Reorientation Evaluation of Bidirectional Line Pattern on Photoinduced Liquid Crystalline Polymer Fabricated by Thermal Nanoimprinting

Makoto Okada[1], Mami Kurita[2], Emi Nishioka[2], Mizuho Kondo[2], Yuichi Haruyama[1], Akira Emoto[3], Hiroshi Ono[4], Nobuhiro Kawatsuki[2], and Shinji Matsui[1]
[1] Laboratory of Advanced Science and Technology for Industry, Univ. of Hyogo, Ako, Hyogo, 678-1205, Japan, [2]Department of Materials Science and Chemistry, Graduate School of Engineering, University of Hyogo, Himeji, Hyogo 671-2280, Japan,
[3]Electronics and Photonics Research Institute, National Institute of Advanced Industrial Science and Technology, Tsukuba, Ibaraki 305-8565, Japan,
[4]Department of Electrical Engineering, Nagaoka University of Technology, Nagaoka, Nigata 940-2188, Japan
E-mail address: m.okada@lasti.u-hyogo.ac.jp

Nanoimprint lithography (NIL) is a simple process to fabricate nanostructure devices with high resolution. We reported that the photoreactive liquid crystalline polymer (P6CAM) [1] material was aligned by thermal nanoimprinting using line and space (L&S) pattern mold[2]. We confirmed that the P6CAM molecules were reoriented parallel to the imprinted line on the imprinted P6CAM film in the case of using a normal L&S pattern mold. If a mold with bidirectional L&S pattern is used for the thermal nanoimprint on the P6CAM, two reorientation directions of the molecules according to the bidirectional mold pattern may be induced. We fabricated the bidirectional line pattern mold by electron beam (EB) lithography and reactive ion etching (RIE) and then demonstrated thermal nanoimprinting using this mold on the P6CAM film on a glass substrate.

The fabricated bidirectional L&S pattern mold has the two periodicities of 4- and 2-μm in the orthogonal direction, as shown in Fig.1. The line heights of 2- and 1-μm lines were about 200 and 100 nm, respectively. We used a thin polydimethylsiloxane (PDMS) layer as an antisticking layer [3]. The mold and P6CAM substrate were heated by 165 °C in thermal nanoimprinting. The imprinting pressure and pressing time were 15 MPa and 4 min, respectively. After thermal nanoimprinting, we observed the imprinted pattern by atomic force microscopy (AFM) as shown in Fig. 2(a). The bidirectional line pattern was clearly imprinted on the P6CAM. Next, we observed the P6CAM pattern by polarization optical micrography (POM) under cross-nicoled conditions. The bright-field of the polarization micrograph indicates that the P6CAM molecules are unidirectionally reoriented. The dark-field indicates that P6CAM molecules are randomly distributed. It was seemed that the brightness of 1 μm-lines was weaker than that of 2 μm-lines. These results indicate that the P6CAM molecules were reoriented bidirectionally according to the mold pattern by thermal nanoimprinting.

Acknowledgements
This work was partially supported by a Japanese Ministry of Education, Culture, Sports, Science and Technology (MEXT), Grant-in-aid for Scientific Research on Innovative Areas ’’ Emergence in Chemistry’’ (201110##).

References

[1] E. Uchida, and N. Kawatsuki: Macromolecules **39** (2006) 9357.
[2] M. Okada, et al.: Jpn. J. Appl. Phys. **49** (2010) 128004.
[3] M. Okada, et al.: J. Vac. Sci. Technol. B **29** (2011) 06FC09

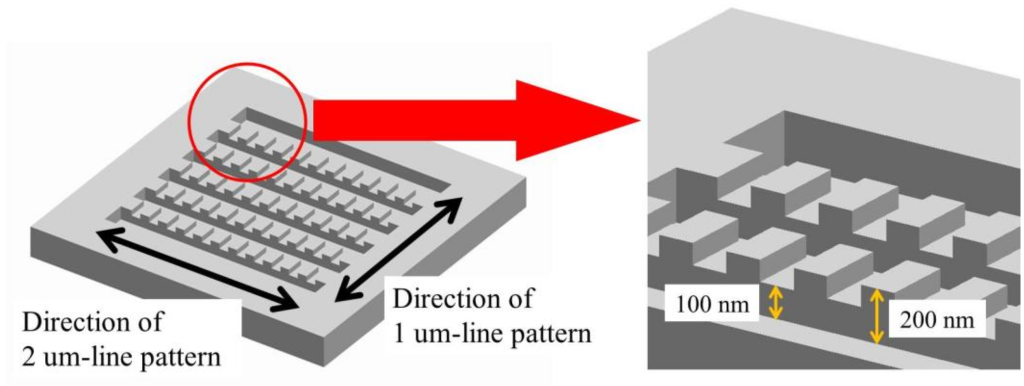

Figure 1. Illustration of bidirectional line pattern mold.

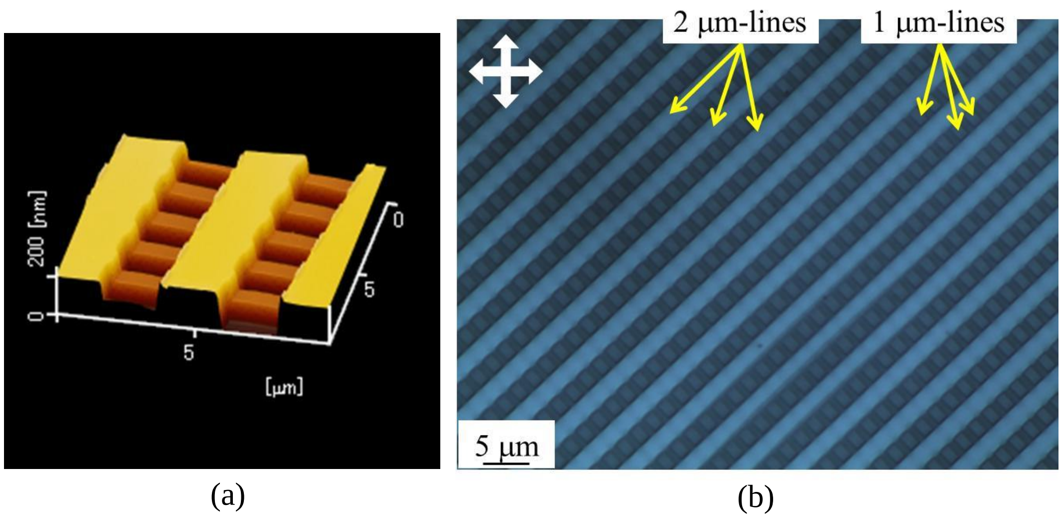

Figure 2. (a) AFM and (b) polarization optical micrography (POM) images of imprinted P6CAM pattern.