Alignment Effect of a Nematic Liquid Crystal on Deposited SiO_x Thin-Film Surface with e-beam Evaporation

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We have studied liquid crystal (LC) aligning capabilities for homeotropic alignment and the control of tilt angles on the SiO_x thin film by electron beam evaporation method. A high tilt angle of about 86.5 ° was obtained, and also the suitable tilt angle of the NLC on the SiO_x thin film at 20~50 nm thickness with e-beam evaporation can be achieved. The uniform LC alignment on the SiO_x thin film surfaces with electron beam evaporation can be achieved. 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.

Keywords : SiO_x thin film, Homeotropic LC alignment effect, Nematic liquid crystal, Tilt angle, Electron beam evaporation

1. INTRODUCTION

The uniformity of LC alignment is very important in LC 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[1-4]. 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]. 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 strongly required[6-9].

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[10]. 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 tilt angle. Also the tilt angle on homeotropic alignment is measured from normal direction on substrate surface.

The tilt 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 tilt angle controls of 2 ° ~ 3 ° are required to apply to display modes

In this research, we reported the LC alignment effects on the SiO_x thin film with oblique electron beam evaporation.

2. EXPERIMENTAL

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

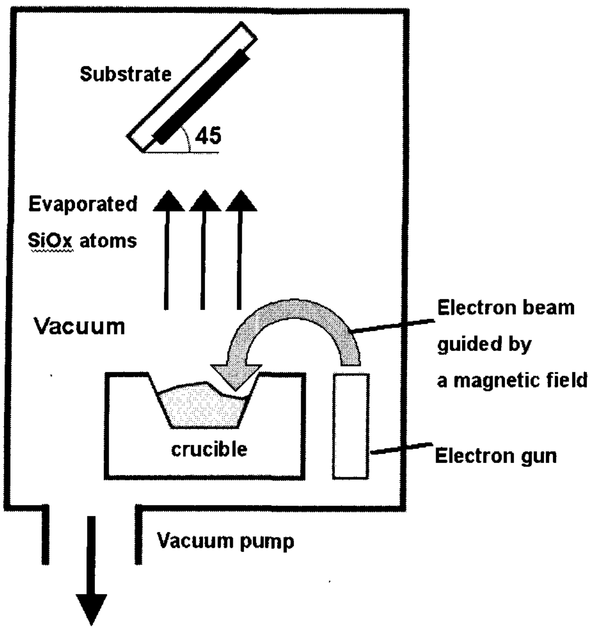


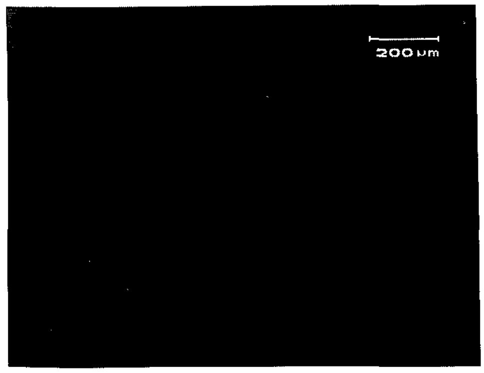
Fig. 1. Electron beam evaporation system.

As the thin film thickness, four kinds of samples were evaporated. The thicknesses of the SiO_x thin film layer were 10 nm, 20 nm, 50 nm, and 100 nm with the evaporation speed of 1~2 nm / sec. After being evaporated, two types of test samples were fabricated. One type of cells were arranged in an anti-parallel configuration, which were used for tilt angle measurements. To determine LC alignment condition, a polarized microscope was used and tilt angles were measured by a crystal rotation method at room temperature.

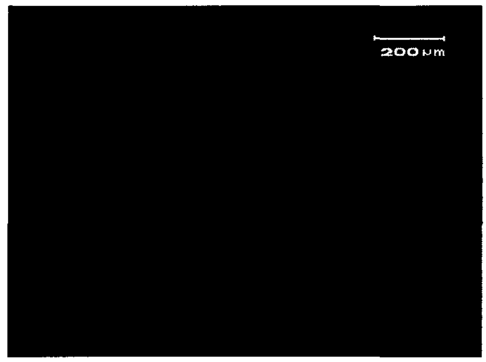
3. RESULTS AND DISCUSSION

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. 1. From all conditions of the microphotographs, the excellent LC alignment states without any impurities, defects generated during the evaporation process and cell assembly processes 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.

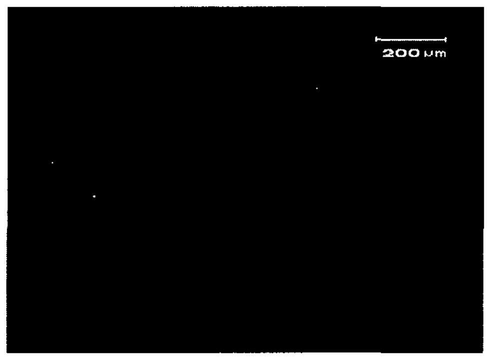
Figure 3 shows the transmittance and incident angle for tilt angle generation on the SiO_x thin film of 50 nm thickness by 45 ° obliqued electron beam evaporation. The observed tilt angle was about 86.5 ° on the treated SiO_x thin film layers at 50 nm thickness.



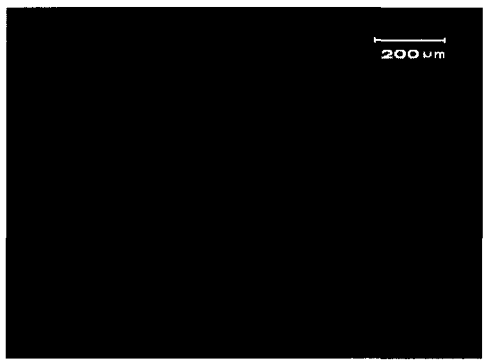
(a) 10 nm



(b) 20 nm



(c) 50 nm



(d) 100 nm

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

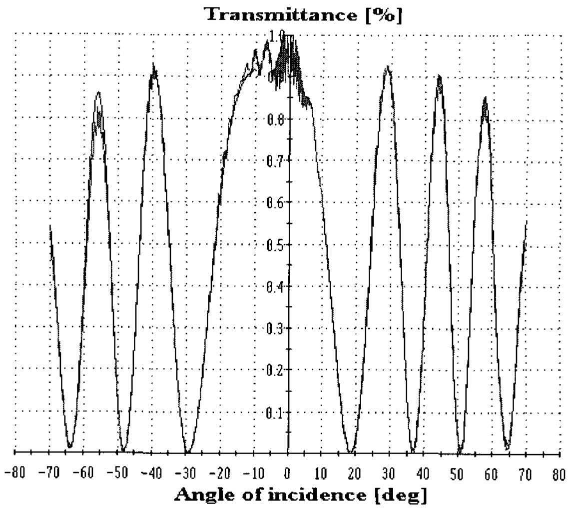


Fig. 3. The transmittance and incident angle for tilt angle generation on the SiO_x thin film surface by 45 ° obliqued electron beam evaporation at 50 nm thickness.

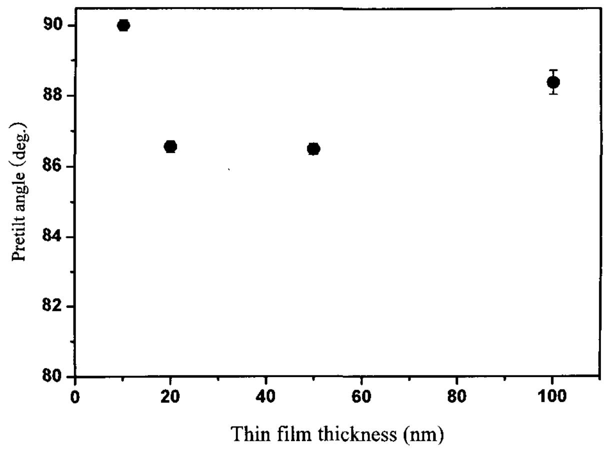


Fig. 4. Generation of tilt angles in a NLC on the SiO_x thin film surface by 45 ° obliqued electron beam evaporation as a function of thin film thickness.

Figure 4 shows the tilt angles of the NLC on the SiO_x thin film surface by 45 ° oblique electron beam evaporation as a function of thin film thickness. The observed tilt 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, low tilt angles were measured. It is considered that the suitable tilt angle of the NLC on the SiO_x thin film at 20~50 nm thickness with e-beam evaporation can be achieved.

4. CONCLUSION

In conclusion, LC alignment effects and generation of tilt angles treated on the SiO_x thin film with 45 ° oblique electron beam evaporation were studied. Good alignment characteristics could be achieved using 45 ° oblique 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.

E-beam evaporation method can be feasible for micro display manufacturing - less than the size of 10 inch. The productivity and less cost are important factors for the micro sized LCD. Without rubbing process, the productivity of the micro LCD will be increased.

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