Molecular orientation of imprinted nm-order pattern of photo-cross-linkable liquid crystalline polymer

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Much attention has been paid to the photoinduced molecular reorientation of photoreactive polymeric materials. Molecular orientation of photo-cross-linkable liquid crystalline polymers (PLCPs) can be controlled by linearly polarized ultra violet and heat treatment. Previously, we found that P6CAM[1)], which is one of PLCPs, can be aligned by thermal nanoimprinting[2)]. It was confirmed from optical measurement results that the P6CAM molecules were reoriented to be parallel to the imprinted 2 μm-line pattern. In addition, the molecular orientation was random at imprinted flat area. So far, we used a μm-order line and space (L&S) pattern mold because the molecular orientation direction was determined by measuring the diffraction efficiency using linearly polarized (LP) 633 nm light or polarization optical micrography (POM), which are limited to the resolution of μm. However, it is important that we examine the P6CAM molecular orientation of the nm-order L&S pattern.

To evaluate the imprinted nm-order L&S P6CAM pattern, we fabricated nm-order L&S patterns arranged in μm-order linear groups, as shown in Fig. 1(a). If the μm-order molecular orientation pattern after thermal nanoimprinting with the mold is observed by POM (Fig. 1(b)), this means that P6CAM molecules are reoriented along a direction of nm-order L&S pattern. We fabricated three types of nm-order L&S patterns by electron beam lithography, as shown in Fig. 2. The nm-order line- and space-widths were 200nm. Then, we carried out thermal nanoimprinting using these molds, which were coated with an antisticking layer. The nanoimprinting temperature and pressure were 165 °C and 15 MPa, respectively. Following, we observed the imprinted P6CAM pattern by POM under crossed-nicols (a polarizer and an analyzer are crossed at 90°, orange arrow in POM images), as shown in Fig. 3. When the molecular direction is reoriented in the same direction as the polarizer and analyzer, the POM observation area is a dark field. We confirmed from POM images that the μm-order P6CAM molecular orientation pattern was formed by thermal nanoimprinting using the nm-order L&S pattern mold. In addition, the contrast of POM images of imprinted P6CAM pattern was changed by the direction of the nm-order L&S pattern (yellow arrow in POM images). These results indicate that the P6CAM molecules were reoriented in different directions due to the direction of the nm-order L&S pattern.

References
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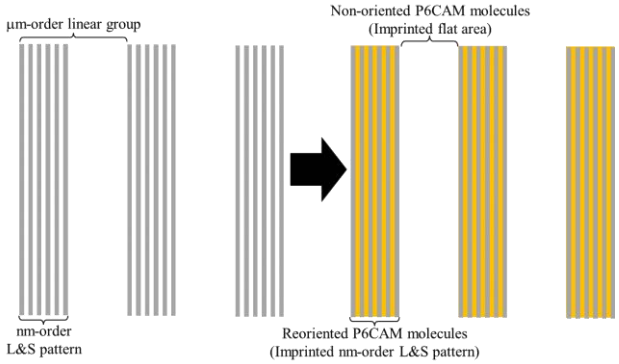


(a) (b)

Fig. 1 Illustration of (a) nm-order L&S pattern mold and (b) μm-order P6CAM molecular orientation pattern.

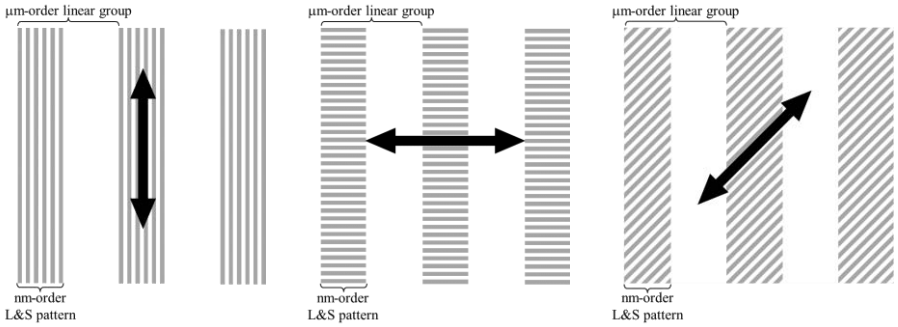
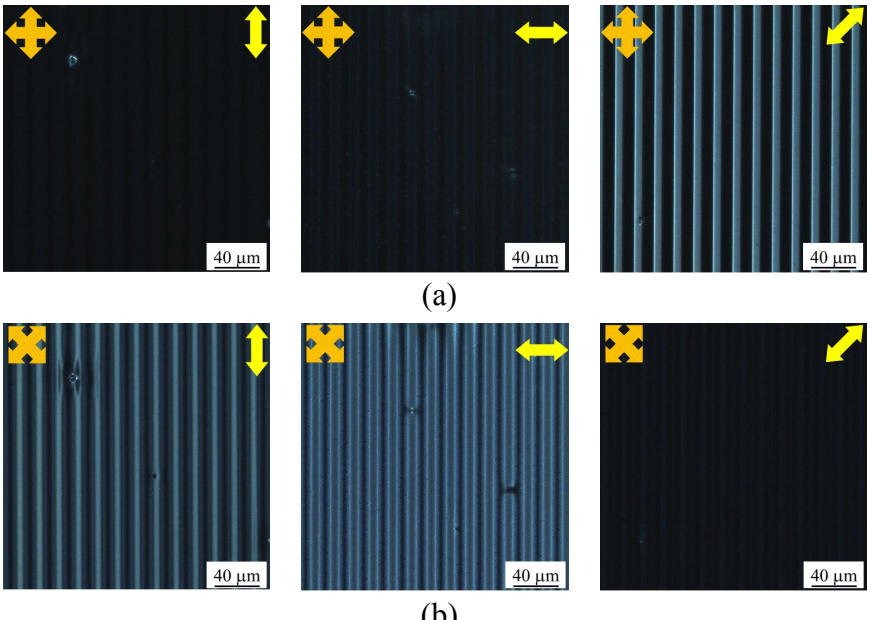


Fig. 2 Illustration of three types of nm-order L&S pattern molds.



(a)

(b)

Figure 3. Polarization optical micrography (POM) under crossed-nicols (orange arrow) at the angle of (a) 0° and (b) 45° images of imprinted P6CAM patterns. Yellow arrows mean the direction of nm-order L&S pattern.