Vertical Alignment of Nematic Liquid Crystal on the SiC Thin Film Layer with Ion-beam Irradiation

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(Received October 27 2006, Accepted November 28 2006)

We studied the nematic liquid crystal (NLC) aligning capabilities using the new alignment material of the SiC (Silicon Carbide) thin film. The SiC thin film exhibits good chemical and thermal stability. The good thermal and chemical stability make SiC an attractive candidate for electronic applications. A vertical alignment of nematic liquid crystal by atomic beam exposure on the SiC thin film surface was achieved. The about 87 ° of stable pretilt angle was achieved at the range from 30 ° to 45 ° of incident angle. Consequently, the vertical alignment effect of liquid crystal electro-optical characteristic by the atomic beam alignment method on the SiC thin film layer can be achieved.

Keywords : Silicon carbide (SiC), Homeotropic LC alignment effect, Nematic liquid crystal (NLC), Tilt angle, Atomic ion beam

1. INTRODUCTION

Thin film transistor (TFT) - liquid crystal displays (LCDs) are widely used as information display devices such as monitors in notebooks, desktops, and LCD-TVs. A rubbing method has been widely used to align liquid crystal (LC) molecules on the polyimide (PI) surface. LCs are aligned due to the induced anisotropy on the substrate surface[1-6]. Rubbed polyimide surfaces have suitable characteristics such as uniform alignment and a high tilt angle. However, the rubbing method has some drawbacks, such as the generation of electrostatic charges and the creation of contaminating particles. Thus we strongly recommend a non-contact alignment technique for future generations of large, high-resolution LCD[7-8].

Most recently, the LC aligning capabilities achieved by atomic beam exposure on the diamond-like carbon (DLC) thin film layer have been successfully studied[9-11]. The structure of SiC is very similar to a diamond, which explains its great degree of hardness. The majority of the bonds in SiC are covalent. Its many advantages, with its ability to withstand high temperatures being the most prominent, are making silicon carbide a choice for new applications and an improved substitute for traditional electronic materials. Also, chemical stability is good. An interesting electronic application of SiC - beyond semiconductor - is in colored screen displays. In case of utilization SiC thin film as LC alignment layer, it will cut down production expenses because it doesn't need separate processing equipments as using the existing TFT insulator material manufacturing equipments. In addition, better thermal stability under high temperature situation will be achieved in comparison of existing LC alignment layer.

In this article, we studied the vertical alignment effect of nematic liquid crystal and generation of pretilt angle using the atomic beam alignment method on the SiC thin films surface. The atomic beam method on the SiC thin films is expected to apply suitable for the use of multi-domain VA.

2. EXPERIMENTAL

The SiC thin films were deposited on indium-tin-oxide (ITO)-coated glass substrates by plasma enhanced chemical vapor deposition (PECVD). The glass substrates were pre-sputtered for 10min using the Ar plasma in the chamber. The SiC thin film was deposited using C_2H_2 : He : SiH_4 gas for 20s at 300°C. The flow amount of C_2H_2 was varied from 30 sccm to 60 sccm. However the quantities of He and SiH_4 were fixed as 600 sccm and 60 sccm each.

The thickness of the SiC thin film layer was about 15 nm. The atomic beam (Kaufman type) exposure system

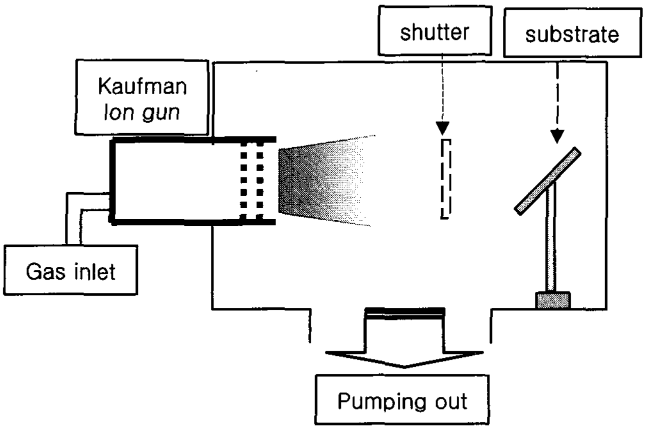


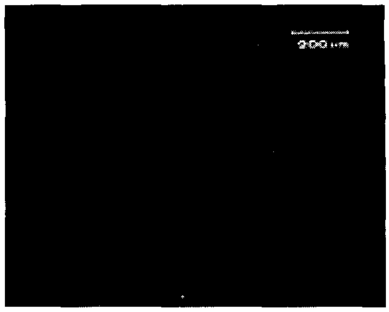
Fig. 1. The Atomic Beam (Kaufman type) exposure system.

is shown in Fig.1. The atomic beam energy used was 200 eV. The gap of the atomic beam aligned LC cell was 60 μm. The LC cell was filled with a nematic liquid crystal (NLC) ($\triangle\varepsilon$= -4.1, from Merck Co.). To determine LC alignment condition, a polarization microscope was used and pretilt angle was measured crystal rotation method at room temperature.

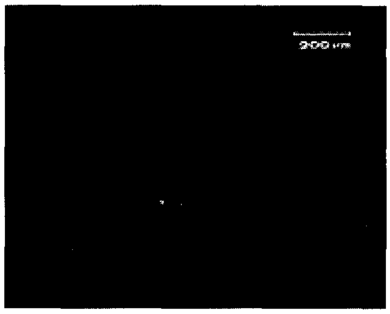
3. RESULTS AND DISCUSSION

Figure 2 shows the microphotographs of LC cell deposited for 20s according to the portions of $C_2H_2/He/SiH_4$ gas atomic beam irradiation to 1 min on the SiC thin films surface. Figure 2(a) shows the microphotograph of LC cell when the portions of $C_2H_2/He/SiH_4$ gas is 30/600/60 deposited for 20s at the PECVD and atomic beam irradiation to 1 min on SiC thin films surface. Figure 2(d) shows the microphotograph of LC cell deposited for 20s when the portions of C_2H_2 / He / SiH_4 gas is 60 / 600 / 60 at the PECVD and atomic beam irradiation to 1 min. Also, according to increasing the above of more or less quantity of carbon, alignment state of LC cell was degraded. As shown in Fig. 2, the excellent LC alignment of the SiC thin film and generation of stable tilt angle when the quantity of C_2H_2, He and SiH_4 gas is 30 sccm, 600 sccm and 60 sccm each at the PECVD among the four conditions for forming the SiC thin film was achieved.

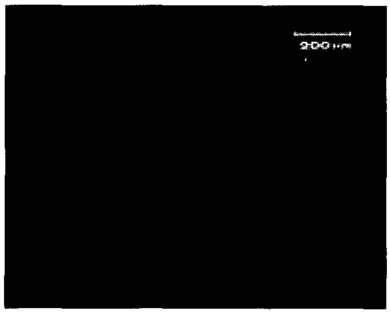
The tilt angle decreased with increasing atomic beam exposure time. This is shown in Fig. 3 for samples exposed to 200 eV atomic beams and for a 30° angle of incidence. The maximum value of tilt angle was achieved at 30s of irradiation time about 87°. As shown in Fig.3, the tilt angle gradually decreases with increasing irradiation time of atomic beam. Therefore, vertical alignment of NLC and the control of ilt angle were also achieved by atomic beam irradiation on the SiC thin film surface.



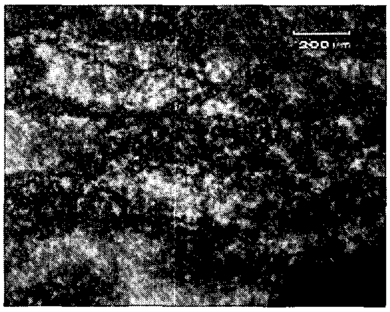
(a) $C_2H_2/He/SiH_4$ = 30/600/60



(b) $C_2H_2/He/SiH_4$ = 40/600/60



(c) $C_2H_2/He/SiH_4$ = 50/600/60



(d) $C_2H_2/He/SiH_4$ = 60/600/60

Fig. 2. Microphotographs of atomic beam aligned LC cell on the four kinds of the SiC thin film(in crossed Nicols).

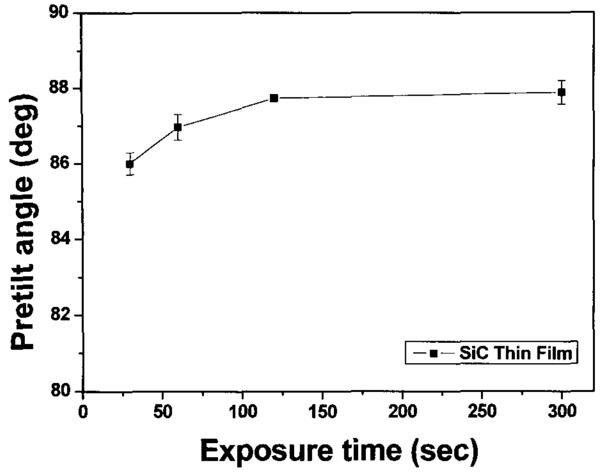


Fig. 3. The tilt angle variation of the LC as a function of the time of exposure of the atomic beam.

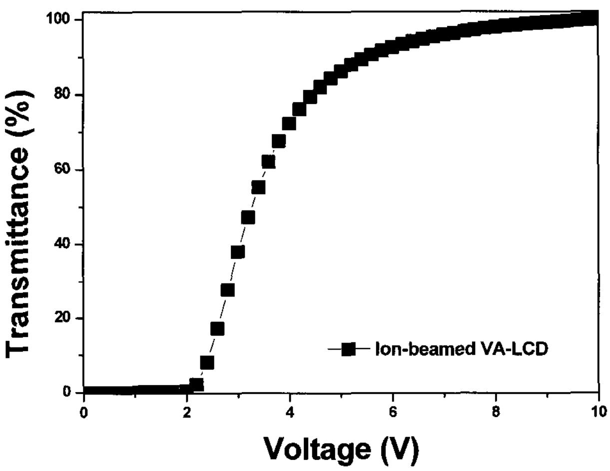


Fig. 4. Voltage-Transmittance curve of the VA-LCD treated on the SiC thin films with ion-beam irradiation.

Using the SiC thin films, VA cell was made. Figure 4 shows that the voltage-transmittance curve for SiC LC cell. An good voltage-transmittance curve can be achieved in the ion beam aligned VA-LCD on the SiC thin film. The threshold voltage was about 2.5 V. As the LC cell was designed for the Normaly Black mode (NB mode), light transmittance increased as the voltage increased. There was no bounce and no decrease of transmittance of light through the VA cell.

Figure 5 shows that the response time characteristics of the VA-LCD. The rising time was 10.3 ms and decay time was 19.2 ms. However, the rising curve was not stable.

4. CONCLUSION

In this paper, we studied about LC alignment effect and control of tilt angle using the atomic beam alignment

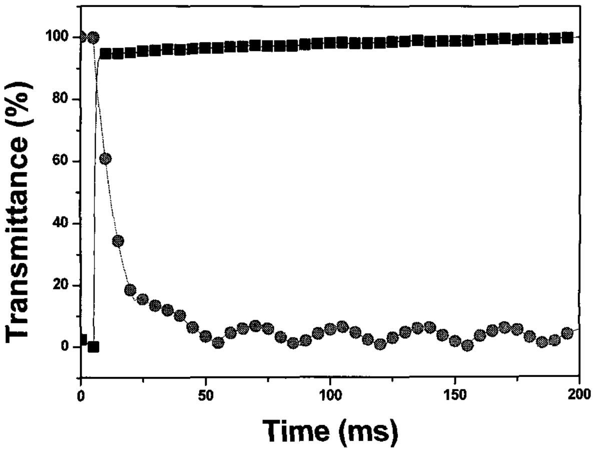


Fig. 5. Response time characteristics of the VA-LCD treated on the SiC thin films with ion-beam irradiation.

method in new alignment layer the SiC thin film. We achieved a good alignment characteristic using the atomic beam alignment method on the SiC thin film when the quantity of C_2H_2, He and SiH_4 gas is 30 sccm, 600 sccm and 60 sccm each at the PECVD. Especially, we achieved the high tilt of about 87 ° when atomic beam conditions were irradiation time of 1min and incident angle of range from 30 ° to 45 °. Therefore, atomic beam alignment method using the SiC thin film was achieved the vertical alignment of NLC, the control of stable tilt angle of manufactured LC cell. The electro-optical characteristic of VA-LCD was good. As a result, proposed atomic beam method using the SiC thin film is effectively expected of use VA-LCD mode.

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