A Control of Pretilt Angles for Homeotropic Aligned NLC on the SiO_x Thin Film Surface by Electron Beam Evaporation

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(Received August 3 2005, Accepted October 19 2005)

We studied the control of pretilt angles for homeotropic aligned nematic liquid crystal (NLC) on SiO_x thin film surface by 45 ° evaporation method with electron beam system. The uniform vertical LC alignment on the SiO_x thin film surfaces with electron beam evaporation was achieved. It is considered that the LC alignment on SiO_x thin film by 45 ° electron beam evaporation is attributed to elastic interaction between LC molecules and micro-grooves at the SiO_x thin film surface created by evaporation. The pretilt angles of about 3.5 ° in aligned NLC on SiO_x thin film surfaces by electron beam evaporation of 45 ° were measured. Consequently, the high pretilt angles of the NLC on the SiO_x thin film by 45 ° oblique electron beam evaporation method can be achieved.

Keywords : SiO_x thin film, LC alignment, Pretilt angle, Electron beam, Evaporation

1. INTRODUCTION

The uniformity of LC alignment is very important in LC display devices. Currently, the rubbing method which rubs polyimide (PI) surface to align LC is being used to mass-produce wide LCD panels[1-6]. Rubbing method promises safe alignment under many experiments, but static, dust, and dirt from rubbing fabric and substrate are being problems, and the limitation of uniform alignment is the disadvantage on large glass substrate applications[5,7-9].

In micro-display panel, due to the changes in alignment by strong UV irradiation or some other reasons with the PI rubbing method[9-13], inorganic alignment method is required[9-13].

Currently, SiO vacuum evaporation method[14], and ion-beam alignment method[12,13] are known as inorganic alignment method. However, oblique evaporation alignment was hard to applicate because pretilt angles of 0 ° and 25 ° occurred respectively with 60 degree angle and 80 degree for incident angle of evaporation. The alignment mechanism of LC molecules on the SiO_x thin film by electron beam evaporation is an important issue for both scientific research and LC device application. But, the LC alignment mechanism is not understood. Two possible mechanisms were proposed to explain the alignment of LC molecules on rubbed polymer films. One is based on an elastic interaction between LC molecules and the micro-grooves on the polymer film surface created by rubbing. The other is based on an intermolecular interaction between LC molecules and polymer chains in the underlying film. LC molecules in contact with electron beam evaporation system are on average oriented along the evaporation direction with a certain tilt angle. The tilt angle on homogenous alignment measured from the substrate surface is called the pretilt angle. Also the pretilt angle on homeotropic alignment is measured from normal direction on substrate surface.

The pretilt angle is a very important parameter that characterizes surface-induced alignment of LC molecules and also an important variable in the fabrication of LC. The pretilt angle controls of 2 ° ~ 3 ° are required to apply to display modes. However, the control of pretilt angles has not been reported yet.

The effect of vertical alignment of NLC with 45 ° oblique evaporation of SiO_x thin film using electron beam system, and the control of pretilt angles have been studied.

2. EXPERIMENTAL

The SiO_x thin films were evaporated on indium-tin-oxide (ITO)-coated glass substrates by 45 ° oblique

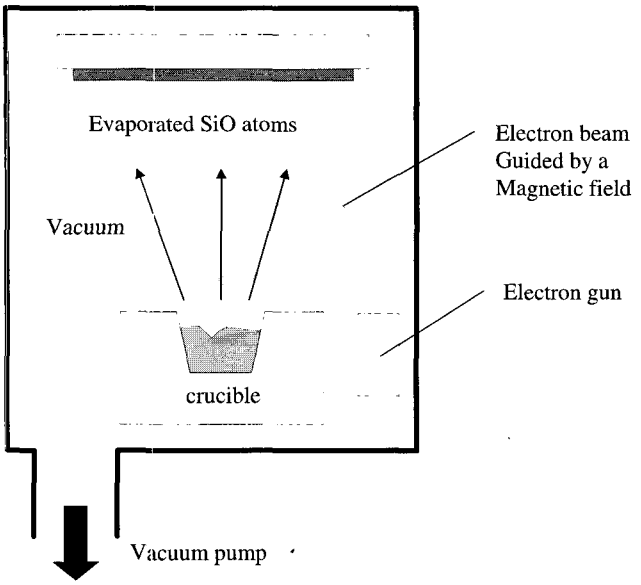


Fig. 1. 45 ° Obliqued electron beam evaporation system.

Table 1. Evaporation conditions of SiO_x thin film.

Parameter	Condition
Evaporation rate	1-2 nm/sec
temperature	30 °C

electron beam evaporation. Indium-tin-oxide (ITO) coated substrates with dimensions of 307 mm × 217 mm × 1.1 mm were used for all measurements reported here. Before being evaporated, the ITO-coated glass substrates were supersonic wave-cleaned in TCE (trichloroethylene), acetone, alcohol solutions respectively for 10 minutes, then were blowed with N_2 gas. After that they were evaporated by electron beam equipment under the condition of 30 °C.

The thickness of the SiO_x thin film layer was about 20 nm and 50 nm respectively with the evaporation speed of 1~2 nm/sec. After being evaporated, the test LC cell samples were fabricated in an anti-parallel configuration with the cell gap of 60 μm. To determine LC alignment condition, a polarized microscope was used and pretilt angles were measured by a crystal rotation method at room temperature.

3. RESULTS AND DISSCUSSION

The microphotographs of vertical aligned LC cells by 45 ° oblique evaporation with electron beam system on the SiO_x thin film surface are shown in Fig. 2. From all conditions of the microphotographs, the excellent LC alignment states without any impurities, defects generated during the evaporation process and cell assembly process are shown. From these results, we consider that the LC alignment on SiO_x thin film by 45 ° electron beam evaporation is attributed to elastic interaction between LC molecules and micro-grooves at the SiO_x thin film surface created by evaporation[10].

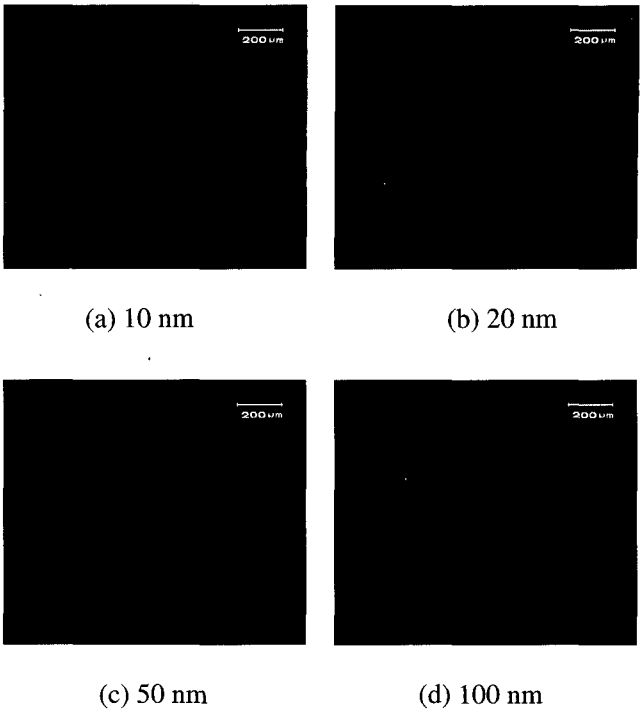
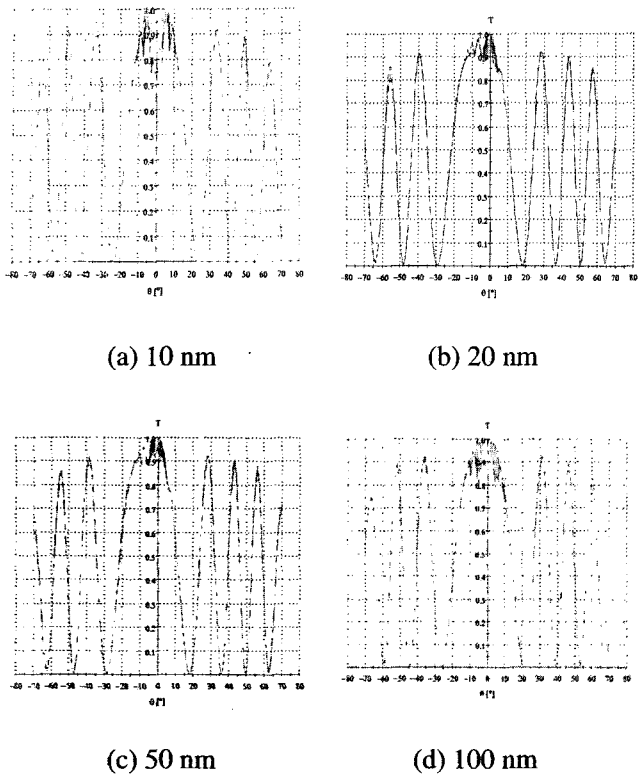


Fig. 2. Microphotographs of the aligned LC cells on the various thickness of SiO_x thin film by 45 ° oblique electron beam evaporation(in crossed Nicols).

Figure 3 shows the transmittance and incident angle for pretilt angle generation on the SiO_x thin film of 10 nm, 20 nm, 50 nm, and 100 nm thickness by 45 ° oblique electron beam evaporation. The observed pretilt angle was about 3.5 ° on the treated SiO_x thin film layers at 20 nm and 50 nm thickness. But at the thickness of 10 nm and 100 nm, the pretilt angles of 0 ° and 1.5 ° were measured.

Figure 4 shows the generation of pretilt angles of NLC on the SiO_x thin film by 45 ° oblique electron beam evaporation as a function of thin film thickness. The measurement of the pretilt angles was conducted with many cells at the equal given condition. We used an average at least more than 3 points per each sample cell, and average value is shown in Fig. 4. The average value of 10 nm thin film was 90.0079 and the standard deviation was 0.0071. In a case of 20 nm thin film, the



(a) 10 nm (b) 20 nm

(c) 50 nm (d) 100 nm

Fig. 3. The relationship between transmittance and incidence angle on SiO_x thin film.

average value of the pretilt angles was about 86.5615 ° and the standard deviation was 0.2149. And the values of 86.4959 ° and 0.0094 are shown as the average and the standard deviation respectively in a case of 50 nm thin film. Also, the average value of the pretilt angles of 100nm thick thin film was about 88.5806 ° and the standard deviation was 0.1729. With this result, it can be known that uniform pretilt angles were formed throughout the LC cells.

4. CONCLUSION

In this study, LC alignment effects and generation of pretilt angle on the SiO_x thin film with 45 ° oblique electron beam evaporation were investigated. A good vertical alignment characteristic could be achieved by vertical alignment of NLC using 45 ° oblique evaporation method with electron beam system. We consider that the LC alignment on SiO_x thin film by 45 ° electron beam evaporation is attributed to elastic interaction between LC molecules and micro-grooves at the SiO_x thin film surface created by evaporation. Also, the pretilt angle of about 3.5 ° was obtained on the SiO_x thin film of 20 nm thickness. Consequently, the vertical alignment method

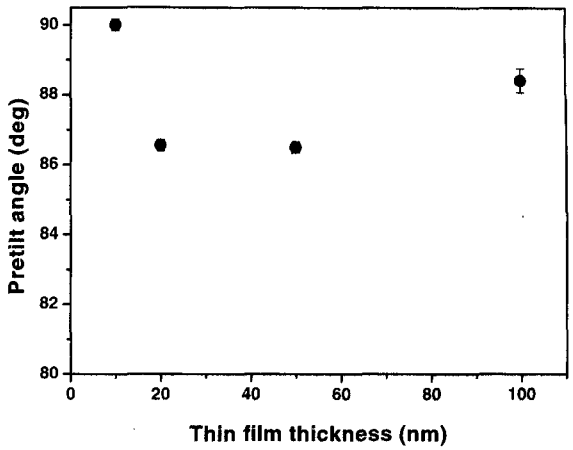


Fig. 4. Generation of pretilt angles aligned NLC on the SiO_x thin film surface by 45 ° oblique electron beam evaporation as a function of thin film thickness.

of SiO_x thin film by 45 ° oblique evaporation method with electron beam is excellent for the generation of pretilt angle.

ACKNOWLEDGMENTS

This work was supported by 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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