Investigation of the Alignment Phenomena on the a-C:H Thin Films by PECVD System using Ion-beam Alignment Method

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We studied the nematic liquid crystal (NLC) aligning capabilities using the new alignment material of a-C:H thin film by plasma enhanced chemical vapor deposition (PECVD) system for 30 sec under 30W rf power at a gas pressure of $1.4*10^{-1}$ torr. A high pretilt angle of about 5° by ion beam exposure on the a-C:H thin film surface was measured. A good LC alignment by the ion beam alignment method on the a-C:H thin film surface was observed at annealing temperature of 250℃, and the alignment defect of NLC was observed above annealing temperature of 300℃. Consequently, the high LC pretilt angle and the good thermal stability of LC alignment by the ion beam alignment method on the a-C:H thin film by PECVD method as working gas at 30W rf bias condition can be achieved.

Keywords : a-C:H thin film, Ion beam exposure, Nematic liquid crystal, Annealing effect, PECVD method

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[5-8] photodissociation[9], and photoisomerization[10] have been reported. Most recently, Chaudhari et al. investigated the hydrogenated amorphous carbon (a-C:H) thin films for new alignment materials[11]. Also recently, we deposited a-C:H thin films using remote plasma enhanced chemical vapor deposition (RPECVD) method and the surface of the deposited thin films was irradiated by Ar ion beam[12-14]. Thus, ion beam alignment using inorganic material for LCD is promising technology among a variety rubbing-free method.

In this manuscript we report on LC alignment, pretilt angle generation and thermal stability with ion beam exposure on the a-C:H thin film surface.

2. EXPERIMENTAL

The a-C:H thin films were coated on indium-tin-oxide (ITO) coated glass substrates by PECVD system. PECVD system is divided into three parts – the vacuum system, power supply and deposition chamber as shown in Fig. 1. The a-C:H thin film was deposited using a mixture C_2H_2 (3 sccm) and He(30 sccm) as working gases. C_2H_2 and He gases were introduced into chamber through separated gas lines. In PECVD system, the deposition was performed for 30 sec under 30 W rf power at a gas pressure of $1.4*10^{-1}$ torr under deposition zone rf bias condition. Table Ⅰ shows the deposited condition of inorganic materials as a-C:H thin films. The ion beam exposure system is shown in Fig. 2.

The ion beam energy used was 200 eV. The LC cells were assembled by an anti-parallel structure to measure the pretilt angle. The thickness of the LC cell for pretilt angle was 60 μm. The LC cells were filled with a fluorinated mixture type NLC without a chiral dopont (Tc=72℃, MJ97359, from Merck Co.). LC alignment ability was observed using a photomicroscope. The pretilt angle of an anti-parallel cell was measured by a TBA 107 (Tilt-Bias Angle Evaluation, from Autronic Co.) equipment.

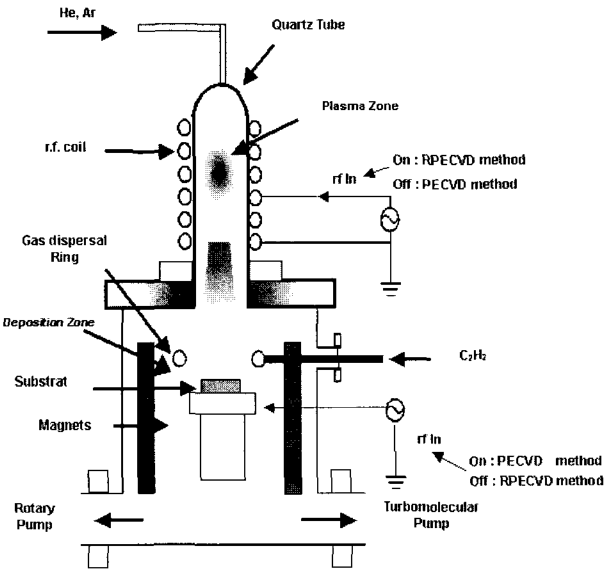

Fig. 1. PECVD system for a-C:H thin film.

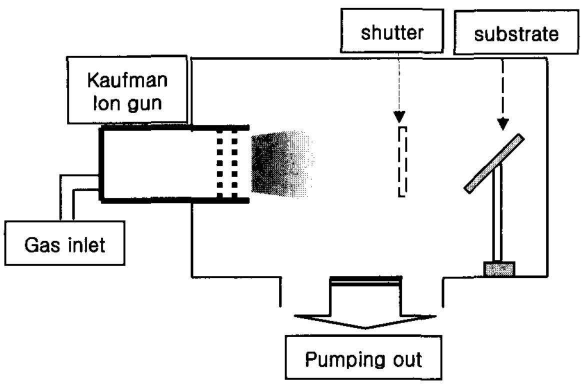

Fig. 2. Ion beam exposure system.

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

Deposition Method	Deposition Time	rf Power (W)	Ion Beam Energy (eV)	Deposition Thickness (nm)
PECVD	30 sec	30	200	20 ~ 30

3. RESULTS AND DISCUSOION

Figure 3 shows micrographs of an LC cell with ion beam exposure on the a-C:H thin films by using RPECVD method and PECVD method. The excellent LC alignment were observed by using RPECVD method with oblique ion beam exposure on the a-C:H thin film as shown in Fig. 3.

Fig. 3. Micrographs of LC cell with ion beam exposure on the two kinds of a-C:H thin films deposited method (in crossed Nicols).

Figure 4 shows the LC pretilt angles with exposure time for 1 min. on the a-C:H thin films as a function of the incident angle. Also the LC pretilt angle decreased according to more increasing the incidental angle over 30 degree of incidental angle by using PECVD method. The peak point of the LC pretilt angle with 30 degree incidental angle on the a-C:H thin films which was deposited by PECVD was observed about 5 degree. Therefore, the high pretilt angle on the a-C:H thin film can be controlled.

Figure 5 shows the micrographs of the aligned LC on the a-C:H thin film which is deposited by PECVD method with ion beam exposure on the a-C:H thin film for 1 min at 100~ 300℃ annealing temperatures for 10min. The good LC alignment with ion beam exposure on the a-C:H thin film was observed until an annealing temperature of 250℃, and the alignment defect of LCs were observed above an annealing temperature of 300℃ as shown in Fig. 5. As a result, thermal stability of LC alignment with new a-C:H thin film was improved by deposition using PECVD method[10].

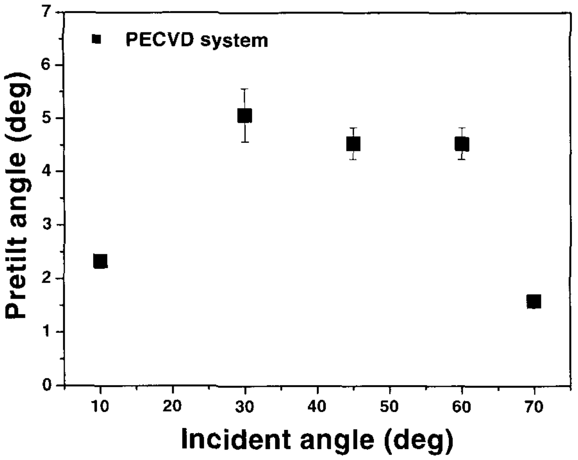

Fig. 4. LC pretilt angles with ion beam exposure on the a-C:H thin film for 1 min as a function of incident angle.

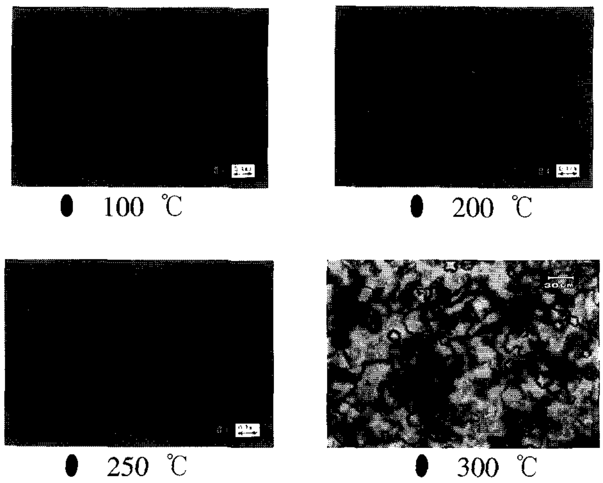

Fig. 5. Micrographs of aligned LC with ion beam exposure on a-C:H thin films deposited method for 10 min at various annealing temperatures (in crossed Nicols).

4. CONCLUSION

In conclusion, the LC alignment capabilities and the generation of pretilt angles with ion beam exposure on the a-C:H thin film surface were investigated through comparison between experimental result from PECVD and RPECVD method, respectively. The a-C:H thin film which was deposited by PECVD method is higher pretilt angle than RPECVD method. The thermal stability of LC alignment with new a-C:H thin film was improved by deposition using PECVD method. Therefore, a high LC pretilt angle and superior LC alignment thermal stability by using PECVD method with ion beam exposure on the DLC thin film layer can be achieved.

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