The Effects of Ion Beam on the Liquid Crystal Alignment Phenomena using a-C:H Thin Films

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Abstract

We investigated the liquid crystal (LC) alignment phenomena using hydrogenated amorphous carbon (a-C:H) thin films. For LC alignment, the surface of a-C:H thin films is treated with low energy ion beam. We investigated the relationship between the properties of a-C:H thin films and LC alignment phenomena.

1. Introduction

Liquid crystal displays (LCDs) are realized by using the anisotropic electro-optical phenomena of liquid crystal (LC) molecules.[1] The unidirectional alignment of LC should be required for these phenomena. The rubbing method[2], photo-alignment method[3] and ion beam method[4] have been used for the alignment of LC molecules in one direction up to now. In the case of rubbing and photo-alignment method, a few mechanisms such as microgroove and anisotropic photochemical dissociation are suggested to explain the LC alignment.

However, there have been few reports on the alignment of LC molecules by ion beam method. [4-5] Also only small numbers of studies have been presented on the relationship between the properties of a-C:H thin films and LC alignment phenomena.

In this study, we investigated the surface properties a-C:H thin films and LC alignment phenomena of ion beam treated a-C:H thin films in twist nematic (TN) mode.

2. Experimental

a-C:H thin films were deposited on indium-tin-oxide (ITO) coated glass substrate by plasma enhanced chemical vapor deposition (PECVD). a-C:H thin films were deposited using C_2H_2 (3 sccm) and He (30 sccm) gases. The surface of a-C:H thin films was treated with post-growth low energy argon ion beam with irradiation conditions as follows: the incidence angle is 45°, irradiation time is changed from 0 to 5 min, and irradiation energy is 200 eV. a-C:H thin films were characterized by Raman spectroscopy. For observation of LC alignment property, LC cells were assembled by an anti-parallel structure. The thickness of LC layer was 60 μm. The LC cell was filled with a fluorinated mixture type nematic (N) LC without a chiral dopont. LC alignment phenomena were investigated

by photomicroscope and PI-checker. PI-Checker is designed to measure the optical anisotropy of the alignment layer on the LC glass substrate.

3. Results and discussion

The as-deposited and ion beam treated thin films are investigated by Raman characterization method and the results are shown in Fig. 1. Fig. 1 results show the typical Raman spectra of a-C:H thin films. As the ion beam irradiation time increase, I_D/I_G ratio is also increases. The increase in I_D/I_G ratio denotes the increase in sp^2 content in a-C:H thin films. So, ion beam has effect on the generation of the graphite structure (C=C bond) in a-C:H thin films.

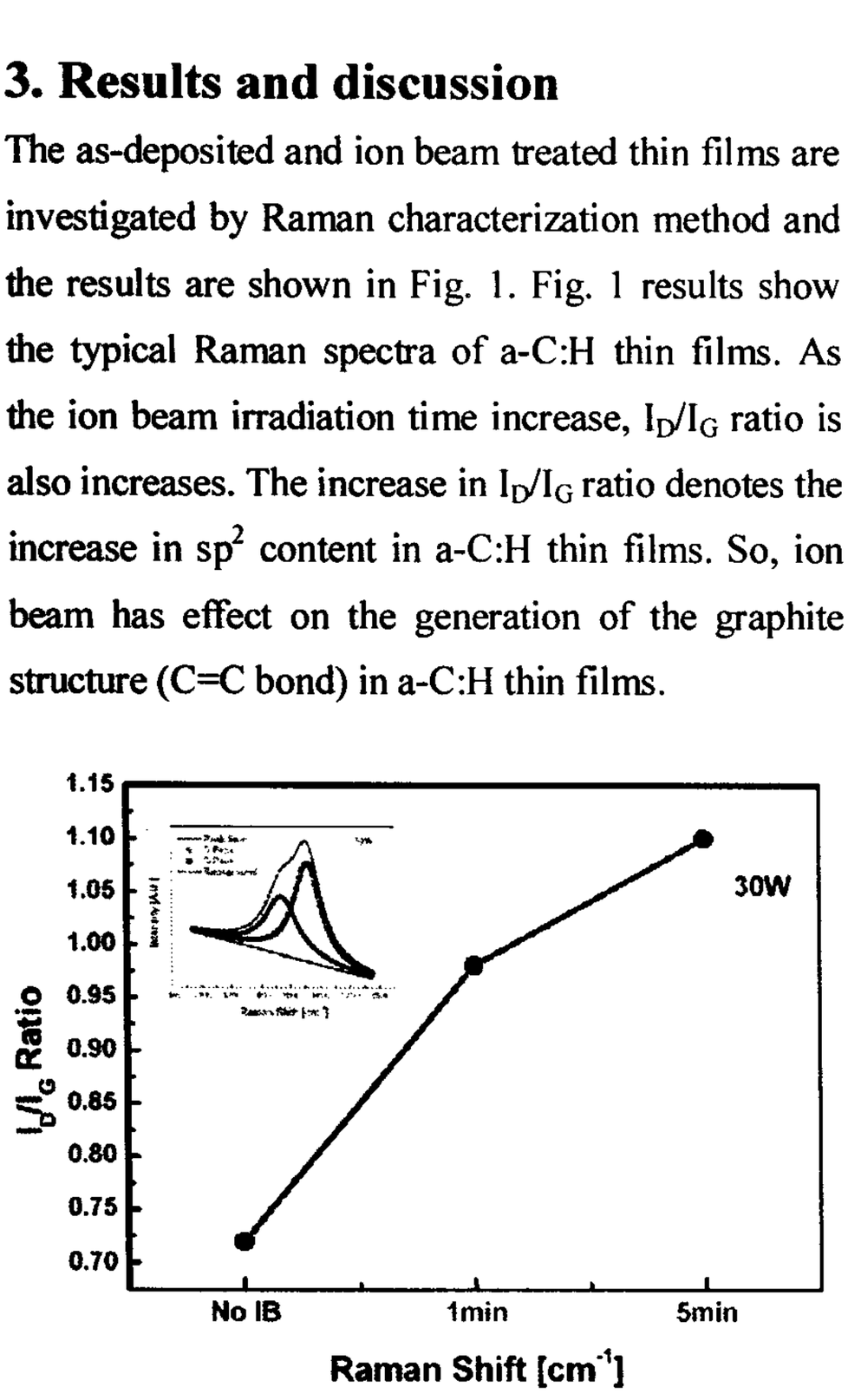

Fig. 1 The I_D/I_G ratio of ion beam irradiated a-C:H thin films as a function of ion beam irradiation time

The surface morphology of a-C:H thin films was observed by AFM. The surface morphology of a-C:H thin films is very smooth and isotropic surface morphology regardless of the ion beam irradiation condition. This tendency is similar to the report of Gwang et al. [6] They investigated the ion beam irradiation effects on the polyimide thin films and then they obtained isotropic surface morphology regardless of ion beam irradiation condition. So, ion beam has little effect on the generation of the microgroove structure on the surface of a-C:H thin films.

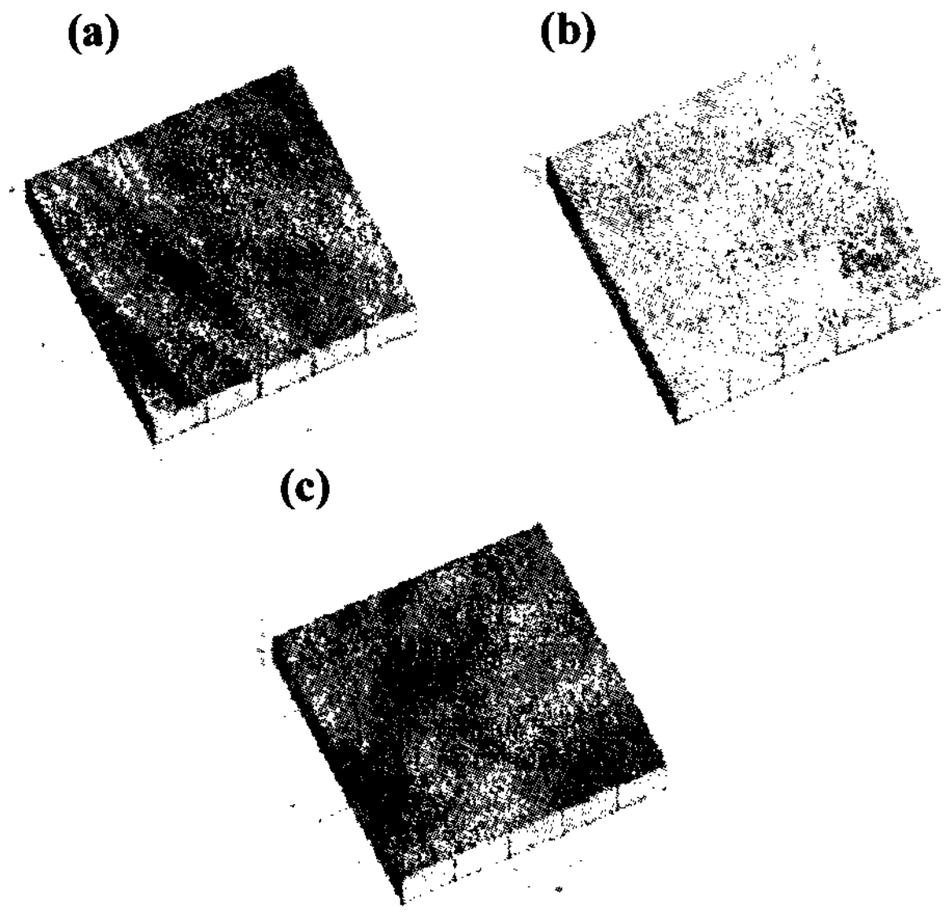

Fig. 2 The surface morphology of a-C:H thin films as a function of ion beam irradiation time (a) 0 min, (b) 1 min, and (c) 5 min

The photomicroscope observation shows the black state only occurred on the ion beam treated a-C:H thin films and the darkness is the same regardless of the ion beam irradiation condition. The appearance of isotropic black state means the anisotropic LC alignment. LC alignment phenomena on the surface of a-C:H thin films means the existence of surface anisotropy on the surface of a-C:H thin films. The surface anisotropy of a-C:H thin films is

investigated by PI-Checker. The PI checker observation shows that as-deposited a-C:H thin films have isotropic structure however the ion beam treated a-C:H thin films have anisotropic structure. These phenomena are the same tendency with the photomicroscope observation results. But PI-checker results show different LC alignment phenomena depending on the ion beam irradiation condition. The maximum Δ and the best LC alignment phenomena are obtained at 1 min condition. The occurrence of anisotropic structure means the existence of surface anisotropy on the surface a-C:H thin films. Therefore, ion beam has an important role to generate the surface anisotropy on the surface a-C:H thin films. Also, it seems that the surface anisotropy more affected by the graphite structure (C=C bond) than surface morphology.[7] Therefore it is thought that the microgroove mechanism is negligible in ion beam treated a-C:H thin films.

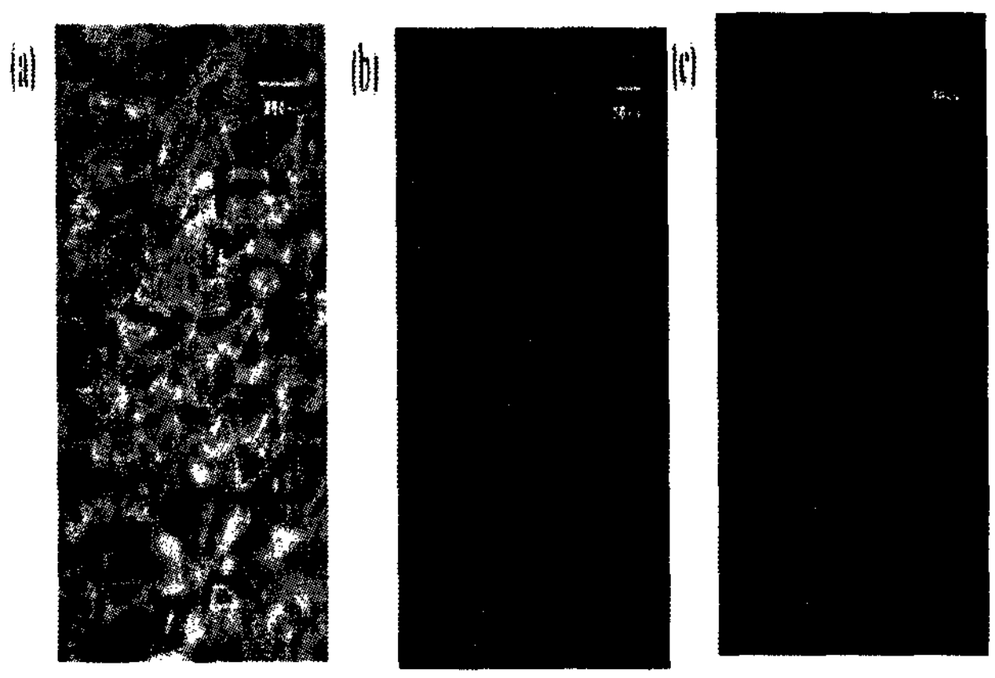

Fig. 3 The photomicroscope photographs of LC cells as a function of ion beam irradiation time (a) 0 min, (b) 1 min, and (c) 5 min

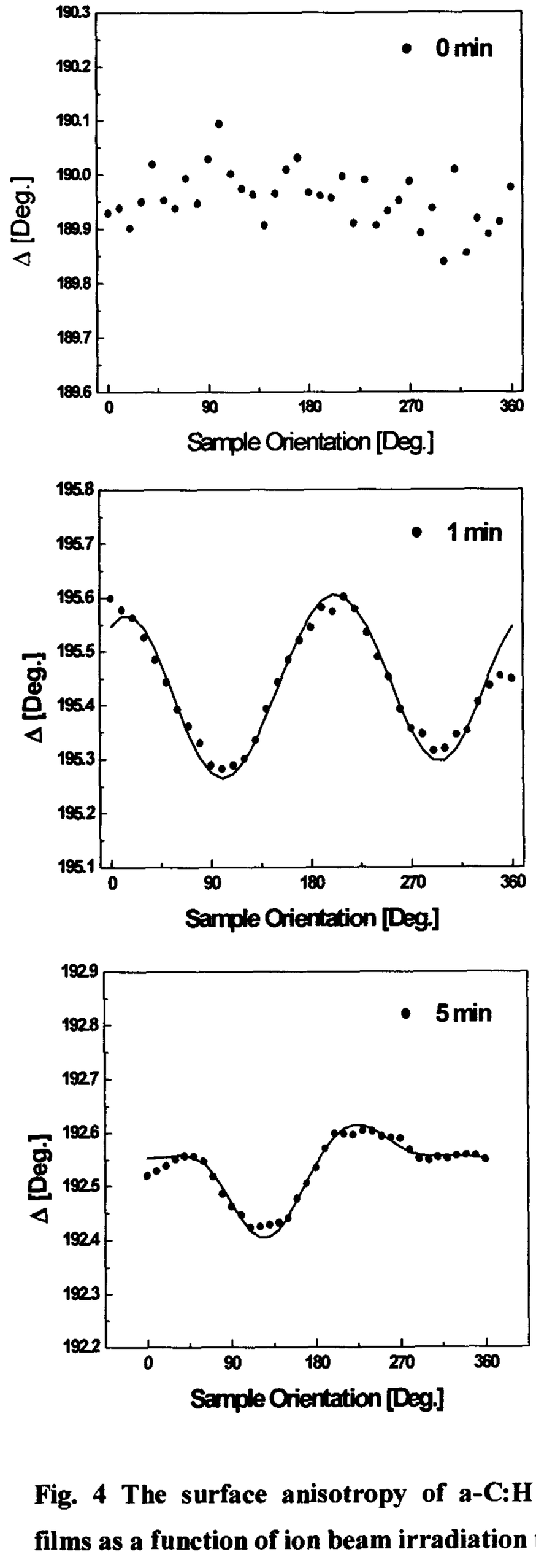

Fig. 4 The surface anisotropy of a-C:H thin films as a function of ion beam irradiation time

4. Conclusion

We investigate the property of a-C:H thin films and LC alignment phenomena. The surface morphology of a-C:H thin films is isotropic regardless of ion beam treatment condition. The structure of a-C:H thin films is changed from high sp^3/sp^2 ratio to low sp^3/sp^2 ratio. It means the increase of graphite structure (C=C bond) in a-C:H thin films. LC alignment phenomena show the generation of the surface anisotropy on the surface a-C:H thin films. It seems that the surface anisotropy is more affected by the graphite structure (C=C bond) than surface morphology. Therefore ion beam has the important role to generate the surface anisotropy of a-C:H thin films.

5. Acknowledgement

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6. References

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