LC Aligning Capabilities of a Nematic Liquid Crystal on Homeotropic Polyimide Surface by New Ion-beam Irradiation

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The liquid crystal (LC) aligning capabilities of a nematic liquid crystal (NLC) on a homeotropic polyimide (PI) surface using a new ion-beam method were studied. Exposure ion-beam of 45 ° incidence angle shows a good LC alignment of the NLC on the homeotropic PI surface. Also, on the homeotropic PI surface, the tilt angle of the NLC by exposure ion-beam of 45 ° incidence angle had a tendency to decrease as increased ion-beam energy density. And, on the homeotropic PI surface, the alignment character of the NLC with respect to ion-beam energy was good at 1500 eV. And we achieved satisfactory result for EO character.

Keywords : Homeotropic, Polyimide, LC alignment, Pretilt angle, Response time, Voltage-transmittance, Ion-beam

1. INTRODUCTION

The LC alignment uniformity is very important in LC devices. The alignment mechanism of LC molecules on a rubbed polyimide (PI) surface is very important for both LC fundamental research and application[1-4]. So, Generally a rubbing method to align LC has been widely used to mass-produce LCD panels. But because rubbing method is contact method between rubbing fabric and indium-tin-oxide (ITO) glass or flexible substrate, rubbing method has some defects[5,6], such as the electrode charges and the creation of contaminating particles. And difficulties in applying for large glass and flexible substrates have been reported.

Thus we strongly recommend a non-contact alignment technique for getting rid of some defects of rubbing method. Most recently, the LC aligning capabilities achieved by ion beam (IB) exposure on the organic and nonorganic thin film surface have been reported successfully[7]. However, the LC alignment effects on a homeotropic PI surface induced by ion-beam irradiation for the rubbing-less thechnique not yet been reported.

In this research, we studied the tilt angle generation and electro-optical performances for a NLC on homeotropic polyimide surfaces with ion-beam exposure.

2. EXPERIMENTAL

In this experiment, the polymer (JALS-696-R2) for homeotropic alignment (JSRS) was used. The polymers were uniformly prepared by spin coating on ITO electrodes and imidized at 140 °C for 30 min. The thickness of the PI film was set at 500 Å.

Figure 1 shows the DuoPIGatron-type ion-beam system used in this experiment. The high-energy-density was used. Incidence angle of exposure ion-beam was 45 ° and range of the ion-beam energy density was 1000~2500 eV. The LC cell was fabricated as a sandwich-type with an antiparallel structure, and the thickness of the cell was 60 ㎛. After fabricating the cell, a mixture of the negative-type NLC (Δn = 0.077, MJ98468, Merck). LC alignment characteristics were observed using a photomicroscope. The tilt angle of the NLC was measured by the crystal rotation method (TBA 107, Tilt-Bias Angle Evaluation, Autronic) at room temperature. VA cell was used at 5 ㎛.

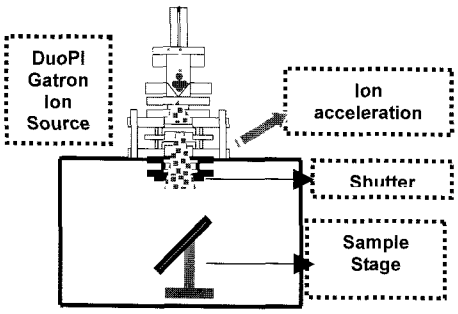

Fig. 1. DuoPIGatron-type ion-beam system.

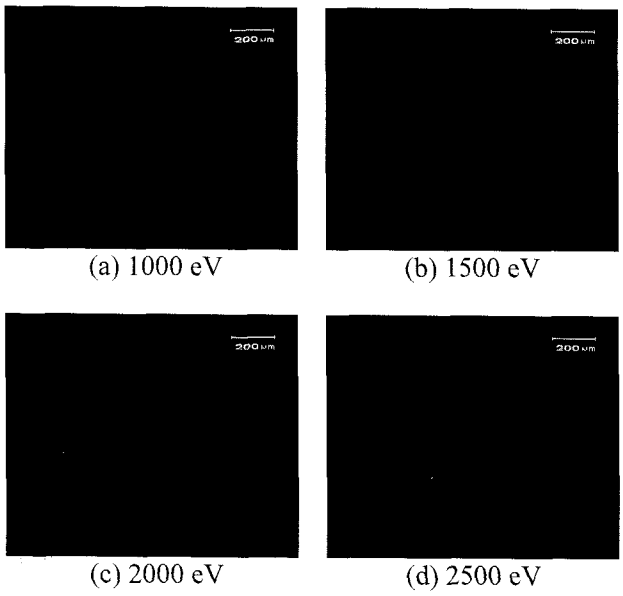

Fig. 2. Microphotograph of NLC on homeotropic PI surface exposed to ion beam of various ion-beam energies (in crossed Nicols).

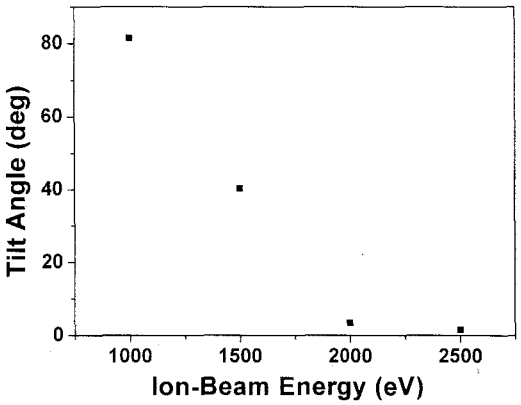

Fig. 3. Tilt angles of NLC on homeotropic PI surface with ion beam exposure as function of ion-beam energy (in crossed Nicols).

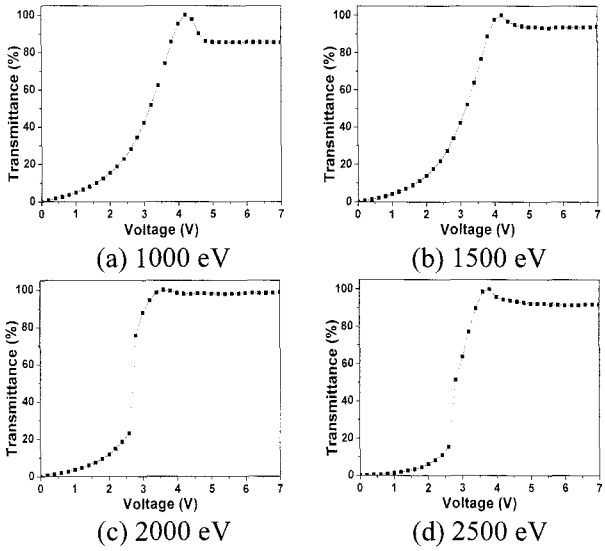

Fig. 4. *V-T* curve of VA cell on homeotropic PI surface exposed to ion beam of various ion-beam energies (in crossed Nicols).

3. RESULTS AND DISCUSSION

Microphotograph of NLC on homeotropic PI surface exposed to ion-beam of various ion-beam energies (in crossed Nicols) shows in Fig. 2. An excellent LC alignment was observed on the homeotropic PI surface to an exposed ion-beam with an incidence angle of 45 ° which showed the best alignment effect and ion-beam energies of 1000, 1500, 2000, 2500 eV. As the energy density of the ion-beam increases, the destruction of the alkyl chain is also enhanced so that subsequent anisotropy results in LC alignment. The ion-beam irradiation duration was just 2 min.

The tilt angles of NLC on homeotropic PI surface with ion beam exposure as function of ion-beam energy (in crossed Nicols) shows in Fig. 3. As the ion-beam energy density was increased, he tilt angles was decreased. The alkyl chain on the suface irradiated with a high-energy-density ion-beam is broken and the most of alkyl chain in its peroendicular remains. These remnanats contribute to the LC alignment angle and density determines the pretilt angle.

V-T character of VA-cells on homeotropic PI surface exposed to ion beam of various ion-beam energies shows in Figure 4. A good *V-T* curve for the aligned LC cells on homeotropic PI surface exposed to ion-beam of various ion beam energies was obtained. The threshold voltage for the aligned LC cells on homeotropic PI surface exposed to ion-beam of 1000 eV was about 2 V, 1500 eV was about 2.4 V, 2000 eV was about 2.6 V and 2500 eV was about 2.6 V.

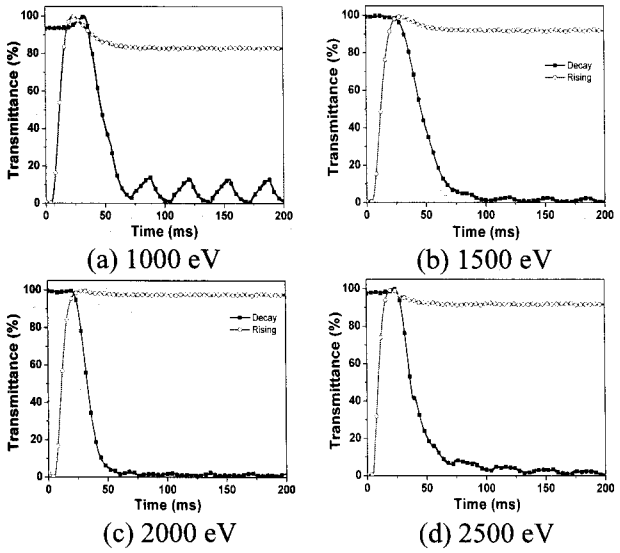

Fig. 5. Response time of VA-cell on homeotropic PI surface exposed to ion beam of various ion-beam energies (in crossed Nicols).

The response time of VA-cell on homeotropic PI surface exposed to ion beam of various ion beam energies shows in Fig. 5.

The rising time for the aligned LC cell on homeotropic PI surface exposed to ion-beam of 1000 eV was about 5.5 ms, 1500 eV was about 5.2 ms, 2000 eV was about 5.6 ms and 2500 eV was about 5.8 ms. And the decay time for the aligned LC cell on homeotropic PI surface exposed to ion-beam of 1000 eV was about 36.9 ms, 1500 eV was about 33.4 ms, 2000 eV was about 27.6 ms and 2500 eV was about 40.9 ms.

4. CONCLUSION

In conclusion, we have studied the LC alignment, tilt angle generation and EO character of VA-cells on a homeotropic PI surface by the ion beam method. A good LC alignment of the NLC on the homeotropic PI surface to an exposed ion beam of 45 °incident angle was observed from previous research. Also, the tilt angle of the NLC on the homeotropic PI surface to an exposed ion beam of 45 °incident angle decreases with increasing ion beam energy density. Also, the alignment character of the NLC on the homeotropic PI surface with respect to ion beam energy was good above 1500 eV. And we achieved satisfactory result for EO character.

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