Alignment Effects for Nematic Liquid Crystal on a New Diamond-like Carbon Layer

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Alignment effects for nematic liquid crystal (NLC) and electro-optical (EO) characteristics of the ion beam (IB) aligned twisted nematic (TN)-liquid crystal display (LCD) with oblique ion beam exposure on the diamond-like carbon (DLC) thin film surface were studied. A high pretilt angle of 3.5° in NLC by ion beam exposure on the DLC thin film layer can be measured. An excellent voltage-transmittance (V-T) curve of the ion beam aligned TN-LCD was observed with oblique ion beam exposure on the DLC thin film surface for 1 min. Also, a faster response time for the ion beam aligned TN-LCD with oblique ion beam exposure on the DLC thin film surface for 1 min can be achieved.

Keywords : Diamond-like carbon, Ion beam alignment, Pretilt angle, EO characteristics

1. INTRODUCTION

Thin film transistor (TFT) - liquid crystal displays CDs) have become one of the fastest growing ormation display devices in recent years. They are dely used in notebook computers and desktop nitors. A rubbing method has been widely used to gn LC molecules on a polyimide (PI) surface. LCs are gned due to the induced anisotropy on the substrate face. Rubbed PI surfaces have suitable characteristics h as uniform alignment and a high pretilt angle. wever, the rubbing method has some drawbacks, such the generation of electrostatic charges and the creation contaminating particles[1]. Thus, rubbing-less hniques for LC alignment are strongly needed in LCD hnology.

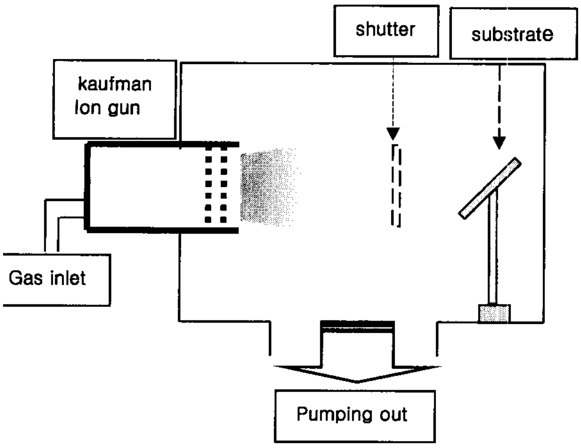
Recently, the LC alignment effects by using the otodimerization[2-5] and photodissociation[6] have n reported. Most recently, the LC aligning abilities by IB exposure on the DLC thin film layer e been successfully studied by P. Chaudhari, et al[7].

This article will report on the pretilt angle generation h ion beam exposure on the DLC thin film layer and characteristics of the ion beam aligned TN-LCD with ique ion beam exposure on the DLC thin film surface.

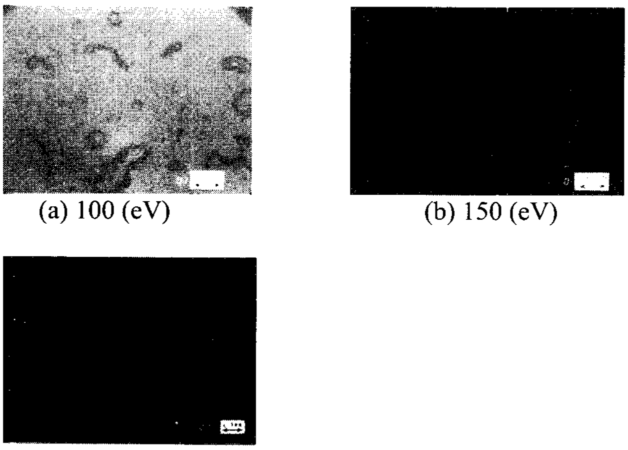
2. EXPERIMENTAL

The DLC thin films were coated on indium-tin-oxi (ITO) coated glass substrates by remote plasn enhanced chemical vapor deposition (RPECVD). Tl glass substrates were presputtered due to the Ar plasn in chamber. The DLC thin film was deposited using tl C_2H_2:He gas for 10 min. The C_2H_2 and He gas we floating 3 sccm and 30 sccm in chamber at roo temperature, respectively. The thickness of the DL layer was 10 nm. The ion beam (Kaufman type Ar i gun) exposure system is shown in Fig. 1. The ion bea energies used were 100, 150, 200 eV. The LC cells we assembled by an anti-parallel structure to measure tl pretilt angle. The thickness of the LC cell for pret angle was 60 μm, and the cell thickness of the ion bea aligned TN-LCD was 5 μm. The LC cells were fill with a fluorinated mixture type NLC without a chir dopont (Tc=87℃, MJ97359, from Merck Co.). Also, tl rubbed polyimide (PI) cell was fabricated to l compared with LC cell by ion beam exposure on tl DLC thin film. LC alignment ability was observed usi a photomicroscope.

Lastly, the pretilt angle of an anti-parallel cell w



ig. 1. Ion beam exposure system used.



(a) 100 (eV) (b) 150 (eV)

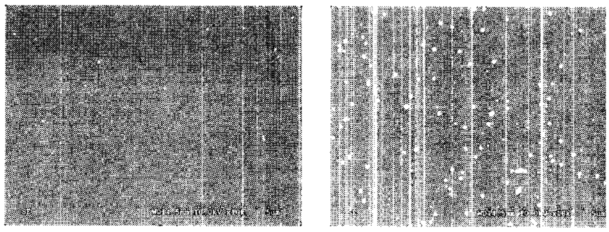
(c) 200 (eV)

ig. 2. Microphotographs of LC cell with ion beam ‹posure on the three kinds of DLC thin film layers as a ınction of ion beam energy intensity (in crossed Nicols).

.easured by a crystal rotation method, and voltage-ansmittance and response time characteristics of the ion ɜam aligned TN-LCD were measured by a DMS)isplay Measurement System, from Autronic Co.) ɿuipment.

3. RESULTS AND DISCUSSION

Figure 2 shows the microphotographs of an LC cell ith ion beam exposure on the three kinds of DLC thin lm layers by ion beam energy intensity. In Fig. 2 (a), e LC alignment defects were measured with ion beam ;posure on the DLC thin film layer (ion beam energy tensity, 100(eV)). Good LC alignment via ion beam ;posure on the DLC thin film layer (ion beam energy tensity, 150(eV)) was observed as shown in Fig. 2 (b).



(a) IB (1min) (b) IB (5min)

Fig. 3. SEM photographs of LC cell with ion b‹ exposure on the DLC thin film layer.

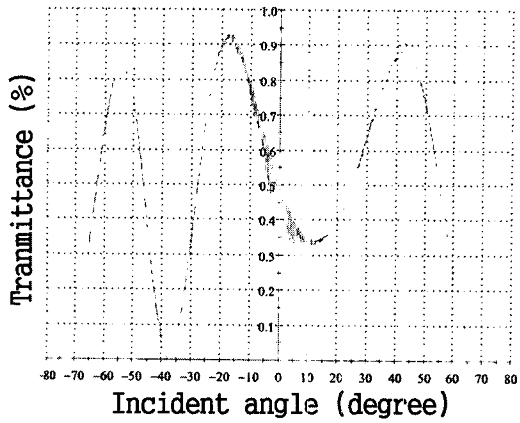


Fig. 4. Transmittance versus angle of incidence in N with ion beam exposure on the DLC film layer.

Also, excellent LC alignment was observed via ion bɛ exposure on the DLC thin film layer (ion beam ene intensity, 200(eV)) as shown in Fig. 2 (c).

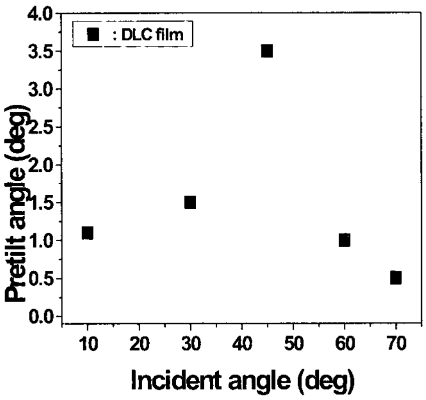
It is contended, herein, that stable LC alignment be obtained on the DLC thin film with an ion bɛ energy intensity 200(eV). Also, the transmittance on DLC thin film was measured using the UV-VIS-ɴ spectrometer. The energy band gap on the DLC thin f was estimated by a Tanc equation from measu transmittance. The energy band gap estimated was ab 2 eV and, then, this value was observed to be an bond.

Figure 3 shows the SEM photographs of LC cell v ion beam exposure on the DLC thin film layer. Iı shown that the many particles were observed with beam exposure on the DLC thin film layer for 5 n However, few particles were observed with ion bɛ exposure on the DLC thin film layer for 1 min. I considered that the particle is attributable to the surf roughness with increased ion beam exposure time.

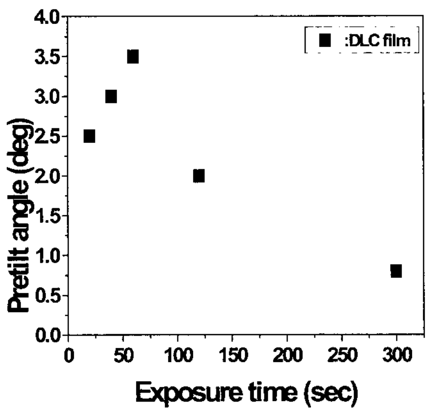
Figure 4 shows the transmittance versus incident an in a NLC for 1min ion beam exposure at an obli‹ direction of 45 degree on the DLC thin film layer (beam energy intensity, 200(eV)).

The LC pretilt angles with ion beam exposure on the .C thin film layer (ion beam energy intensity 200(eV)) 1 min as a function of the incident angle are shown in ;. 5. It is shown that the LC pretilt angle generated s about 3.5 ° with ion beam exposure at an oblique ection of 45° on the DLC thin film layer for 1min. In lition, the pretilt angle decreases with an increasing :ident angle at over incident angle of 45°. It is clear .t the high LC pretilt angle can be achieved with :ident angle of 45°.

Figure 6 shows the LC pretilt angles with incident gle of 45° on the DLC thin film layer (ion beam ergy intensity, 200(eV)) as a function of exposure time. e results revealed that the high LC pretilt angle was iieved by ion beam exposure on the DLC thin film 'er for 1 min, and the pretilt angle rapidly decreased th increasing ion beam exposure time over 1min. The ak point of the LC pretilt angle was observed with ion am exposure time on the DLC thin film for 1 min. so, the LC pretilt angle decreased due to the increase



;. 5. LC pretilt angles with ion beam exposure on the .C thin film layer for 1 min as a function of incident gle.



;. 6. LC pre-tilt angles with ion beam exposure on the .C thin film layer as a function of exposure time.

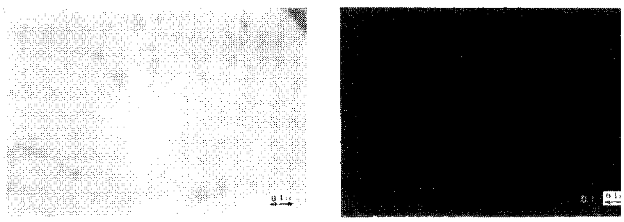
in surface roughness at over ion beam exposure time 1min. Therefore, the high pretilt angle on the DLC th film layer can be controlled.

Table 1 shows LC pretilt angles with ion bea exposure on DLC thin film layers as a function of i beam energy intensity. The highest pretilt angle with exposure on the DLC thin film layer with ion bea energy intensity 200(eV) can be obtained.

Figure 7 shows the microphotographs of the ion bea aligned TN-LCD with oblique ion beam exposure on t DLC thin film layers for 1 min (in crossed Nicols). Monodomain alignment of the ion beam aligned T LCD can be observed.

Table 1. LC pretilt angles with ion beam exposure on t DLC thin film layer for 1 min as a function of ion bea energy intensity.

Samples	Energy (eV)	Incident angle (degree)	Exposure time (min)	Pretel (degre
A	100	45	1	0.4
B	150	45	1	1.5
C	200	45	1	3.5



(a) off-state (b) on-state

Fig. 7. Microphotographs of the ion beam aligned T LCD with oblique ion beam exposure on the DLC th film layers for 1 min (in crossed Nicols).

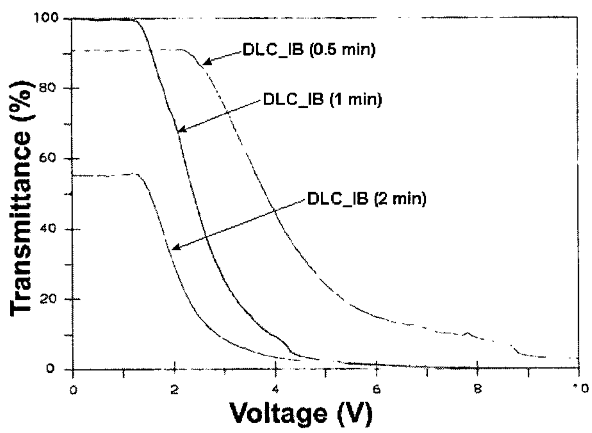
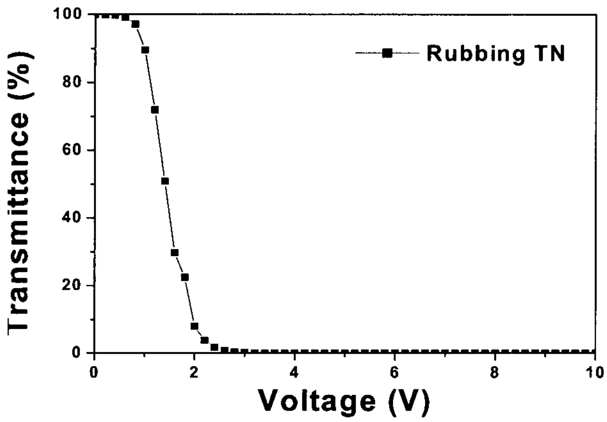


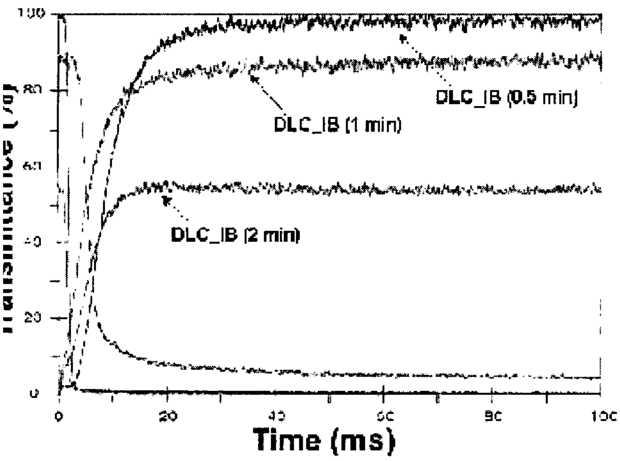
Fig. 8. V-T curves of the ion beam aligned TN-LC with oblique ion beam exposure on the DLC thin fi surface.

Figure 8 shows the V-T curves of the ion beam igned TN-LCDs with oblique ion beam exposure on ie DLC thin film surface. An excellent V-T curve can e achieved in the ion beam aligned TN-LCD with ion eam exposure on the DLC thin film surface for 1 min. he transmittances of the ion beam aligned TN-LCD on e DLC thin film surface decreased by increasing the n beam exposure time. Consequently, this system iggests that the best ion beam exposure time needed to hieve good V-T characteristics of the ion beam aligned N-LCD is about 1 min. Also, the threshold voltage of e ion beam aligned TN-LCD with ion beam exposure 1 min on the DLC thin film surface is almost the same that of the rubbing aligned TN-LCD on the PI surface.

Figure 10 shows the response time characteristics of e ion beam aligned TN-LCD with ion beam exposure n the DLC thin film surface. It reveals that the response ne characteristics of the ion beam aligned TN-LCD on



g. 9. V-T curves of the rubbing TN-LCDs on the PI rface.



g. 10. Response time characteristics of the ion beam igned TN-LCDs with oblique ion beam exposure on e DLC thin film surface.

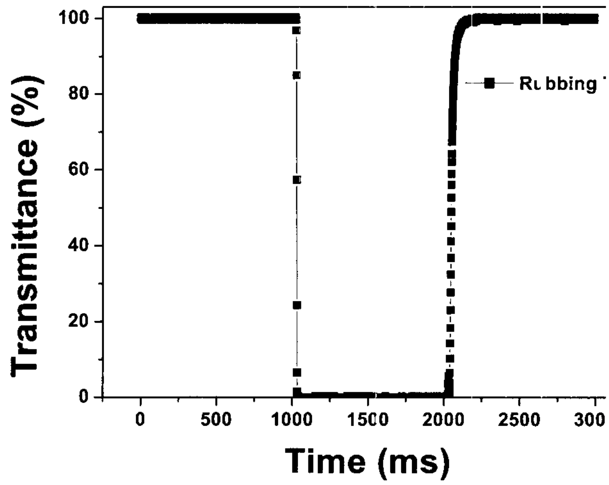


Fig. 11. Response time characteristics of rubbing T LCDs on the PI surface.

the DLC thin film surface improved by decreasing beam exposure time. A low transmittance level v measured in the ion beam aligned TN-LCD with beam exposure on the DLC thin film surface for 2 m Therefore, stable response time characteristics for the beam aligned TN-LCD with ion beam exposure on DLC thin film surface for 1 min can be produced. Fr these results, it is contended, herein, that the ion be exposure time needed to achieve a good V-T curve a response time characteristics is about 1 min, as shown Fig. 8 and 10.

Figure 9 and 11 show the V-T curve and respo time characteristics of the rubbing aligned TN-LCD the polyimide(PI) surface. It reveals that the characteristics of the ion beam aligned TN-LCD with beam exposure on the DLC thin film surface for 1 r are almost the same as those of the rubbing aligned T LCD on the PI surface.

4. CONCLUSION

In conclusion, we studied the generation of pre angles with ion beam exposure on the DLC thin fi layer, and the EO characteristics of the ion beam aligr TN-LCD with oblique ion beam exposure on the D thin film surface were studied. A high pretilt angle 3.5° with ion beam exposure on the DLC thin film la was measured.

A good V-T curve and response time were obser for the ion beam aligned TN-LCD with ion be exposure on the DLC thin film surface for 1 min. Fina the EO characteristics of the ion beam aligned TN-LC with ion beam exposure on the DLC thin film surface 1 min are almost the same as those of the rubbi gned TN-LCD on the PI surface.

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