Effects of rubbing strength on the molecular orientation in polyimide films as substrates of liquid crystal displays

Naoto Yamashita[1], Masaru Takizawa[2], Hidetoshi Namba[1], Kenichi Izumi[3], and Tetsuo Tominaga[3]

1) Department of Physical Sciences, Faculty of Science and Engineering, Ritsumeikan University, Kusatsu, Shiga 525-8577, Japan

2) Research Organization of Science and Engineering, Ritsumeikan University, Kusatsu, Shiga 525-8577, Japan

3) JSR Corporation, Yokkaichi, Mie 510-8552, Japan

1. Introduction

In liquid crystal (LC) displays, various kinds of polyimide films as substrates are widely used to align LC molecules. In this study, an effect of the rubbing strength on the molecular orientation in the films of PMDA//PDA and TCA//PDA was studied by near edge x-ray absorption fine structure (NEXAFS). PMDA//PDA is the aromatic polyimide with a planar shape as shown in the inset of Fig. 1. TCA//PDA is the alicyclic one with a bridge-like side chain as shown in the inset of Fig. 2.

2. Experimental

The polymers were dissolved in an organic solvent and spin-coated onto indium-tin-oxide-coated glass plates. After heating to 80 °C to evaporate the solvent, the polymers were baked at 230 °C for 20 min. The polyimide films were rubbed using a rayon-cloth rubbing machine at 400 rpm rotation speed, 30 mm/sec plate speed. In order to change the rubbing strength, the depth of the pile impression was set to either 0.2 mm or 0.4 mm.

NEXAFS measurements were performed at the BL-8 of SR Center at Ritsumeikan University, equipped with a grazing incidence monochromator with a varied-line-spacing plane grating [1]. Carbon K-edge NEXAFS spectra of the samples were measured in both partial and total electron yield by a micro-channel plate detector with retarding grids. In the partial electron yield (PEY), the retarding voltage was set to -150 V, while that was 0 V in the total electron yield (TEY). The incident angle of SR with respect to the surface normal was varied and the electric vector of SR was changed in parallel to the rubbing direction.

3. Results and Discussion

Figures 1 and 2 show C K-edge NEXAFS spectra of the samples. These peaks are attributed to the C 1s→π* transitions in PMDA, TCA and PDA. The intensities of these peaks increased with incident angles, indicating that the main chains of the polymer molecules are aligned in the rubbing direction. The intensity ratio of these peaks (blue divided by red) did not show a significant dependence on the rubbing strength in either PEY or TEY. On the other hand, the intensity ratio was slightly larger in PEY than in TEY for PMDA//PDA. This result indicates that the polymer molecules in PMDA//PDA films are less oriented in bulk.

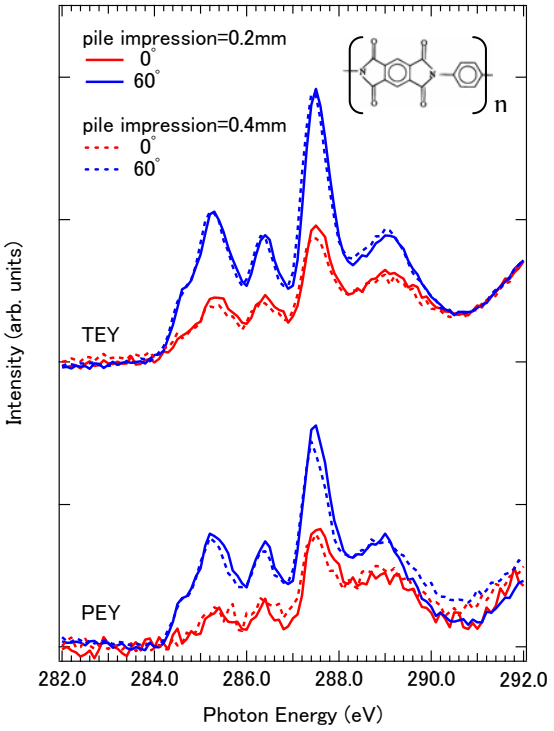

Fig. 1 C K-edge NEXAFS spectra of PMDA//PDA.

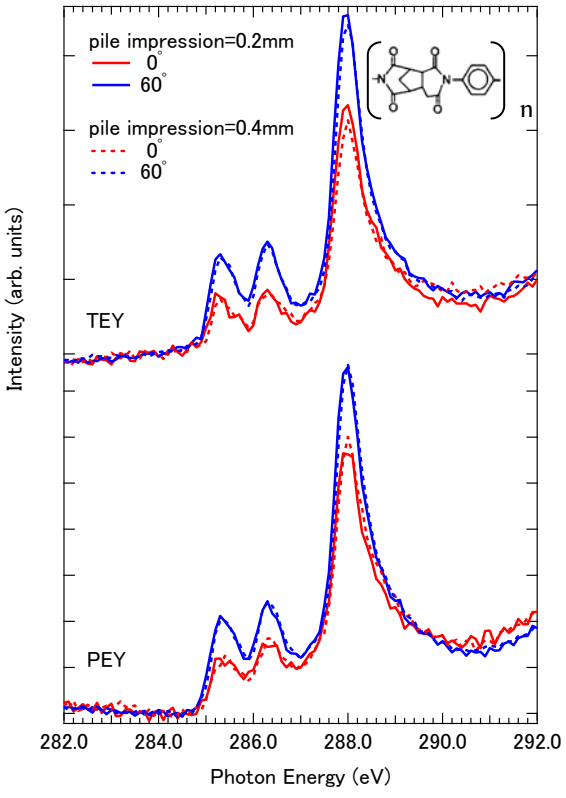

Fig. 2 C K-edge NEXAFS spectra of TCA//PDA.

4. Conclusions

We have investigated the rubbing strength effect on the orientation of two different kinds of polyimide films by NEXAFS. We have found that the rubbing process under the present experimental conditions aligned the polyimide films in the deep region from the surface. By weaker rubbing the substrate, a depth profile of the alignment of the polyimide films can be controlled.

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Reference

[1] H. Namaba *et al.*, J. Synchrotron Rad. **5**, 557 (1998).