Ultra-High Q-Factor Polymer Microring Resonators Fabricated by Two Types of Nanoimprinting Lithography

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Polymer microring resonators have been exploited for the past two decades and utilized for several important applications, such as biochemical sensing[1], acoustic detection[2], and others. However, standard fabrication methods that are used for processing inorganic materials generally cannot apply to polymer microring resonators, and alternative fabrication methods are needed.

Nanoimprinting lithography (NIL) is one of the technologies that can pattern the polymer resist at low-cost by pressing a mold on the polymer-coated substrate, as illustrated in Fig. 1(a). Using NIL followed by plasma etching to remove the residual polymer layer, we can fabricate high-resolution and low surface roughness microring resonators, as Fig. 2(a) and (b) shows. The obtained Q-factor exceeds 1,480,000, marking the record Q-factor of the polymer microring resonator to date.

In addition to the traditional NIL, we introduce a modified process, Damascene soft NanoImprinting Lithography (DsNIL), to prepare polymer microring resonators[3]. Different from the conventional NIL, the microring resonators are fabricated by creating the cladding template first via soft-UV imprinting, followed by simple backfilling of a high refractive index polymer to form the waveguide core, as shown in Figure 1(b). This method can be easily implemented without expensive instruments and can be conducted in a normal lab environment as it can minimize the effect of dust on the substrate. As demonstrated in Fig. 2(c) and (d), the resulting microring resonator intrinsically forms a residual layer free and a smooth surface with a meniscus profile due to the final heating process with the temperature above its T_g. The measured Q-factor of the microring is ~ 500,000.

1. Chao, C. Y., Fung, W. & Guo, L. J. Polymer microring resonators for biochemical sensing applications. *IEEE Journal on Selected Topics in Quantum Electronics* **12**, 134–142 (2006).
2. Zhang, C., Ling, T., Chen, S. L. & Guo, L. J. Ultrabroad Bandwidth and Highly Sensitive Optical Ultrasonic Detector for Photoacoustic Imaging. *ACS Photonics* **1**, 1093–1098 (2014).
3. Lin, W.-K. *et al.* High Q-Factor Polymer Microring Resonators Realized by Versatile Damascene Soft Nanoimprinting Lithography. *Adv Funct Mater* (2024) doi.org/10.1002/adfm.202312229

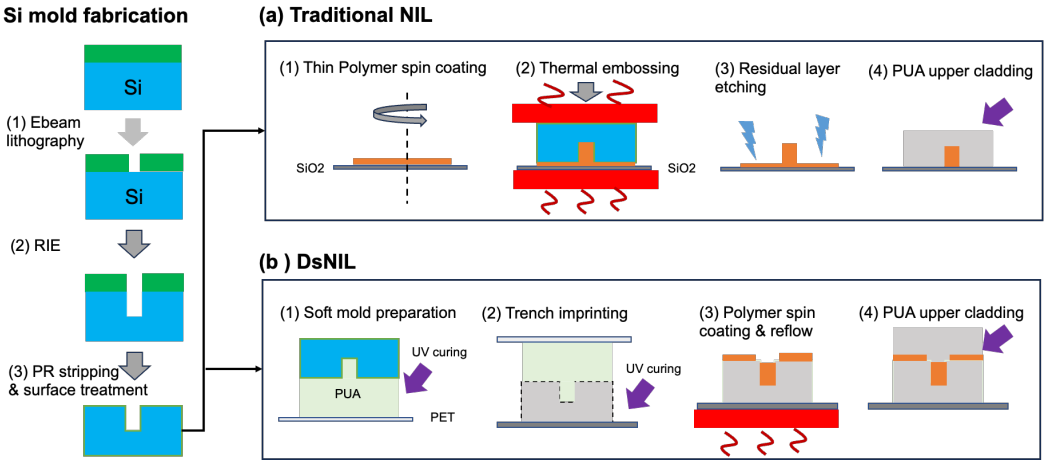

Figure 1: Fabrication process of (a) traditional NIL and (b) DsNIL.

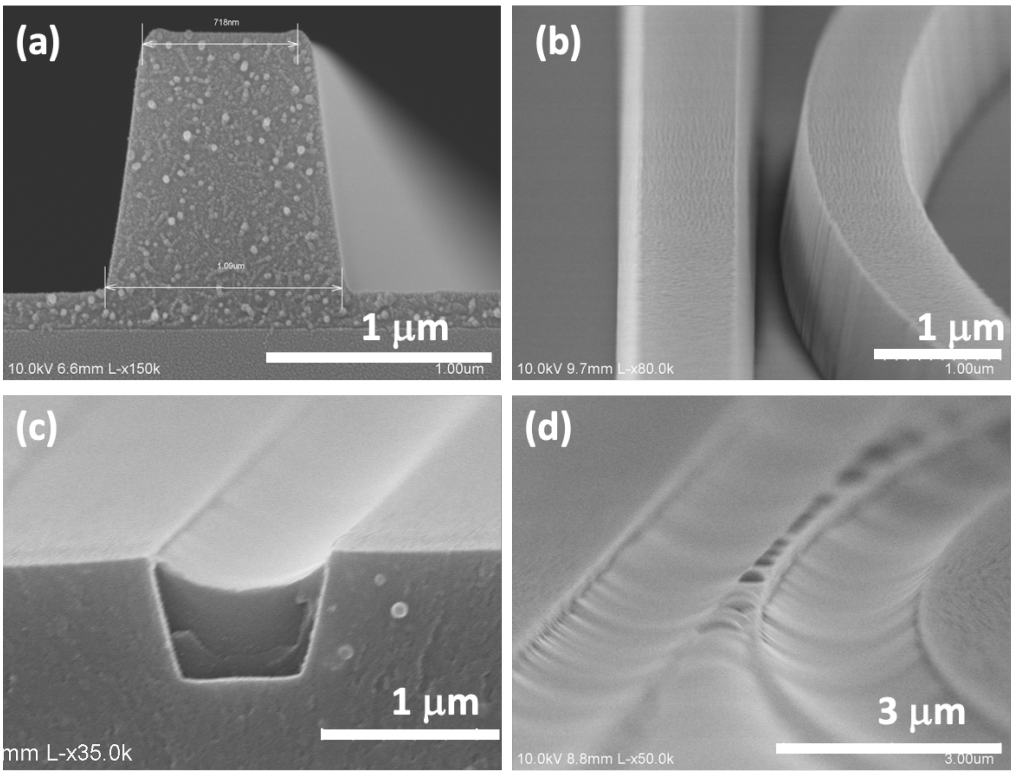

Figure 1: SEM images of cross-sectional and perspective views of the polymer microring resonators fabricated by (a-b) traditional NIL and (c-d) DsNIL.