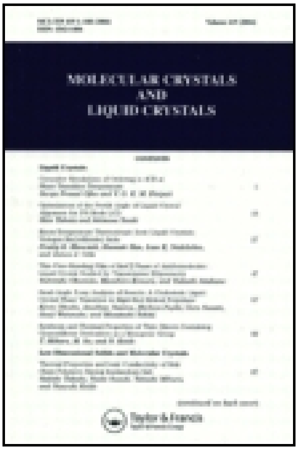

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Liquid Crystal Alignment Effects using a Sio Thin Film

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Liquid Crystal Alignment Effects using a Sio Thin Film

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We studied the nematic liquid crystal (NLC) aligning capabilities using the new alignment material of a SiO thin film. The homogenous alignment was obtained by using ion beam (IB) exposure on the SiO thin film, when positive type NLC ($\Delta\varepsilon > 0$) was injected into the LC cell. However, the homeotropic alignment was obtained using ion beam exposure on the SiO thin film, when negative type NLC ($\Delta\varepsilon > 0$) was injected into the LC cell. The LC aligning capability on the SiO thin film depends on the dielectric anisotropy type of LC.

Keywords: dielectric anisotropy; homeotropic; homogenous; ion beam (IB); nematic liquid crystal (NLC); SiO

INTRODUCTION

The liquid crystal (LC) devices are widely used in multi field like notebook, monitor, small-size LCD TV, digital camera, medical

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equipment and so on. To use LC as actual indication element, it is essential to align uniformly, and it is rubbing method to align LC on polyimide surface that is used to produce now [1,2]. These rubbing method is suitable for mass-produce because of its simple process but has some drawbacks such as the generation of electrostatic charges and the creation of contaminating particles of rubbing velours [3–14]. Recently to solve these problems, as rubbing-less technique for LC alignment, it was reported to align by ion beam exposure on diamond-like carbon (DLC) [15,16]. Generally DLC thin film has characteristics like transparency, resistance, adherence and the surface uniformity by ion beam so it was reported that it is suitable for LC display devices. Especially it was also reported that the transparency and surface uniformity of DLC thin film are equivalent to polyimide thin film [9]. Since then lots of research fellows go deep into the study of LC alignment with various inorganic thin films.

In this study, we fabricated SiO thin film and researched into LC alignment by ion beam exposure on SiO thin film surface [17].

EXPERIMENTAL

SiO thin film was deposited on the glass substrate coated with ITO (Indium-Tin-Oxide) by using rf sputter as shown in Figure 1. ITO substrate cleaning process was like this. Before putting glass substrate coated with ITO into the chamber, supersonic cleansing was carried out in the solution of TCE (trichloroethylene), acetone and alcohol each for 10 minutes. After being put into the chamber, a substrate surface was pre-sputtered with using argon plasma for 10 minutes. SiO thin film was deposited with 8 sccm of Ar inflowed and was irradiated for 30 minutes with targeting SiO_2 under 200 W rf power. The thickness of SiO thin film was about 30 nm.

Figure 2 shows ion beam irradiation system (kaufman type), and the energy of ion beam used in this experiment was 200 eV. The exposing angle was 45 degree, and the exposing time was 1 minute. For measuring the pretilt angle, the LC cells were fabricated as a sandwich type and the thickness was controlled at 60 μm. For comparing the alignment reliableness rubbing cells were also fabricated, and liquid crystals were used positive (+) dielectric NLC ($\Delta\varepsilon = +8.2$ from Merck Co.) and negative (−) dielectric LC ($\Delta\varepsilon = -4$ from Merck Co.). A polarized microscope was used for checking the LC alignment state; the LC pretilt angles were measured by the crystal-rotation method at room temperature.

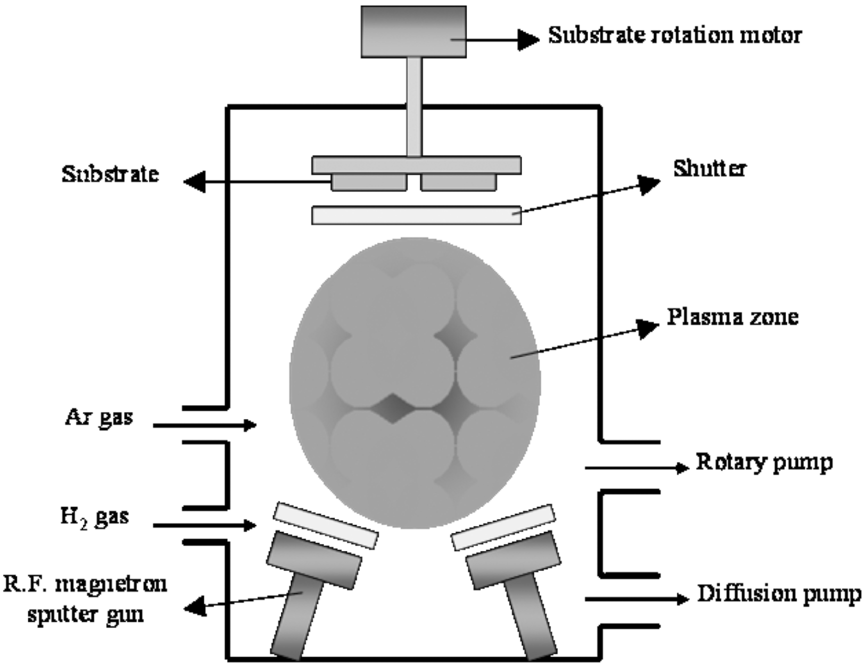

FIGURE 1 Sputtering deposition system.

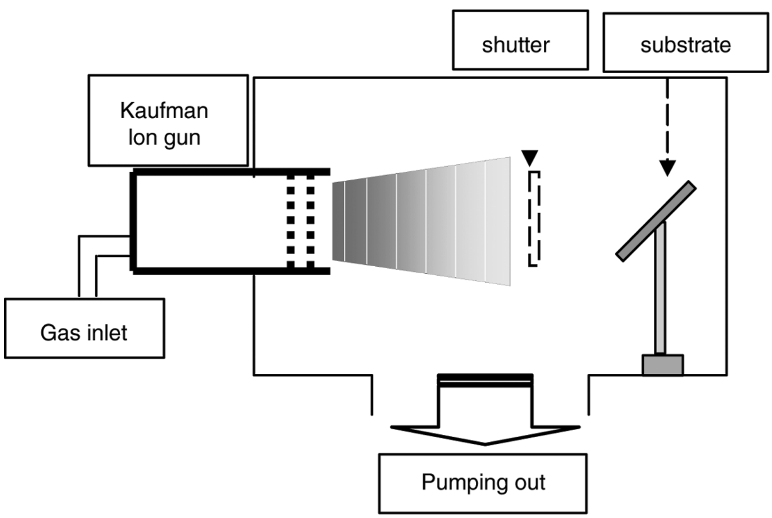

FIGURE 2 Ion beam exposure system used.

RESULTS AND DISCUSSION

Figure 3 shows the microphotographs of LC cells with ion beam exposure on SiO surface for 30 seconds (in crossed Nicols). A good LC alignment could be achieved.

Figure 4 show the microphotographs of LC cell which ion beam alignment direction was 45° with the polarizer axis as the same cell like Figure 3. The cell with positive LC showed the white state when ion beam alignment direction was 45° with the polarizer axis as the same like Figure 3(a). This result shows the cell forms planar alignment by positive LC. However, the cell with negative LC showed the white state even if alignment direction was 45° with the polarizer axis as the same cell like Figure 3(b). It means that the cell form homeotropic alignment.

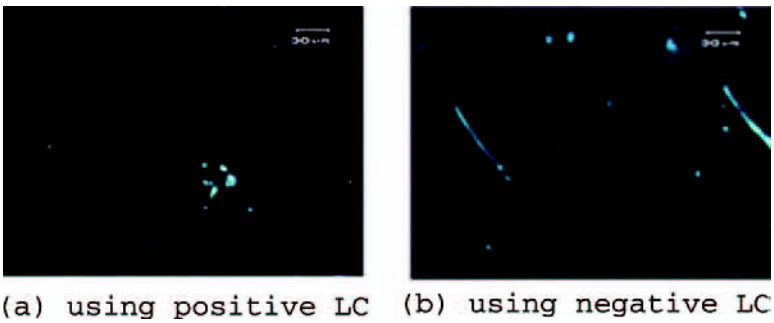

FIGURE 3 Micrographs of the ion beam aligned on SiO thin film cells (in crossed Nicols).

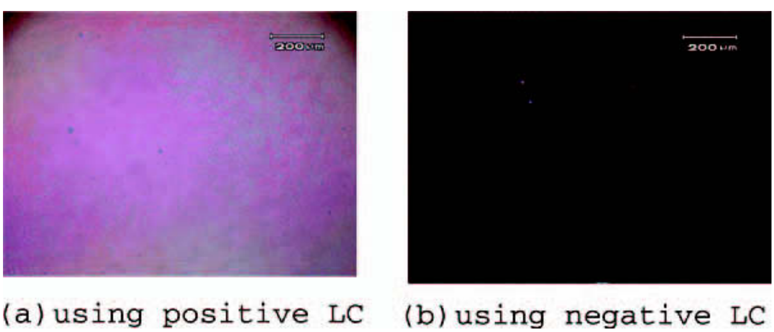

FIGURE 4 Microphotographs of LC cell which ion beam alignment direction is 45° with the polarizer axis as the same cell like Figure 3.

Therefore, orientation has two alignment state, positive LC makes planar alignment state and negative LC makes homeotropic alignment state.

Also, the alignment direction of LC was parallel to the incident direction of the ion beam irradiation. A unidirectional LC alignment on SiO surface was generated by ion beam irradition which selectively destroyed unfavorably oriented rings of atoms, and the planes of the remaining rings induced LC molecules to align in the direction of ion beam irradiation [15].

Figure 5 shows the relationship between the transmittance and the incidence angle of NLC by measuring the pretilt angle using the crystal-rotating method with ion beam exposure for 60 seconds on the SiO surface. As shown in Figure 5(a), LC cell which was irradiated with ion beam on its SiO thin film surface shows the relationship between the transmittance and the incidence angle of LC cell injected positive dielectric NLC. The graph almost symmetrical on an axis of symmetry, and the calculation shows that the pretilt angle is less than 1 degree, which is considered to be a low angle. In the result, LC cell which was irradiated ion beam on its SiO thin film surface shows homogenous alignment if positive dielectric NLC is injected.

However, when negative dielectric NLC is injected, LC cell graph also shows nearly symmetry on an axis of symmetry and the angle reaches to 90 degrees as shown in Figure 5(b). Finally, LC cell which was injected negative LC shows homeotropic alignment. Therefore, LC alignments with ion beam exposure on SiO thin film surfaces depend on the dielectric anisotropy. It is considered that aligning capability is

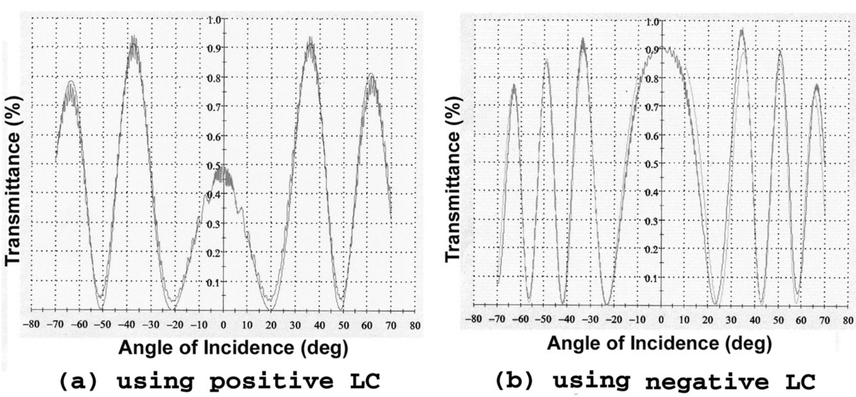

FIGURE 5 The relationship between transmmitance and incidence angle on SiO thin film with the illuminating time.

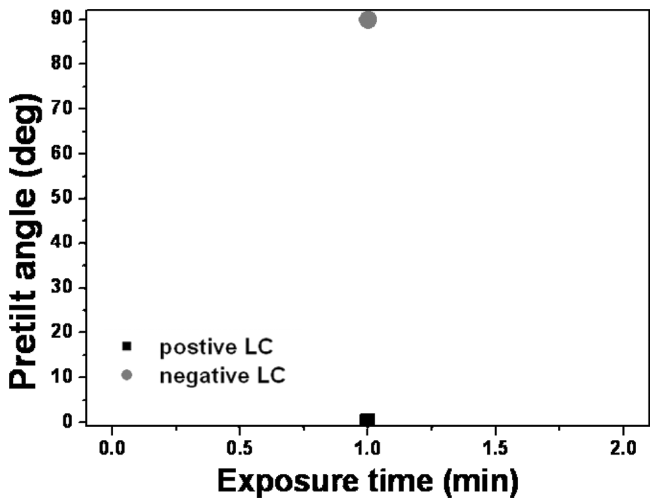

FIGURE 6 The pretilt angle of nematic LC when ion beam was illuminated on SiO thin film.

weak. The reason is that dielectric anisotropy of LC affects to LC alignment orientation. Generally, all organic alignment layers have one LC orientation because LC alignment depends on chemical structure. However, in the case of inorganic thin film, it is hard to apply alignment rule like the case of organic alignment layers. The reason is that ion beam alignment method is similar to photodissociation method on a PI surface. Ion beam alignment method generated unidirectional LC orientation by selectively destroyed unfavorably oriented rings of atoms. As a result, selectively destroyed atoms in the SiO thin film can be to generate weak anchoring.

Figure 6 shows the pretilt angle of LC cell which is illuminated ion beam for 30 seconds on SiO thin film. The LC cell which was irradiated ion beam on SiO thin film surface shows almost 0 degree of pretilt angle when positive dielectric LC is injected. However, in the case of negative dielectric LC is injected, the pretilt angle was nearly 90 degrees.

CONCLUSION

We studied the LC alignment effect aligned with ion beam on SiO thin film. We could obtain good cells from LC cell aligned with ion beam on SiO thin film. And LC cell which is irradiated ion beam on SiO thin film surface shows homogenous alignment when positive dielectric

LC was injected. However, LC cell injected negative dielectric LC shows homeotropic alignment. Therefore, we observed that LC alignment with ion beam exposure on SiO thin film surfaces depend on the dielectric anisotropy.

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