Fabrication of Polymer Optical Waveguides using Imprint Technology and Roll Press Coating

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Co-packaged optics (CPO) is one of promising solutions for reducing power consumption in datacenters[1], and polymer optical waveguides realize power-effective links among optical components in the CPO[2]. Forming waveguides by imprint technology has advantages over lithography technology in terms of fabrication stability and simultaneous formation with 3D structure such as a mirror for optical coupler[3]. In this study, fabrication of polymer waveguides is demonstrated through two different processes using imprint technology.

In process A, shown in Fig. 1 (a), an under cladding polymer was firstly coated on a 4-inch silicon substrate. After a core material is coated over the under cladding layer, the core structure was formed by an imprint process. Finally, the over cladding was formed. In process B, shown in Fig. 1 (b), the grooves were firstly prepared by an imprint process on the under cladding layer and then the core material was coated over this prepared substrate. The residual core material was deprived by a roll process, and finally the over cladding was coated. The molds were made of dimethylpolysiloxane (PDMS). The mold load of imprint process was 14.1 kPa and 2.89 kPa in process A and B, respectively.

The cross-sectional views of waveguides fabricated by the process A and B are shown in Fig. 2 (a) and (b), respectively. Near-field patterns at a wavelength of 1310 nm are depicted in Fig. 2 (c) and (d), which correspond to Fig. 2 (a) and (b) respectively. The waveguide fabricated through the process A was attended by a residual layer of the core material with a thickness of more than 5 µm. Due to this residual layer, the beamwidth at the emitting edge is widen to 14.0 and 10.4 µm in the horizontal and the vertical direction, respectively. On the other hand, the waveguide fabricated through the process B has no sign of the residual layer; the beamwidth at the emitting edge was 8.3 and 5.4 µm in the horizontal and in the vertical direction, respectively. The obtained beam profile is compatible with the mode field diameter of the standard single mode fiber (SSMF) (9.2 µm), hence the process B is more suitable for fabricating polymer waveguides. In future works, the process condition will be optimized to match the beam profile of the waveguide to that of SSFM.

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[1] R. Stone *et al.*, European Conference on Optcal Communications, 9333175 (2020).
[2] T. Amano *et al*., Optical Fiber Communication Conference, Th4A.1 (2021)
[3] F. Nakamura *et al.*, Journal of Vacuum Science & Technology B vol. 40, no.6 (2022).

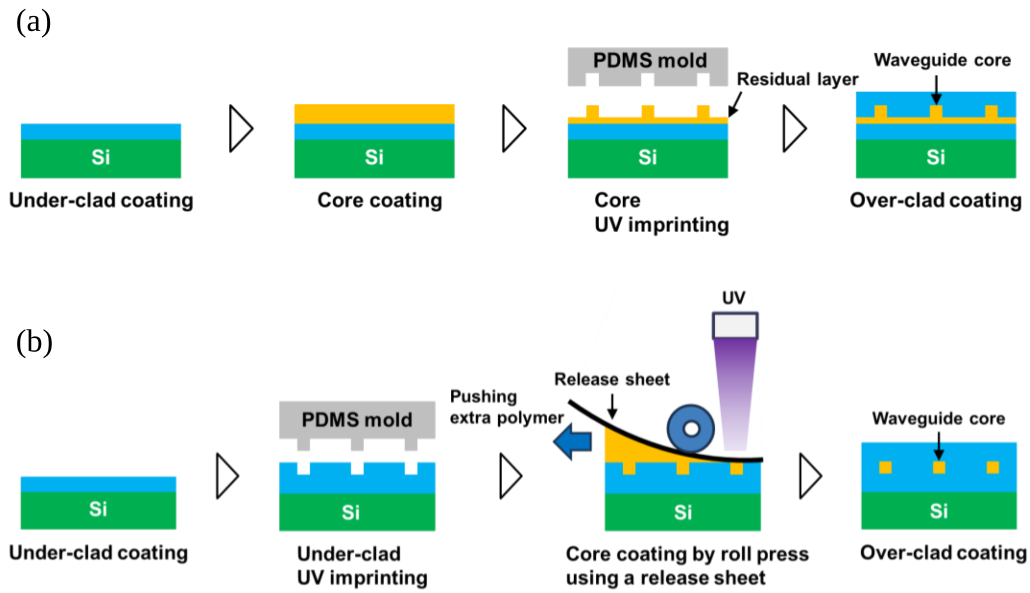

Figure 1: Process flow of optical polymer waveguide using imprint process
(a) core imprinting (process A), and
(b) under-clad imprinting and core coating by roll press (process B).

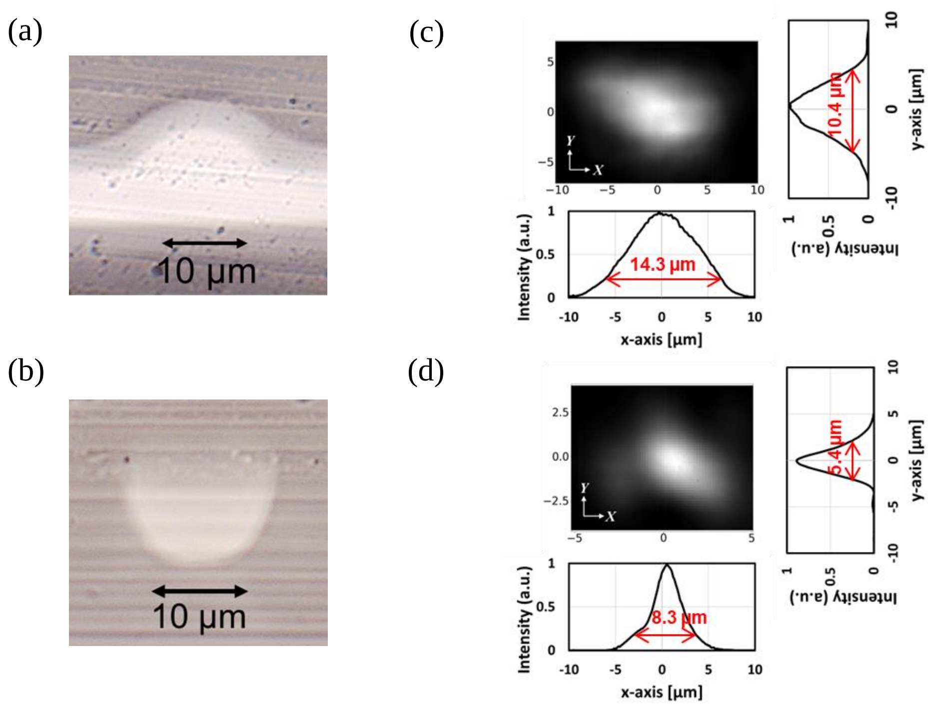

Figure 2: Results of fabricating polymer waveguides by imprint technology.
cross-sectional photo of waveguide fabricated (a) process A, (b) process B.
near-field pattern at the edge of waveguides (c) process A, (d) process B.