Homeotropic Alignment Effect for Nematic Liquid Crystal on the SiO_x Thin Film Layer by New Ion Beam Exposure

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(Received October 16 2006, Accepted November 28 2006)

We studied homeotropic alignment effect for a nematic liquid crystal (NLC) on the SiO_x thin film irradiated by the new ion beam method. SiO_x thin films were deposited by plasma enhanced chemical vapor deposition (PECVD) and were treated by the DuoPIGatron ion source. A uniform liquid crystal alignment effect was achieved over 2100 eV ion beam energy. Tilt angle were about 90 ° and were not affected by various ion beam energy.

Keywords : Homeotropic alignment effect, Nematic liquid crystal, SiO_x thin film, Plasma enhanced chemical vapor deposition, Ion beam method, Tilt angle

1. INTRODUCTION

Liquid Crystal Display (LCD) has become one of the major display devices of flat panel display (FPD). LCD has demonstrated from small-portable displays to large sized TVs. LCD technology has been developed to be suitable for all these applications [1]. To achieve high picture quality of LCD, it is necessary that the LC alignment effect be uniform on a substrate [2, 3]. Until now, the rubbing method has been widely used to align LC molecules uniformly [4, 5]. Though rubbing method is simple, it has root problems – such as the generation of defects by dust and static electricity, and difficulty in achieving uniform LC alignment on a large sized substrate [6]. To solve these dust and static electricity problems, additional processes are necessary. Hence, productivity and manufacturing cost can deteriorate. Therefore, the non-contact alignment [7] - Ion-beam exposure on the inorganic thin-film [8-10] has been investigated to solve the problems of rubbing method. DuoPIGatron type ion gun system can generate higher current density and more uniform plasma than existing Kaufman type Ar ion gun, it is expected that new type ion gun system can be adapted to larger LCD panel manufacturing.

In this study, we investigated the liquid crystal homeotropic alignment effect as a function of ion beam irradiation energy on SiO_x thin film with the DuoPIGatron type ion gun.

2. EXPERIMENTAL

LC cells were made to investigate LC alignment effect on the SiO_x thin film for variety of the ion beam energy. Indium-tin-oxide (ITO)-coated glass substrates with dimensions of 150 × 217 × 0.7 mm^3 were used for all measurements. SiO_x thin films were deposited on ITO-coated glass substrates by PECVD. Before the thin film deposition process, the ITO-coated glass substrates were sequentially cleaned with supersonic wave in trichloro-ethylene (TCE) – acetone – methanol – deionized water solution for 10 min, and glass substrates were blown and dried with N_2 gas.

SiO_x thin films were deposited using the mixture gas of SiH_4 (25 sccm), N_2O (375 sccm), and He (2000 sccm). SiO_x thin films were deposited at 420 ℃, and the rf power was 75 W. The thickness of SiO_x thin film was about 100 ㎚. After the deposition process, ion beam was irradiated on the SiO_x thin films. The ion beam irradiation energy were 1200, 1500, 1800, 2100, and 2400 eV, respectively. The other condition of the ion beam irradiation were same. The irradiation time of ion beam was 1 min, and the incident angle was 45 °.

After the irradiation, the LC cells were assembled in antiparallel configuration to measure LC tilt angle and alignment effect. The cell gap of LC cells was about 60 ㎛, and nematic liquid crystal (T_c = 75 °, $\Delta\varepsilon$ = -4) was injected in the LC cells. LC alignment effects were observed, and the tilt angle of the antiparallel LC cells

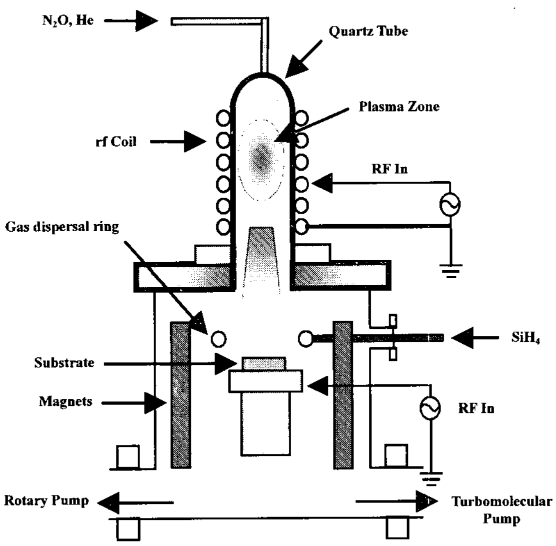


Fig. 1. Schematic diagram of an PECVD.

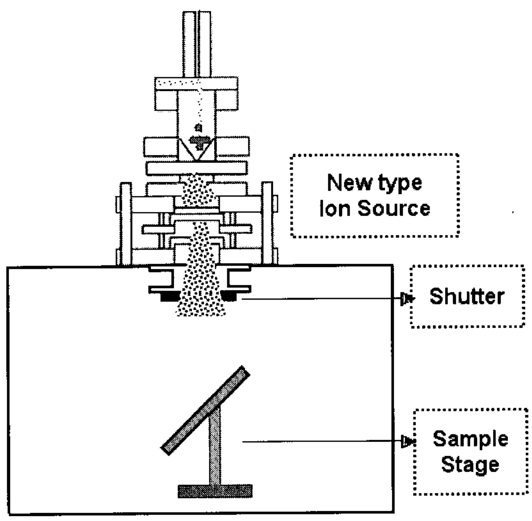


Fig. 2. Schematic diagram of an DuoPIGatron type ion beam.

was measured by a crystal rotation method at room temperature.

3. RESULTS AND DISCUSSION

Figure 3 shows that photographs of the NLC alignment effect on the SiO_x thin film with the various ion beam energy. Figure 3(a) is the photograph of a LC cell was irradiated by 1200 eV ion beam energy on the SiO_x thin-film, and Fig. 2(b), (c), (d) and (e) are photographs of 1500 eV, 1800 eV, 2100 eV and 2400 eV ion beam energy, respectively. It was shown that the stronger ion beam energy was irradiated on the thin film, the LC alignment effect was more uniform. At 1200 eV ion beam energy, the LC alignment effect was not achieved.

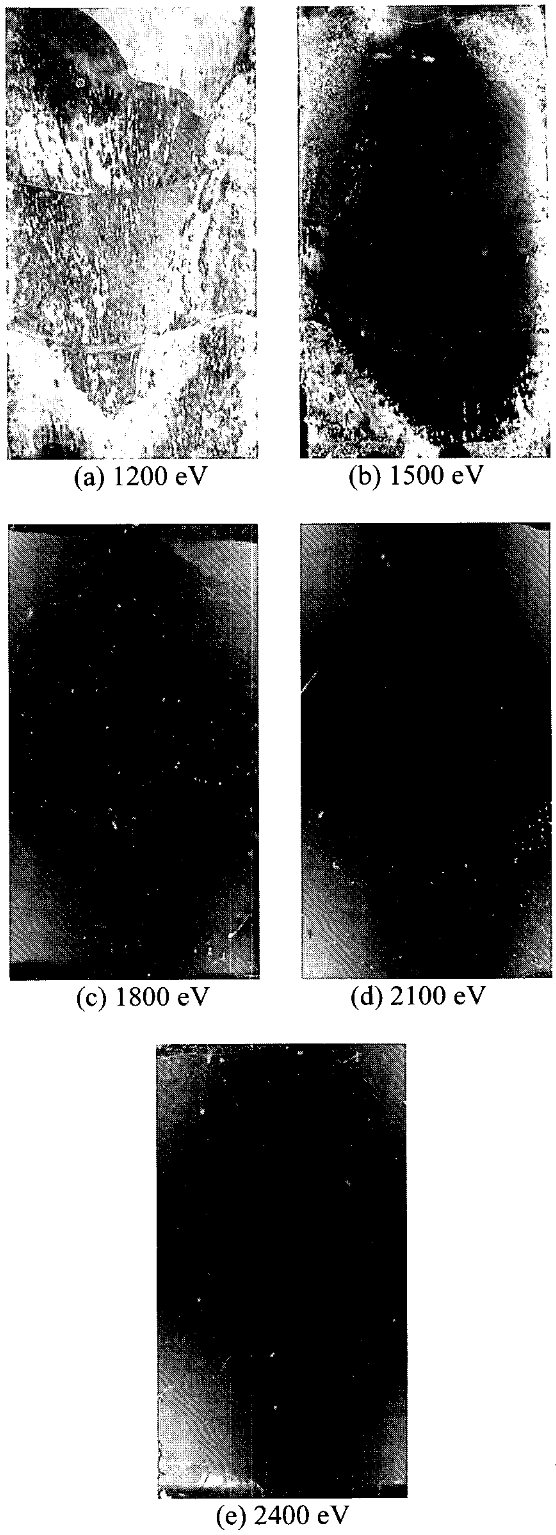
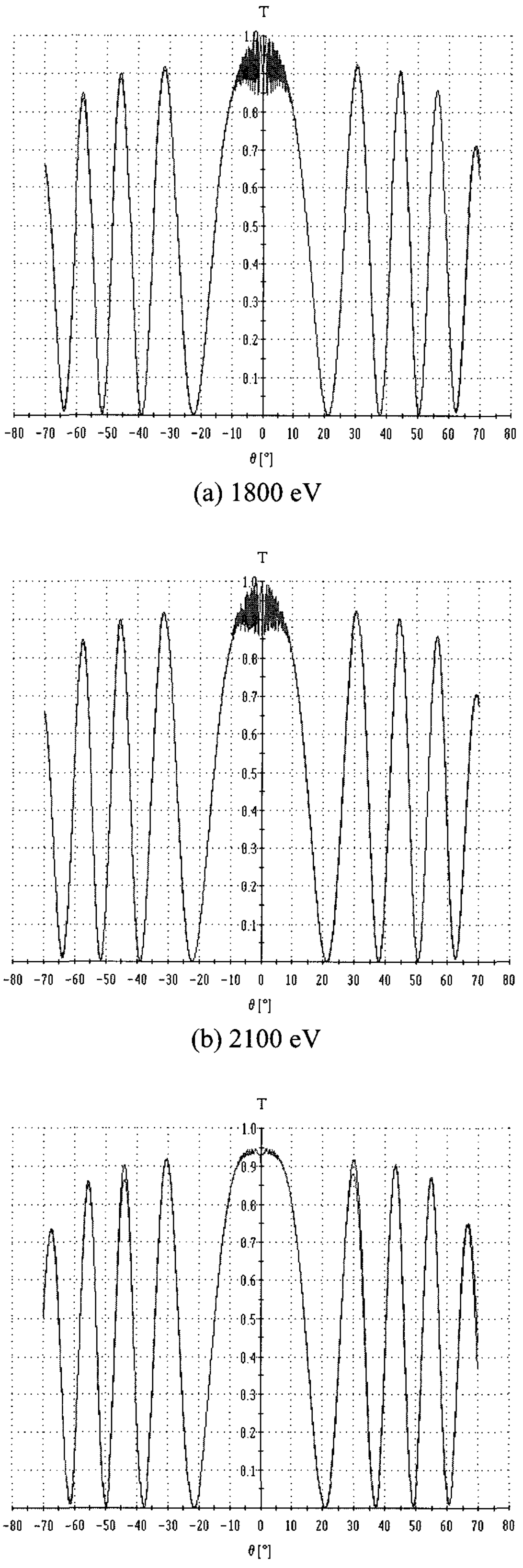


Fig. 3. Photographs of nematic liquid crystal cells on the SiO_x thin film by new ion beam(crossed Nicols.).



(a) 1800 eV

(b) 2100 eV

(c) 2400 eV

Fig. 4. Tilt angle of aligned NLC on the SiO_x thin film with ion beam exposure.

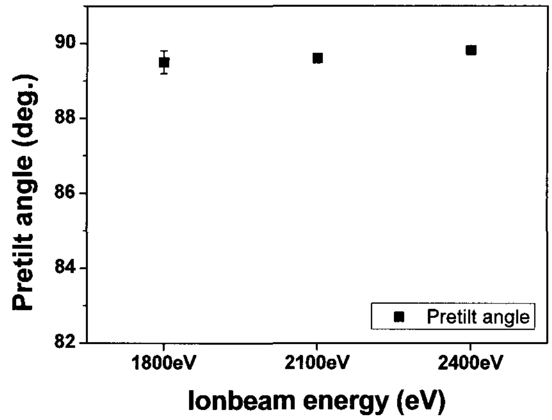


Fig. 5. Tilt angle generation for nematic liquid crystal on the SiO_x thin film with ion beam incidence energy.

When the higher ion beam energy – at 1500 eV and 1800 eV was irradiated on the SiO_x thin film, the LC alignment effect became better, but some alignment defects were observed. At the energy of 2100 eV and 2400 eV, LC alignment effect were uniform without defect and impurities. It is considered that strong ion beam energy can affect the LC alignment on the SiO_x thin-film. It is known that alignment by ion beam may be due to the destruction of bonds perpendicular to the ion beam direction [11]. The higher electric field is applied, the more bonds can be destroyed. It is considered that LC alignment can be achieved under the higher electric field.

Figure 4 and Fig. 5 shows that the graph of tilt angle on the SiO_x thin film, which was irradiated at various ion beam intensity. Because LC alignment effect were uniform over 1800 eV ion beam intensity, tilt angle of LC cells which were aligned by ion beam over the energy of 1800 eV were measured by crystal rotational method. As shown in Fig. 4, LC alignment on the SiO_x thin film showed homeotropic alignment. Figure 5 shows a plot of the tilt angle as a function of the incidence angle of the ion beam. The tilt angle was kept with 90 ° not to be related with ion beam energy.

4. CONCLUSION

In this study, LC alignment effect and tilt angle at the various irradiated ion beam energy on the SiO_x thin-film was investigated. The DuoPIGatron ion beam source was used for the experiments. This new type ion beam equipment is expected to align LC on the larger glass substrate than preexisting ion beam source, because this DuoPIGatron ion beam source can achieve higher current and plasma density. Tilt angle was about 90 °, and LC alignment was homeotropic alignment. Antiparallel LC cell made with glass substrates which was treated at 2100 eV and 2400 eV ion beam energy on the SiO_x thin-film had uniform and excellent LC alignment effect. As a result, SiO_x thin-film deposited by PECVD and irradiated by ion beam had uniform and homeotropic alignment effect without rubbing process. And it is expected to adapt to VA mode on the larger galss substrate.

ACKNOWLEDGMENTS

This work was supported by the National Research Laboratory program (M1-0203-00-0008) and the Ministry of Information & Communications of Korea under the Information Technology Research Center (ITRC) Program.

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