Liquid Crystal Alignment on the SiC Thin Film by the Ion Beam Exposure Method

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Abstract

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 makes SiC an attractive candidate for electronic applications. A vertical alignment of nematic liquid crystal by ion 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. The good LC alignment is main-tained by the ion beam alignment method on the SiC thin film surface at high annealing temperatures up to 300.

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[1-4]. Rubbed polyimide 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[4]. Thus we strongly recommend a non-contact alignment technique for future generations of large, high-resolution LCD.

Most recently, the LC aligning capabilities achieved by ion beam exposure on the diamond-like carbon (DLC) thin film layer have been successfully studied by P. Chauhari et al[5]. The structure of SiC is very similar to that 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 [6]. Also, chemical stability is good. An interesting electronic application of SiC - beyond semiconductor - is in colored screen displays[6]. In case of utilizing SiC thin film as a 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. However, The specific reports about the mecha-nism of LC alignment using the DLC, NDLC and SiC thin film have not existed yet.

In this paper, we studied the vertical alignment effect of nematic liquid crystal and generation of pretilt angle using the ion beam alignment method on the SiC thin films surface. The ion beam method on the SiC thin films is expected to apply suitable for the use of multi-domain Vertical Alignment (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 sub-strates 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 rates for C_2H_2 was varied from 30 sccm to 60 sccm. However the rates for 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 ion beam (Kaufman type) exposure system is shown in Fig.1. The ion beam energy used was 200 eV. The gap of the ion beam aligned LC cell was 60 µm. The LC cell was filled with a nematic liquid crystal (NLC) (△e = -4.1, from Merck Co.). To determine LC alignment condition, a polarization microscope was used and the pretilt angle was measured by the crystal rotation method at a room temperature.

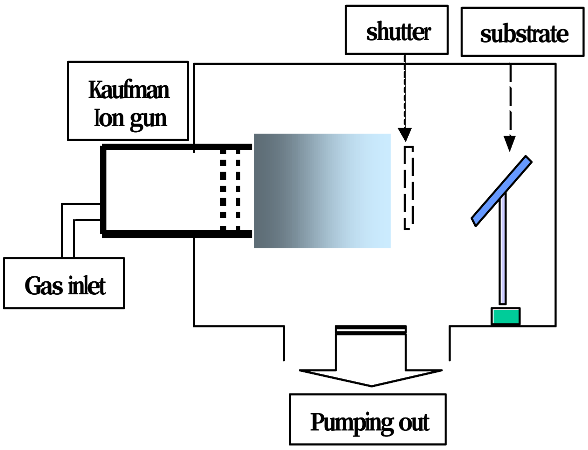
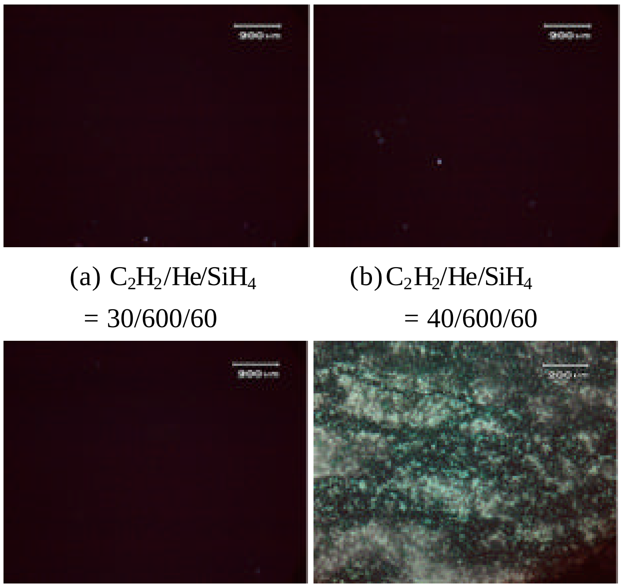


Figure 1. The ion beam (Kaufman type) exposure system.

3. Results and Disscussion

Figure 2 shows the microphotographs of LC cells deposited for 20 sec according to the portions of C_2H_2/He/SiH_4 gases and ion beam irradiation for 1 min on the SiC thin films surface. Figure 2(a) shows the microphotograph of a LC cell deposited for 20 sec when the portions of C_2H_2/He/SiH_4 gas are 30/600/60 at the PECVD and ion beam irradiation to 1 min on SiC thin films surface. Figure 2(d) shows the microphotograph of a LC cell deposited for 20 sec when the portions of C_2H_2/He/SiH_4 gas are 60/600/60 at the PECVD and ion beam irradiation to 1 min. By a small increase of carbon content, alignment state of LC cells were degraded. As shown in Fig. 2, the excellent LC alignment and the generation of stable pretilt angle were obtained in the condition of C_2H_2/He/SiH_4=30/600/60 each at the PECVD among the four conditions for forming the SiC thin film was achieved.



(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 ion beam aligned LC cell on the four kinds of the SiC thin film (in crossed Nicols).

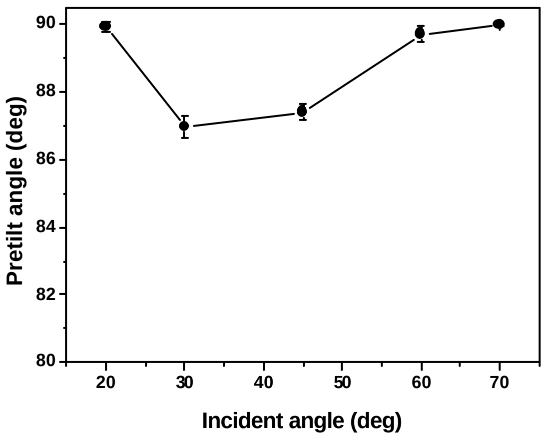
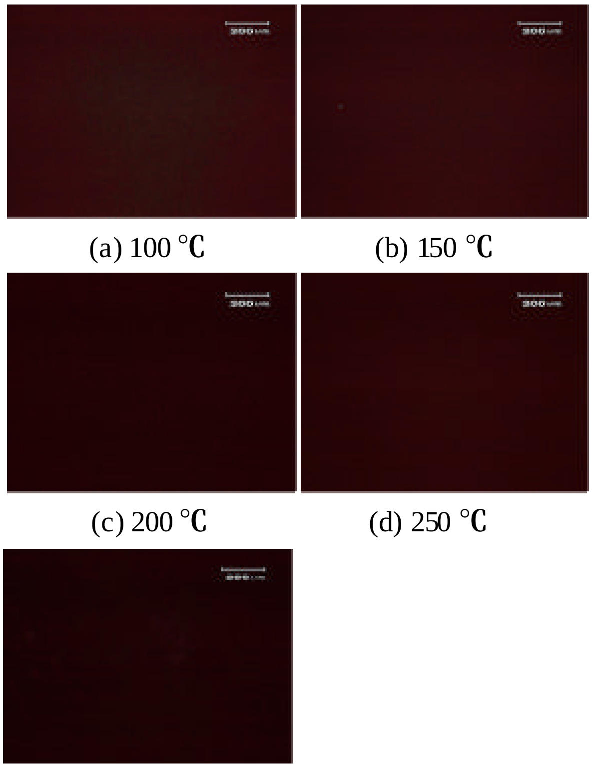


Fig. 3. Generation of pretilt angles in NLC with IB exposure on the SiC thin film surfaces for 1 min as a function of incident angle

Figure 3 shows the LC pretilt angle variation with the incident angle of ion beam on the SiC thin film which is deposited as the condition of C_2H_2/He/SiH_4 =30/600/60 deposited for 20s at the PECVD and ion beam irradiation to 1 min on SiC thin films surface. The LC pretilt angle has the stable pretilt angle value at range from 30 ° to 45 ° about 87 °, and the pretilt angle gradually decreases with increasing the incident angle of ion beam. As a result, vertical alignment of NLC and the control of pretilt angle were achieved by the ion beam irradiation method on the manufactured SiC thin film surface.



(a) 100 ℃ (b) 150 ℃

(c) 200 ℃ (d) 250 ℃

(e) 300 ℃

Fig. 4. Microphotographs of ion beam aligned LC cell on the SiC thin film for 10 min as a function of annealing temperature(in cross Nicols).

Figure 4 shows alignment microphotograph of LC cell which was cool gradually after annealing for 10 min at 100 ℃, 150 ℃, 200 ℃, 250 ℃, and 300 ℃ on the SiC thin film which is deposited for 20sec when the portions of C_2H_2/He/ SiH_4 gas is 30/600/60 deposited at the PECVD and ion beam irradiation to 1 min. As shown in Fig. 4, a good LC alignment was obtained when the annealing temperature was from 100 ℃ up to 300 ℃. Namely, the ion beam method using the SiC thin film achieved good thermal stability up to 300 ℃.

4. Conclusion

In this paper, we studied about LC alignment effect and the controllability of pretilt angle in a new alignment layer of the SiC thin film by the ion beam alignment method. We achieved a good alignment characteristic using the ion 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 pretilt of about 87 ° when ion beam irradiation was performed for 1 min with a range of incident ion beam angle from 30 ° to 45 °. Also, the aligned structure of LC on the SiC thin film by the ion beam alignment method was stably maintained up to 300 ℃. Therefore, with the vertical aligned SiC thin film by the ion beam alignment method it is possible to achieve the controllability of stable pretilt angle and good thermal stability of manufactured LC cell. As a result, the proposed ion beam method using the SiC thin film is effectively expected of use for multi-domain VA.

5. Acknowledgements

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