LC Aligning Properties for Homeotropic Alignment of NLC on the SiO_x Thin Film as Incident Angle of Electron Beam Evaporation Angle

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In this study, liquid crystal (LC) aligning properties for homeotropic alignment on the SiO_x thin film by electron beam evaporation method with electron beam system in accordance with the evaporation angles were investigated. Also, the control of pretilt angles homeotropic aligned LC on SiO_x thin film as the function of the evaporation angles were studied. The uniform vertical LC alignment on the SiO_x thin film surfaces with electron beam evaporation was achieved with all of the thin film angle conditions. It is considerated that the LC alignment on the SiO_x thin film by 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 values of the pretilt angles according to the evaporation angle were from about 0.7 ° to about 3.4 °. The highest pretilt angles of about 3.4 ° in aligned NLC on the SiO_x thin film surfaces by electron beam evaporation were measured under the condition of 45 °. Also, good LC alignment states on the treated SiO_x thin film layer by electron beam evaporation were observed at annealing temperature of 250 ℃. Consequently, the high pretilt angle and the good thermal stability of LC alignment on the SiO_x thin film by electron beam evaporation can be achieved.

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

1. INTRODUCTION

Thin film transistor (TFT) - liquid crystal displays (LCDs) are widely used as information display devices such as monitors, and LCD-TVs. The uniformity of LC alignment is very important in LCD devices. Currently, a rubbing method which rubs polyimide (PI) surface to align LC has been widely used to mass-produce wide LCD panels. LCs are aligned due to the induced anisotropy on the substrate surface[1-7].

Rubbed polymer surfaces have suitable characteristics such as uniform alignment and a high pretilt angle. However, the rubbing method has some drawbacks, such as the generation of electrostatic charges and the creation of contaminating particles from rubbing fabric and substrate[5,7-9]. Also, difficulties in applying for large glass substrate have been reported. Thus we strongly recommend a non-contact alignment technique for future generations of large, high-resolution LCD. Also, in micro-display panel, due to the changes in alignment by strong UV irradiation or some other reasons with the inorganic alignment method is required[10-13].

Currently, SiO vacuum evaporation method[14], and ion-beam alignment method[12,13] are known as inorganic alignment method. However, obliqued evaporation alignment was hard to practical application 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, even though the LC alignment mechanism is not understood completely. 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 on the SiO_x thin film surface by electron beam evaporation have not been reported yet.

The effect of vertical alignment of NLC on the SiO_x thin film as the function of evaporation angle using electron beam system, the control of pretilt angles and thermal stability have been studied.

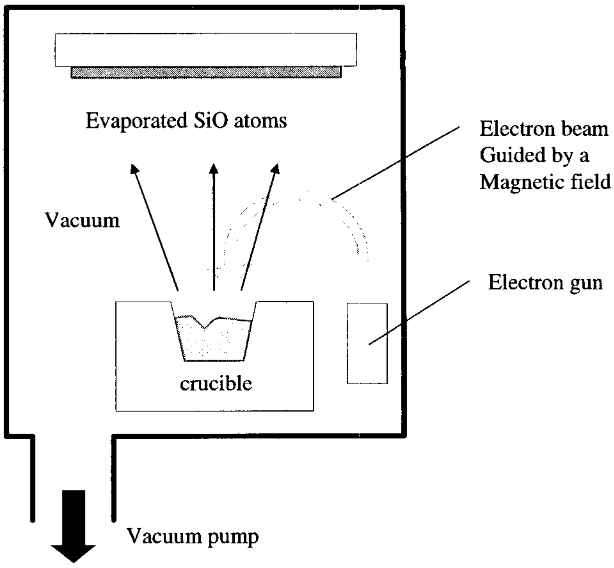


Fig. 1. Electron beam evaporation system.

2. EXPERIMENTAL

The SiO_x thin films were evaporated on indium-tin-oxide (ITO)-coated glass substrates by obliqued electron beam evaporation from 45 ° to 85 °. 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, and then were blown 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 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.

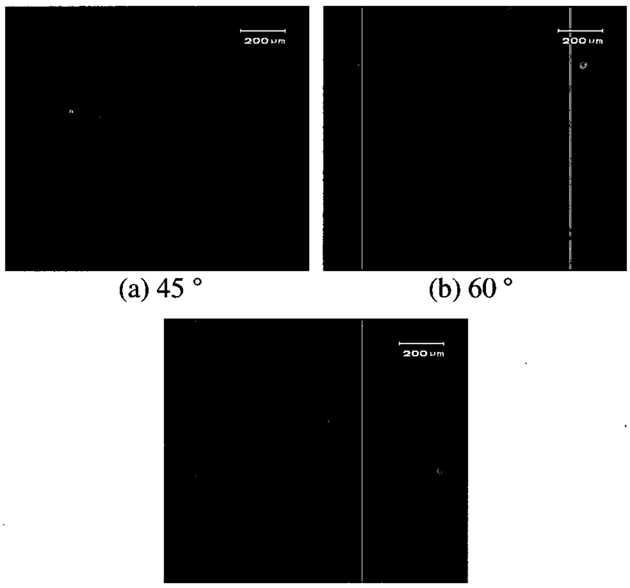
LC cell samples were heated on the hot plate for 60 minutes at 150 ℃, 200 ℃ and 250 ℃ and got cooled slowly at room temperature to verify the thermal stability.

Table 1. Evaporation conditions of SiO_x thin film.

Parameter	Condition
Evaporation rate	1-2 nm/sec
Temperature	30 °C
Thin film thickness	20 nm

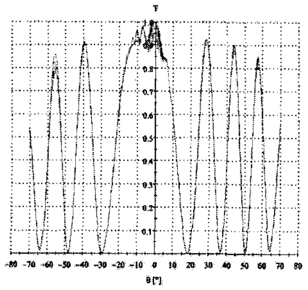
3. RESULTS AND DISSCUSSION

In Fig. 2, the microphotographs of vertical aligned LC cells by obliqued evaporation with electron beam system on the SiO_x thin film surface are shown. From the each conditions of microphotographs with the obliqued evaporation angles of 45 °, 60 °, and 85 °, the excellent LC alignment states are shown without any impurities,

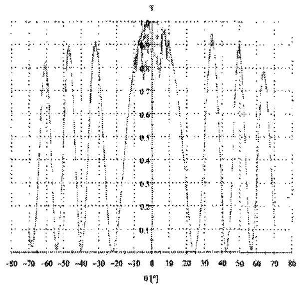


(a) 45 ° (b) 60 ° (c) 85 °

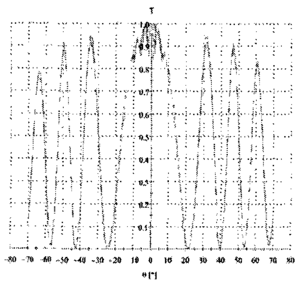
Fig. 2. Microphotographs of the aligned LC cells on the various obliqued evaporation angles of SiO_x thin film by electron beam evaporation(in crossed Nicols).



(a) 45 °



(b) 60 °



(c) 85 °

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

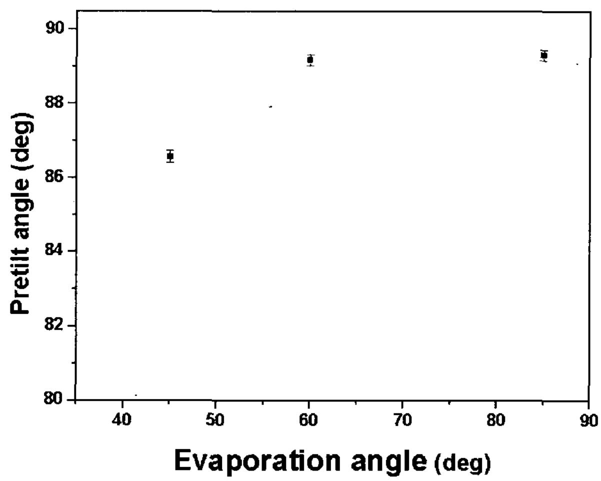
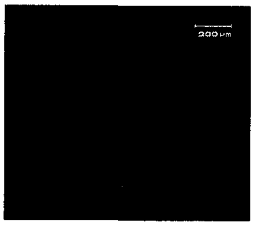
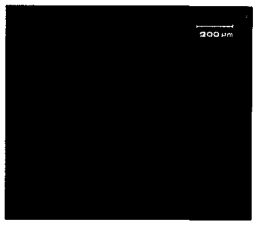


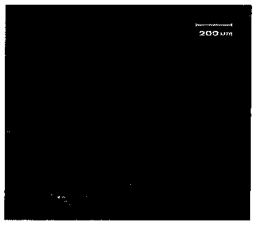
Fig. 4. Generation of pretilt angles in a NLC on the SiO_x thin film surface by obliqued electron beam evaporation as a function of evaporation angle.

defects generated during the evaporation process and cell assembly process. With these results, it is considered that the LC alignment on SiO_x thin film by 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].

Figure 3 shows the transmittance and incident angle for pretilt angle generation on the SiO_x thin film of 45 °,

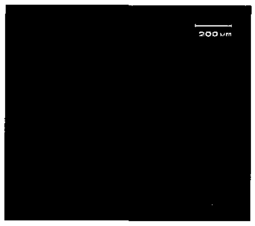
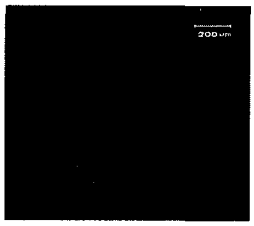



•150 ℃ •200 ℃

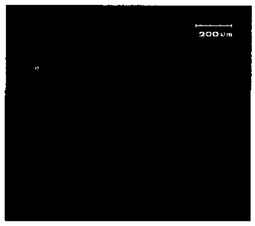


•250 ℃

(a) 45 ° obliqued evaporation

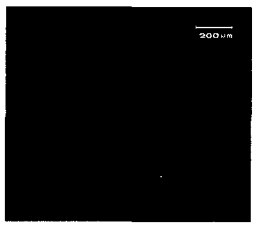
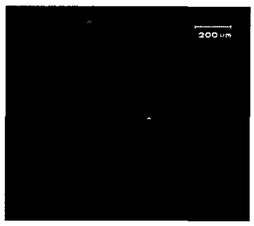



•150 ℃ •200 ℃



•250 ℃

(b) 60 ° obliqued evaporation

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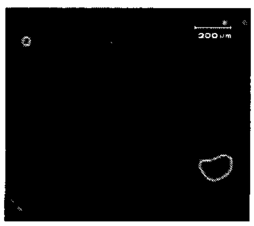

•250 ℃

(c) 85 ° obliqued evaporation

Fig. 5. Microphotographs of LC cell as a function of the baking temperature on hot plate(for 60 minutes, in crossed Nicols).

60 °, and 85 ° electron beam evaporation angle. The each error value of pretilt angles as the measurement point was insignificant. Among the some graphs with the each evaporation angle condition, the representative pretilt angle graphs were used in Fig. 3.

Figure 4 shows the generation of pretilt angles of NLC on the SiO_x thin film by electron beam evaporation as a function of evaporation angle. 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 values were used in Fig. 4. The observed average values are 86.56 °, 89.18 °, and 89.32 ° as the evaporation angle of 45 °, 60 °, and 85 ° respectively. In this result, the useful pretilt angle for vertical alignment application can be achieved with the evaporation condition of 45 °.

Figure 5 shows the thermal stability of the LC cells with the evaporation angles of 45 °, 60 °, and 85 ° respectively. The LC alignment states of each cell were maintained with the annealing temperature from 150 ℃ to 250 ℃. However, some defects begun to appear from the annealing condition of 250 ℃ of the 85 ° evaporation LC cell. The LC alignment states are maintainable to the temperature almost 250 ℃.

4. CONCLUSION

In this study, LC alignment effects, generation of pretilt angle and thermal stability of the SiO_x thin film with obliqued electron beam evaporation as the function of the evaporation angles were investigated. Good vertical alignment characteristics could be achieved by vertical alignment of NLC using 45 °, 60 °, and 85 ° obliqued evaporation method with electron beam system. We consider that the LC alignment on the SiO_x thin film 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 3.4 ° was obtained on the SiO_x thin film of 45 ° evaporation angle. Consequently, the vertical alignment method of SiO_x thin film by 45 ° obliqued evaporation method with electron beam is excellent for the generation of pretilt angle.

The LC alignment states were maintained with the annealing temperature 150 ℃, 200 ℃, and 250 ℃.

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