Nanoscale Control over the Size of Polymer Nanochannels via Cross-Linking Agent Concentration of UV-Resin for Nanoimprint Lithography

Junseo Choi and Sunggook Park
Mechanical and Industrial Engineering Department and Center for BioModular Multi-Scale Systems for Precision Medicine (CBM^2), Louisiana State University, Baton Rouge, LA 70803
sunggook@lsu.edu

Recently, polymers have been used to fabricate nanochannel or nanopore devices for optics and biosensors [1-3]. Compared to the devices made in silicon and glass-based inorganic materials, polymers have many advantages such as low material cost, various physiochemical properties, and well-developed surface-modification protocols. Polymer-based nanochannel devices have been fabricated using low-cost and high-throughput molding techniques, as exemplified by nanoimprint lithography (NIL). While NIL is capable of patterning sub-10 nm patterns, the dimensional control in the fabrication of sub-50 nm patterns has always been a challenge. This challenge not only occurs during the imprinting process but also it is more significant in the stamp fabrication. Nanostructures in Si fabricated by electron beam lithography (EBL) or focused ion beam milling (FIB) often show different dimensions from the designed values. Also, EBL or FIB performed under the same condition in different runs may lead to dimensional variations at nanoscale. The main hypothesis of this work is that nanoscale control over the pattern size in NIL can be achieved by using the same Si master mold and UV curable resists of different chemical/physical properties. Furthermore, the replicated UV resists can further be used as molds for thermal NIL into thermoplastics due to their excellent demolding property for thermal-NIL [3].

In this work, we demonstrate the use of UV-resin shrinkage phenomenon to reduce nanoscale dimensions in a controlled manner. A Si master mold was prepared via a combination of photolithography and focused ion beam milling, which was replicated with UV resins on a polyethylene terephthalate (PET) backbone substrate by UV-NIL. The size of the nanopatterns was controlled by using the same Si master mold but using UV resins with five different compositions of cross-liking agent from 0 to 99 wt%. UV resins were exposed to UV light (365 nm) for 2 min at an intensity of 30 mW/cm^2. Furthermore, the fabricated UV resins of different sizes were used as molds for thermally imprinting cyclic olefin copolymer (COC) at 170 ^{o}C, 3.5 MPa for 15 min. We will also show the translocation behavior of lambda-DNA through the bonded nanochannels of different sizes.

1. J. Choi, C. Lee, and S. Park, Microsyst. Nanoeng. **5**, 12 (2019)
2. Z. Jia, J. Choi, and S. Park, ACS Appl. Mater. Interfaces **10**, 40927 (2018)
3. J. Wu, R. Chantiwas, A. Amirsadeghi, S. Soper, and S. Park, Lab Chip **11**, 2984, (2011)