Pattern-size Effect of Reorientation of Photoinduced Liquid Crystalline Polymer by Thermal Nanoimprinting

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The photoinduced orientation of polymeric films has received a lot of attention because of its potential used in many kinds of optical and photonics applications. While studying the photoinduced molecular orientation of photoreactive polymers, N. Kawatsuki et al. found that P6CAM exhibits a large photoinduced molecular reorientation [1, 2]. Previously, we reported that the P6CAM was reoriented by thermal nanoimprinting using 2 μm-line and space (L&S) pattern mold [3]. We assumed that the pattern size is a one of the important factors in reorientation process of P6CAM by thermal nanoimprinting. We therefore evaluated the pattern size dependence of the degree of the orientation.

We fabricated the 2 and 20 μm-L&S convex patterns by electron beam lithography and reactive ion etching. The pattern height was 300 nm. We used OPTOOL HD-1100TH (Daikin Industries.) as a release agent to form a fluorinated self-assembled monolayer on the mold. We carried out thermal nanoimprinting using these molds on P6CAM. The film thickness of P6CAM was about 1 μm. The mold and substrate were heated by 165 °C. The imprinting pressure and time were 15 MPa and 120 sec, respectively. Figures 1(a) and 1(b) show the optical micrographs of the 2 and 20 μm-L&S imprinted P6CAM patterns, respectively. The patterns were clearly imprinted on the P6CAM. We next observed the P6CAM pattern by polarization optical micrography (POM) under cross-nicoled conditions. Figure 2(a) shows the schematic diagram of observation place. The bright-field of the polarization micrograph indicates that the P6CAM is unidirectionally reoriented. The dark-field shows that P6CAM orients randomly. Figures 2(b) and 2(c) show the POM images of the 2 and 20 μm-L&S imprinted P6CAM patterns, respectively. In the case of 2 μm-L&S pattern, the whole L&S pattern on P6CAM was bright-field. However, when we used the 20 μm-L&S pattern mold, the lines of the dark-field were observed on the imprinted line and space, as shown in Fig. 2(b). The line-width of dark-field was about 5 μm. These results indicate that the degrees of orientation of P6CAM are different between the 2 μm-L&S and 20 μm-L&S patterns.

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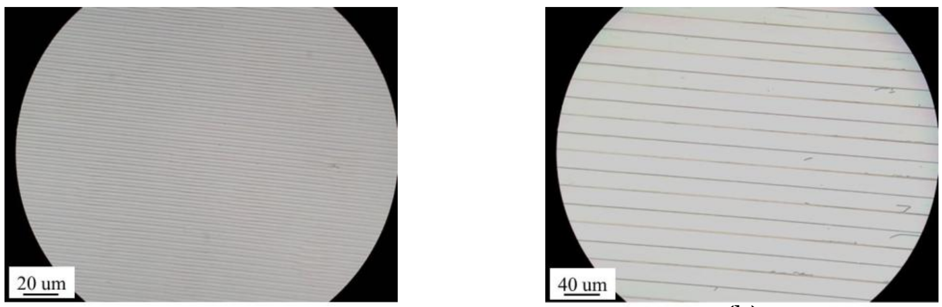
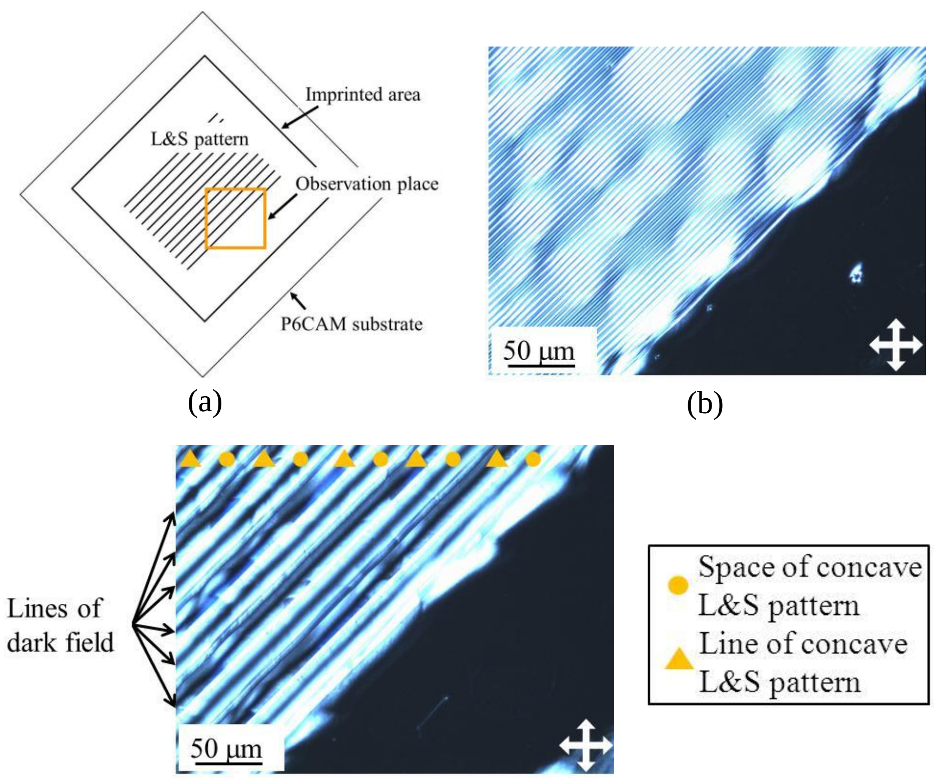
References

[1] E. Uchida, and N. Kawatsuki: Macromolecules **39** (2006) 9357.
[2] N. Kawatsuki, T. Kawanishi, and E. Uchida: Macromolecules **41** (2008) 4642.
[3] M. Okada, et al.: Jpn. J. Appl. Phys. **49** (2010) 128004.



(a) (b)

Figure 1. Optical micrographs of (a) 2 and (b) 20 μm-L&S imprinted P6CAM patterns.



(c)

Figure 2. (a) Schematic diagram of observation place. Polarization optical micrography (POM) images of (a) 2 and (b) 20 μm-L&S imprinted P6CAM patterns