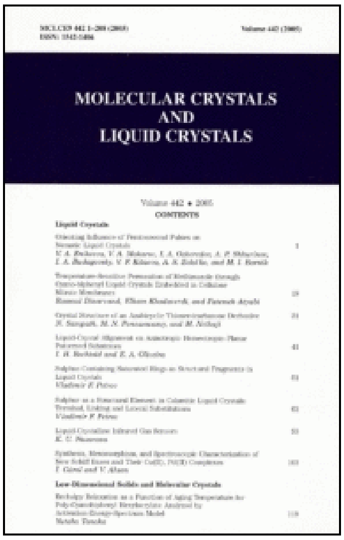

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Pretilt Angles Transition via Mixture Liquid Crystal System

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Pretilt Angles Transition via Mixture Liquid Crystal System

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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.

Keywords Blend polyimide; contact angle; imidizing; liquid crystal alignment; rubbing

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 types of 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 *et al.*

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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 fluoric moieties [6]. Elsewhere, blending of homeotropic and homogeneous PI via the rubbing or polarized deep-ultraviolet techniques [7,8], dual alignment layer [9], and amorphous fluorinated carbon thin film via an ion-beam (IB) [10], and etc. were suggested by many researchers.

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.

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 prebaked 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 rotation rate 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 60 μm. The commercial negative ($\Delta\varepsilon = -4$, 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 were measured by the crystal rotation method (Autronic TBA 107). The TBA 107 was equipped with a Helium-Neon (HeNe) laser tube, a polarizer, and photodiode detector. The LC alignment characteristics were observed using photomicroscope (Olympus BXP51). 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 (Phoenix 450, Surface Electro Optics).

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

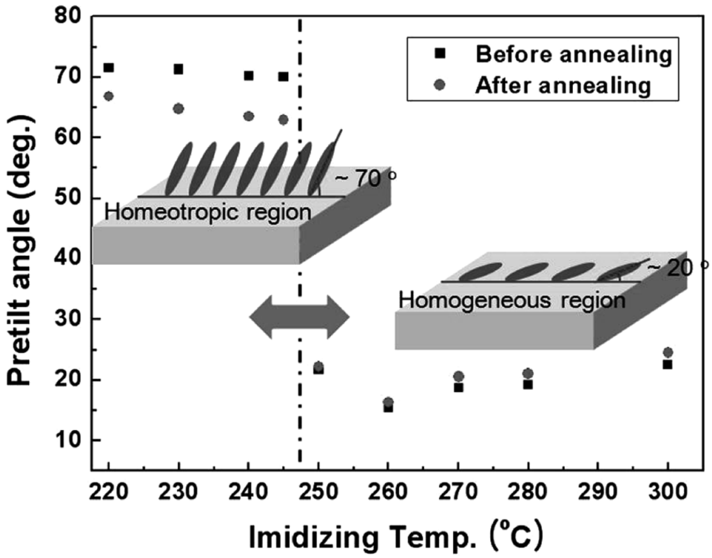

Figure 1. Pretilt angles of LCs on rubbed blended PI layer as a function of imidizing temperature before and after annealing.

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 backbones, the side chains of PI component would be broken, thereby 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 1. The apparent transition point was also observed between 245 and 250°C.

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.

The water contact angles on rubbed blended PI layers according to the imidizing temperature were measured to reveal the relationship with pretilt angle in Figure 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

Table 1. Before and after annealing pretilt angles of LCs on rubbed blended PI layer with increased imidizing temperature

	Pretilt angle		
Baking temp.	Before annealing	After annealing	State of LC alignment
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	

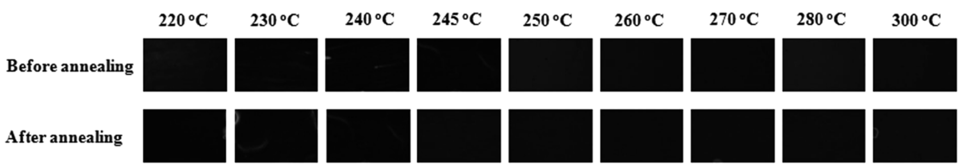

Figure 2. Optical photomicrographs of LCs for antiparallel cell before and after annealing by increasing imidizing temperature from 220°C to 300°C (under crossed Nichols).

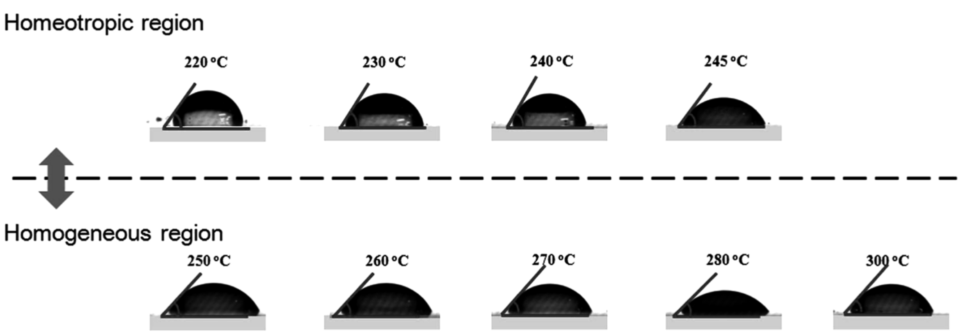

Figure 3. Water contact angles on rubbed blended PI layers as a function of imidizing temperature.

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.

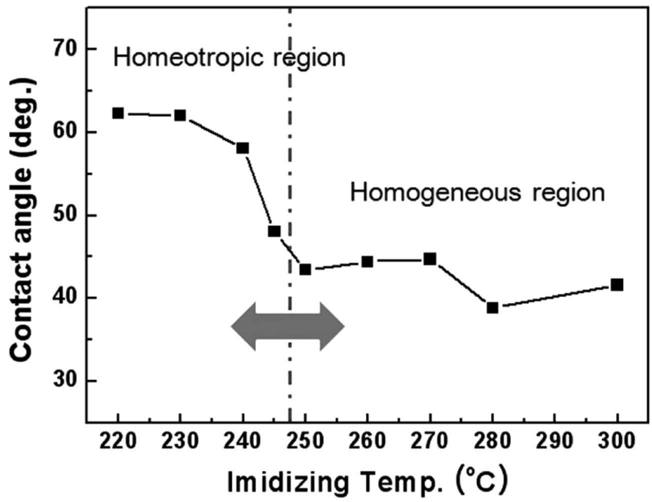

Figure 4. The plot of contact angles.

Conclusions

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.

Acknowledgments

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References

[1] Berreman, D. W. (1972). *Phys. Rev. Lett.*, *28*, 1683.
[2] Toney, M. F., Russell, T. P., Logan, J. A., Kikuchi, H., Sands, J. M., & Kumar, S. K. (1995). *Nature*, *374*, 709.
[3] Seo, D. S., Kobayashi, S., & Nishikawa, M. (1992). *Appl. Phys. Lett.*, *61*, 2392.
[4] Seo, D. S., & Kobayashi, S. (1999). *J. Appl. Phys.*, *86*, 4046.
[5] Uchida, T., Ohgawara, M., & Wada, M. (1980). *Jpn. J. Appl. Phys., Part 1*, *19*, 2127.
[6] Seo, D. S. (1999). *J. Appl. Phys.*, *86*, 3594.
[7] Yeung, F. S., Ho, J. Y., Li, Y. W., Xie, F. C., Tsui, O. K., Sheng, P., & Kwok, H. S. (2006). *Appl. Phys. Lett.*, *88*, 051910.

[8] Ho, J. Y. L., Chigrinov, V. G., & Kwok, H. S. (2007). *Appl. Phys. Lett.*, *90*, 243506.
[9] Kim, J. B., Kim, K. C., Ahn, H. J., Hwang, B. H., Kim, J. T., Jo, S. J., Kim, C. S., & Baik, H. K. (2007). *Appl. Phys. Lett.*, *91*, 023507.
[10] Kim, J. B., Kim, K. C., Ahn, H. J., Hwang, B. H., Hyun, D. C., & Baik, H. K. (2007). *Appl. Phys. Lett.*, *90*, 043515.
[11] Vaughn, K. E., Sousa, M., Kang, D., & Rosenblatt, C. (2007). *Appl. Phys. Lett.*, *90*, 194102.
[12] Park, H. G., Oh, B. Y., Kim, Y. H., Kim, B. Y., Han, J. M., Hwang, J. Y., & Seo, D. S. (2009). *Electrochem. Solid State Lett.*, *12*, J37.