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# NDLC 박막 위에 Ion Beam 배향한 TN-LCD의 전기광학특성

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# EO Characteristics of the Ion Beam Aligned TN-LCD on the NDLC Thin Film Surface

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**Abstract**

The nitrogenated diamond-like carbon (NDLC) exhibits high electrical resistivity and thermal conductivity that are similar to the properties shown by diamond-like carbon (DLC) films. These diamond-like transparent properties in NDLC come in a material consisting of $sp^2$-bonded carbon versus the $sp^3$-carbon of DLC. The diamond-like properties and nondiamond-like bonding make NDLC an attractive candidate for applications. Liquid crystal (LC) alignment capabilities with ion beam exposure on NDLC thin films and electro-optical (EO) performances of the ion-beam-aligned twisted nematic liquid crystal display (TN-LCD) with oblique ion beam exposure on the NDLC thin film surface were studied. An excellent uniform alignment of the nematic liquid crystal (NLC) alignment with the ion beam exposure on the NDLC thin films was observed. In addition, it can be achieved that the good EO properties of the ion-beam-aligned TN-LCD. Finally, we will present the residual DC property of the ion-beam-aligned TN-LCD on the NDLC thin film surface.

Key Words: NDLC, TN-LCD, the residual DC, ion-beam, NLC

## 1. 서 론

Thin film transistor (TFT) - liquid crystal displays (LCDs) are widely used as information display devices such as monitors in notebooks, desktops, and LCD-TVs. A rubbing method has been widely used to align liquid crystal (LC) molecules on the polyimide (PI) surface. LCs are aligned due to the induced anisotropy on the substrate surface [1-4]. 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 [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].

A NDLC thin film exhibits high electrical resistivity and thermal conductivity similar to

that of DLC thin films. Significantly, these diamond-like transparent properties in NDLC thin film come in a material consisting of $sp^2$-bonded carbon versus the $sp^3$-carbon of DLC. The diamond-like properties and nondiamond-like bonding make NDLC thin film an attractive candidate for applications such as high performance microelectronics [7].

Preparation of NDLC thin films can be carried out at low substrate temperature and with high deposition rates using PECVD [8].

In this study, we reported the electro-optical (EO) characteristics of the ion-beam-aligned TN-LCD with oblique ion beam exposure on four types of the NDLC thin film surface.

## 2. 실 험

The NDLC thin films were deposited on indium-tin-oxide(ITO)-coated glass substrates by plasma enhanced chemical vapor deposition (PECVD). The glass substrates were pre-sputtered due to the Ar plasma in the chamber. The NDLC thin film was deposited using $C_2H_2$ : He : $N_2$ gas for 30sec in order to settle the working pressure the total flux was flux as 33 sccm. Namely, As the flow amount of $N_2$ was increased, that of He was correspondingly decreased.

The thickness of the NDLC thin film layer was 3-15 nm. The IB (Kaufman Ar ion gun) exposure system is shown in Fig.1. The IB energy used was 200 eV and IB exposure time was 30 sec. The incident angle of the ion beam was set at 45 degree. Because the highest pretilt angle was achieved by IB exposure on NDLC thin film layer at this angle [9]. The cell thickness of the ion-beam-aligned TN-LCD was 5μm. The LC cell was filled with a nematic liquid crystal (NLC) (Tc = 72°C , $\Delta\varepsilon$=8.2, from Merck Co.). The residual DC voltage properties of ion-beam-aligned TN-LCD were measured by a capacitance-voltage hysteresis method.

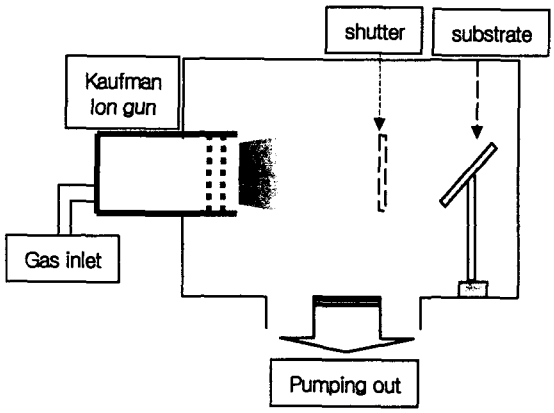


Figure 1. The IB exposure system.

## 3. 결과 및 고찰

The LC pretilt angle variation according to ion beam incident angle on NDLC thin films. The LC pretilt angle variation according to ion beam irradiation time on NDLC thin films. The LC pretilt angle has the maximum value at 1 min about 10 degree, and the pretilt angle rapidly decreases with increasing ion beam exposure time. As mentioned earlier, TFT-LCDs are widely used. So to utilize the data, to be applicable for TFT-LCD, we determined Ion beam exposure time to 30 sec. (6~7 degree). Ion beam irradiation causes the increase of $sp^2$ -fraction and the decrease of the thickness of the NDLC thin films. Ion beam irradiation contributes to the generation of the pretilt angle and that value of the pretilt angle is more affected by surface roughness than $sp^2$ -fraction of the NDLC thin films [10].

Figure 2 shows V-T curves of the ion-beam-aligned TN-LCDs with oblique ion beam exposure on the NDLC thin film surface.

An excellent voltage-transmittance (V-T) curve can be achieved in the ion-beam-aligned TN-LCD with ion beam exposure on the NDLC thin film surface which contains 30 sccm of nitrogen gas. The transmittances of the ion-beam-aligned TN-LCD on the NDLC thin film do not have a considerable difference according to the portion of nitrogen gas. Consequently, this system suggests that ideal the portion of nitrogen gas needed to achieve good V-T characteristics of the ion-beam-aligned TN-LCD is 30 sccm.

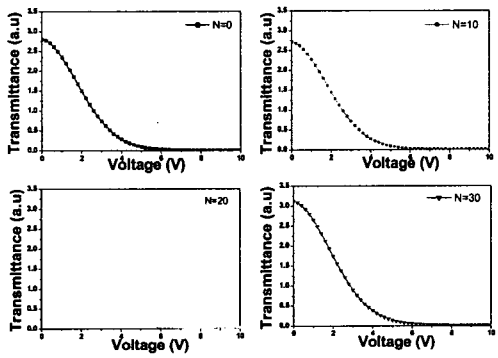


**Figure 2.** V-T curves of the ion-beam-aligned TN-LCD with oblique ion beam exposure on the NDLC thin film surface.

Figure 3 shows the response time characteristics of the ion-beam-aligned TN-LCD with ion beam exposure on the NDLC thin film surface. The response time characteristics of the ion-beam-aligned TN-LCD on the NDLC thin film surface improved by increasing the portion of nitrogen gas. Therefore, the fastest response time characteristic for the ion-beam-aligned TN-LCD with ion beam exposure on the NDLC thin film is produced at 30 sccm of nitrogen gas. From these results, it is contended, herein, that the portion of nitrogen gas needed to achieve an optimistic V-T curve and a good response time characteristics is 30 sccm, as shown in Fig. 2 and Fig. 3.

The response times for ion-beam-aligned TN-LCD according to various portions of nitrogen gas on the NDLC thin film surface. Considering transmittance of response time characteristics, the fastest response time of ion-beam-aligned TN-LCD with various portions of nitrogen gas on the NDLC thin film surface was optically measured to be about 19.23 ms when nitrogen gas was 30 sccm.

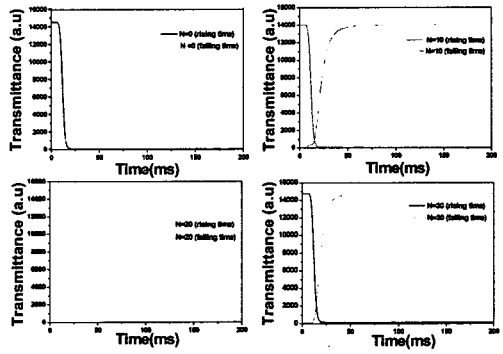


**Figure 3.** The response time characteristics of the ion-beam-aligned TN-LCD with oblique ion beam exposure on the NDLC thin film surface

Figure 4 shows the capacitance-voltage characteristics of the ion-beam-aligned TN-LCD with oblique ion beam exposure on the various portions of nitrogen gas of NDLC thin film surface. As the portion of nitrogen gas increases, the residual DC voltage of the ion-beam-aligned TN-LCD was increased as shown in Fig. 4. However, the residual DC voltage of the ion-beam-aligned TN-LCD was very small. As a result, an excellent residual DC voltage characteristic was achieved. The residual DC voltage of the TN-LCD strongly depends on the condition of the alignment layer. Consequently, the EO characteristics of the ion-beam-aligned TN-LCD with oblique ion beam exposure on the NDLC thin film surface are improved more than those of the DLC thin

film surface.

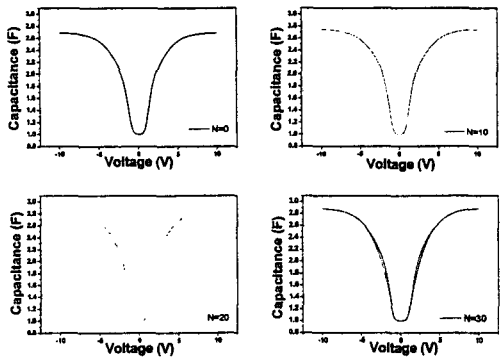


**Figure 4.** The capacitance-voltage characteristics of the ion-beam-aligned TN-LCD with oblique ion beam exposure on the portions of nitrogen of NDLC thin film surface

## 4. 결 론

LC alignment capabilities and the variation of pretilt angles with ion beam irradiation on the NDLC thin films, and the EO characteristics of the ion-beam-aligned TN-LCD with oblique ion beam exposure on the NDLC thin film surface were studied. The good V-T curves were observed for the ion-beam-aligned TN-LCD with ion beam exposure on various portions of nitrogen gas of the NDLC thin film. Also, the fastest response time of about 19.23 ms can be achieved for the ion-beam-aligned TN-LCD with ion beam exposure on the NDLC thin film for 30 sccm of nitrogen gas. Finally, the residual DC voltage of the ion-beam-aligned TN-LCD with ion beam exposure to 30 sec on various portions of nitrogen gas of the NDLC thin film surfaces is excellent.

## 감사의 글

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