Temperature dependence of molecular orientation of liquid crystalline polymer induced by nanoimprint-graphoepitaxy

Makoto Okada[1], Risa Hosoda[2], Yusuke Taniguchi[2], Yuichi Haruyama[1], Hiroshi Ono[3], Nobuhiro Kawatsuki[2], and Shinji Matsui[1]

1Laboratory of Advanced Science and Technology for Industry, Univ. of Hyogo, Ako, Hyogo, 678-1205, Japan

2Department of Materials Science and Chemistry, Graduate School of Engineering, Univ. of Hyogo, Himeji, Hyogo 671-2280, Japan, 3Department of Electrical Engineering, Nagaoka Univ. of Technology, Nagaoka, Nigata 940-2188, Japan

E-mail address: m.okada@lasti.u-hyogo.ac.jp

Nanoimprint technology can easily fabricate various nanostructures. In addition, a resin pattern is formed by nanoimprinting without any etching processes. This means that we are able to obtain a nanostructure of functional material[1)]. We reported that the molecular orientation of P6CAM, which is one of photo-cross-likable liquid crystalline polymers (PLCPs), is induced by thermal nanoimprinting[2)]. The unidirectional molecular orientation of PLCPs is normally aligned by linearly polarized UV and heat treatment. However, by using thermal nanoimprinting without LPUV irradiation, the P6CAM molecules can be reoriented parallel to the imprinted line. We call the nanoimprint process for inducing the molecular orientation "nanoimprint-graphoepitaxy". It has the potential to produce new functions by fusing material function with nanostructure function. To enhance the nanoimprint-graphoepitaxy, we should clarify the molecular orientation mechanism. We therefore examined the temperature dependence of molecular orientation of liquid crystalline polymer (LCP) by nanoimprint-graphoepitaxy.

We used poly[6-[4-(4-cyanophenyl)phenoxy]hexyl methacrylate] (P6CiM, Fig.1; P3421-4CNBPHMA:Polymer Source Inc.) as the LCP and carried out nanoimprint-graphoepitaxy using the mold with a positive tone-line and space (L&S) pattern. The line and space widths were both 2 μm, and the pattern depth was 200 nm. The pattern size was too large for P6CiM molecules. The nanoimprint pressure and time were 10 MPa and 5 min, respectively. We carried out nanoimprint-graphoepitaxy at 60°C, 80°C, 100°C, and 120°C and observed the imprinted P6CiM patterns by polarized optical micrography (POM) under crossed Nicols (a polarizer and an analyzer are crossed at 90°, orange arrow in POM images), as shown in Fig.2. The yellow arrows in POM images indicate the P6CiM line direction. According to the provided information from Polymer Source Inc., the LC-transition and melting temperatures of the P6CiM (P3421-4CNBPHMA; Polymer Source Inc.) were 49 °C and 110 °C, respectively. The contrast of POM images were changed depending on the nanoimprint temperature. The P6CiM pattern fabricated by 60 °C, which is near LC-transition temperature, was high contrast. On the other hand, in the case of 120 °C which is over melting temperature, we observed very low contrast. In our previous work, we confirmed that temperature dependence of P6CAM molecular orientation was not observed[3]. However, the above results suggest that molecular orientation of P6CiM depended on nanoimprint temperatures. In the presentation, we will discuss the molecular orientation of P6CiM in detail.

Acknowledgement
This work was partially supported by JSPS KAKENHI Grant Number 26870505.

References
1) M. Aryal, et al.:Vac. Sci. Technol. B **26** (2008) 2562.
2) M. Okada, et al.: Jpn. J. Appl. Phys. **49** (2010) 128004.
3) M. Okada, et al.: Microelectron. Eng. **123** (2014) 159.

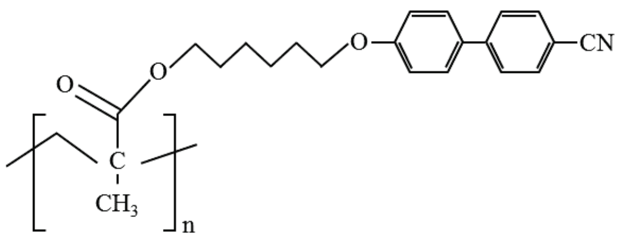

Fig. 1 Chemical structure of P6CiM.

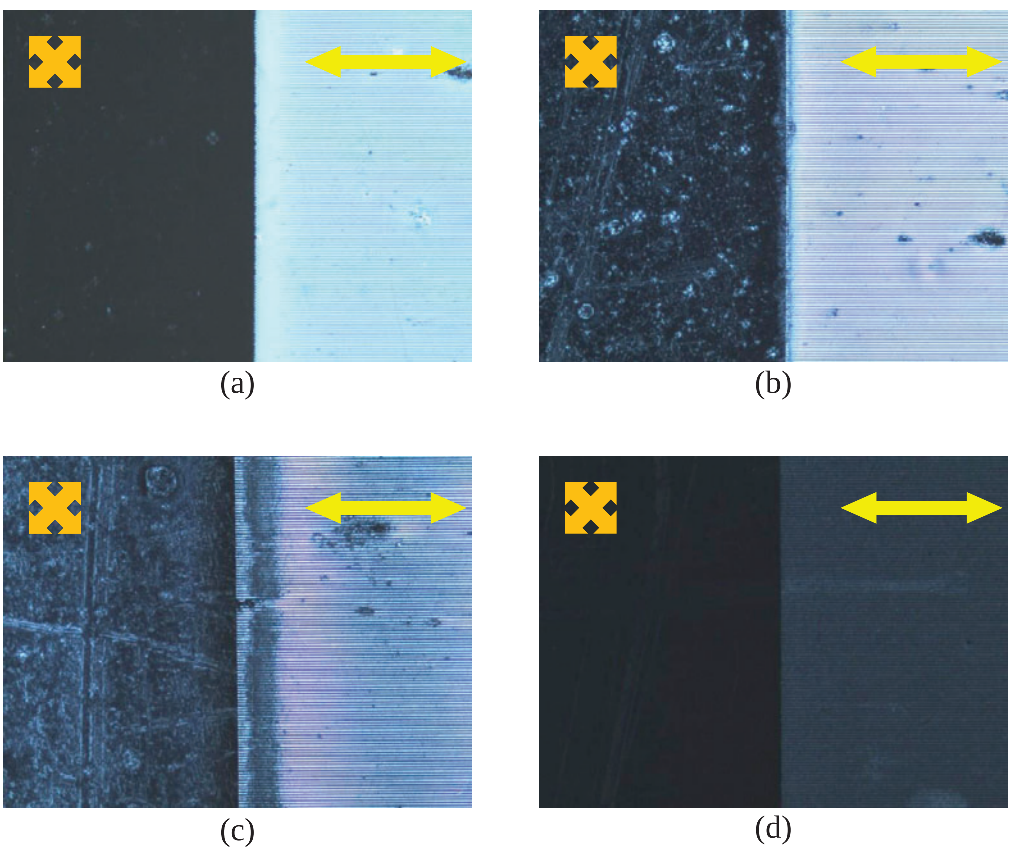

Fig. 2 POM images of P6CiM pattern fabricated by nanoimprint-graphoepitaxy with (a) 60°C, (b) 80°C, (c) 100°C, and (d) 120°C.