LC Aligning Capabilities by Ion Beam Exposure on a Diamond-like Carbon Surface

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Abstract
We studied the liquid crystal (LC) alignment capabilities and the generation of pretilt angles with ion beam exposure on a diamond like carbon (DLC) layer. A high pretilt angle of 3.5° with ion beam exposure on the DLC layer can be obtained. A high pretilt angle in NLC by ion beam alignment method on the DLC layer can be achieved.

1. Introduction

Liquid crystal displays (LCDs) have become one of the fastest growing information display devices in recent years. They are widely used in notebook computers and desktop monitors. A rubbing method has been widely used to align LC molecules on a polyimide (PI) surface. LCs is aligned due to the induced anisotropy on the substrate surface. Rubbed PI 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 [1]. Thus, rubbing-less techniques for LC alignment are strongly needed in LCD technology. Recently, the LC alignment effects by using the photodimerization [2-8] and photodissociation [9-13] have been reported. Most recently, the LC aligning capabilities by ion beam exposure on the DLC layer have been successfully studied by P. Chaudhari et al [14]. This article will report on LC alignment and pretilt angle generation with ion beam exposure on the DLC layer.

2. Experimental

The DLC films were coated on indium-tin-oxide (ITO) coated glass substrates by remote plasma enhanced chemical vapor deposition (RPECVD). The glass substrates were pre-sputtering due to the Ar plasma in chamber. The DLC film was deposited using the C_2H_2 : He gas for 10 min. The thickness of the DLC layer was 3~15 nm. The ion beam (Kaufman type Ar ion gun) exposure system is shown in Fig. 1.

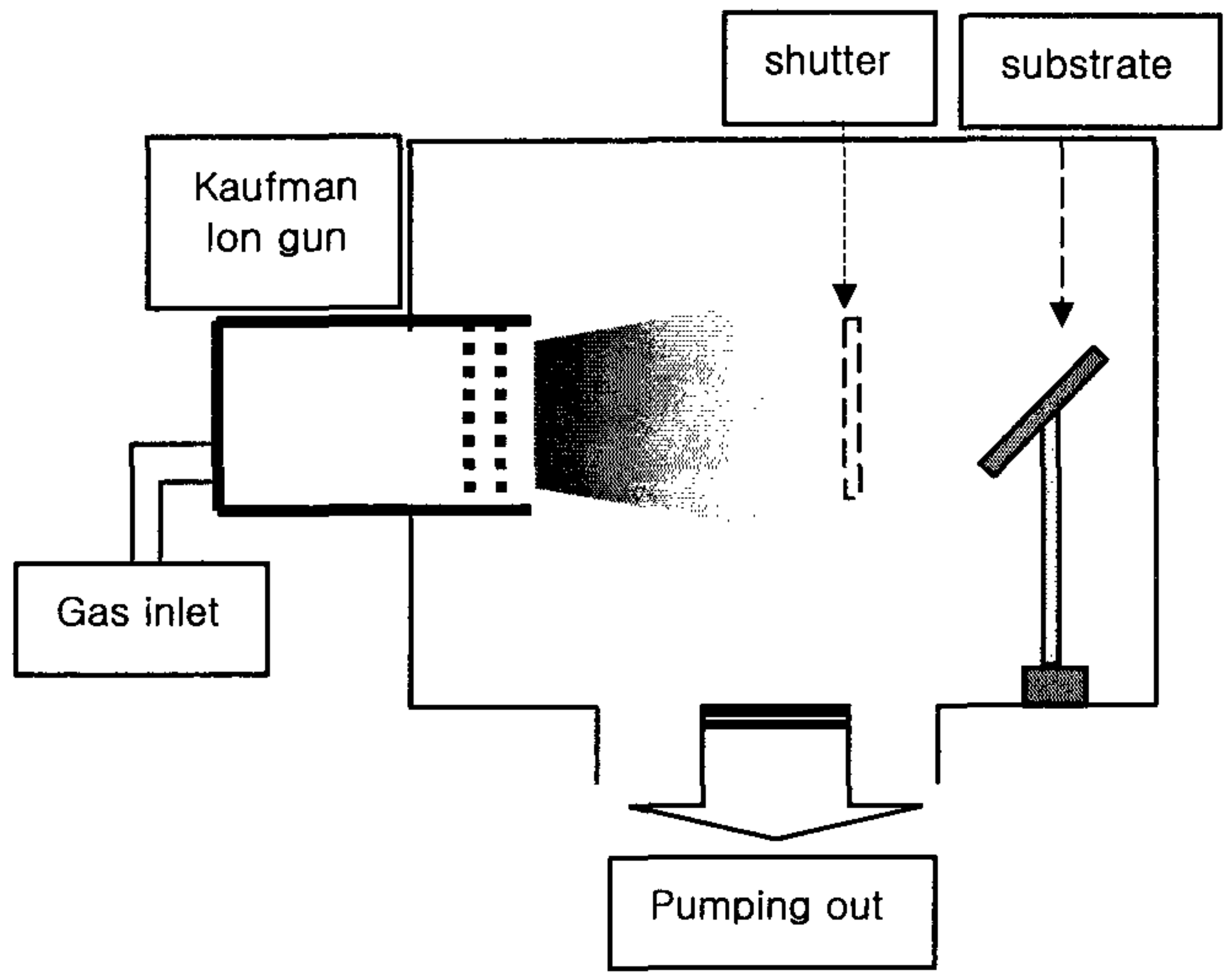


Figure 1. Ion beam exposure system.

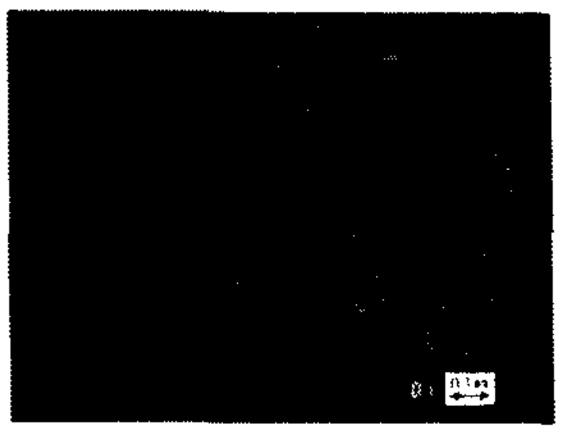
The ion beam energy used was a 200 eV. The LC cell was assembled by an anti-parallel structure to measure the pretilt angle. The thickness of the LC layer was 60 μm. The LC cell was filled with a fluorinated mixture type NLC without a chiral dopont (Tc=72℃, MJ97359, from Merck Co.). Also, the rubbing aligned cell was fabricated. LC alignment ability was observed using a photomicroscope. Lastly, the pretilt angle of an anti-parallel cell was measured by a crystal rotation method

3. Results and discussion

Figure 2 shows the microphotographs of an LC cell with ion beam exposure on the three kinds of DLC thin film layers for 1 min. In Fig. 2 (a), good LC alignment with ion beam exposure on the DLC film layer for 1 min in 1 : 30 (C_2H_2 : He) ratio was observed. Also, excellent LC alignment was observed via ion beam exposure on the DLC layer for 1 min in a 3 : 30 (C_2H_2 : He) ratio as shown in Fig. 2 (b). However, the LC alignment defects were measured via ion beam exposure on the DLC layer for 1 min in 5 : 30 (C_2H_2 : He) ratio as shown in Fig. 2 (c). It is contended, herein, that stable LC alignment can be obtained on the DLC film in a 3 : 30 (C_2H_2 : He) ratio. Also, the transmittance on the DLC film was measured using the UV-VIS-NIR spectrometer. The energy band gap on the DLC film was estimated by using a Tanc equation from measured transmittance. The energy band gap estimated was about 2 eV, and then, this value was observed to be a sp^3 bond.

(a) 1:30 (C_2H_2 : He)

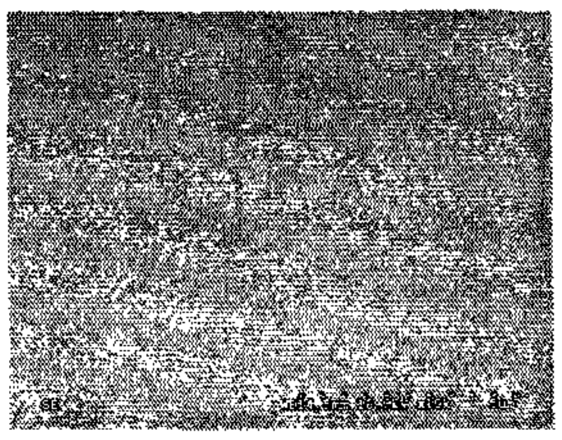
(b) 3:30 (C_2H_2 : He)



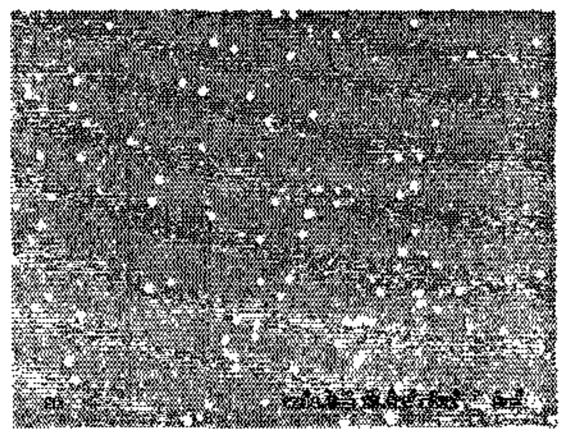
(c) 5:30 (C_2H_2 : He)

Figure 2. Microphotographs of LC cell with ion beam exposure on the three kinds of DLC layers (in crossed Nicols).

Figure 3 shows the SEM photographs of LC cell with ion beam exposure on the DLC layer. It is shown that the particles were observed with ion beam exposure on the DLC layer for 5 min. However, few particles were observed with ion beam exposure on the DLC layer for 1 min. It is considered that the particle is attributable to the surface roughness with increased ion beam exposure time.



(a) IB (1min)



(b) IB (5min)

Figure 3. SEM photographs of LC cell with IB exposure on the DLC thin film layer.

Figure 4 shows the transmittance versus incident angle in the NLC with ion beam exposure at an oblique direction of 45 degree on the DLC layer for 1 min.

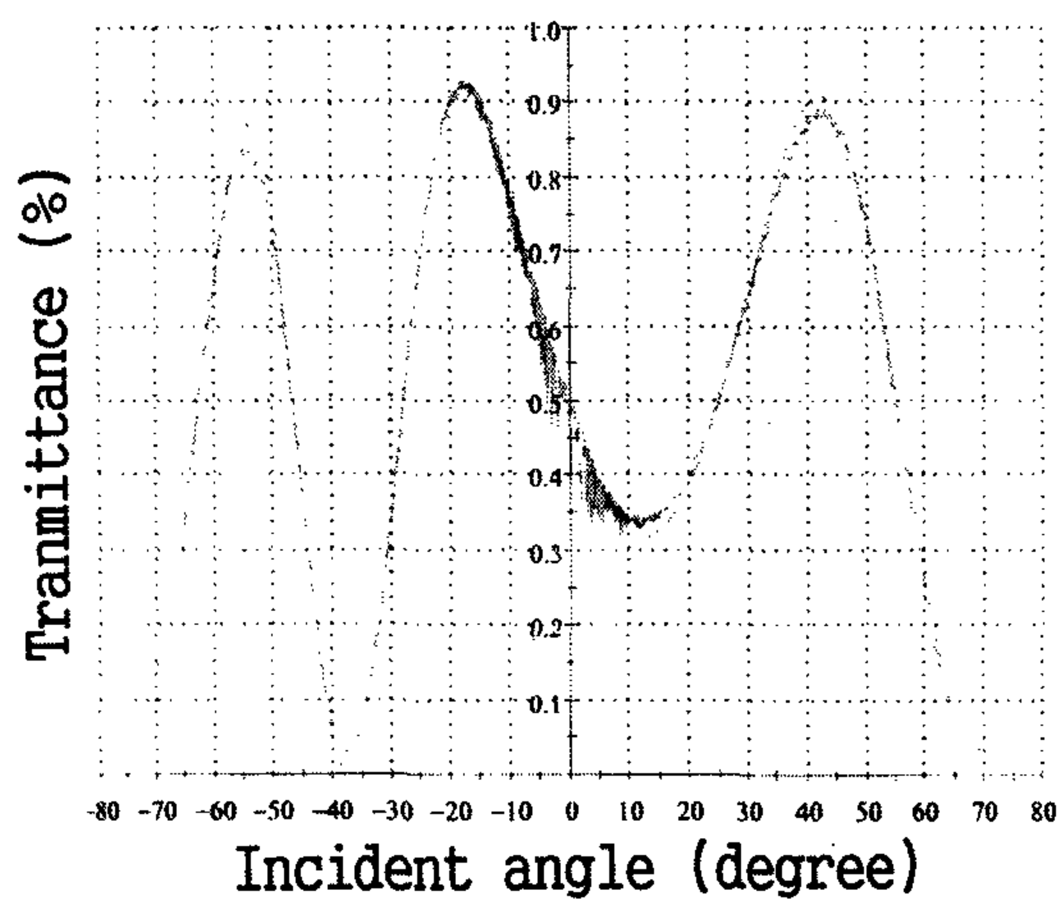


Figure 4. Transmittance versus angle of incidence in the NLC with ion beam exposure on the DLC layer.

The LC pretilt angles with ion beam exposure on the DLC layer (3 : 30 ratio for C_2H_2 : He) for 1 min as a function of the incident angle are shown in Fig. 5. It is shown that the LC pretilt angle generated was about 3.5° with ion beam exposure at an oblique direction of 45° on the DLC layer for 1 min. In addition, the pretilt angle decreases with an increasing incident angle at over incident angle of 45°. It is clear that the high LC pretilt angle can be achieved with incident angle of 45°.

Figure 6 shows the LC pretilt angles with ion beam exposure on the DLC layer (3 : 30 ratio for C_2H_2 : He) as a function of exposure time. The results revealed that the high LC pretilt angle, which was achieved via ion beam exposure on the DLC layer for 1 min, and the pretilt angle rapidly decreased with increasing ion beam exposure time. The peak point of the LC pretilt angle was observed with ion beam exposure time on the DLC film for 1 min. Also, the LC pretilt angle decreased due to the increase in surface roughness at over 2 min of ion beam exposure time. It is considered that this roughness increase due to increasing ion beam exposure time that generated destroy of oriented rings of atoms related to LC alignment. Therefore, the high pretilt angle on the DLC layer can be controlled.

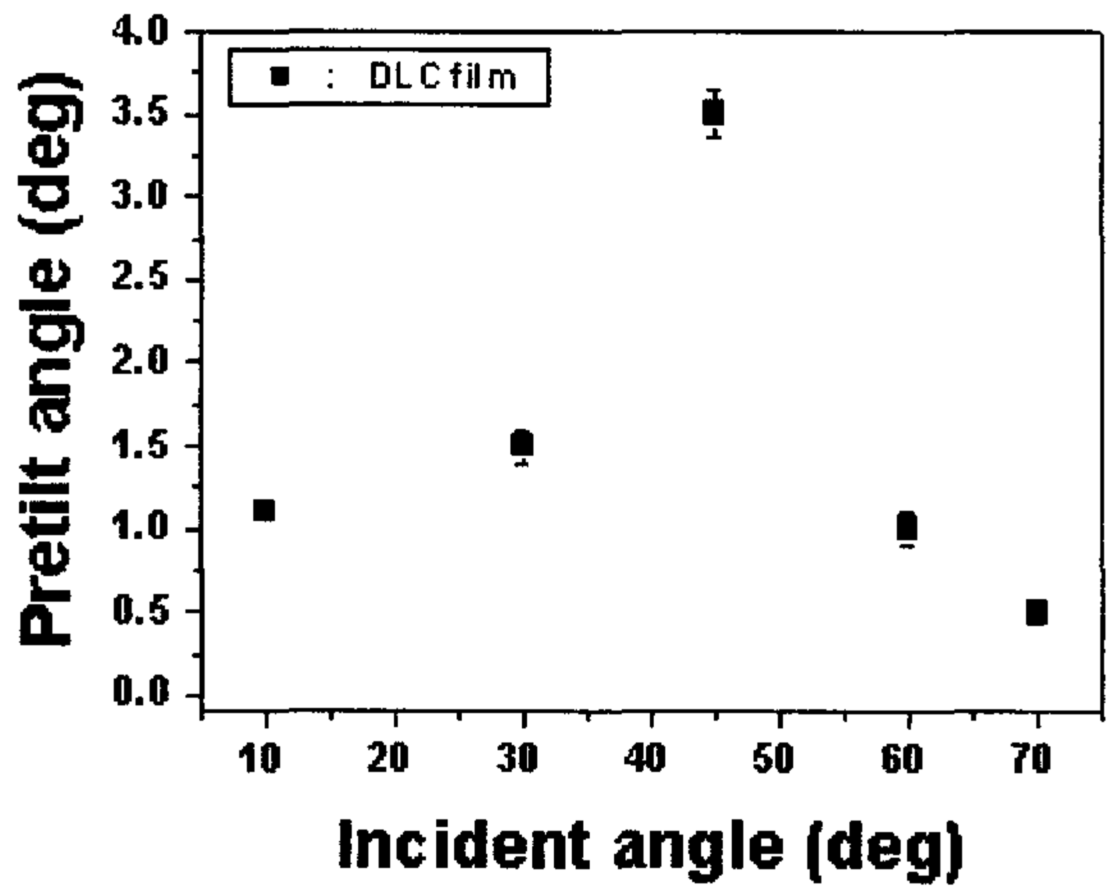


Figure 5. LC pretilt angles with ion beam exposure on the DLC layer for 1 min as a function of incident angle.

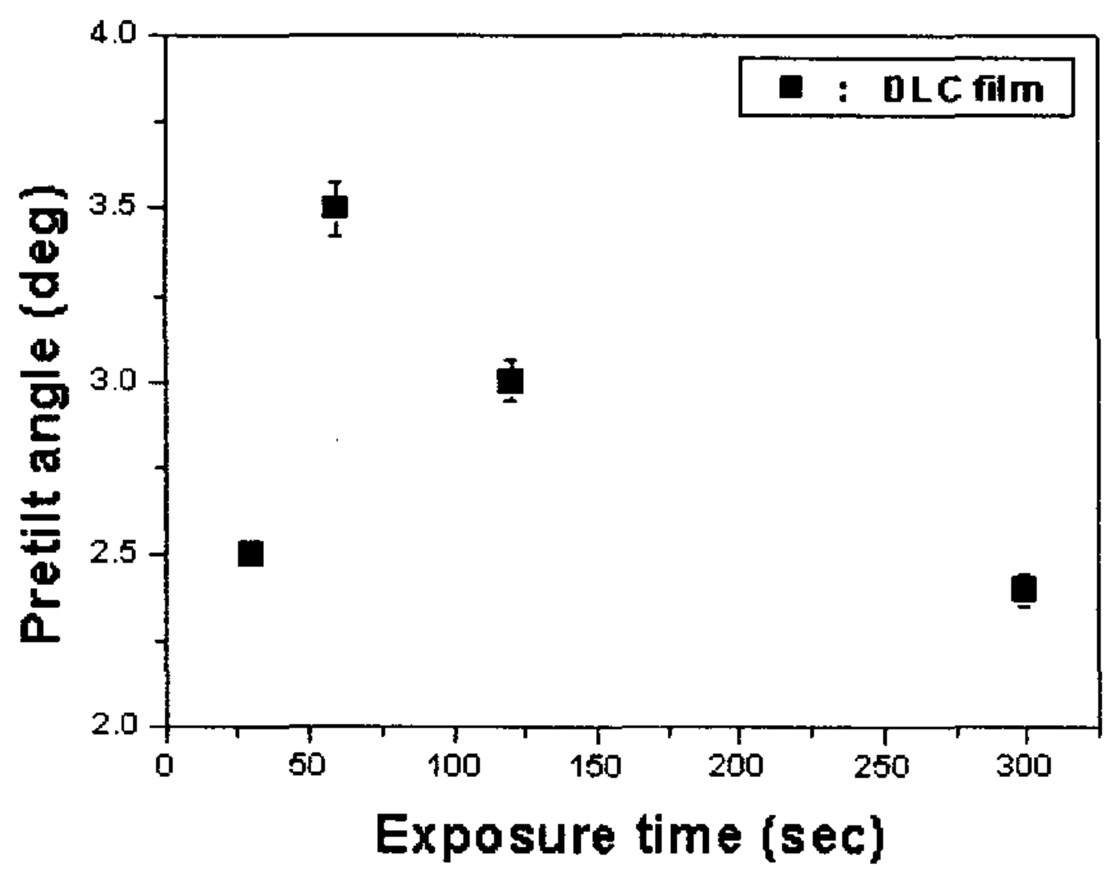


Figure 6. LC pretilt angles with ion beam exposure on the DLC layer as a function of exposure time.

In conclusion, we studied the LC alignment capabilities and the generation of pretilt angles with ion beam exposure on the DLC layer. A high pretilt angle of 3.5°via ion beam exposure on the DLC layer was measured. Therefore, a high LC pretilt angle and stable LC alignment via the ion beam alignment method on the DLC layer can be achieved.

4. Acknowledgements

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5. References

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