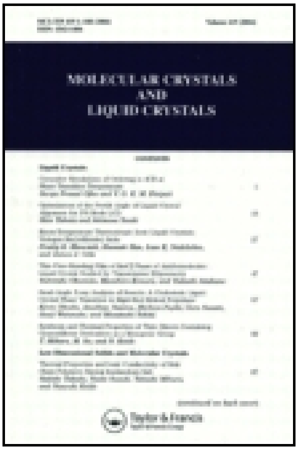

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LC Alignment Effects and EO Performances for Homeotropic Aligned NLC on the SiO_x Thin Film Layer by e-Beam Evaporation

Jong-Hwan Kim [a], Hyung-Ku Kang [a], Jin-Woo Han [a], Soo-Hee Kang [a], Young-Hwan Kim [a], Jeong-Min Han [a], Jeoung-Yeon Hwang [a], Chul-Ho Ok [a], Dae-Shik Seo [a] & Yong-Pil Park [b]

[a] Department of Electrical and Electronic Engineering, Yonsei University, Seoul, Korea

[b] Department of Electronic Engineering, Dongshin University, Naju, Jeonnam, Korea

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Jong-Hwan Kim
Hyung-Ku Kang
Jin-Woo Han
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Jeong-Min Han
Jeoung-Yeon Hwang
Chul-Ho Ok
Dae-Shik Seo
Department of Electrical and Electronic Engineering, Yonsei University, Seoul, Korea

Yong-Pil Park
Department of Electronic Engineering, Dongshin University, Naju, Jeonnam, Korea

In this study, liquid crystal (LC) alignment effects for homeotropic alignment on the SiO_x thin film by electron beam evaporation method with electron beam system and electro-optical (EO) performances of homeotropic aligned liquid crystal display (LCD) were studied. Also, the control of pretilt angles of homeotropic aligned LC on SiO_x thin film as a function of thin film thickness were investigated. The uniform vertical LC alignment on the SiO_x thin film surfaces with electron beam evaporation was achieved in any of the thin film thickness conditions. It is considered that the LC alignment on the SiO_x thin film by electron beam evaporation is attributed to the elastic interaction between LC molecules and micro-grooves at the SiO_x thin film surface created by evaporation. In addition, LC cell of the SiO_x thin film by electron beam evaporation had good EO property.

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Address correspondence to D.-S. Seo, Department of Electrical and Electronic Engineering, Yonsei University, Shinchon-dong, Seodaemoon-gu, Seoul 120-749, Korea (ROK). E-mail: dsseo@yonsei.ac.kr

Keywords: alignment; electron beam (e-beam); evaporation; electro-optical performances; pretilt angle; response time; thermal stability

INTRODUCTION

Aligned liquid crystals (LCs) are widely used in flat panel display (FPD) technology. They are aligned by inducing anisotropy on the surface of a substrate. This surface is usually a polymer such as polyimide, coated on a glass substrate [1–6]. Rubbed polyimide surfaces have suitable characteristics such as uniform alignment and a high pretilt angle. However, the rubbing method has some drawbacks [7]. These include the debris left by the cloth during the rubbing process in an otherwise clean room environment; concern with electrostatic discharging and its influence on the electronic circuitry below the thin polyimide film. Thus a non-contact alignment technique would be highly desirable for future generations of large, high-resolution LCDs.

A number of alternative alignment techniques have been reported, but none of these have so far been implemented in large-scale manufacturing [8–11]. Most recently, the LC aligning capabilities achieved by ion beam (IB) exposure on the diamond-like carbon (DLC) thin film layer and SiO vacuum evaporation method have been successfully studied [12–14].

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 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 $2^\circ \sim 3^\circ$ 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.

In this research, we studied LC alignment effects and the electro-optical (EO) performances with obliqued electron beam evaporation on the SiO_x thin film.

EXPERIMENTAL

The SiO_x thin films were evaporated on indium-tin-oxide (ITO)-coated glass substrates by 45° obliqued electron beam evaporation as shown in Fig. 1. ITO-coated substrates with dimensions of $307\,mm \times 217\,mm \times 1.1\,mm$ 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 at 30°C.

To determine the characteristic according to film thickness, the thicknesses of the SiO_x thin film layer were 10 nm, 20 nm, 50 nm, and 100 nm, respectively, with the evaporation speed of $1\sim2$ nm/sec. After being evaporated, two types of test samples were fabricated.

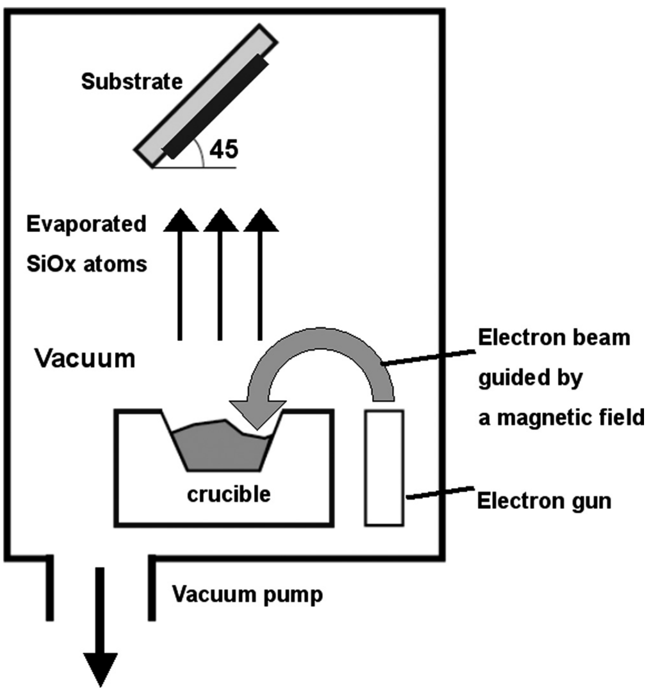

FIGURE 1 Electron beam evaporation system.

One was arranged in an anti-parallel configuration, which was used for pretilt angle measurements. And the other was VA-LCD cell which was used for Electro-Optical measurement. To determine LC alignment condition, a polarized microscope was used, and pretilt angles were measured by a crystal rotation method at room temperature. In addition, Voltage-Transmittance and response time characteristics of NLC were measured by LCD EOMS (Electro-Optical Measurement, from Sesim Photonics Technology) equipment.

RESULTS AND DISCUSSION

The polarized microphotographs of vertically aligned LC cells by 45° obliqued evaporation with electron beam system on the SiO_x thin film surface are shown in Figure 2. From all conditions of the microphotographs, the excellent LC alignment was achieved without any impurities, and defects during the evaporation process. There was no change

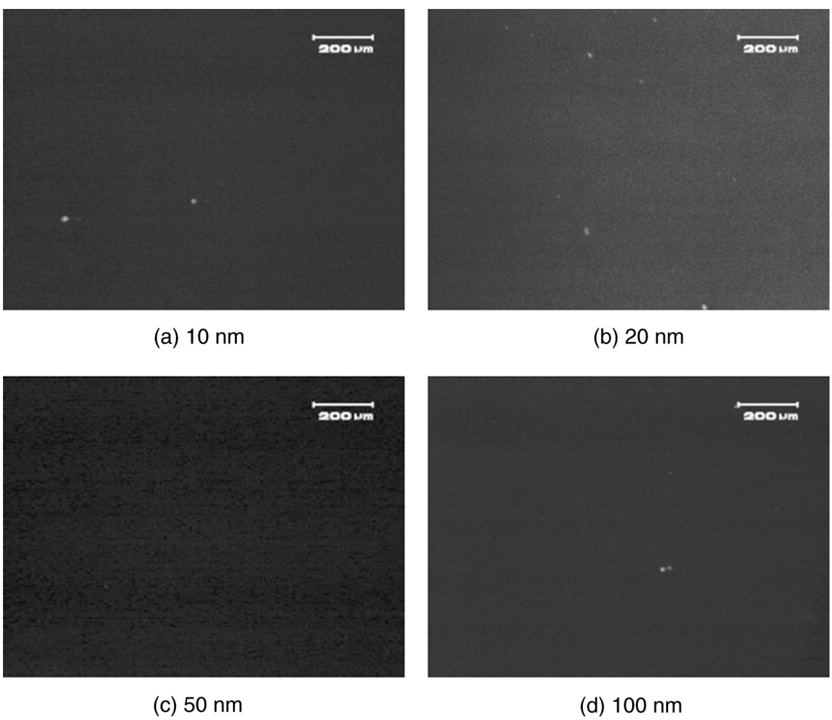

FIGURE 2 Microphotographs of the aligned LC cells on the various thickness of SiO_x thin film by 45° obliqued electron beam evaporation (in crossed Nicols).

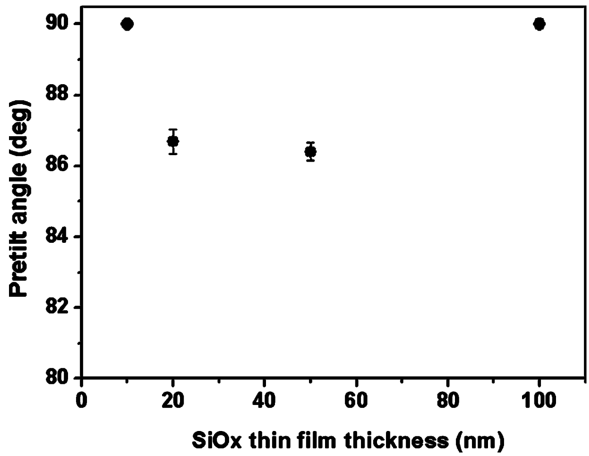

FIGURE 3 Generation of pretilt angles in a NLC on the SiO_x thin film surface by 45° obliqued electron beam evaporation as a function of thin film thickness.

of alignment characteristic in connection with various film thickness. 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 [8].

Figure 3 shows the pretilt angles of the NLC on the SiO_x thin film surface by 45° obliqued electron beam evaporation as a function of thin film thickness. 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, lower pretilt angles were measured. It is considered that the suitable pretilt angle of the NLC on the SiO_x thin film can be achieved at $20 \sim 50$ nm thickness with e-beam evaporation.

Figure 4 shows the transmission of light as a function of applied voltage for the VA-LCD treated on the SiO_x thin film with 45° obliqued e-beam evaporation. It is shown that the good states of V-T curve on the SiO_x thin film surface with e-beam evaporation.

Figure 5 shows the response time characteristics of the VA-LCD treated on the SiO_x thin films with 45° obliqued e-beam evaporation. The response time was optically measured to be about 28.7 ms.

CONCLUSIONS

In conclusion, LC alignment effects and generation of pretilt angles treated on the SiO_x thin film with 45° obliqued electron beam

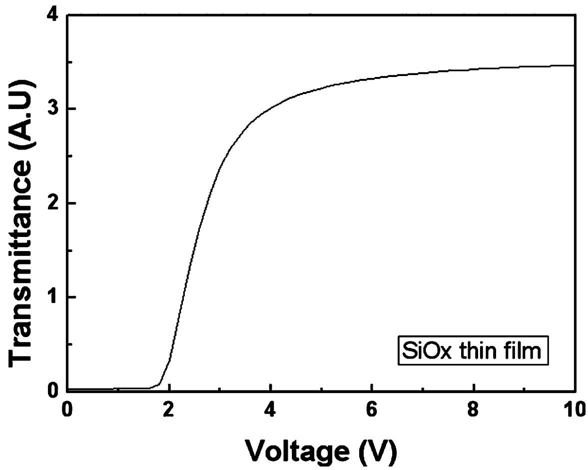

FIGURE 4 Voltage-Transmittance curve for the VA-LCD treated on the SiO_x thin films with 45° oblique e-beam evaporation.

evaporation were studied. Good alignment characteristics could be achieved using 45° 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,

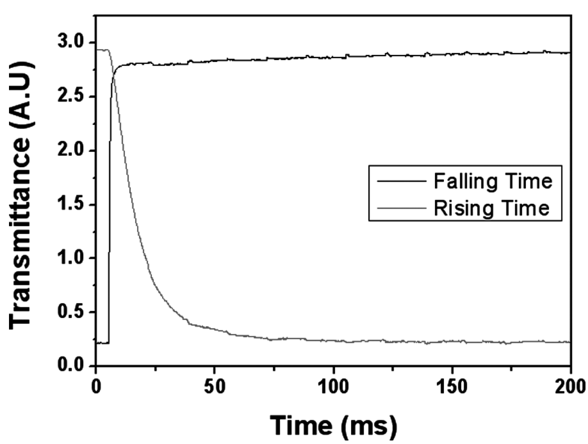

FIGURE 5 Response time characteristics of the VA-LCD treated on the SiO_x thin films 45° obliqued e-beam evaporation.

Good VT and response time performances for the VA-LCD on the SiO_x thin film surface with e-beam evaporation were achieved.

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