UV-Imprinted Single-Mode Polymer Waveguides for Optical Interconnections

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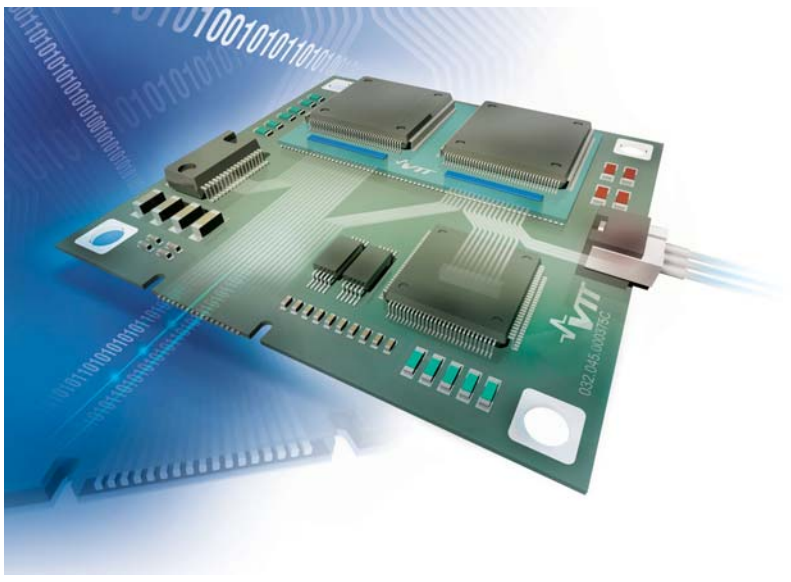


Target application

Polymer waveguides are fabricated for optical interconnection applications. Single-mode waveguides are especially attractive for:

- Interconnecting micro-photonic integrated circuit devices such as silicon photonics chips
- Coupling photonic devices to optical fibers.

Design and materials

Waveguides were made by the use of wafer-scale UV nano-imprinting process and ORMOCER® photocurable hybrid polymers. Imprint-based fabrication enables smooth waveguide side walls, thus resulting in low optical loss waveguides. OrmoClad was used as the cladding material, and OrmoCore as the core material. Refractive index difference between the core and cladding was about 1 %. Waveguides were optimized for operation at 1300-1600 nm wavelengths.

Fabrication

Process to make the inverted-rib waveguides is illustrated in the figure. The under cladding material is first deposited on top of a substrate, and it is imprinted to pattern the waveguide grooves. Obducat Eitre 6 nano-imprint tool was mostly used. In the next step, the grooves are filled by spin-coating the core layer. The final step is deposition of the top cladding layer.

Stamp fabrication

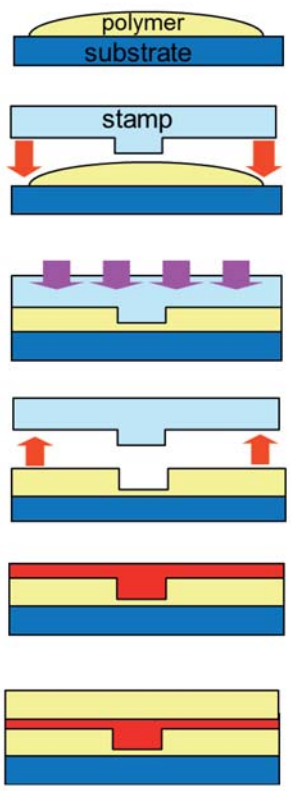
Imprinting stamp was mastered by UV lithographic patterning of a photoresist layer. To form the stamp wafer, the photoresist pattern was then transferred by UV imprinting to an Ormocer layer on a glass wafer.

Optical performance

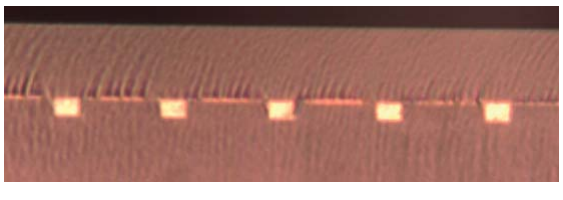
Optical attenuation characterized by measuring the optical power losses when propagating through 27 cm-long waveguide spirals or shorter reference waveguides

Wavelength	1305 nm	1530 nm
Measured Attenuation	0.35 dB/cm	0.84-0.89 dB/cm
Material Attenuation (from data sheet)	0.23 dB/cm	ca 0.7 dB/cm
Waveguide Attenuation	0.12 dB/cm	0.14-0.19 dB/cm

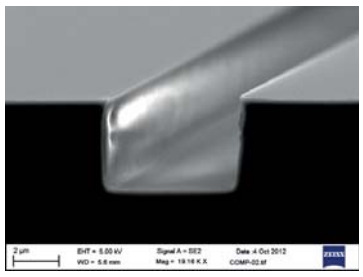
Process steps to make inverted-rib waveguides



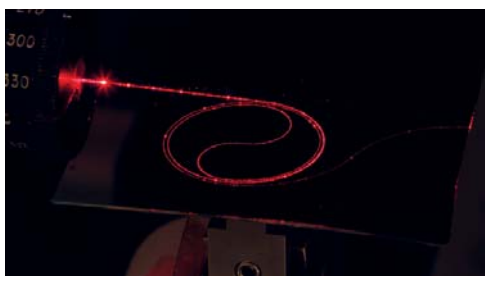
1. Under cladding material deposition
2. Imprinting with stamp
3. UV curing
4. Stamp release
5. Core material deposition & curing
6. Top cladding deposition & curing



Cross-section of an array of five parallel optical waveguides. Waveguide width 6 µm and height 4 µm



SEM picture of imprinted waveguide trench



Red light travelling in a 27-cm long spiral waveguide (note: waveguide is designed for 1550 nm, thus it is not single-mode and optimal at 633 nm)

Acknowledgements

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