휴대용 통신단말에 사용되는 혼합액정계에서의 프리틸트각 특성에 관한 연구

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Pretilt Angle Properties of Mixture Nematic Liquid crystal for Mobile Information Device

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요 약

본 연구에서는 폴리이미드 박막위에서의 수직 및 수평배향에서 혼합액정의 배향 특성에 대해서 연구하였다. 혼합액정은 러빙을 이용하여 배향처리하였으며, 러빙에 사용된 폴리이미드 박막은 알킬기를 Side Chain으로 가진 수직배향용 배향막과 그렇지 배향막으로 나누어서 프리틸트각 특성을 측정하였다. 실험결과 혼합액정을 사용하여 양호한 배향상태를 얻을 수 있었으며, 고온에서의 열안정성에서도 우수한 특성을 보이는 것을 알 수 있었다. 또한 프리틸트각의 발생 원리를 이해하기 위해서 접촉각 측정을 실시하였으며, 이 둘이 밀접한 상관관계를 갖고 있음을 알 수 있었다.

Key Words : liquid crystal, liquid crystal alignment, rubbing, imidizing, contact angle

ABSTRACT

We studied the state of the dual liquid crystal (LC) alignment which displays both homeotropic and homogeneous alignment on blended polyimide (PI) layer. The research was conducted using rubbing method at different imidizing temperatures and the blended PI was made using homeotropic PI having an alkyl side chain and homogeneous PI without the side chain. The uniform LC alignments were achieved, and have thermal stability. The results of contact angles were similar to that of pretilt angles.

I. Introduction

Liquid crystal display (LCD) device is composed of several materials such as a liquid crystal (LC), a liquid crystal alignment layer, thin film transistors (TFTs) and so on. The LC alignment layer has an important role to align LC molecules uniformly.[1-4] Conventionally, rubbed polyimide(PI) layer was used as the LC alignment layer.[1-4] Two type sof LC alignment layer have been mostly used ; one is homeotropic PI layer which has an alkyl side chain, the other, homogeneous PI layer without the side chain. However, there is much demand for an alignment layer that is able to change pretilt angles by simple process.

Recently, many techniques have been proposed, which is able to change pretilt angles. The first attempt was well-known SiO_2 evaporation method.[5] Uchida *etal.* have shown that the oblique surface structure of SiO_2 under various deposition conditions can produce tilting alignment of LC molecules. High pretilt angle was achieved by using rubbed PI containing fluoricmoieties.[6] Elsewhere, blending of homeotropic and homogeneous PI via the rubbing orpolarized deep-ultraviolet techniques,[7, 8] dual alignmet layer,[9] and amorphous fluorinated carbon thin film via an ion-beam(IB),[10] and etc. were suggested by many researchers.

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In this study, we studied the LC alignment transition between homeotropic and homogeneous on blended PI layer using rubbing method at different imidizing temperatures. The high imidizing temperature for the blended PI can break side chain of the PI, and then affects pretilt angles transition. The uniform LC alignments were achieved, and have thermal stability. The results of contact angles were similar to that of pretilt angles

Ⅱ. Experimental

Indium-tin-oxide (ITO)-coated glass was cleaned in a trichloroethylene-acetone-methanol-deionized water in sequence for 10 min and dried by N_2 gas. Blended PIs (JSR Co. Ltd., Japan) for the homogeneous and homeotropic alignment layers were prepared in containing ratio of 50:50. The blended PI was uniformly coated on ITO-coated glass substrates for 30 sec. at 3000 rpm at room temperature. The blended PI layers were pre-baked at 80°C for 10 min. and then were fully baked at 220 - 300°C for 1 hour. The blended PI layers were rubbed using rubbing machine wrapped with a nylon cloth. The rubbing strength (RS) is defined by the following equation.[3]

$$RS=NM(2prn/V-1)$$

Where, N is the cumulative number of rubbings, M is the depth of the fibers(mm), r is the radius of the drum(cm), n is the rotationrate of the drum(rpm), and V is the velocity of the substrate stage(cm/s). For this experiment, all of the blended PI layers were rubbed with a RS of 300 for LC alignment. To observe the pretilt angle and LC orientation, antiparallel LC cells were fabricated using the rubbed blended PI layers substrates with a cell gap of 60mm. The commercial negative ($D\varepsilon$=-4, MJ98468, Merck) LCs were injected into the cell in the isotropic state in order to minimize the influence of creating flow alignment by the capillary action.

To certify the thermal stability of LCs we compared pretilt angles of LCs in antiparallel cells before and after annealing of 100 °C. The pretilt angles of the LCs with respect to the planar direction in antiparallel cell we remeasured by the crystal rotation method(AutronicTBA107). The TBA107 was equipped with a Helium-Neon(HeNe) laser tube, apolarizer, and photodiode detector. The LC alignment characteristics were observed using photo microscope(OlympusBXP51). The static contact angles of distilled water on each imidized surface were determined using a Rame-Hart telescopic goniometer and a Gilmont syringe with a 25 gauge flat-tipped needle using a contact angle analyzer(Phoenix450, Surface Electro Optics)

Ⅲ. Results and Discussion

Figure 1 shows the measured pretilt angles of LCs on rubbed blended PI layer as a function of imidizing temperature before and after annealing of 100 °C. The graph shows that homeotropic and homogeneous LC orientations were generated by varying the imidizing temperature from 220 to 300°C and tilt transition was occurred at a specific temperature between 245 and 250°C. This is due to overbaking of the blended PI layer. If the PI further imidized the back bones, the side chains of PI component would be broken, there by promoting nearly homogeneous alignment.[11] Under the temperature at 245°C, the pretilt angle was nearly similar in range of 70°, which would correspond to homeotropic alignment. However, above the transition point the pretilt angles were produced at about 30°, as homogeneous alignment. Moreover, pretilt angles were scarcely changed after annealing. This indicates the LC alignment on rubbed blended PI layer is stable to maintain a performance via inferior thermal condition. The before and after annealing pretilt angles of LCs on rubbed blended PI layer with increased imidizing temperature are summarized in Table I. The apparent transition point was also observed between 245 and 250°C.

Table 1. Before and after annealing pretilt angles of LCson rubbed blended PI layer with increased imi- dizing temperature.

Baking temp.	Pretilt angle		State of LC alignment
	Before annealing	After annealing	
220	71.5	66.8	Homeotropic
230	71.3	64.7	
240	70.2	63.5	
245	70.1	63.0	
250	21.8	22.2	Homogeneous
260	15.5	16.3	
270	18.7	20.6	
280	19.2	21.1	
300	22.5	24.5	

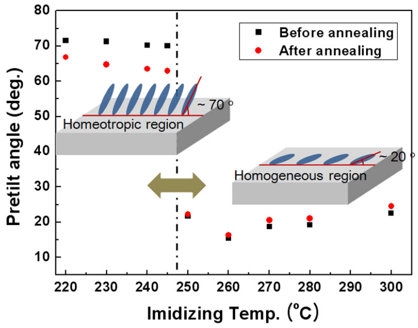

Figure 1. Pretilt angles of LCs on rubbed blended PI layer as a function of imidizing

Figure 2 shows optical photomicrographs of LCs for antiparallel cell (under crossed Nichols). Clear good alignment with no disclination was observed in all samples. These results indicate that LCs were well-aligned on rubbed blended PI layer and that state of LC alignment was not affected with increasing imidizing temperature.

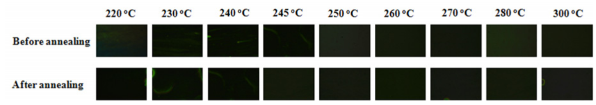

Figure 2. Optical photomicro graphs of LCs for anti-parallel cell before and after annealing byincreasing imidizing temperature from 220°C to300°C (under crossed Nichols).

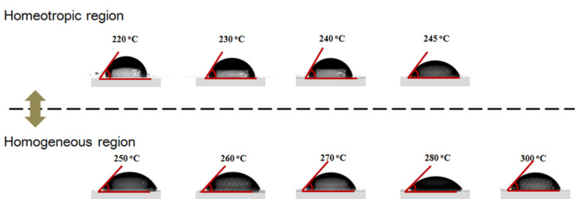

Figure 3. Water contact angles on rubbed blended PI layers as a function of imidizing temperature.

The water contact angles on rubbed blended PI layers according to the imidizing temperature were measured to reveal the relationship with pretilt angle in Fig. 3. The pretilt angle of LCs on PI layer is affected by surface tension and wettability, so we adopted water contact angles in static mode.[12] The upper side images represented the homeotropic region under the imidizing temperature of 245°, which had relatively high contact angles. While the lower side images had low contact angles over the imidizing temperature of 250°C, and it represented the homogeneous region. These results showed a similar tendency between contact angles and pretilt angles, and corresponded previous data.[12] The imidizing temperature was primary factor to break side chains of blended PI components, and caused wettability variation, and then changed pretilt angles. Figure 4 showed the plot of contact angles we measured.

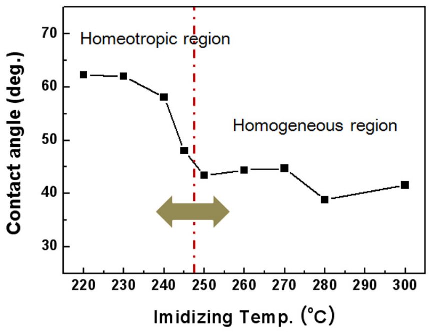

Figure 4. The plot of contact angles.

Ⅳ. Conclusion

We achieved dual alignment states on blended PI layer, including homeotropic and homogeneous alignment, according to imidizing temperature using rubbing method for variable application in LCDs. The measured pretilt angles discriminated between homeotropic and homogeneous alignment, and the transition point was observed between 245°C and 250°C. Moreover we annealed antiparallel cells at 100°C to obtain thermal stability, and observed a good and stable alignment via thermal condition. The uniform LC alignment was observed by all samples regardless of imidizing temperature. The contact angles corresponded to tendency of pretilt angles. This result suggests a promising method to obtain both VA and TN cells using this technique.

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