Alignment property change in DLC alignment layer containing various hydrogen concentration

Jong Bok Kim, Kyung Chan Kim, Han Jin Ahn, Byung Har Hwang and Hong Koo Baik
Department of Metallurgical Engineering, Yonsei University, Shinchon 134, Seodeamoon, Seoul 120-749, Korea, 82-2-2123-2838, thinfilm@yonsei.ac.kr

Abstract

Diamond like carbon (DLC) films are known that they show homogeneous alignment property when they are irradiated by Ar ion beam. The DLC films in most of studies were deposited by CVD and contain large mount of hydrogen. In order to identity the hydrogen effect on alignment property, DLC films is deposited by RF magnetron sputter using various ratio of Ar and H_2 as reactive gas. DLC films are characterized by FT-IR, Raman and contact angle. Alignment property is estimated by measuring pretilt angle.

1. Objectives and Background

As the size of Liquid Crystal Display become large, rubbing method with polyimide is facing to some limit due to drawbacks such as debris generation, high heat treatment process and difficulty of uniform imidization[1)~2)].

Recently, IB irradiation method with inorganic layer has studied as new alignment method[3)~5)]. Especially, DLC films is interesting because it has good physical and mechanical properties[6)] and it is easy to change material property through hydrogen concentration. IB irradiation method is convenient to control pretilt angle through changing irradiation angle or time.

However, DLC films have contained large amount of hydrogen in most of studies. So it is difficult to identify the role of hydrogen in liquid crystal alignment.

In this study, DLC films are deposited by RF magnetron sputter with various hydrogen ratio in reactive gas. The DLC film properties are analyzed by FT-IR in order to compare relative hydrogen concentration with each DLC films. Then the structure and surface energy is measured by Raman spectroscopy and contact angle. We observe the alignment property on various thin films which have different property through measuring pretilt angle.

2. Results and discussion

DLC films are grown by competition processes, which are reactive sputtering of a graphite target and etching of deposited films by hydrogen ions and radical[7)]. Namely, high hydrogen ratio in reactive gas doesn't mean high hydrogen concentration in DLC films. Though it is difficult to measure quantitative hydrogen, relative hydrogen concentration is characterized by IR absorption spectra. Fig 1. shows the IR absorption spectra from 2700cm^{-1} to 3200cm^{-1} of DLC films which are deposited at the different hydrogen partial pressure. This absorption band consists of various C-H bonds. Through the area of this region, we can know that DLC films have large amount of hydrogen with increasing hydrogen partial pressure of reactive gas.

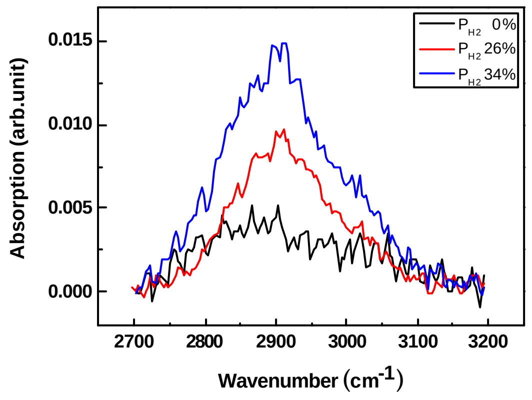

Figure 1. IR absorption spectra of DLC films which is deposited at various hydrogen partial pressure. Hydrogen partial pressure over total pressure is (a) 0%, (b) 26% and (c) 34%.

The structure of each DLC film is investigated by Raman spectroscopy. Fig. 2 shows I_D/I_G value of DLC films from Raman spectroscopy. Raman spectroscopy is a standard nondestructive tool for characterizing the structure of DLC film. The Raman spectum of DLC consists of two peak, the G peak around 1580-1600 cm^{-1} and the D peak around 1350cm^{-1}, and the ratio of D peak to G peak (I_D/I_G) is generally proportional to sp^2/sp^3 fraction in DLC film[8)~9)]. In this study, the I_D/I_G value is the lowest in P_{H2}(26%). It means DLC film which deposited at P_{H2}(26%) has lowest sp^2/sp^3 ratio. We speculate that the hydrogen atoms occupy at sp^3 site in DLC films at low hydrogen partial pressure, but they occupy at sp^2 site at high hydrogen partial pressure.

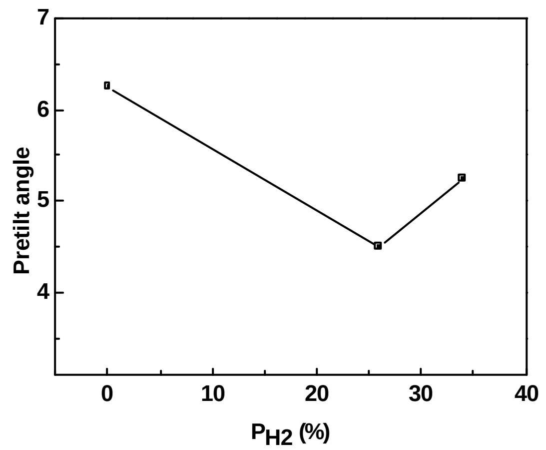

Figure 2. Dependence of the I_D/I_G ratio on the hydrogen partial pressure in various DLC films.

Surface energy change shows the similar trend with I_D/I_G change (Fig. 3). In that, Total surface energy is the minimum at P_{H2}(26%).

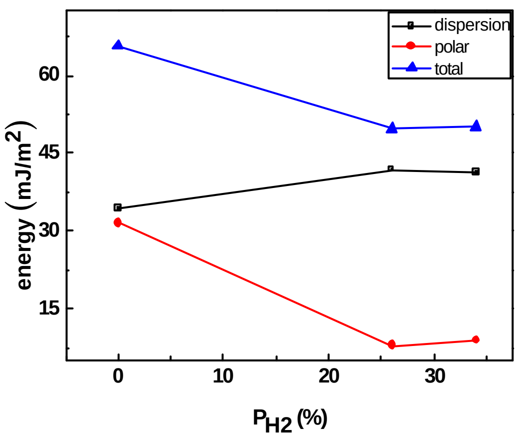

Figure 3. the surface energy, polar and dispersion component as a function of the hydrogen partial pressure.

So we can expect the lowest pretilt angle at P_{H2}(26%)[10)]. Fig. 4 show pretilt angle at various DLC films. This result doesn't agree with surface energy data. Though P_{H2}(26%) has minimum surface energy, pretilt angle of P_{H2}(26%) is the lowest. It is thought due to the highest dispersion component of surface energy. The highest dispersion component induces the strong van der Waals dispersion interaction between the LC molecules and alignment layer. It makes the lowest pretilt angle. This trend agrees with other study[11].

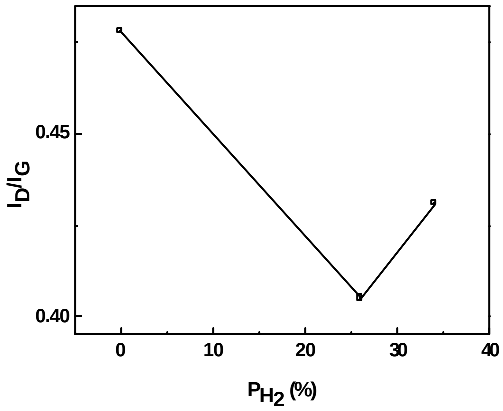

Figure 4. the pretilt angle as a function of the hydrogen partial pressure.

3. Impact

IB irradiation method using DLC alignment layer has many advantages such as clean process due to non-contact method. DLC film property can be controlled by changing reactive gas species and their ratio. It is easy to deposit DLC layer uniformly when comparing with imidization of polyimide. So IB method with DLC has possibility of industrial application.

4. Conclusion

In this study, DLC was used as a alignment layer. In order to change alignment property, we changed the hydrogen partial pressure in reactive gases. The film property was characterized by FT-IR, Raman spectroscopy and contact angle. It affected on alignment property. The pretilt angle of P_{H2}(26%) which had the highest dispersion component was the lowest due to the strong van der Waals dispersion interaction.

5. Reference

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