioned above, the illuminated region through the photomask upheave by contraction and redistribution of the photopolymer matrix occurs during curing process. Therefore, the LC molecules in the valley of the grating surface start to reorient when the voltage is applied.

Figure 2 illustrates the iso-contrast map of the cell. Clearly, the symmetric viewing property can be seen. The ASVA cell has the axially symmetric transmittance property in the ON state. However, the VA mode has the intrinsical leakage of light in the OFF state along the nonpolarizer directions so that it has relatively low contrast along these directions.

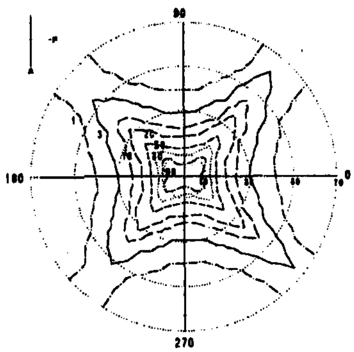


FIGURE 2 Iso-contrast map

In summary, we have demonstrated the wide-viewing LCD mode that is realized by the ASVA configuration, This configuration is obtained using two dimensional surface grating treated to induce initially vertical alignment. The multi-domain size is easily varied and the rubbing process is not needed in this configuration. Therefore, defect free structures can be obtained in contrast to other multi-domain modes based on multiple rubbing processes. Moreover, the perfect dark condition can be obtained in the OFF state, which results in high contrast and wide characteristics.

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