Fraunhofer IISB

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LEB

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Large area fabrication of hybrid polymer waveguides for planar Bragg grating sensors using UV-enhanced Substrate Conformal Imprint Lithography (UV-SCIL)

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Introduction

Optical sensor devices have gained a lot of interest in the past few years, especially microstructures for applications like lab-on-a-chip systems [1]. High accuracy and wafer scale patterning of optical structures as well as suitable materials are key issues to provide the production of low cost but high quality devices. This work presents a new approach to produce planar Bragg grating devices using printable hybrid polymers (ORMOCER®s) as waveguiding material. The refractive index of these materials is locally modified via excimer laser radiation and, thus, a planar Bragg grating can be written into the waveguides. For the first time, UV-enhanced Substrate Conformal Imprint Lithography (UV-SCIL) [2] as a cost-effective and wafer-scale structuring technique was used to pattern waveguides using ORMOCER®s.

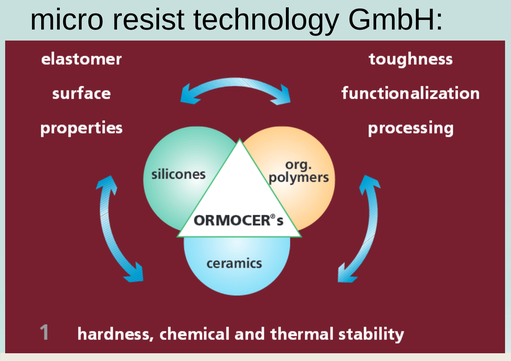
Material

- Investigated hybrid polymers from micro resist technology GmbH:

OrmoComp®; → n = 1.505

OrmoStamp® → n = 1.485

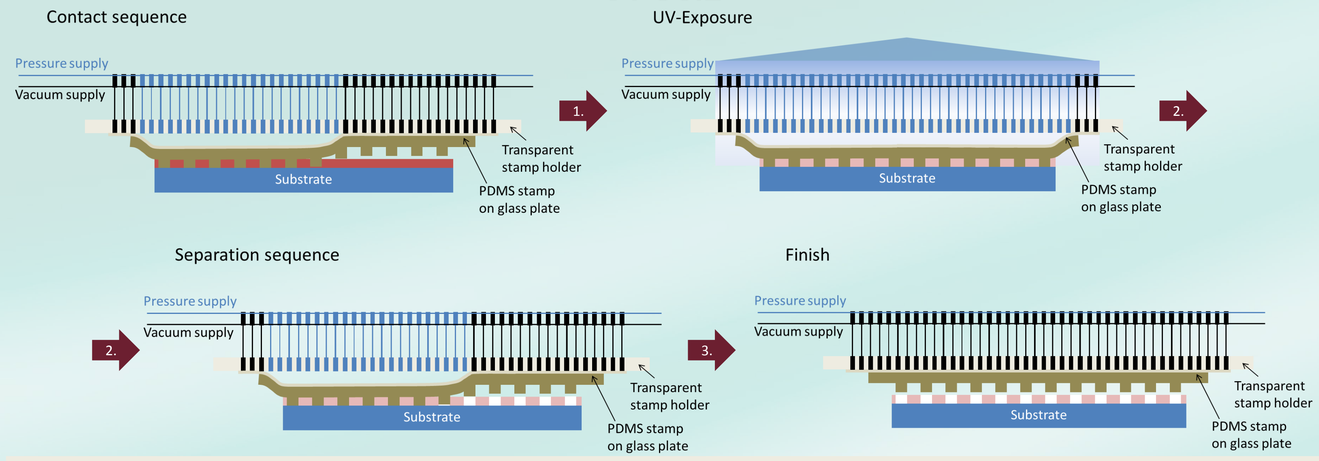
@ λ = 1510 nm (25°C)



Chemical constituents of ORMOCER®s and their properties

- UV-curable imprint polymers
- Combination of advantages of organic and inorganic components
- Viscosity allows high layer thicknesses (up to 60 µm verified)

UV-SCIL



Scheme of the UV-SCIL-process

Waveguide patterning

MA/BA8 and SCIL tool at Fraunhofer IISB

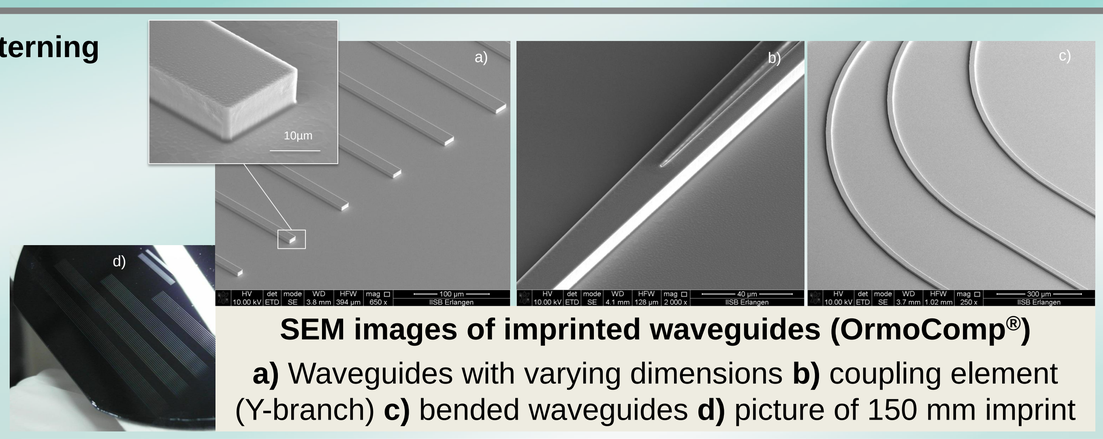
- Wafer preparation:

Material	**OrmoComp®**	**OrmoStamp®**
Layer thickness	10 µm to 15 µm	10 µm
Spin speed (90sec)	5000 rpm to 3000 rpm	3000 rpm
Softbake	2 min at 90°C	2 min at 90°C

- Imprint performance: SCIL tool on a MA/BA8 mask aligner from SUSS MicroTec (UV lamp power: 37 mW/cm² at 365 nm)

Exposure time	120 sec	180 sec

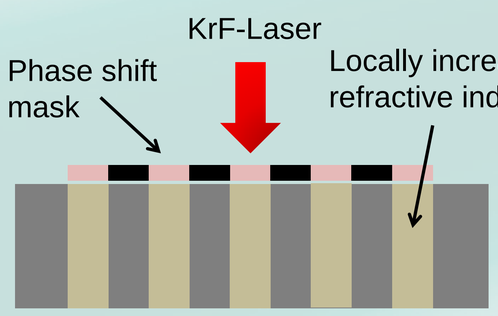
- Process development: → reduction of residual layer thickness
  → reduction of air bubbles
  → optimization of imprinted area (for 100 mm and 200 mm wafers)



SEM images of imprinted waveguides (OrmoComp®)

a) Waveguides with varying dimensions **b)** coupling element (Y-branch) **c)** bended waveguides **d)** picture of 150 mm imprint

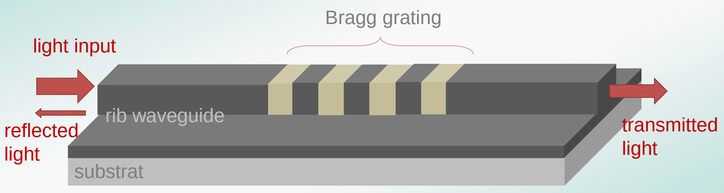
→ Full wafer-scale imprint (100 mm) of different waveguide structures using hybrid polymers from micro resist technology
→ OrmoComp®, OrmoStamp® successfully applied as resists for UV-SCIL



Process data:

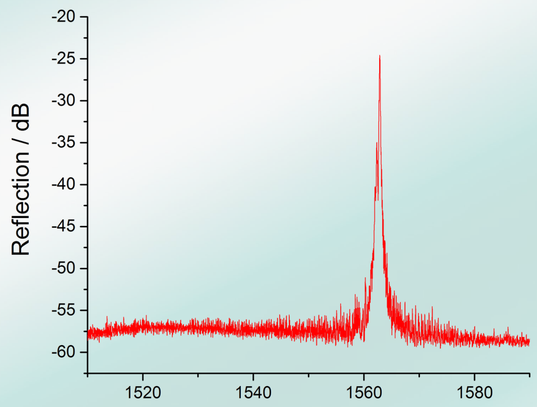
Wavelength: 248 nm (KrF)
Fluence: 16000 mJ/cm²
Frequency: 100 Hz
Mask Pitch: 1036 nm

Scheme of writing process for planar Bragg grating into OrmoComp® waveguide



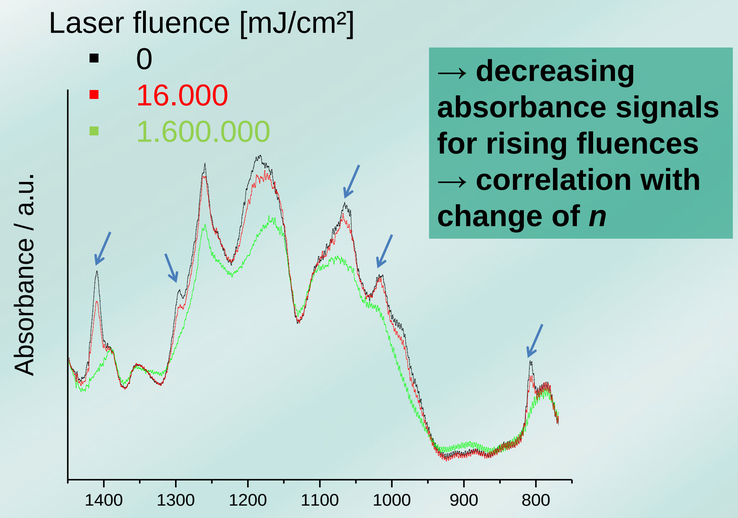
Scheme of a processed planar Bragg grating

Planar Bragg grating (PBG)



Optical characterization of planar Bragg grating in OrmoComp® waveguide

→ Reflected signal proofs the presence of a Bragg grating written into the waveguide



→ decreasing absorbance signals for rising fluences → correlation with change of *n*

FTIR Measurements of planar OrmoComp® layers irradiated with different laser fluences

Conclusions

In conclusion, this work presents a proof-of-concept to produce planar Bragg grating sensors using:

- UV-SCIL as structuring technique for hybrid polymers
- Hybrid polymers as both, imprint resist and waveguide material for planar Bragg grating devices
- Laser induced modification of the refractive index of hybrid polymers

In addition, first promising investigations on the connection between modified refractive index and change of chemical composition of the hybrid polymers

References

[1] S. Balslev , A. M. Jorgensen , B. Bielenberg , K. Mogensen , D. Snakenborg , O. Geschke , J. Kutter, A. Kristensen, Lab Chip 6, 213-217 (2006)

[2] M.A. Verschuuren, Substrate conformal imprint lithography for nanophotonics, PhD thesis, Utrecht University, 2010.

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