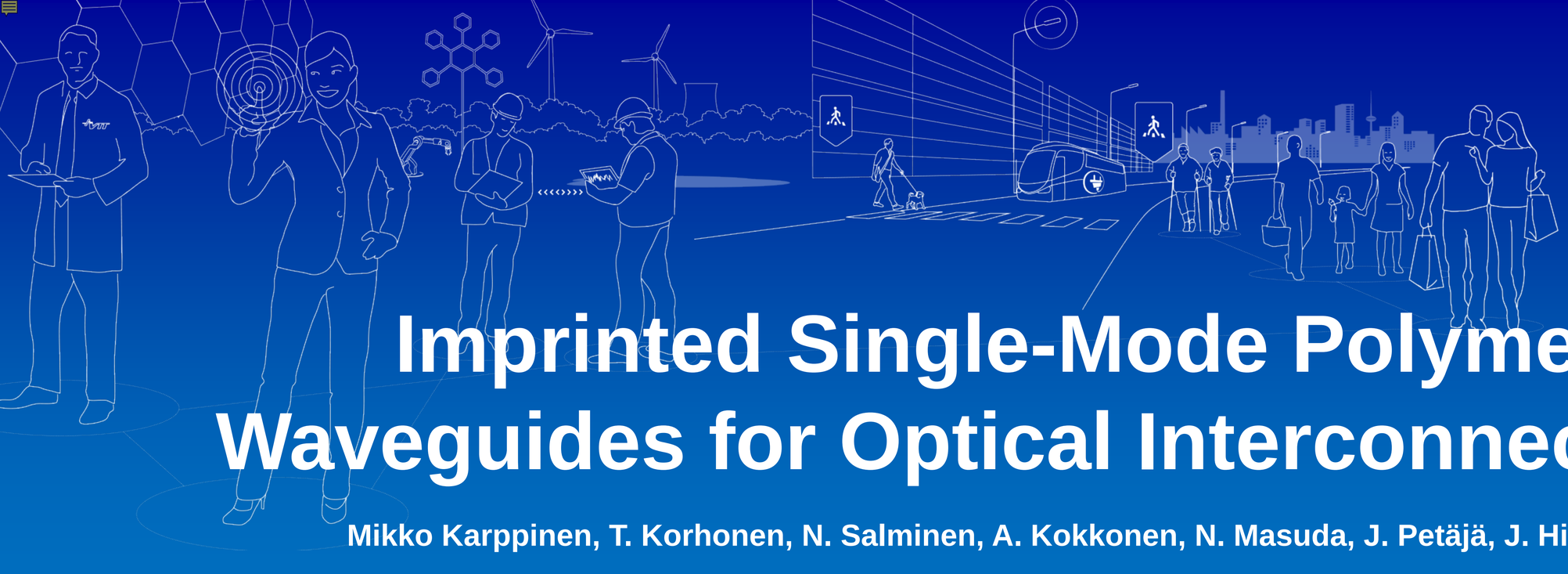

Imprinted Single-Mode Polymer Waveguides for Optical Interconnections

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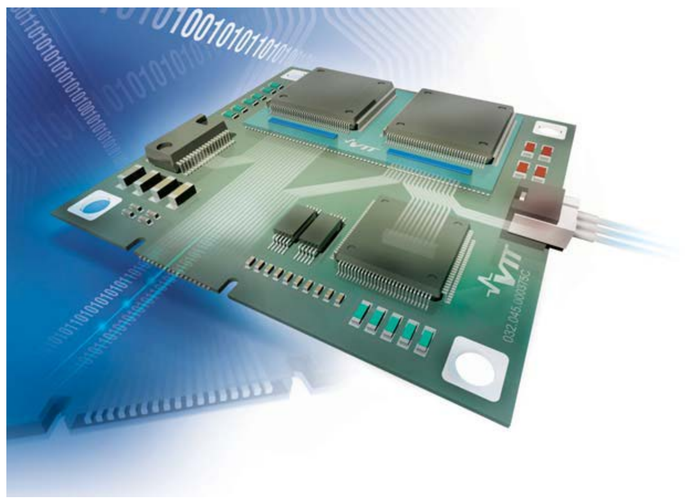
TECHNOLOGY FOR BUSINESS



Target applications

Polymer waveguides are fabricated for optical interconnection applications.

Single-mode waveguides are especially attractive for:

- Intra-package interconnects: e.g. communication between photonic integrated circuit chips (such as, silicon photonic chips)
- Out-of-package/board interconnects: as coupling media between photonic devices and optical fibers

Fabrication

Waveguides are made by direct-pattern UV nano-imprinting based processes, which enable:

- Smooth waveguide side walls, resulting in low loss waveguides
- Use of various substrate materials
- Embedding of optical coupling structures
- Stacking of waveguide layers (i.e. multilayers), with high precision overlay alignment (ca 1 µm accuracy)

Wafer-scale nanoimprinting tool (Obducat Eitre 6) based on air pressure technology was mostly used, resulting in good yield over the full wafer.

Design and materials

Waveguides were made of ORMOCER™ photocurable hybrid polymers. OrmoClad was used as the cladding material, and OrmoCore in the waveguide cores. Refractive index contrast between the core and cladding was 0.6–1.0 % in waveguides optimized for operation at 1300–1600 nm wavelengths.

Both rib and inverted-rib type waveguides are made (see figure).

Stamp fabrication

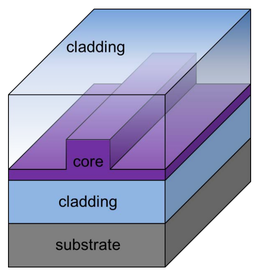
Imprinting stamps were mastered by UV lithographic patterning of a photoresist layer. To form the stamp wafer, the photoresist pattern is then transferred by UV imprinting to an Ormocer layer on a glass wafer.

Optical performance

Optical attenuation was characterized by measuring the optical losses when propagating through long waveguide spirals.

Wavelength	1305 nm	1530 nm
Measured **Total 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

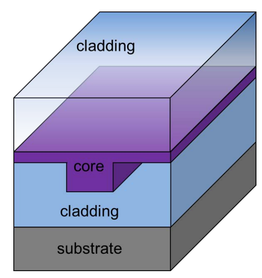
Waveguide structures made by imprint-based process:



Ridge/Rib waveguide

- *Guiding strip is superimposed onto a slab layer*

(*Core layer patterned by imprint*)

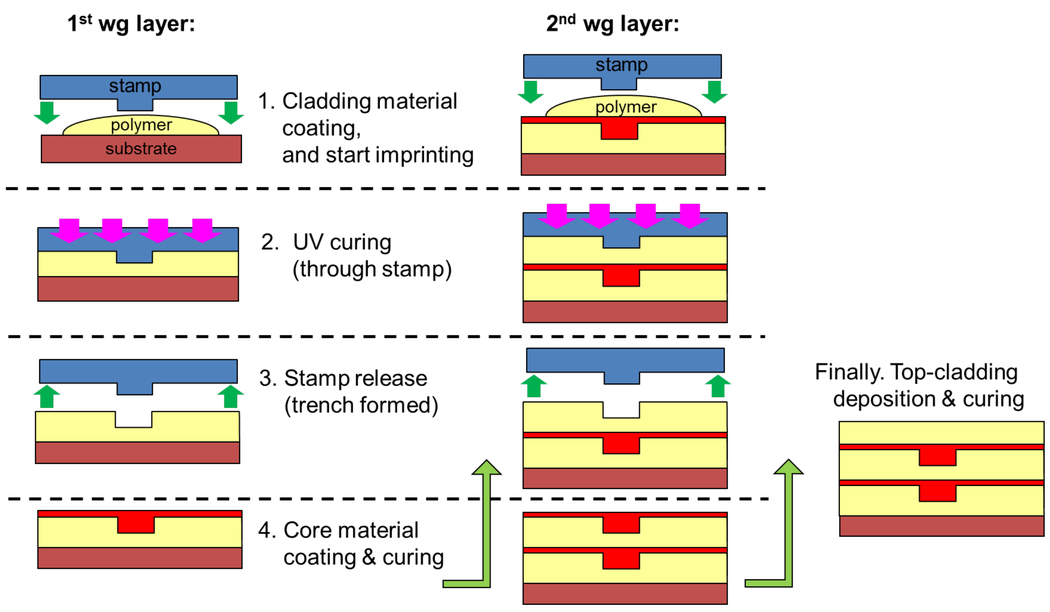


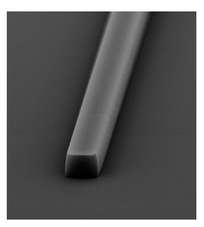
Inverted-Rib waveguide

- *Slab layer is on top of the guiding strip*

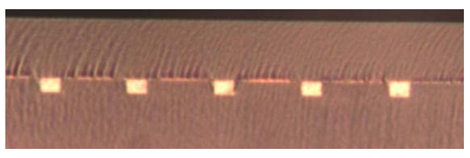
(*Under cladding patterned by imprint*)

Process steps to make multilayer inverted-rib waveguides:





SEM of ridge waveguide with imprinted end face



Cross-section of 5 parallel waveguides
(core dimensions 5.5 x 4.5 µm; slab thickness <0.5 µm)

Cross-section of two stacked layers of parallel waveguides

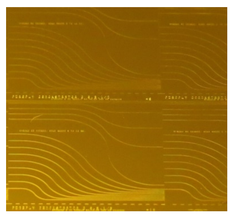
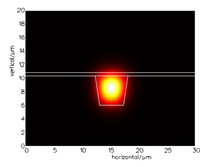
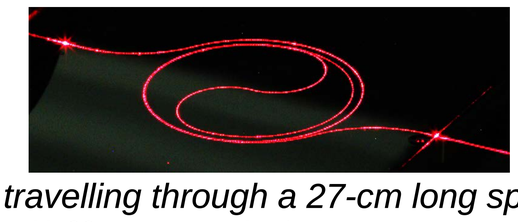


Photo showing part of a waveguide circuit wafer



Simulated TE mode profile, showing single-mode operation



Red light travelling through a 27-cm long spiral waveguide
(Photo taken with 20 s exposure time)

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