Electro-Optical Performances of In plane Switching (IPS) Cell on the Inorganic Thin Film by Ion Beam (IB) Method

Sang-Hoon Kim*, Jeoung-Yeon Hwang, Jong-Hwan Kim, Jung-Min Han, and Dae-Shik Seo
Dept. of Electrical & Electronic Eng., College of Eng., Yonsei University, Korea
Sung-yeon Kim*, *Byeong-Yun Oh, and Jae-Min Myoung
Dept. of Materials Science and Eng., College of Eng., Yonsei University, Korea
Phone: (+82) 2-2123-4617 , E-mail: dsseo@yonsei.ac.kr

Abstract

We studied the nematic liquid crystal (NLC) alignment capability by the Ion beam (IB) alignment method on a NDLC (Nitrogen doped Diamond Like Carbon) as a-C:H thin film, and investigated electro-optical (EO) performances of the IB aligned In plane switching (IPS) cell with NDLC surface. A good LC alignment by IB exposure on a NDLC surface was achieved. Monodomain alignment of the IB aligned IPS cell can be observed. The good electro-optical characteristics of the IB aligned IPS cell was observed with oblique IB exposure on the NDLC as a-C:H thin film for 1min.

1. Introduction

Liquid crystal displays (LCDs) are widely used as information display devices such as monitors in notebooks, desktops, and LCD TV. A rubbing method has been widely used to align liquid crystal (LC) molecules on the polyimide (PI) surface [1-3]. Rubbed polyimide surfaces have suitable characteristics such as uniform alignment and a high pretilt angle. However, the rubbing method has some drawbacks, such as the generation of electrostatic charges and the creation of contaminating particles [4,5]. Thus we strongly recommend a non-contact alignment technique for future generations of large, high-resolution LCD.

Most recently, the LC aligning capabilities achieved by ion beam (IB) exposure on the diamond-like carbon (DLC) thin film layer have been successfully studied by P. Chauhari et al [6]. Also, our research group already studied IB alignment method using DLC thin film [7-10].

In this article, we report on LC alignment and pretilt angle generation with IB exposure on the surface of NDLC (nitrogen doped diamond like carbon) as a-C:H:N thin-film[11,12] deposited by rf magnetron sputtering and EO characteristics of the ion beam aligned IPS cell with oblique IB exposure on the NDLC as a alignment layer.

2. Experiment and Results

The a-C:H:N (NDLC) thin films were prepared by RF magnetron co-sputtering equipped with a 5 N-purity carbon target. The glass substrates were first cleaned with standard cleaning procedures (TCE–acetone–methanol) and then rinsed in deionized water. Cleaned substrates were loaded in the central region of the substrate holder located about 50mm away from the targets.

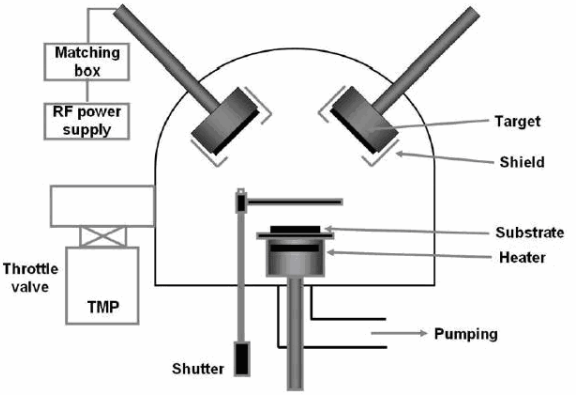


Fig. 1. The schematic diagram of sputter system.

The sputtering chamber was initially evacuated by a turbo molecular pump to the base pressure of about 7.5_10_4 Pa. For the NDLC films deposition, the

working pressure was maintained at about 0.67 Pa with Ar-ambient gas. Prior to the film deposition, pre-sputtering was performed for 10 min to remove any contamination on the target surface. The schematic diagram of sputter system is shown in Figure 1. The thickness of the NDLC thin film layer was about 20nm. The table 1 shows the experimental condition of the five kinds of NDLC.

Table 1. Deposition condition of the five kinds of NDLC thin film

	Ar(sccm)	N_2 (sccm)
1	10	2
2	10	4
3	10	6
4	10	8
5	10	10

The IB system is shown in Fig. 2. The IB power was used 1200eV. The gap of the Ion beam aligned LC cell was 60 μm, and the cell thickness of the Ion beam aligned IPS cell was about 4μm. The LC cell was filled with a nematic liquid crystal (NLC) (T_c = 72°C, △ε=8.2, from Merck Co.). To determine LC alignment condition, a polarization microscope was used and pretilt angle was measured crystal rotation method at room temperature. Voltage-Transmittance (*V-T*) and response time characteristics of the UV aligned TN-LCD were measured by a LCMS-200 (Electro-Optical Measurement, from Sesim Photonics Technology) equipment.

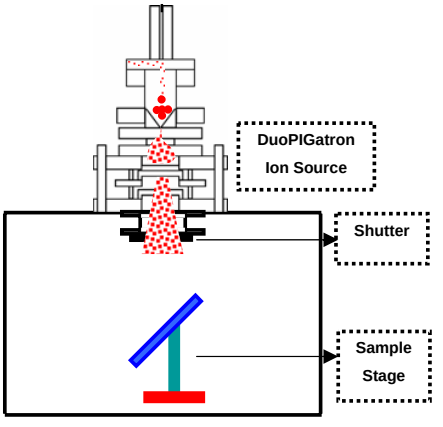
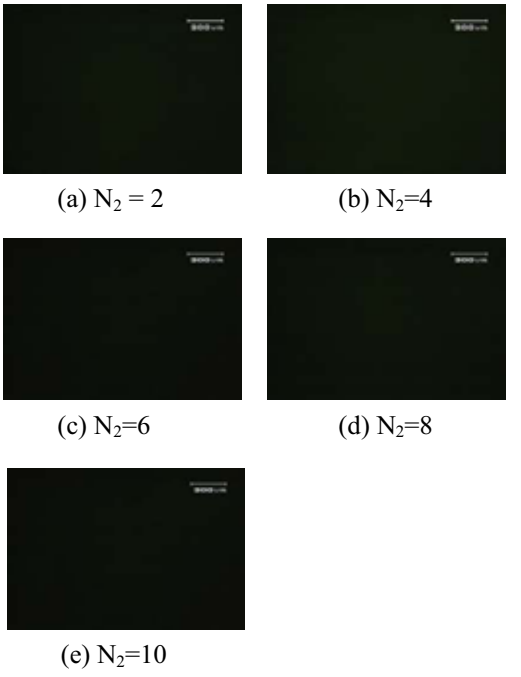


Fig. 2. Ion beam exposure system

Figure 3 shows the microphotographs of LC cells under IB exposure to 1 min on the four kinds of NDLC thin films. Fig. 2 (a) shows the microphotograph of LC cell under IB irradiation to 1 minute on the NDLC (N_2=2sccm) thin films. Fig. 2 (e) shows the microphotograph of LC cell under IB exposure to 1 min on the NDLC (N_2=10sccm) thin films. As shown in Fig. 3, the excellent LC alignment of the NDLC by sputtering when N_2 gas is from 2sccm to 10sccm among the five conditions for forming the NDLC thin film was achieved.



(a) N_2 = 2 (b) N_2=4

(c) N_2=6 (d) N_2=8

(e) N_2=10

Fig. 3. Microphotographs of IB aligned LC cell on the four kinds of the NDLC thin film (in crossed Nicols).

The LC pretilt angle observed with IB exposure on the NDLC thin film as a function of N_2 gas percent are shown in Fig. 4. It is shown that the LC pretilt angle generated was about 3º in the all-incident angle on the NDLC thin film when N_2 gas was 2 and 4 sccm. However, LC pretilt angle generated show decrease with increasing N_2 gas percent. So, NDLC thin film with low pretilt angle was used in the IPS cell.

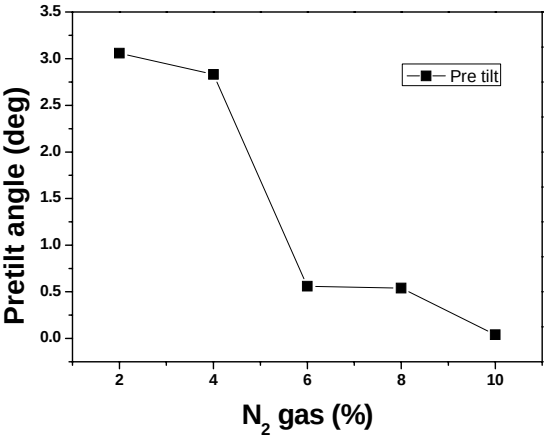


Fig. 4. Generation of pretilt angles in NLC with IB exposure on NDLC thin film surfaces for 1 min as a function of N_2 gas percent.

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.

(a) 100℃ (b) 150℃

(c) 200℃ (d) 250℃

Fig. 5. Microphotographs of the LC alignment characteristics on the NDLC thin film deposited using sputter as a function of annealing temperature (in crossed Nicols).

Figure 5 are the microphotographs of the LC alignment on the NDLC thin film deposited using sputter. It was shown that there were defects at 200℃. At 250℃, LC alignment was destroyed.

Figure 6 shows a good transmission of light as a function of applied voltage across IPS cells made of NDLC thin film as alignment layers. A stable *V-T* curve of IB aligned IPS cell on the NDLC thin film was measured.

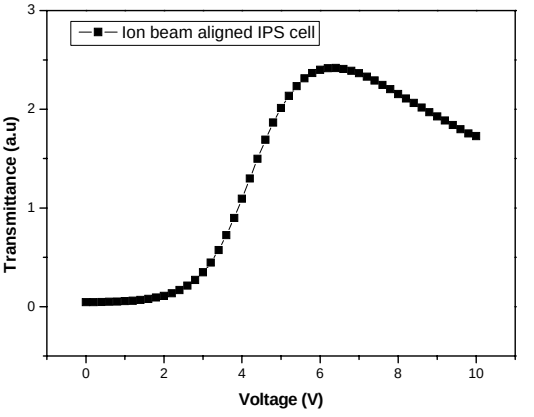


Fig. 6. Voltage-transmittance characteristics of the IB aligned IPS cell on NDLC thin film

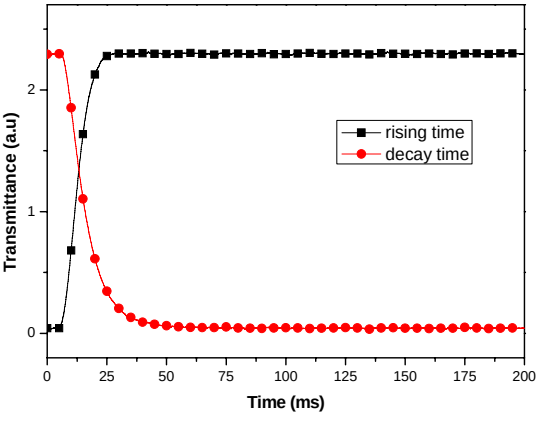


Fig. 7. Response time characteristics of the IB aligned IPS cell on NDLC thin film

Figure 7 shows the response time characteristics of the IB aligned IPS cells made of NDLC thin films, as

alignment layers. A stable curve for IB aligned IPS cell on the NDLC thin films is shown.

4. Conclusion

In conclusion, we studied about LC alignment effect and the controllability of pretilt angle in a new alignment layer of the NDLC thin film deposited by rf magnetron sputtering, and investigated electro-optical performances of the IB aligned IPS cell with the IB exposure on NDLC thin film surface. We achieved a good alignment characteristic using IB alignment method on the NDLC thin film when N_2 gas is from 2sccm to 10sccm at the sputtering. Also, we obtained high pretilt angle on the NDLC, and then NLC alignment capabilities show decrease with increasing N_2 gas percent. Finally, the EO characteristics of the IB aligned IPS cell using IB alignment method on the NDLC as a alignment layer.

5. Acknowledgements

This work was supported by NGE(Next Growth Engine) project for Ministry of Commerce, Industry and Energy.

6. References

[1] J. M. Geary, J. W. Goodby,. A. R. Kmetz, and J. S., J. Patel,. Appl. Phys. **62**, 4100 (1987).

[2] D.-S. Seo, K. Muroi, and S. Kobayashi, Mol. Cryst. Liq. Cryst. **213**, 223 (1992).

[3] D.-S. Seo, S. Kobayashi, and M. Nishikawa, Appl. Phys. Lett. **61**, P. 2392 (1992).

[4] K. Kobayashi and Y. Limura, SPIE. **2175**, p.123 (1994).

[5] M. Nishikawa, B. Taheri, and J. L. West, SID'98. p.131 (1998)

[6] P. Chaudharl, J. Lacey, J. Doyle, E. Galligan, S. C. Alan, A. Callegarl, G. Hougham, N. D.Lang, P. S. Andry, R. John, K. H. Yang, M. Lu, C. Cal, J. Speidell, S. Purushothaman, J. Ritsko, M. Samnt, J. Stohrt, Y. Nakagawa, Y. Katoh, Y. Saitoh, K.Saka, H. Satoh, S. Odahara, H. Nakano, J. Nskshski and Y. Shiota, Nature. **411**, p.56 (2001).

[7] J.-Y. Hwang, Y.-M. Jo, S.-J. Rho, H.-K. Baik and D.-S. Seo, Jpn. J. Appl. Phys. **41**, L992 (2002)

[8] J.-Y. Hwang, C.-J. Park, , S.-J. Roh, H.-K. Baik, and D.-S. Seo, Ferroelectrics. **310** (2004).

[9] C.-J. Park, J.-Y. Hwang, H.-J. Ahn, K.-C. Kim H.-K. Baik, and D.-S. Seo, Trans. EEM. **5**,15 (2004).

[10] S.-J. Rho, D.-K. Lee, H.-K. Baik, J.-Y. Hwang, Y.-M. Jo, and D.-S. Seo, Thin Solid Films. **420**, 259 (2002).

[11] C.-J Park,., J.-Y Hwang, H.-J Ahn,., K.-C Kim, H.-K Baik, and D.-S Seo, Trans. EEM. **3**, 2 (2002).

[12] C.-J. Park, J.-Y. Hwang, H.-K. Kang, H.-J Ahn, J.-B. Kim, K.-C. Kim, H.-K. Baik, and D.-S. Seo, Jpn. J. Appl. Phys. **44,** 1352 (2005).