Liquid Crystal Alignment Effect on the Inorganic Thin Film by Sputtering and using Ultraviolet Exposure Mothod

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Abstract

We studied the nematic liquid crystal (NLC) alignment capability by the Ultraviolet (UV) alignment method on a a-C:H thin-film , and investigated electro-optical performances of the UV aligned twisted nematic (TN)- liquid crystal display (LCD) with the UV exposure on a-C:H thin film surface. A good LC alignment by UV irradiation on a a-C:H thin-film surface was achieved. Monodomain alignment of the UV aligned TN-LCD can be observed. The good electro-optical (EO) characteristics of the UV aligned TN-LCD was observed with oblique UV exposure on the a-C:H thin film surface for 1min.

1. Introduction

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 [1-3]. 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 [4,5]. 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 (IB) exposure on the diamond-like carbon (DLC) thin film layer have been successfully studied by P. Chauhari et al [6]. They deposited DLC thin films using plasma enhanced chemical vapor deposition (PECVD) method and the surface of the deposited thin films was irradiated by Ar ion beam. Also, our research group already studied IB alignment method using DLC thin film [7].

In this article, we report on LC alignment and pretilt angle generation with UV exposure on the surface of a-C:H thin-film deposited by rf magnetron sputtering, and EO characteristics of the ion beam aligned TN-LCD with oblique *Ultraviolet* (UV) exposure on the a-C:H surface.

2. Experiment and Results

The a-C:H thin films were deposited on indium-tin-oxide (ITO)-coated glass substrates by rf magnetron sputtering using a 5N-purity C target. The base pressure was under ~10^{-6} Torr and the working pressure was maintained to be 5×10^{-3} Torr with Ar ambient. The a-C:H thin films were deposited by varying the sputtering power from 150W to 200W at room temperature. The thickness of the a-C:H thin film layer was about 20nm.

The UV exposure (Oriel Co.) system is shown in Fig. 1. The UV source was a 1kW mercury lamp. The UV energy density used was 80 mW/cm^2. The gap of the UV-aligned LC cell was 60 µm, and the cell thickness of the Photoaligned TN-LCD was about 5 µm. The LC cell was filled with a nematic liquid crystal (NLC) (T_c = 72°C , $\triangle\epsilon$=8.2, from Merck Co.). To determine LC alignment condition, a polarization microscope was used and pretilt angle was measured crystal rotation method at room temperature. Voltage-Transmittance (V-T) and response time characteristics of the UV aligned TN-LCD were measured by a LCD-700 (LCD Evaluation System, from Otsuka

Electronics Co.) equipment.

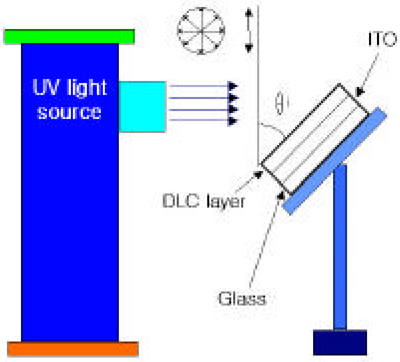
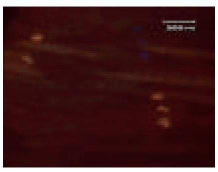
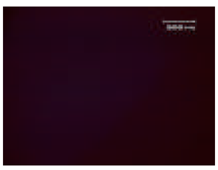


Fig. 1. UV exposure system used.

Figure 2 shows the microphotographs of LC cell under UV irradiation to 1 minute on the a-C:H thin films surface of the a-C:H thin films. Figure 2 (a) shows the microphotograph of LC cell under UV irradiation to 1 minute on the a-C:H thin films surface of the a-C:H thin films with an rf power of 160W. Figure 2 (d) shows the microphotograph of LC cell under UV irradiation to 1 minute on the a-C:H thin films surface of the a-C:H thin films with an rf power of 200W. As shown in Fig. 2, the excellent LC alignment of the a-C:H thin film by sputtering when RF power is 175W and 200W among the four conditions for forming the a-C:H thin film was achieved. However, the alignment defect of the NLC was observed under 150W, and 160W. Therefore, NLC alignment capabilities show increase with increasing RF power.

(a) 150W/8min (b) 160W/8min

(C) 175W/8min (b) 200W/8min

Fig. 2. Microphotographs of UV aligned LC cell on the four kinds of the a-C:H thin film deposited by sputtering (in crossed Nicols).

The LC pretilt angle observed with nonpolarized UV exposure on the a-C:H thin film as a function of incident angle are shown in Fig. 3 It is shown that the LC pretilt angle generated was below 1° in the all-incident angle on the a-C:H thin film.

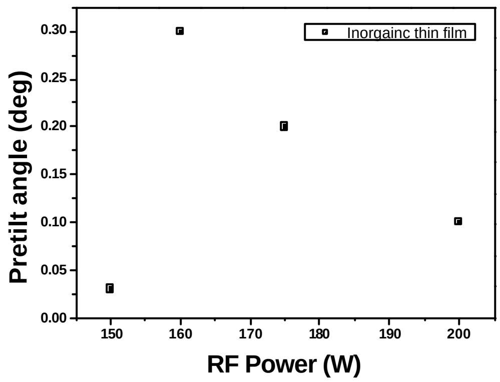


Fig. 3. Generation of pretilt angles in NLC with UV exposure on a-C:H thin film surfaces for 1 min as a function of RF power.

Figure 4 shows a good transmission of light as a function of applied voltage across twisted nematic liquid crystal cells made of a-C:H thin films, as alignment layers. A stable V-T curve of UV aligned TN-LCD on the a-C:H thin film was measured. Furthermore, few backflow bounce effect on UV aligned TN-LCD was observed though the cell used NLC without a chiral dopant.

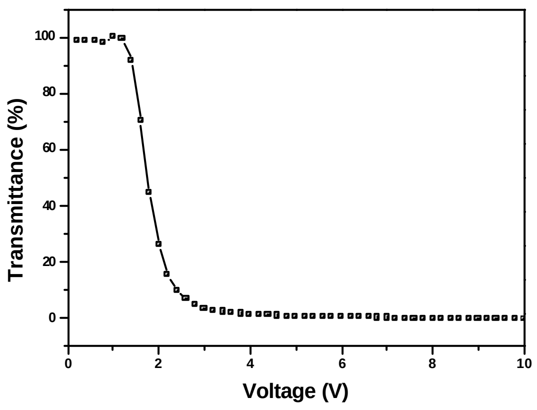


Fig. 4 Voltage-transmittance characteristics of the UV aligned TN-LCDs on a-C:H thin films deposited by sputtering.

Figure 5 shows the response time characteristics of the UV aligned twisted nematic liquid crystal cells made of a-C:H thin films, as alignment layers. A stable curve for UV aligned TN-LCD on the a-C:H thin films is shown. Few backflow bounce effect on UV-aligned TN-LCD was observed. Through this phenomenon, we could know that the UV aligned TN-LCD is very stable cell.

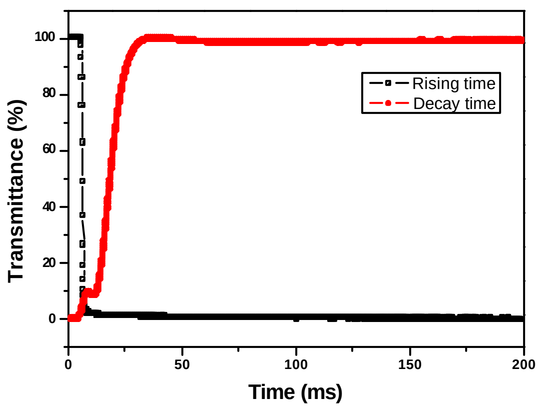


Fig. 5 Response time (RT) characteristics of the UV aligned TN-LCDs on a-C:H thin films deposited by sputtering.

Image sticking was also very important factor for the functioning of displays. This arises from residual charges that accumulate in a local region as the voltage is left on. When the voltage is removed, the image survives and gradually fades away with time as the charge is dissipated. We show in Fig. 6 the Capacitance-Voltage characteristics of the UV-aligned twisted nematic liquid crystal cells made of a-C:H thin films, as alignment layers. The residual charge characteristic of UV-aligned TN cell was very small. We evaluated the residual DC voltage characteristics using capacitance-voltage characteristics. That method is the same as used by Nissan chemical. Nissan chemical, alignment layer manufacturing company of Japan, uses capacitance-voltage characteristics as evaluation method. That method measures residual DC voltage by changing DC bias voltage which was measured electrical capacity of liquid crystal panel from the gap of C-V hysterisis curve. As a result, a good characteristic was achieved on a-C:H thin films using UV exposure method, as a new alignment layer and alignment method..

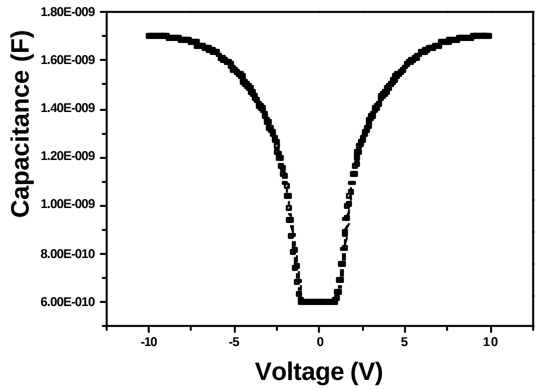


Fig. 6. The Capacitance-Voltage characteristics of the UV-aligned twisted nematic liquid crystal cells made of a-C:H thin films, as alignment layers.

4. Conclusion

In conclusion, we studied about LC alignment effect and the controllability of pretilt angle in a new alignment layer of the a-C:H thin film deposited by rf magnetron sputtering, and investigated electro-optical performances of the UV aligned twisted nematic (TN)- liquid crystal display (LCD) with the UV exposure on a-C:H thin film surface. We achieved a good alignment characteristic using UV alignment method on the a-C:H thin film when RF power is 175W and 200W each at the sputtering. Finally, the EO characteristics of the UV aligned TN-LCD using UV alignment method on the a-C:H thin film for 1 min are almost the same as that of the rubbing aligned TN-LCD on the PI surface. Finally, the residual DC voltage of the UV-aligned TN-LCD with UV exposure to 1 min on the a-C:H thin film surfaces was good.

5. Acknowledgements

This work was supported by NGE (Next Growth Engine) project.

6. References

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