Transactions of the Korean Nuclear Society Autumn Meeting
PyeongChang, Korea, October 30-31, 2008

Liquid Crystal Alignment of Ion Beam Treatment

Chan Young Lee, Jae Sang Lee
Proton Energy Frontier Project. Korea Atomic Energy Research Institute
*Corresponding author: chlee@kaeri.re.kr

1. Introduction

Uniform alignment of liquid crystal molecule is necessary for high quality liquid crystal displays(LCDs). Now, a rubbing method has been widely used to align LC molecules on the polyimide(PI) surface. However, the rubbing method has some disadvantage, such as the generation of electrostatic charges and the creation of contaminating particles. To overcome these problems, a non-rubbing-free method is highly desirable for future generation of large, high-resolution LCD technology [1]. The ion beam method which is one of the rubbing-free method was used as the alignment process as well as powerful industrial applications.

In this study, we observed changes of property of thin film and pretilt angle of liquid crystal due to the variation of the ion beam density, energy and irradiation time. In addition to, we checked voltage-transmittance (V-T) to evaluate the electro-optical characteristics as well as the changes of the structural property were analyzed with AFM analysis. Also, we obtained large area and uniform beam (480mm) in ion beam treatment using DuoPIGatron ion source [2,3] for industrial application in the future.

2. Methods and Results

1. Preparation of Liquid crystal and ion beam treatment

Liquid crystal(LC) cells were prepared for experiments in the following manner. We used a glass and polyimide film as the substrate. The polymers were uniformly coated on indium-tin-oxide(ITO) electrodes using spin coating, and imidized at 120℃ for 1hr. The thickness of the PI film was set at 500Å. LC cells were fabricated at room temperature and TN (Twisted nematic) mode was prepared. Ion beam treatment system was used for the control of the properties of thin film, PI. The ion beam system was developed including ion source and beam measurement system as well as vacuum system to obtain uniform and broad beam size covering 400mm [4]. The Fig 1 shows the uniform ion beam current density and we found optimal condition to alignment on polyimide with ion beam. The surface properties of PI films were controlled by argon ion beam irradiation. The irradiation time of argon ion beam was changed from 1~10 min at ion beam energy of 1500eV~3000eV. In both case of ion beam irradiation conditions, the incident angle of ion beam was 45°.

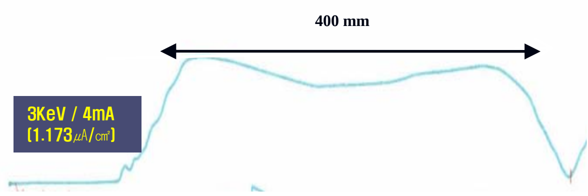


Fig. 1. Ion beam current density measurement

2. Pretilt angle measurement

The pretilt angle is the tilt of the LC moleucle's axial director away from the plane of the surface and is very important and essential factor of the alignment of LC and overcome the problem of opposite tilt and disclination defects. The pretilt angle of the anti-parallel LC cells was measured by a crystal rotation method at room temperature [5]. The pretilt angle of rubbing method is 5.86° and every data was taken as average value of three times at different places on untreated and modified LC cells. As a results, we found the LC cells with 3000eV energy, beam current of 4mA(1.173 ㎂/㎠) and treatment time of 5min are the most optimal conditions compared with rubbing method. The Fig. 2 shows LC cells pictures with microscope and cells were destroyed above 5000eV. So we need to acquire optimal conditions to apply at industrial application.

(a) rubbing method (b) 3000eV, 5min (c) 5000eV, 10min
Fig. 2. The microscope picture of LC cells

3. Voltage – Transmittance (V-T) Characteristics

The voltage-transmittance characteristic of the rubbing-aligned TN cell and the ion-beam aligned TN cell were measured by electric-optical measurement system. Fig. 3. shows V-T curves of the rubbing-aligned and ion beam treated PI surface. A good V-T curve was achieved in the ion beam treatment under specific condition comparing with rubbing method. Such good parameter characteristics of ion beam are suited to replace rubbing method.

4. Atomic force microscopy (AFM) measurement

AFM observation was carried out for untreated and treated PI film in order to clarify the effect of the variation fo dose at a 3000eV.

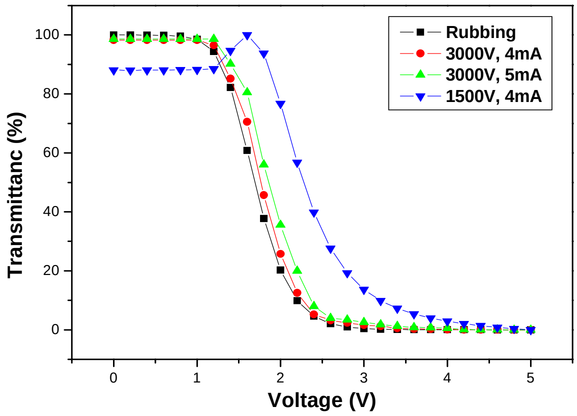
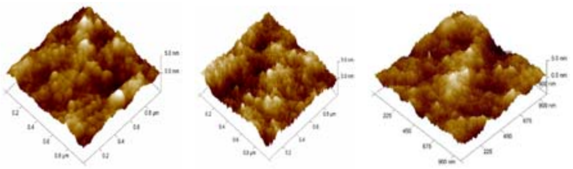


Fig. 3. Comparison of the Voltage – Transmittance Curve



(a) (b) (c)

Fig. 4. AFM image of surface morphology ((a) Rubbing method, (b)3000eV/4mA/5mA, (c)5000eV/6mA/10min

Fig 4. shows the surface nano-morphology of untreated and treated film at energy 3000eV, 4mA/6mA under same exposure time. The surfaces of treated samples have more rough than the rubbed treatment and the surface roughness was increased with an increase in ion beam exposure time. This means the surface nano-morphology of PI film was affected by energy and treatment time

Table. 1. The comparison of Ra and Rmax (Z-axis : 1nm/div.)

	Rubbing method	Ion bema treatment	
		3000eV, 4mA, 5min	3000eV, 6mA, 10min
Ra (nm)	0.583	0.651	0.648
Rmax (nm)	5.53	5.85	6.18

3. Conclusions

We investigated LC alignment capabilities and variation of pretilt angles with Ar+ ion beam treatment on PI film. Especially, we designed and set-up an ion beam system which has large and uniform beam to apply industrial application. In the experiment, high pretilt angle of 0.8° via ion beam exposure on the PI film was measured, and a good electric-optical curve as well as response time was measured comparing with rubbing. We anticipate that LCD display technologies using a rubbing-free process can be expected to solve current problems with displays and provide a good foundation for further development of displays industry hereafter.

REFERENCES

[1] J. Ienuing, Appl. Phys. Lett. 21, 173 (1982)
[2] M.O'Neil and S. M. Kelly, J. Phys. D33(2000) R67
[3] J. S. Lee, B. Y. Kim and J. H. Lee, J. Korean Phys. Soc. 47, 79 (2005)
[4] T. J. Scheffer and J. Nehering, J. Appl. Phys. 48, 1783 (1977)
[5] T. Opera, J. W. Baran and J. Zmija, Cryst. Res. Technol. 23,1073 (1988)