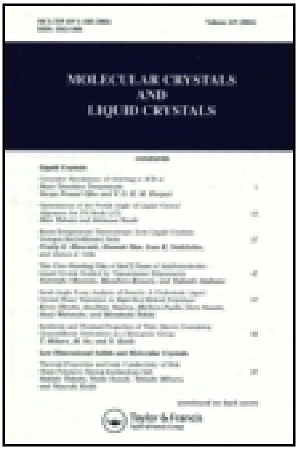


Molecular Crystals and Liquid Crystals

Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/gmcl20

Liquid Crystal Alignment Characteristics on the NDLC Thin Film Deposited using PECVD and Sputter

Sung-Ho Choi [a], Byeong-Yun Oh [a], Byoung-Yong Kim [a], Jeong-Min Han [a], Jin-Woo Han [a], Chul-Ho Ok [a], Sang-Keuk Lee [a], Jeoung-Yeon Hwang [a] & Dae-Shik Seo [a]

[a] Department of Electrical and Electronic Engineering, College of Engineering, Yonsei University, Seodaemun-gu, Seoul, Korea

Version of record first published: 22 Sep 2010

Mol. Cryst. Liq. Cryst., Vol. 480, pp. 3–9, 2008

ISSN: 1542-1406 print/1563-5287 online
DOI: 10.1080/15421400701821093

Liquid Crystal Alignment Characteristics on the NDLC Thin Film Deposited using PECVD and Sputter

Sung-Ho Choi, Byeong-Yun Oh, Byoung-Yong Kim, Jeong-Min Han, Jin-Woo Han, Chul-Ho Ok, Sang-Keuk Lee, Jeoung-Yeon Hwang, Dae-Shik Seo
Department of Electrical and Electronic Engineering, College of Engineering, Yonsei University, Seodaemun-gu, Seoul, Korea

Applying inorganic thin film to liquid crystal (LC) alignment layer has been observed for the alternative of the LC alignment method. In this study, LC alignment characteristics of the nitrogen doped diamond like carbon (NDLC) thin film which was deposited using different deposition method–sputtering and plasma enhanced chemical vapor deposition (PECVD) system was investigated. The difference of the thin film deposition method and the rate of composition gas can affect the LC alignment. The NDLC thin film that was deposited using sputter showed uniform LC alignment at the 1200 eV of the ion beam intensity while the NDLC thin film that was deposited using PECVD showed uniform LC alignment at the 1800 eV of the ion beam intensity in our previous research. The uppermost of the thermal stability of NDLC thin film was 200°C. However, NDLC thin film deposited using sputter showed stability at high temperature, compared with NDLC thin film deposited using sputter.

Keywords: LC alignment; NDLC thin film; pretilt angle; PECVD; sputter; thermal stability

INTRODUCTION

Uniform LC alignment is necessary to achieve good picture quality in LCD [1,2]. As the LCD applications have larger panel and higher quality more and more, uniform LC alignment and movement of LC

This work was supported by National Research Laboratory program (M1-0412-00-0008) and by the Ministry of Information & Communications of Korea under the Information Technology Research Center (ITRC) Program.

Address correspondence to Dae-Shik Seo, Department of Electrical and Electronic Engineering, Yonsei University Shinchon-dong, Sudaemoon-gu, Seoul 120-749, Korea (ROK). E-mail: dsseo@yonsei.ac.kr

have been more important. Until now, major LC alignment process is rubbing process. Rubbing process is simple and cheap in the manufacturing [3–5]. However, through the rubbing process, defects can be produced by debris and electrostatic. These defects can make manufacturing process be difficult [6]. And it is difficult for rubbing process to align LC molecules on the large substrate uniformly. Therefore, non-contact LC alignment process have been studied instead of rubbing process [7–9]. Ion-beam irradiation on the inorganic thin film is the one of the non-contact LC alignment process [10–12]. Especially, the experiment of the ion-beam irridation on the NDLC thin film was investigated by Chauharl et al. NDLC thin film have a high mechanical hardness, a high electrical resistivity, a low friction coefficient, optical transparency and chemical inertness. Ion-beam irradiation of the inorganic thin film can remove existing coating process of the alignment layer and rubbing process. To coat alignment layer on the glass substrate, spin coating method is used widely, but it is difficult to apply to large glass substrate, and more than 95% of the amount of alignment layer is used wastefully. Because of these reasons, slit process is applied to large-size panel manufacturing, however it's disadvantage is that the thickness of alignment layer is not uniform. If NDLC thin film on glass substrate as alignment layer is deposited, existing deposition equipment–PECVD and sputter, can be used. In addition, NDLC thin film can be deposited uniformly with precise thickness. As glass substrate of panel is larger, deposition equipment is also larger to perform the deposition process. Our research group previously reported LC aligning effect on the NDLC thin film using PECVD [13]. In this study, the LC alignment characteristics on the NDLC thin film using sputter was investigated and compared to those using PECVD.

EXPERIMENTAL

The NDLC thin films were deposited on indium-tin-oxide (ITO)-coated glass substrates by plasma-enhanced chemical vapor deposition (PECVD) and sputtering system. ITO-coated substrates with dimensions of $307\,\mathrm{mm} \times 217\,\mathrm{mm} \times 1.1\,\mathrm{mm}$ were used for all measurements. Before being deposited, the ITO-coated glass substrates were supersonic wave-cleaned in TCE (trichloroethylene), acetone, alcohol solutions, respectively, for 10 minutes, and then were blown with N_2 gas. After that, they were deposited by PECVD and sputter deposition equipment, respectively. The deposition condition of the PECVD was C_2H_2:He:N_2 gas for 3:0:30 sccm, and deposition time was 30 sec. The deposition condition of the sputter was N_2 gas for 4 sccm, and deposition time was 10 min, and the thickness of thin film was 200 nm. The NDLC thin films were irradiated by ion-beam. After being irradiated, LC cells were arranged in an anti-parallel configuration, which was used for pretilt angle measurements. LC cells were injected into nematic liquid crystal (NLC) ($Tc = 72°C$, $\Delta\varepsilon = 8.2$). The thickness of the liquid crystal cells for twisted nematic (TN) cells were 50 μm. To determine LC alignment condition, a polarized microscope was used, and pretilt angles were measured by a crystal rotation method at room temperature.

RESULTS AND DISCUSSION

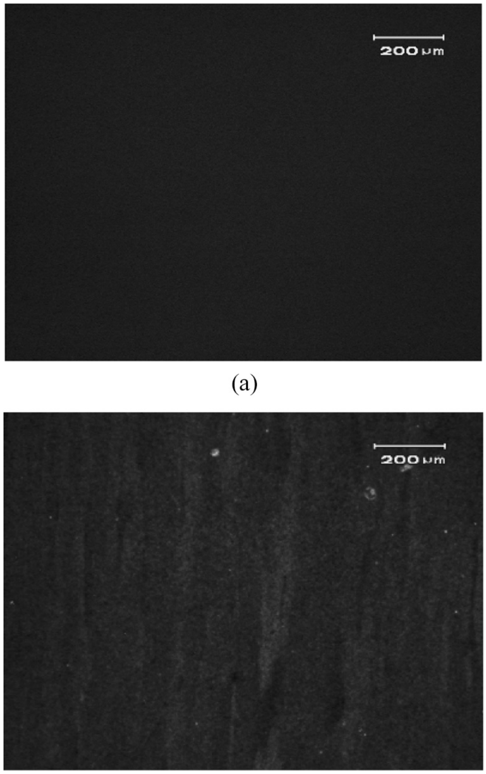
Figure 1 shows the microphotograph of LC alignment on the NDLC thin film deposited through sputter and PECVD at the ion beam irradiation intensity of 1200 eV. NDLC thin film by sputter depicted in Figure 1 (a) showed better alignment effect than PECVD demonstrated in Figure 1 (b) [13]. LC alignment was not uniform and had defects on the NDLC thin film using PECVD. There was a difference of the ion beam intensity that bombarded on the NDLC thin film concerning of the types of thin film deposition. It is considered that the difference of thin film deposition methods and the difference of used gas, and pressure.

Figure 2 is the graph of the transmittance in the various incident angle on the NDLC thin film. The pretilt angle concerning of LC cell on the NDLC thin film was deposited through sputter, and was irradiated by ion beam at 1200 eV. The graph shows that the LC alignment is homogenous, and the pretilt angle was about 2°.

Figure 3 is the graph of pretilt angle concerning of LC cell on the NDLC thin film was deposited through PECVD as the irradiation intensity. At the 1800 eV, the pretilt angle showed peak value, and also showed the most uniform alignment effect.

To measure LC anchoring energy between the LC molecules and NDLC thin film layer, thermal stability experiment was carried out. After each LC cell was heated, and was cooled down slowly, the LC alignment effect was observed by microphotograph. Figure 4 are the microphotographs of the LC alignment on the NDLC thin film deposited using sputter. It was shown that there were defects at 200°C. At 250°C, LC alignment was destroyed.

The important thing was that the microphotographs of the NDLC film deposited using sputter became brighter at the 200°C than those of the NDLC film deposited using PECVD [13]. It means that the LC alignment on the NDLC thin film using sputter is destroyed at lower



(a)

(b)

FIGURE 1 Microphotograph of the LC alignment characteristics on the NDLC thin film deposited by different deposition methods at the ion beam irradiation intensity of 1200 eV (in crossed Nicols) (a) sputter, (b) PECVD.

temperature, and has a lower anchoring energy, compared with LC alignmet on the NDLC thin film using PECVD.

CONCLUSION

In this study, the LC alignment characteristics that the NDLC thin film through PECVD and sputtering, respectively, were studied. The NDLC thin film that was deposited using sputter showed uniform LC alignment at the 1200 eV of the ion beam intensity. The pretilt angle was 2°. On the other hand, the NDLC thin film that was deposited using PECVD showed uniform LC alignment and high pretilt angle at the 1800 eV of the ion beam intensity. Concerning

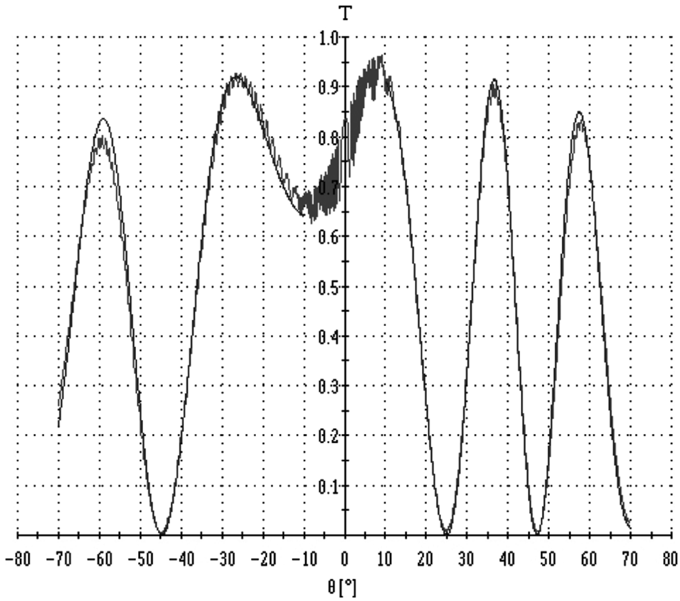


FIGURE 2 Graph of pretilt angle of LC of the NDLC thin film deposited using sputter.

the ion beam intensity, uniform LC alignment of the NDLC thin film that was deposited using sputtering was achieved at the lower intensity. And the pretilt angle of the NDLC thin film that was deposited

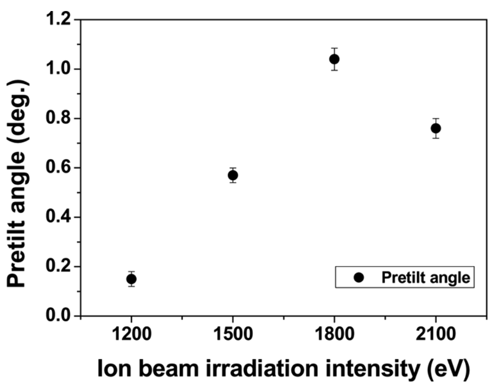


FIGURE 3 Pretilt angle of the LC on the NDLC thin film deposited using PECVD as a function of the ion beam irradiation intensity.

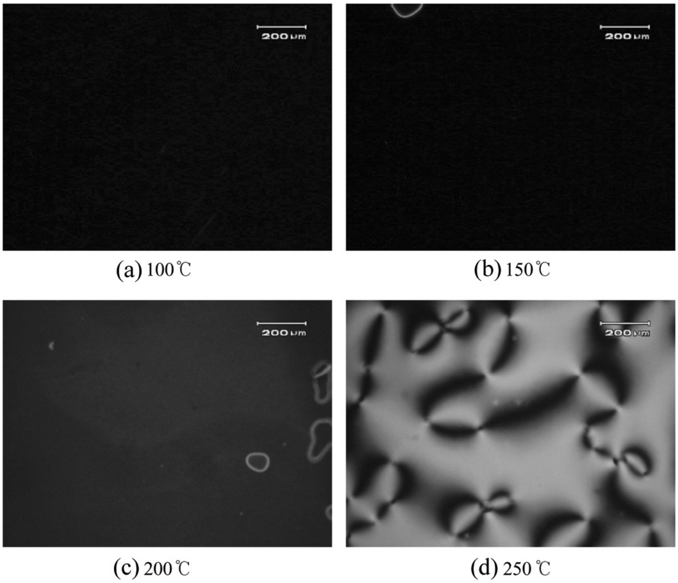


FIGURE 4 Microphotographs of the NLC on the NDLC thin film deposited using sputter as a function of annealing temperature (in crossed Nicols).

using sputter was higher than those of NDLC thin film that was deposited using PECVD. The uppermost of the thermal stability of NDLC thin film was 200°C, respectively. However, NDLC thin film deposited using PECVD showed stability at high temperature without defects, compared with NDLC thin film deposited using sputter.

REFERENCES

[1] Geary, J. M., Goodby, J. W., Kmetz, A. R., & Patel, J. S. (1987). *J. Appl. Phys.*, *62*, 4100.
[2] Seo, D.-S., Muroi, K., & Kobayashi, S. (1992). *Mol. Cryst. Liq. Cryst.*, *213*, 223.
[3] Seo, D.-S., Kobayashi, S., & Nishikawa, M. (1992). *Appl. Phys. Lett.*, *61*, 2392.
[4] Seo, D.-S., Araya, K., Yohsida, N., Nishikawa, M., Yabe, Y., & Kobayashi, S. (1995). *Jpn. J. Appl. Phys.*, *34*, L503.
[5] Sugiyama, T., Kuniyasu, S., Seo, D.-S., Fukuro, H., & Kobayashi, S. (1990). *Jpn. J. Appl. Phys.*, *29*, 2045.
[6] Matsuda, H., Seo, D.-S., Yoshida, N., Fujibayashi, K., & Kobayashi, S. (1995). *Mol. Cryst. Liq. Cryst.*, *264*, 23.
[7] Imura, Y., Kobayashi, S., Hashimoto, T., Sugiyama, T., & Katoh, K. (1996). *IEICE Trans. Electron.*, *E79-C*, 1040.
[8] Lien, S. C. A., Chaudhari, P., Lacey, J. A., John, R. A., & Speidell, J. L. (1998). *IBM J. Res. Develop.*, *42*, 537.

[9] Janning, J. L. (1972). *Appl. Phys. Lett.*, *21*, 173.
[10] Park, C.-J., Hwang, J.-Y., Kang, H.-K., Kim, Y.-H., Seo, D.-S., Ahn, H.-J., Kim, K.-C., Kim, J.-B., & Baik, H.-K. (2005). *Trans. EEM*, *6*, 22.
[11] Kang, H.-K., Hwang, J.-Y., Park, C.-J., Seo, D.-S., Kim, K.-C., Ahn, H.-J., Kim, J.-B., & Baik, H.-K. (2005). *Mol. Cryst. Liq. Cryst.*, *434*, 135.
[12] Kim, J.-H., Kang, H.-K., Han, J.-W., Kang, S.-H., Kim, Y.-H., Hwang, J.-Y., & Seo, D.-S. (2006). *Trans. EEM*, *7*, 1.
[13] Han, J.-M., Choi, S.-H., Kim, B.-Y., Han, J.-W., Kim, J.-H., Kim, Y.-H., Hwang, J.-Y., Lee, S.-K., Ok, C.-H., & Seo, D.-S. (2007). *Trans. EEM*, *8*, 1.