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Generation of pretilt angle in NLC and EO characteristics of transcription-aligned TN-LCD fabricated by transcription alignment on polyimide surfaces

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In this work, we have investigated the monodomain alignment of a nematic liquid crystal (NLC) in cells fabricated by transcription alignment on a polyimide (PI) surface with side chain. The generated pretilt angle of the NLC is about 3.7°; it decreases with increasing rubbing time of the original substrate. It is considered that the generation of the pretilt angle in a NLC may be attributed to steric interaction of the polymer side chain. It is also suggested that LC alignment produced by transcription alignment techniques is attributable to the memory effect of the NLC on the PI surface. We also observed good voltage–transmittance characteristics for a transcription-aligned twisted nematic (TN-LCD) on a PI surface; it is almost the same as for a rubbing-aligned TN-LCD. Finally, we suggest that the slow response time characteristics of a transcription-aligned TN-LCD may be attributed to the weak anchoring strength of the NLC.

1. Introduction

The uniform alignment of liquid crystals (LCs) on treated substrate surfaces is very important for the achievement of high quality display in liquid crystal display (LCD) technology [1]. The rubbing method is a widely used technique for LC alignments. Pretilt angle formation, which is a very important step in the alignment process, prevents the creation of reverse tilt disclinations in a twisted nematic LCD (TN-LCD). Pretilt angle generation of NLCs by a unidirectional rubbing treatment on rubbed polyimide (PI) surfaces has been demonstrated and discussed by many investigators [2–11].

Recently, non-rubbing techniques for uniform LC alignment have been needed in thin-film-transistor (TFT)-LCD. In a previous paper, we reported that the TFTs were damaged by induced static electricity during rubbing [12]. Also, we previously discussed uniform alignments of the NLC in cells on PI-Langmuir–Blodgett (LB) films in relation to non-rubbing techniques [13, 14]. Recently, Toko has reported on the electro-optical (EO) performance and pretilt angle generation in cells fabricated by transcription alignment on PI surfaces [15]. Pretilt angles of the NLC around 0.5° were generated on various PI surfaces with alkyl side chains [15]. However, the pretilt angles need to be about 2° ∼ 3° in order to avoid reverse tilt disclination and for practical operation of the TN-LCD. Most recently, we reported the observation of high pretilt angle for NLC in cells fabricated by transcription alignment on a PI surface with side chain [16].

In this paper, we report the pretilt angle generation of the NLC and EO characteristics of transcription-aligned TN-LCD fabricated by transcription alignment on a PI surface with side chain.

2. Experimental

In this study, we used a PI film with side chains as a super (S) TN-LCD (see figure 1). The precursors were coated on indium tin oxide (ITO) coated glass substrates by spin-coating, and imidized at 250°C for 1 h. The thickness of the PI films used was 500 Å. The fabrication processes for the transcription alignment cells are shown in figure 2. The original substrates (PI films) were unidirectionally rubbed using a machine equipped with a nylon roller (Y_0-15-N, Yoshikawa Chemical Industries Co., Ltd). The definition of the rubbing strength, *RS*, has been given in previous papers [5, 6]. The transcribed

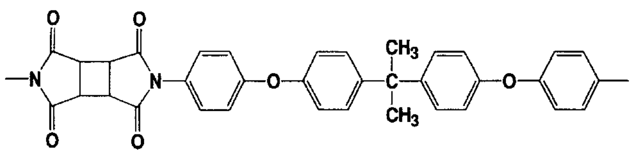

Figure 1. Chemical structure of the polymer.

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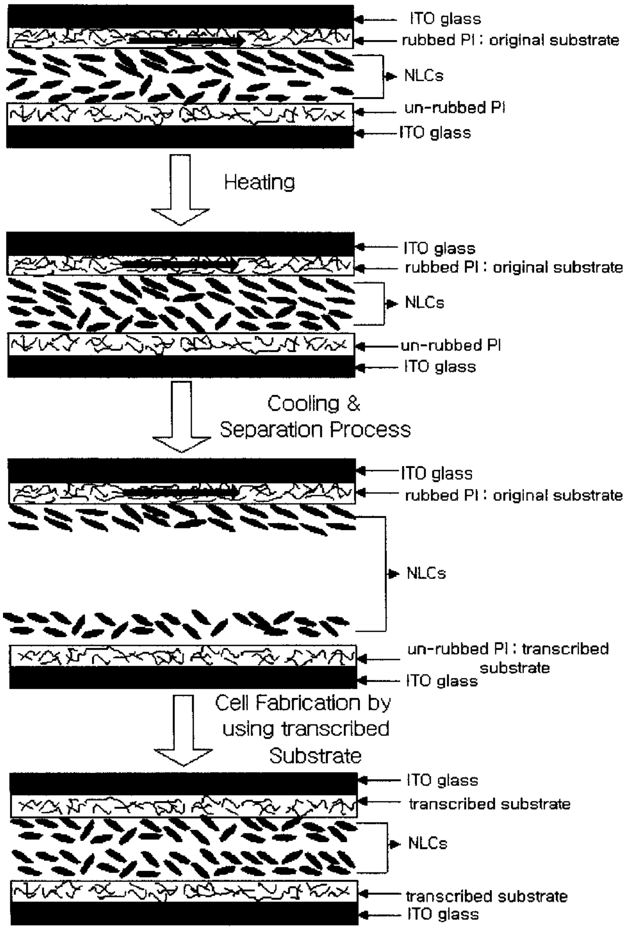


Figure 2. Fabrication processes for the transcription alignment cell.

substrates used unrubbed PI films. The transcription alignment cells were fabricated with a rubbed PI surface (original substrate) and an un-rubbed PI surface (transcribed substrate), and were heated at 101°C (where the NLC shows the isotropic phase) for LC injection. The NLC used in this experiment was a fluorinated type mixture with clearing temperature $T_c = 91$°C (ZLI-4792, E. Merck). The cell was cooled to room temperature, and the LC changed from the isotropic phase into the nematic phase. The NLC molecules were aligned along the rubbing direction of the rubbed PI surface (original substrate). The original substrate was then separated from the transcribed substrate. The transcribed substrate was stacked upon another transcribed substrate to form the transcription alignment cell. All LC layers were 60 μm thick. The pretilt angles of the NLC in the nematic phase were measured by the crystal rotation method [17] at room temperature.

To measure the EO characteristics, the transcription-aligned TN-LCD was assembled; the NLC is formed with a twist angle of 90° without chiral dopant. The LC layers of transcription-aligned TN-LCD used were about 5 μm thick. The LC orientation capability was evaluated by observation of optical microscopic textures and generation of pretilt angles. We then observed the EO characteristics of transcription-aligned and rubbing-aligned TN-LCDs on the PI surface.

3. Results and discussion

Figure 3 gives a photomicrograph of an aligned NLC in a cell fabricated by transcription alignment on a PI surface (between crossed Nicols); monodomain alignment of the NLC is demonstrated. The NLC molecules are aligned along the transcribed direction due to its memory effect on the PI surface. In this study, the characteristics of LC alignment agree with the results of Toko [15]. Therefore, we consider that the LC alignment in a cell fabricated by transcription alignment on PI surfaces is attributable to the memory effect of the NLC. The use of transmission versus incident angle to measure pretilt angle using the crystal rotation method in a cell fabricated by transcription alignment on a PI surface is shown in figure 4. Table 1 shows the pretilt angles of the NLC in cells fabricated by transcription alignment on PI surfaces with different rubbing times of the original substrate. The generated pretilt angles of the NLC are about 1.2° ~ 3.7° on the original substrate with a given rubbing time. It is large enough to avoid reverse tilt disclination and for the practical operation of a TN-LCD. It can be seen that the pretilt angle of the NLC decreases with increasing rubbing time of the original substrate. We consider that the pretilt angle of the NLC may be attributed to steric interaction due to the side chain of the polymer on the PI surface [8, 10]. In a previous paper, it is reported that the pretilt angle of NLC generated is about 3° on a rubbed PI surface with side chain [5]. From these results, we consider that the

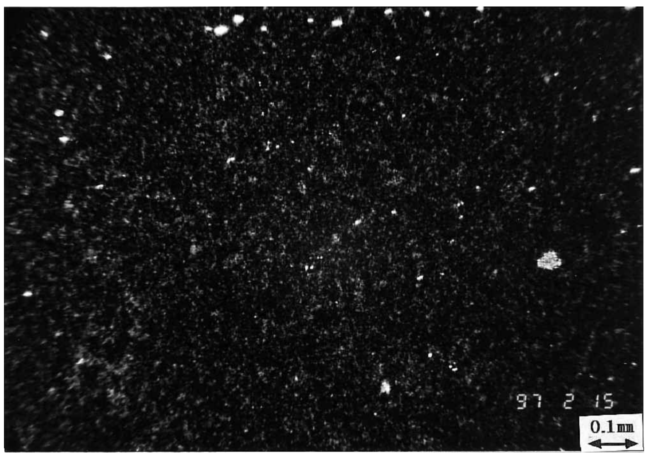


Figure 3. Photomicrographs of aligned NLC in a cell fabricated by transcription alignment on a PI surface.

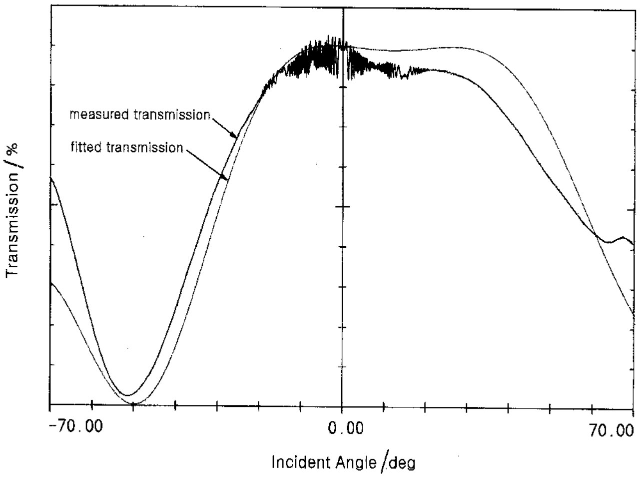


Figure 4. Transmission versus incident angle in the measurements of pretilt angle using the crystal rotation method in a cell fabricated by transcription alignment on a PI surface.

Table 1. Pretilt angles of NLC in cells fabricated by transcription alignment on PI surfaces.

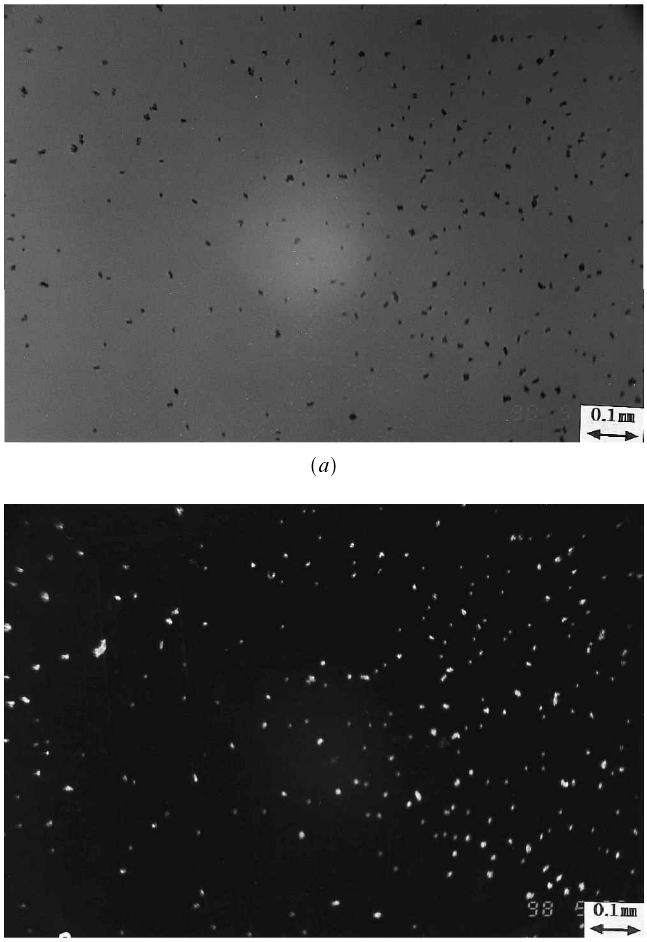
Rubbing times of original substrate	Pretilt angles/°
1 period	1.2 ~ 3.69°
3 periods	0.25 ~ 2.28°

generated pretilt angle of a NLC in cells by transcription alignment on a PI surface is almost equal to that for a rubbing alignment cell.

Next, we investigated the EO characteristics of a transcription-aligned TN-LCD. The photomicrographs of a transcription-aligned TN-LCD fabricated by transcription alignment on a PI surface with side chain are shown in figure 5. It can be seen that reverse tilt disclinations are not formed in the on-state; excellent contrast is also seen.

Figure 6 shows the voltage–transmittance (V–T) characteristics of a transcription-aligned TN-LCD fabricated by transcription alignment and of a rubbing-aligned TN-LCD on a PI surface with $RS = 164$ mm. Good transmittance characteristics for the transcription-aligned TN-LCD are obtained. Table 2 gives the applied voltage versus transmission for a transcription-aligned and rubbing-aligned TN-LCDs on PI surface; it is seen that the threshold voltage of the transcription-aligned TN-LCD is high compared with the rubbing-aligned TN-LCD.

The response time characteristics of a transcription-aligned TN-LCD on a PI surface are shown in figure 7. It is seen that the curve of the transcription-aligned TN-LCD is less sharp than that of the rubbing-aligned TN-LCD in their decay time characteristics. Also, no backflow effect on the transcription-aligned TN-LCD is observed. Table 3 shows the response times for transcription-aligned and rubbing-aligned TN-LCDs on PI



(*a*)

(*b*)

Figure 5. Photomicrograph of a transcription-aligned TN-LCD on a PI surface: (*a*) off-state; (*b*) on-state.

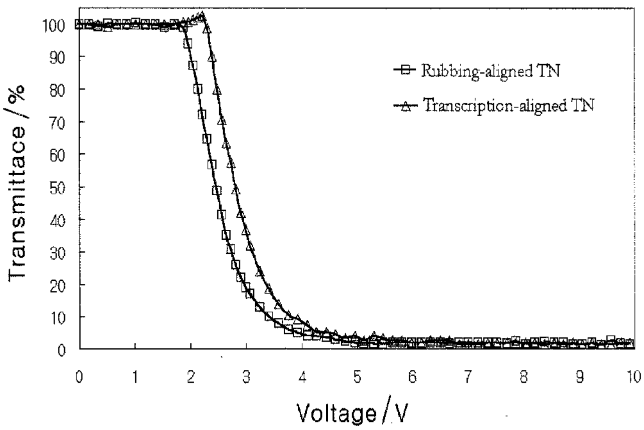


Figure 6. Voltage–transmission characteristics for a transcription-aligned and rubbing-aligned TN-LCDs on PI surface.

Table 2. Applied voltage versus transmittance for transcription-aligned and rubbing-aligned TN-LCDs on PI surface.

TN-LCD alignment	V_{10} [a]/V	V_{90} [b]/V
Rubbing	3.4	1.9
Transcription	3.74	2.39

[a] 10% transmittance.
[b] 90% transmittance.

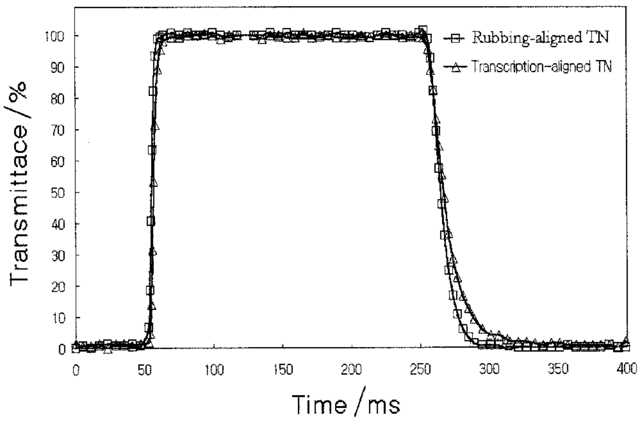


Figure 7. Response time characteristics for transcription-aligned and rubbing-aligned TN-LCDs on PI surface.

Table 3. Response time characteristics for transcription-aligned and rubbing-aligned TN-LCDs on PI surface.

TN-LCD alignment	Rise time τ_r/msec	Decay time τ_d/msec	Response time τ/msec
Rubbing	8.4	26	34.4
Transcription	8.4	33.8	42.4

surface. The slow response time characteristics for the transcription-aligned TN-LCD are clearly observed. Recently, Toko has reported that the azimuthal anchoring energy of the NLC in a cell fabricated by transcription alignment on PI surface is about 5×10^{-4} J m^{-2} [15]. In a previous paper, it was reported that the azimuthal anchoring energy of the NLC is about 1×10^{-4} J m^{-2} on a rubbed PI surface with side chain [18]. Therefore, it is considered that the anchoring strength in a cell by transcription alignment is weak compared with that for a rubbing-aligned cell. From these results, we suggest that the slow response time for the transcription-aligned TN-LCD may be attributed to the weak anchoring strength between the LC molecules and the polymer surface due to transcription alignment on PI surface.

4. Conclusion

In conclusion, monodomain alignment of the NLC in cells fabricated by transcription alignment on a PI surface was observed. The generated pretilt angle of the NLC was about 3.7° in cells with one rubbing period of the original substrate. We consider that the pretilt angle of a NLC fabricated by transcription alignment is attributed to steric interaction due to the polymer side chain. We also suggest that the LC alignment obtained by transcription alignment on a PI surface is attributable to the memory effect of the NLC. Good voltage–transmittance characteristics for a transcription-aligned TN-LCD on PI surface were observed, almost the same as for a rubbing-aligned TN-LCD. Finally, we consider that the slow response time characteristics for a transcription-aligned TN-LCD may be attributed to the weak anchoring strength of the NLC.

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References

[1] Cognard, J., 1982, *Mol. Cryst. liq. Cryst.*, **78** Suppl. 1, 1.
[2] Geary, J. M., Goodby, J. W., Kmetz, A. R., and Patel, J. S., 1987, *J. appl. Phys.*, **62,** 4100.
[3] Kuniyasu, S., Fukuro, H., Maeda, S., Nakaya, K., Nitta, M., Ozaki, N., and Kobayashi, S., 1988, *Jpn. J. appl. Phys.*, **27,** 827.
[4] Myrvold, B. O., and Kondo, K., 1994, *Liq. Cryst.*, **17,** 437.
[5] Seo, D.-S., Muroi, K., and Kobayashi, S., 1992, *Mol. Cryst. liq. Cryst.*, **213,** 223.
[6] Seo, D.-S., Kobayashi, S., and Nishikawa, M., 1992, *Appl. Phys. Lett.*, **61,** 2392.
[7] Nishikawa, M., Miyamoto, T., Kawamura, S., Tsuda, Y., Bessho, N., Seo, D.-S., Iimura, Y., and Kobayashi, S., 1995, *Mol. Cryst. liq. Cryst.*, **275,** 15.
[8] Seo, D.-S., Yoshida, N., Kobayashi, S., Nishikawa, M., and Yabe, Y., 1995, *Jpn. J. appl. Phys.*, **34,** 4876.
[9] Becker, M. E., Kilian, R. A., Kosmowski, B. B., and Milynsky, D. A., 1986, *Mol. Cryst. liq. Cryst.*, **130,** 167.
[10] Sugiyama, T., Kuniyasu, S., Seo, D.-S., Fukuro, H., and Kobayashi, S., 1992, *Jpn. J. appl. Phys.*, **29,** 2045.
[11] Seo, D.-S., Oh-ide, T., Matsuda, H., Isogami, T., Muroi, K., Yabe, Y., and Kobayashi, S., 1993, *Mol. Cryst. liq. Cryst.*, **231,** 95.
[12] Matsuda, H., Seo, D.-S., Yoshida, N., Fujibayashi, K., and Kobayashi, S., 1995, *Mol. Cryst. liq. Cryst.*, **264,** 23.
[13] Seo, D.-S., Matsuda, H., Oh-ide, T., and Kobayashi, S., 1993, *Mol. Cryst. liq. Cryst.*, **224,** 13.
[14] Seo, D.-S., Kobayashi, S., Kang, D.-Y., and Yokoyama, H., 1995, *Jpn. J. appl. Phys.*, **34,** 3607.
[15] Toko, Y., 1997, *Mol. Cryst. liq. Cryst.*, **304,** 107.
[16] Seo, D.-S., Lee, B.-H., and Kobayashi, S., 1997, *Liq. Cryst.*, **24,** 473.
[17] Scheffer, T. J., and Nehring, J., 1977, *J. appl. Phys.*, **48,** 1783.
[18] Kobayashi, S., and Iimura, Y., 1994, *SPIE*, **2175,** 122.