Effect of liquid crystal alignment with ion beam irradiation on inorganic layer

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1. Introduction

In liquid crystal alignment field, the rubbing method has some drawbacks, such as the generation of electrostatic charges and the creation of contaminating particles. Thus, rubbing-free methods for LC alignment are strongly needed in LCD technology [1].

In this study, we used the new liquid crystal alignment layers which were produced a-C:H thin film using MOCVD method that has simple manufacturing process. Also the ion beam method was used as the alignment process. Ion of Ar was irradiated in the fluence range of $1.0 \times 10^{15} \sim 7.0 \times 10^{15}$ cm^{-2} into a-C:H thin film. After Ar ion irradiation, the chemical condition of carbon atom was detected Raman spectroscopy and electrical characteristics such as pretilt angle, V-T curve and Voltage Holding Ratio (VHR) were measured also.

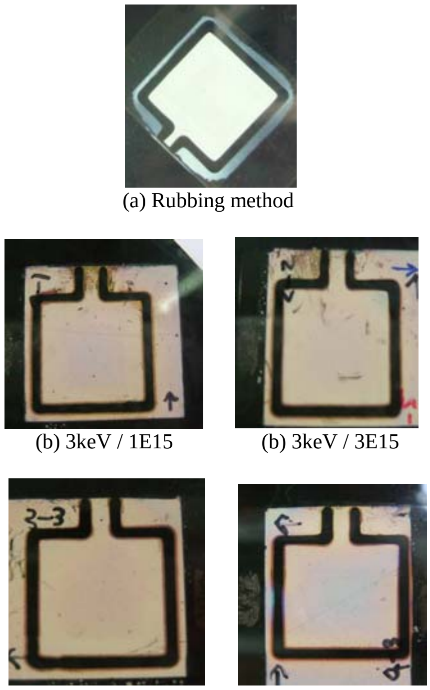
In the Raman spectroscopy analysis, D-peak intensities were increased according to ion fluence. The pretilt angle and V-T characteristic electrical characteristics were increased but VHR characteristic was decreased with ion fluence.

2. Methods and Results

1. Fabrication of Liquid crystal cell and the state of LC allignment

We used a glass which washed with ultrasonic cleaner after cutting by 30 x 30 mm^2 and Indium-Tin-Oxide (ITO) electrodes, 10 x 10mm^2 were uniformly coated on it. MOCVD system was used for deposition of a-C:H thin films. The a-C:H thin films were deposited using a mixture of Ar (100 sccm) and C_2H_2 (100 sccm) as working gases. The deposition was performed for 2min under 500W rf power at a gas pressure of 10^{-2} torr. The thickness of the a-C:H thin film was about 15~20nm.

Ion beam irradiation system was used to control of the properties of a-C:H thin films and consists of three parts-system, ion gun, vacuum chamber and beam measurement system. The ion beam current density is very different according to energy, gas flow and ion etc but, we found the uniform ion beam current density [2]. The surface properties of a-C:H thin films were controlled by argon ion beam irradiation. The argon ion beam irradiation range was changed from 1.0×10^{15} cm^{-2} to 7.0×10^{15} cm^{-2} min at 3keV ion beam energy with incident angle, 45°. After Ar beam irradiation on deposited a-C:H glass, two glass were cross-over with polarizing filters to identify alignment states and Fig 1 shows them which were measured under a various condition.



(a) Rubbing method
(b) 3keV / 1E15
(b) 3keV / 3E15
(c) 3keV / 5E15
(d) 3keV / 7E15

Fig. 2. The state of of LC cells with a various condition

2. Raman spectroscopy Pretilt angle measurement

Raman spectroscopy is the best way to obtain the detailed bonding structure of a-C:H thin films. It is widely used as a non-destructive way to characterize the structural quality of diamond, graphite, and a-C:H thin films. In this study, the structure of a-C:H thin films was characterized using Jovin Yvon, Spex, 1404p Raman spectrometer. The Raman spectrometer used 514.5 nm argon lasers at 500 mW. The scan range was 1000–2000 cm^{-1}. We found D peak were changed slowly with deposition time. Generally, Diamond peak has a single Raman active mode at 1332 cm^{-1} while single graphite has a single Raman active mode at 1580 cm-1 (G peak), but Disordered graphite has a second mode at around 1350 cm-1 (D peak). The Raman spectra of most disordered carbons, which do not have particular graphitic ordering, have two Raman active modes (D and G peak) [3].

3. Pretilt angle measurement

The pretilt angle of LC cells using ion beam irradiated a-C:H thin films is shown in Fig. 3. As shown in this figure, the pretilt angle was changed with ion fluence from 0.04° to 0.578°.

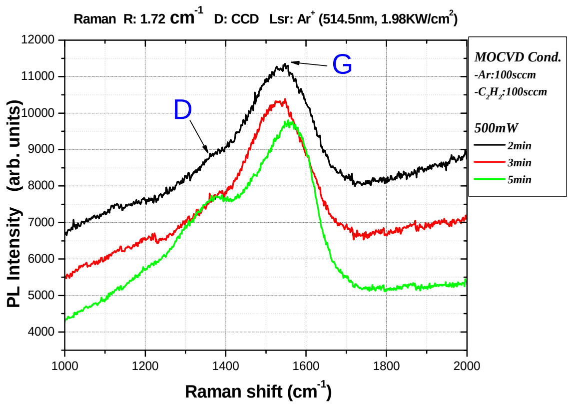


Fig. 3. The Raman spectra of a-C:H thin films as a function of deposition time.

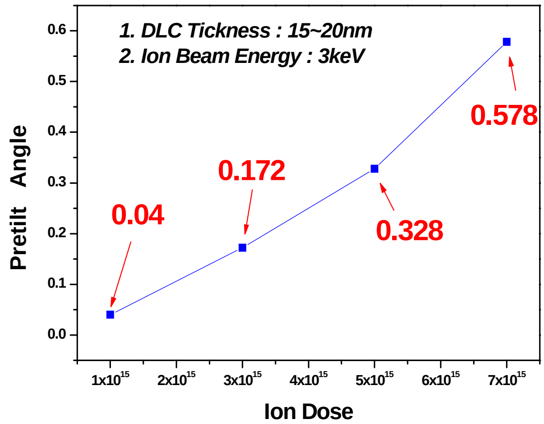
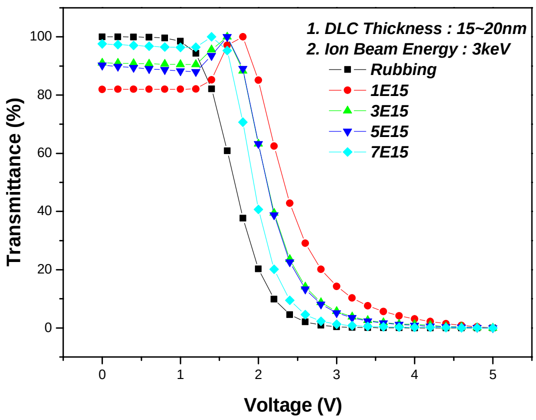


Fig. 4. The pretilt angle of a-C:H films as a function of deposition time.

4. V-T (Voltage-Transmittance) curve measurement

The voltage-transmittance characteristic of the rubbing-aligned TN cell and the ion-beam aligned TN cell were measured by electric-optical measurement system. Fig. 5. shows V-T curves of the rubbing-aligned and ion beam irradiation a-C:H thin film surface. The result of ion beam method comparing with rubbing method was not achieved over all but, under specific condition, good parameter was founded to replace rubbing method.



3. Conclusions

In this study, a-C:H thin films were deposited by MOCVD. The LCD cell was assembled with low energy ion beam irradiated a-C:H thin films. We investigated LC alignment capabilities and variation of pretilt angles with Ar ion beam treatment on a-C:H film. In the experiment, we found disordered graphite which changed as of deposition time in Raman spectroscopy and electrical characteristic such as pretilt angle and the state of alignment and V-T curve was changed with ion fluence. In results, we anticipate that LCD display technologies using a rubbing-free process can be expected to solve current problems with displays and provide a good foundation for further development of displays industry hereafter.

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