Study on LC Aligning Capability by the UV Alignment Method on a-C:H Thin Films

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Abstract

We studied the nematic liquid crystal (NLC) aligning capabilities by the UV alignment method on a a-C:H thin film surface. A good LC alignment by UV exposure on the a-C:H thin film surface at 200 Å of layer thickness was achieved. Also, a good LC alignment by the UV alignment method on the a-C:H thin film surface was observed at annealing temperature of 180 ℃. However, the alignment defect of the NLC was observed above annealing temperature of 200 ℃. Consequently, the good thermal stability of LC alignment by the UV alignment method on the a-C:H thin film surface 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, PC monitors and TVs etc. The uniform alignment of LC is one of the essential processes for LCD fabrication. The most conventional process for LC alignment employs a mechanically rubbed polyimide (PI) surface. LCs are aligned due to the induced anisotropy on the substrate surface. The rubbing alignment method has suitable characteristics such as uniform alignment and a high pretilt angle. However, rubbed PI surfaces involve some problems such as the generation of dust and static electricity[1-3], and a complicated process for multi-domain LC alignment[4]. Thus, rubbing-less techniques for LC alignment are strongly needed in LCD technology. Recently, the LC alignment effects by the photodimerization[5-7] and photodissociation[8-13] have been reported. 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. Chaudhari et al[14]. Thus, ion beam alignment using inorganic material for LCD is promising technology among a variety rubbing-free method. However, ion beam alignment method has to need vacuum chamber and can be generated problem of LC orientation and non-homogeneity pretilt angle by high energy of ion beam. Also, UV alignment technique using non-polarizer for LC alignment has revealed good LC orientation by simple process[12].

In this article we report on LC alignment and pretilt angle generation with UV exposure on the DLC (a-C:H) thin film surface.

2. Experiment and Results

The a-C:H thin films were coated on indium-tin-oxide (ITO) coated glass substrates by Inductively Coupled Plasma Chemical Vapor Deposition System (ICP-CVD). The ICP-CVD system is shown in Fig. 1. The a-C:H thin film was deposited using C_2H_2: He gas for 1~3 min. The C_2H_2 and He gases were floating 3 sccm and 30 sccm in the chamber at room temperature, respectively. The thickness of the a-C:H layer was controlled at 100~300 Å. Table 1 shows the deposited condition of inorganic materials as a-C:H thin films. The UV exposure (Oriel Co.) system is shown in Fig. 2. The UV source was a 1000 W Mecurry lamp. The UV energy density used was 51.9 mW/cm^2. The LC cell was assembled in 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 of NLC without a chiral dopant (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 the NLC was measured by a crystal rotation method.

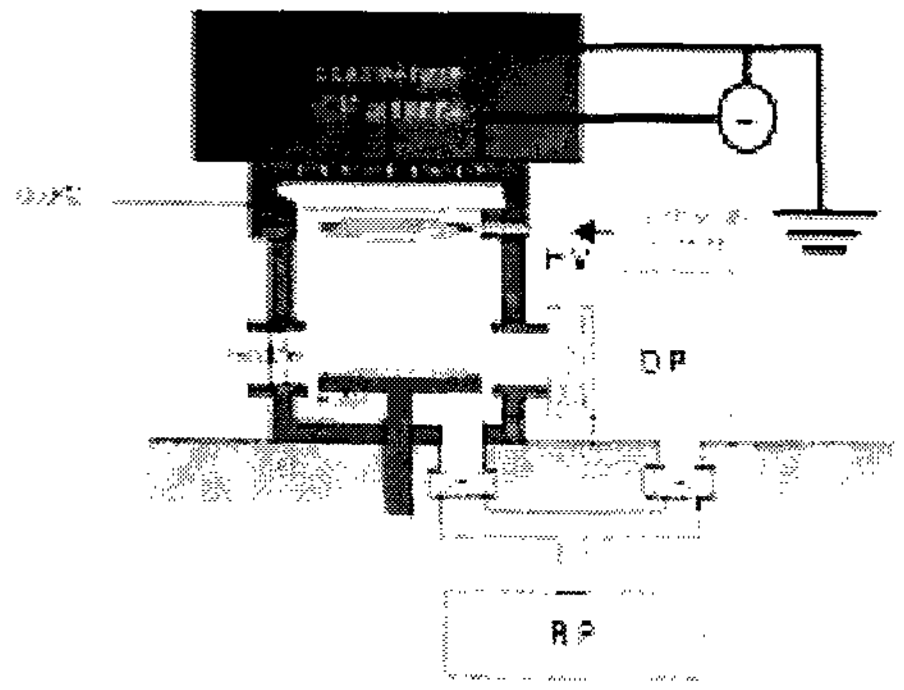


Figure 1 ICV-CVD system for a-C:H thin.

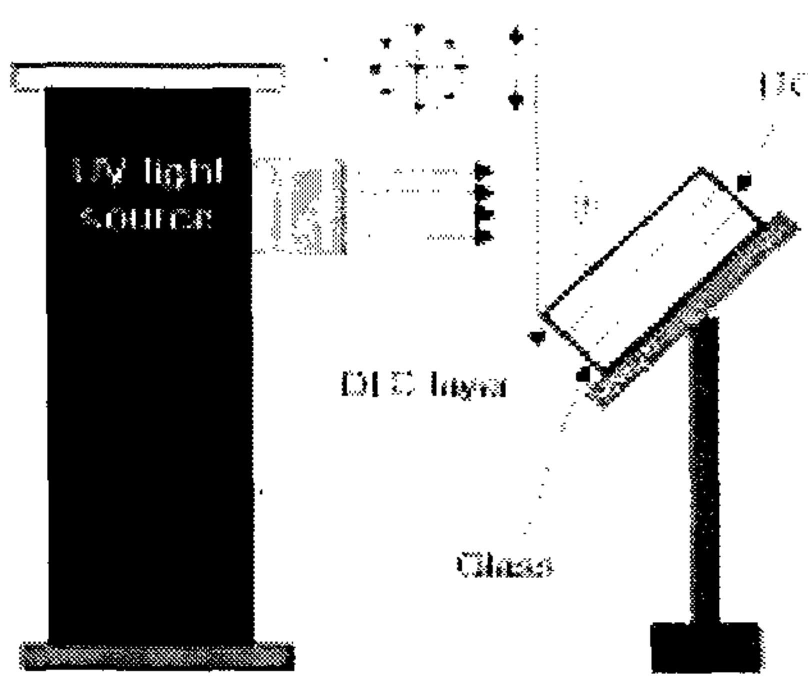


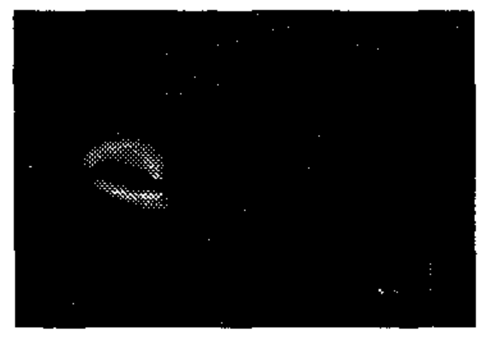
Figure 2 UV exposure system used.

Table 1 Deposited condition of a-C:H thin film.

Alignment Layer	Deposited Time (~1.7Å/sec)	Deposited Pressure (mTorr)	Ratio for C_2H_2 : He (sccm)	Layer Thickness (Å)
DLC_UV (1)	1 min	200	3 : 30	100
DLC_UV (2)	2 min	200	3 : 30	200
DLC_UV (3)	3 min	200	3 : 30	300

Figure 3 shows micrographs of an LC cell with non-polarized UV exposure on three kinds of a-C:H thin film for 30 min. In Fig. 3(a), good LC alignment via UV exposure on the a-C:H thin film (100 Å) deposited using C_2H_2: He gas for 1 min was observed. Also, excellent LC alignment was observed via non-polarized UV exposure on the a-C:H thin film (200 Å) deposited using C_2H_2: He gas for 2 min as shown in Fig. 3(b). However, the LC alignment defects were observed with non-polarized UV exposure on the a-C:H thin film (300 Å) deposited using C_2H_2: He gas for 3 min as shown in Fig. 3(c). It is contended, herein, that stable LC alignment can be obtained on the a-C:H thin film with 200 Å of layer thickness. Therefore, it is considered that LC aligning capability depend on a-C:H thin film thickness.

(a) 100 Å



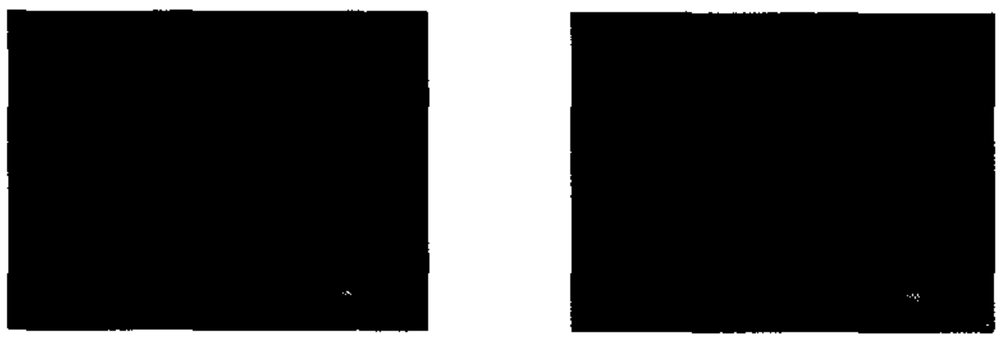
(b) 200 Å

(C) 300 Å

Figure 3 Micrographs of LC cell with non-polarized UV exposure on the three kinds of a-C:H thin films (in crossed Nicols).

Figure 4 shows micrographs of an LC cell using linearly polarized or non-polarized UV light on a-C:H thin film (200 Å) for 30 min. It is shown that the excellent LC alignment were observed by the non-polarized UV light with an incidence angle of 45° on the a-C:H thin film for 30 min as shown in Fig. 4 (a). However, the many disclination was observed via the linearly polarized UV exposure on the a-C:H thin film for 30 min as shown in Fig. 4 (b). The LC alignment by the non-polarized UV exposure was better than that by the linearly polarized UV exposure. Therefore, it is considered that an inorganic material for LCD was used by non-polarized UV light as superior LC alignment, but an organic material for LCD used by linearly polarized UV light as superior LC alignment.

The alignment direction of LC was parallel to the direction of the non-polarized UV light. Unidirectional LC alignment on the a-C:H thin film was generated by UV exposure which selectively destroyed unfavorably oriented rings of atoms, and the planes of remaining rings made LC molecules to align to the direction of the UV exposure[14].



(a) non-polarized UV light (b) polarized UV light

Figure 4 Micrographs of LC cell with non-polarized .UV or linearly polarized UV exposure on a-C:H thin films (in crossed Nicols).

The LC pretilt angles observed with non-polarized UV exposure on the a-C:H thin film (200 Å) for 30 min as a function of the incident angle are shown in Fig. 5. It is shown that the LC pretilt angle generated was below 1° in the all-incident angle on the a-C:H thin film. Also, the pretilt angle increases with increasing incident angle. It is considered that the generation of LC pretilt angle in the non-polarized UV exposure is attributable to the high incident angle as UV exposure[12].

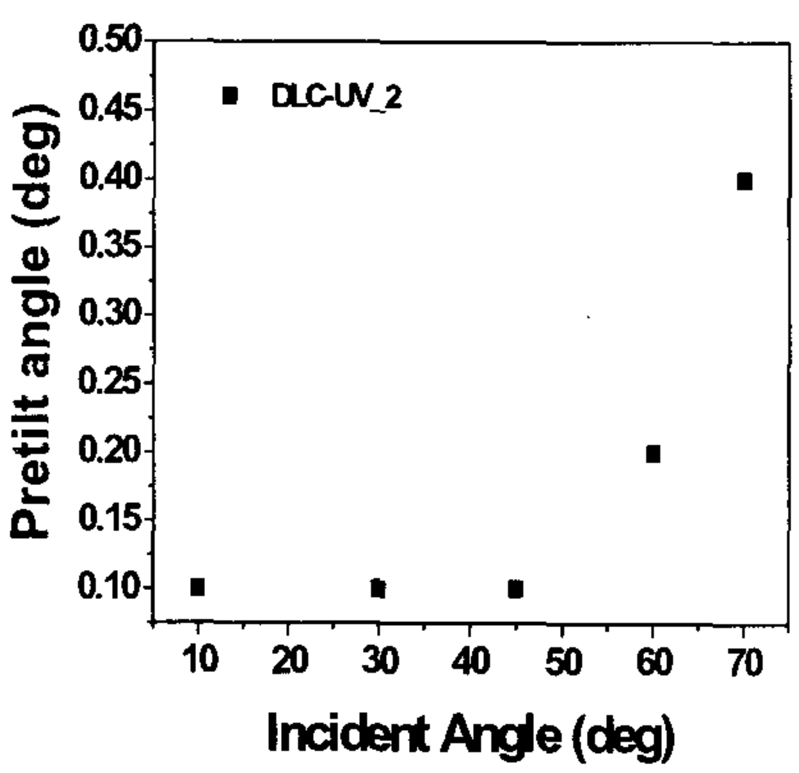
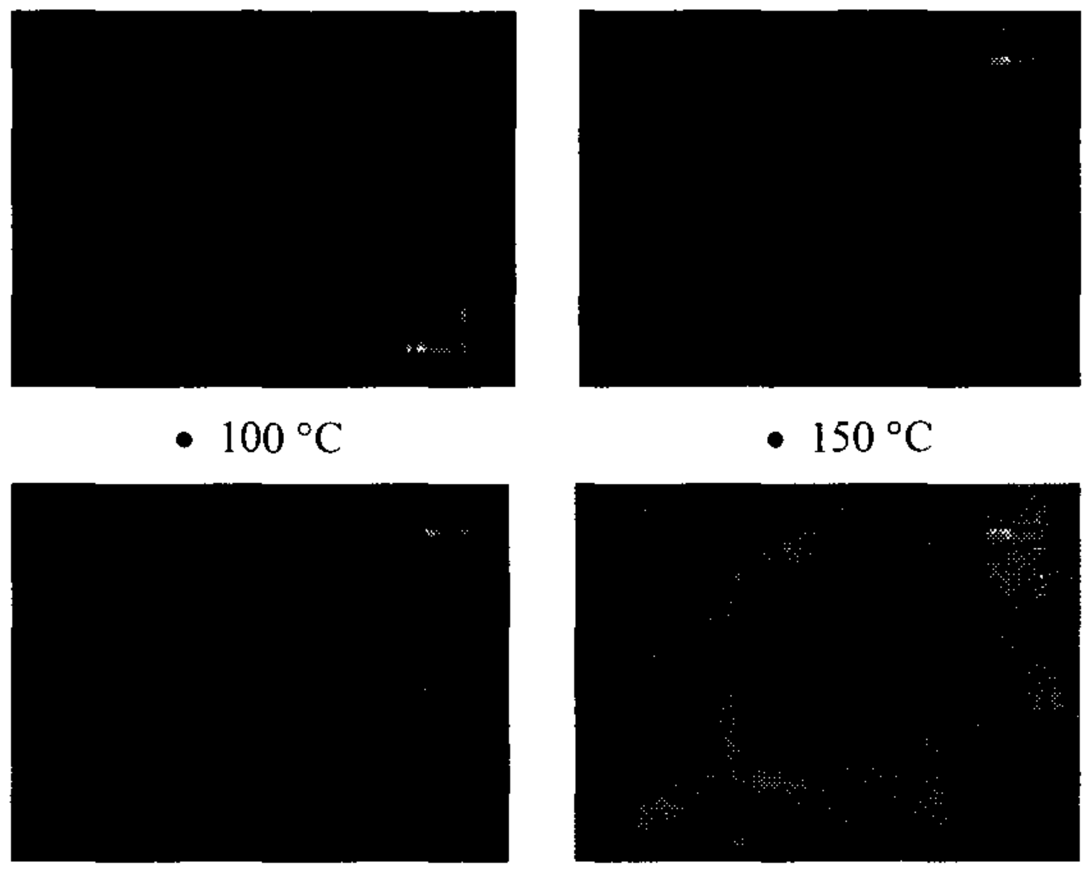


Figure 5 LC pretilt angles with non-polarized UV exposure on the a-C:H thin film for 30 min as a function of incident angle.

Figure 6 (a) shows micrographs of the aligned LC with non-polarized UV exposure on the a-C:H thin film for 30 min at various annealing temperatures (in crossed Nicols). In Fig. 6, good LC alignment with UV exposure on the a-C:H thin film was observed up to an annealing temperature of 180 ℃, and the alignment defects of LCs were observed above an annealing temperature of 200 ℃. From these results, the thermal stability of LC alignment with UV exposure on the a-C:H thin film was found to be almost the same as that of the rubbed PI layer. Therefore, superior LC alignment and thermal stability can be achieved via non-polarized UV exposure on the a-C:H thin film.



• 100 °C • 150 °C

• 180 °C • 200 °C

Figure 6 Micrographs of aligned LC with non-polarized UV exposure on the a-C:H thin film surface for 1 min at various annealing temperatures (in crossed Nicols).

3. Conclusion

We studied LC alignment capabilities and the generation of pre-tilt angles with IB exposure on the DLC thin film layer. A high pre-tilt angle of 3.5° via IB exposure on the DLC thin film layer was measured. Superior LC alignment ability via IB exposure on the DLC thin film layer was observed until an annealing temperature of 200℃. Therefore, a high LC pre-tilt angle and superior LC alignment thermal stability via the IB alignment method on the DLC thin film layer can be achieved.

4. Acknowledgement

This work was supported by the Korea Research Foundation Grant (KRF-2002-042-D00092).

5. References

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