Replication of Nanostructures on Polyethylene Terephthalate with Laser-Assisted Roller Nanoimprinting

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Polymer films with nanostructured surfaces have been increasingly used in optics. Because polyethylene terephthalate (PET) has high transparency and flexibility, PET has been applied to substrates of organic light-emitting devices.[1] Thermal nanoimprinting is one of the most convenient methods to fabricate nanostructures on polymer films. For PET which is one of the crystalline polymers, thermal nanoimprinting at lower than crystalline temperature has been studied to keep the transparency and flexibility.[2] However, this process takes long time for the replication. In this study, for the reduction of the replication time, we used laser-assisted roller nanoimprinting (LARN). In LARN, nanostructures are replicated rapidly because only the surfaces of the mold and polymer are rapidly heated and cooled.[3] In PET films, therefore, nanostructures can be replicated before the crystallization, and the transparency and flexibility can be kept.

We used a mold with a 600-nm-pitch line and space (L/S) pattern and PET film (thickness: 250 μm). Figure 1 shows the schematic of LARN. A fiber laser of 100 W and 0.76 mm diameter (wavelength: 1070 nm) was irradiated on the mold. The L/S is replicated in an area by the laser scanning and the feeding of the mold and PET film. Firstly, the mold and PET film were not fed, and the L/S was replicated in a line. We verified the laser scanning speed, measured the width of the replicated line by an optical microscope, and calculated the replication speed. The replication speed was the product of the width and the scanning speed. Second, we replicated the L/S in an area with the scanning speed at the highest replication speed.

Figure 2(a) shows the relationship between the replication speed and the scanning speed. At the scanning speed of 400 mm/s, the replication speed was the highest. The highest replication speed was 57 mm^2/s. Figure 3 shows an optical photograph of the replicated L/S in an area. The scanning speed and feeding speed were 400 and 0.6 mm/s, respectively. The area of the replicated L/S and the replication time were 500 mm^2 and 30 s, respectively. The results indicated that nanostructures are rapidly replicated on the PET film by LARN.

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[1] Y. Li, L. W. Tan, X. T. Hao, K. S. Ong, F. Zhua, L. S. Hung, *Appl. Phys. Lett.*, 86 (2005) 153508.

[2] M. Cecchini, F. Signori, P. Pingue, S. Bronco, F. Ciardelli, and F. Beltram, *Langmiur*, 24 (2008) 12581.

[3] K. Takahashi, K. Nagato, J, Wang, T. Hamaguchi, M. Nakao, *Proc. EIPBN* (2014) .

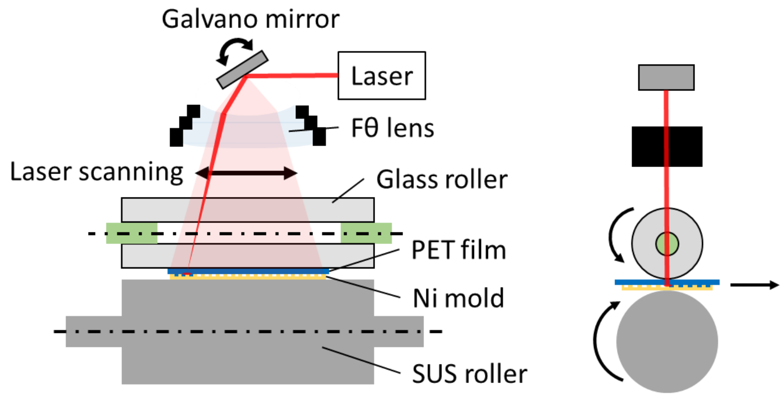

Figure 1. Schematic of experimental set up.

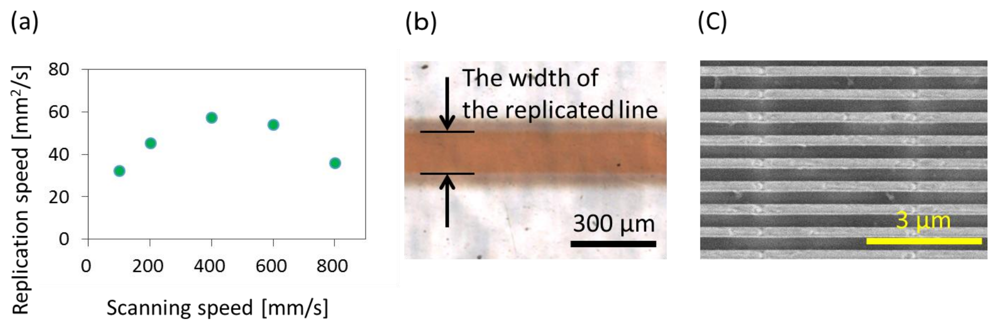

Figure 2. (a) Relationship between the replication speed and the scanning speed, (b) optical microscope image at the scanning speed of 400 mm/s, and (c) scanning electron microscope image of the replicated L/S on PET film at the scanning speed of 400 mm/s.

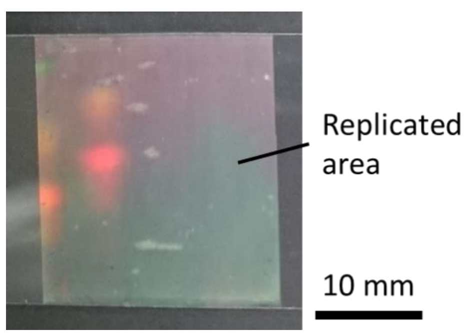

Figure 3. Optical photograph of the replicated L/S in an area on PET film at the scanning speed of 400 mm/s and the feeding speed of 0.6 mm/s.