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Integrated Hybrid GRIN Lenses

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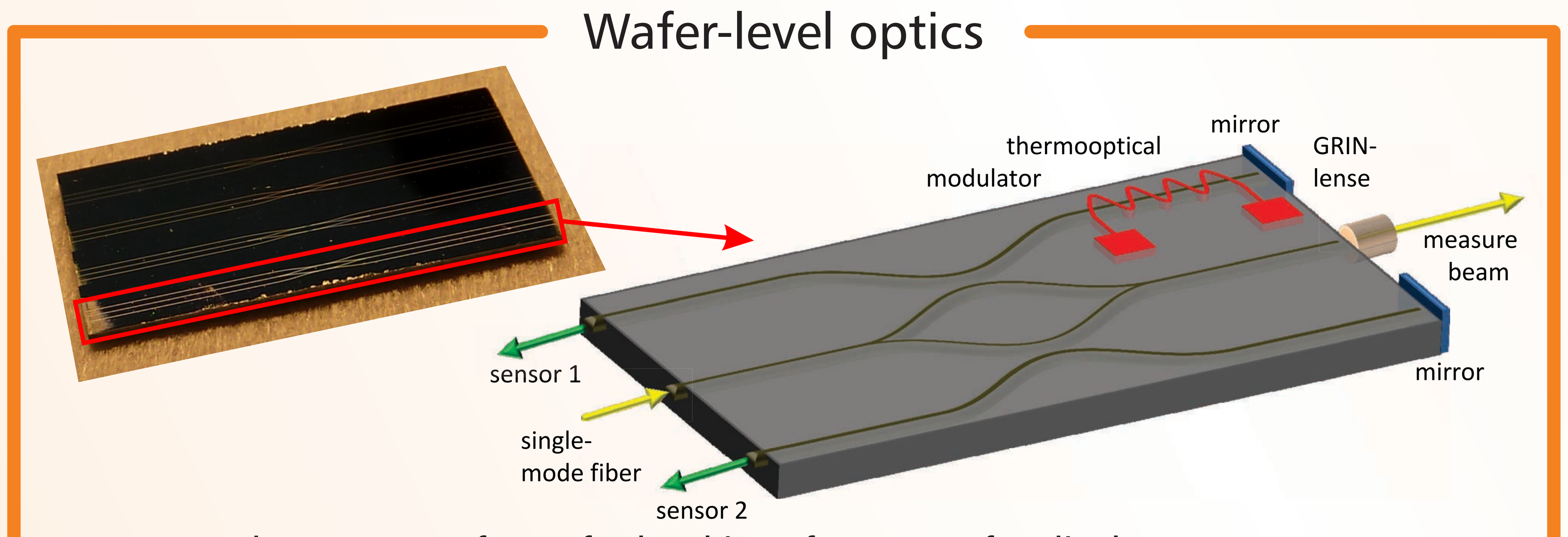
Wafer-level optics



Concept and prototype of a wafer-level interferometer for displacement measurements

Advantages
- low cost by mass production (semiconductor technologies)
- high reliability
- high precision in geometric dimensions and positions (defined by lithography mask)
- can be combined with integrated photonic elements on the same substrate
- high refractive index range

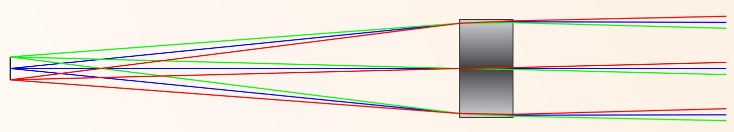
Exemplary applications
- efficient coupling structures between integrated optics and free space
- beam shaping for integrated laser diodes

Challenges
- 2D structuring for 3D functionality
- High transmittance

Design

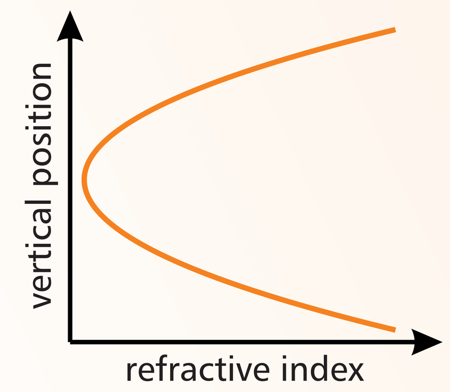
Design Principle: Independent wavefront control in two perpendicular directions

Direction 1: Perpendicular to the substrate

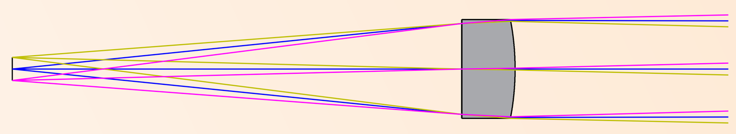


- GRIN element, variation of the refractive index during the layer deposition process
- Description of the refractive index profile:

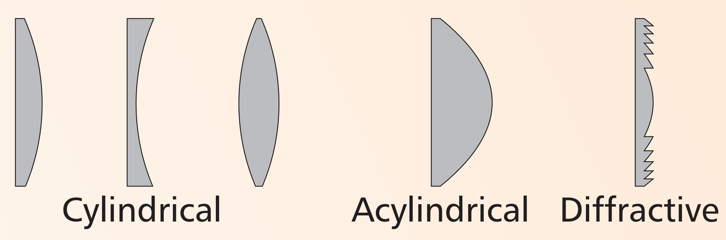
$$n(y) = n_0 + n_1|y| + n_2|y|^2 + n_3|y|^3 + \ldots$$



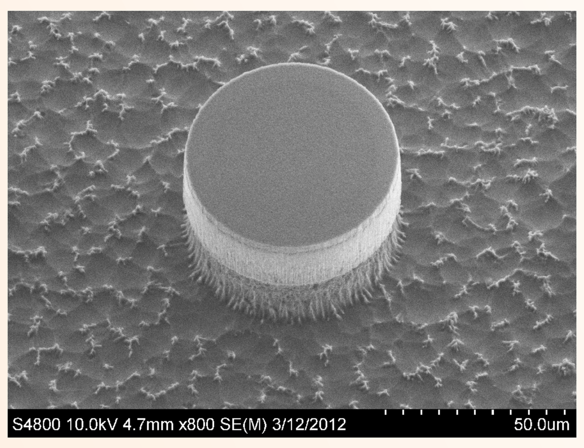
Direction 2: Parallel to the substrate

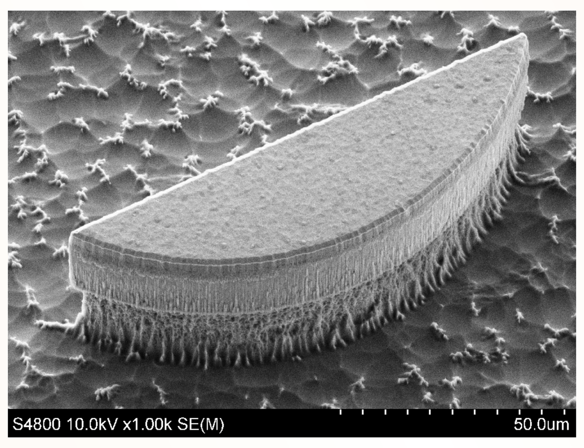


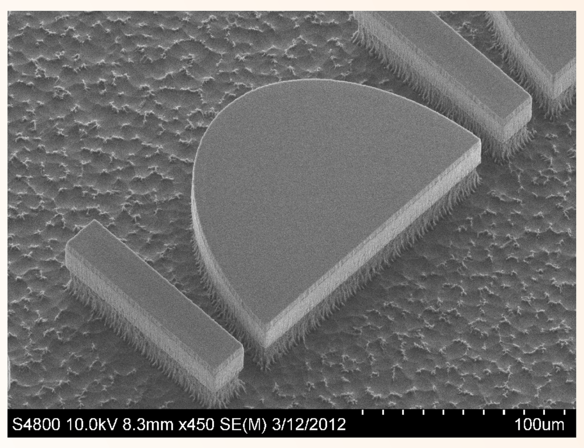
- Etching process with perpendicular, optical quality side walls
- Element shape determined by 2D-profile of the lithographic mask

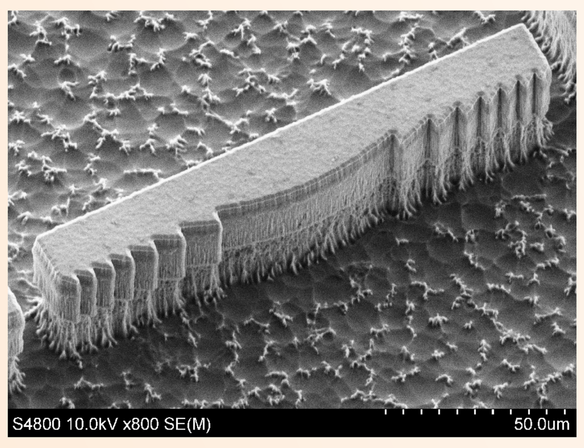


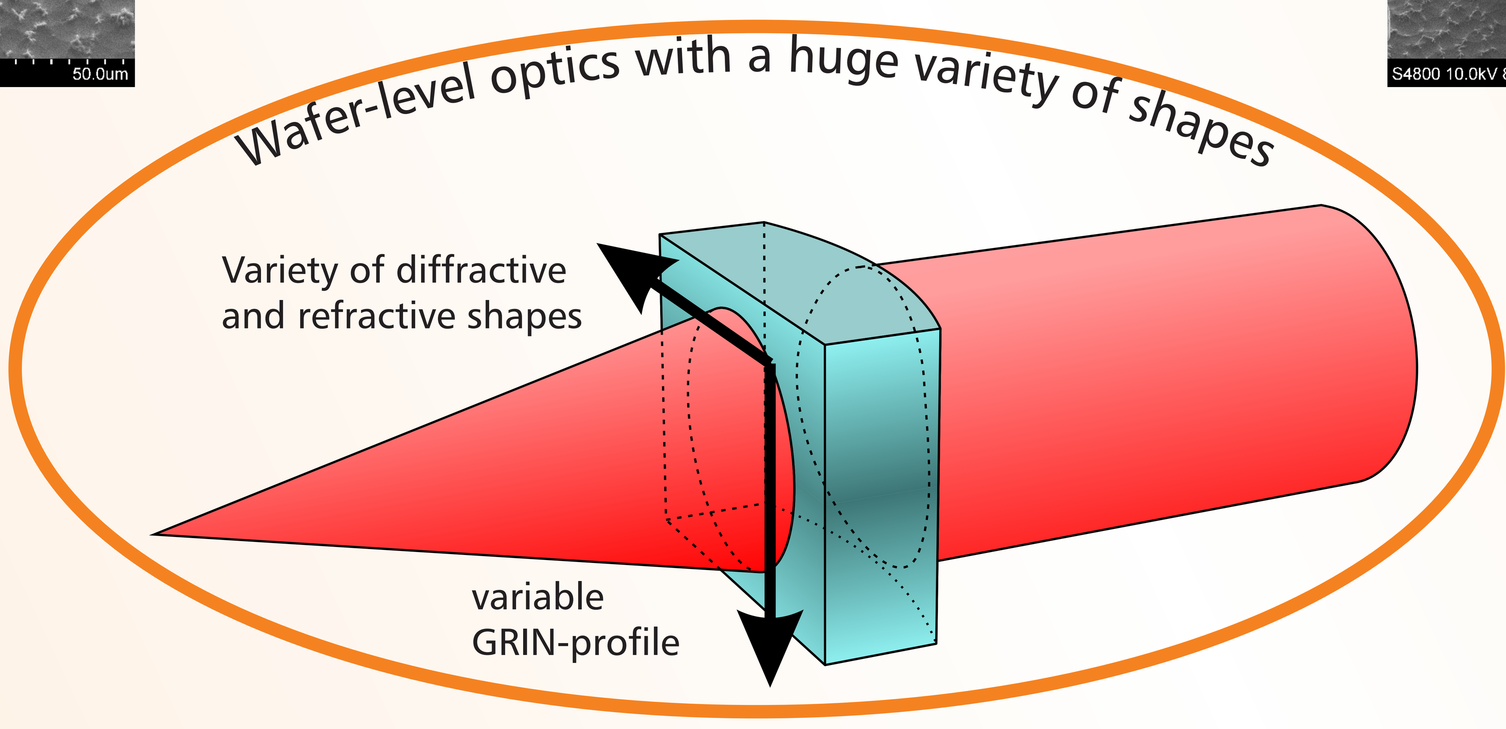
Design process
- Raytracing-based optimisation
- Simultaneous variaton of the refractive or diffractive shape and the GRIN-profile
- Merit function based on the wavefront aberration of the output beam

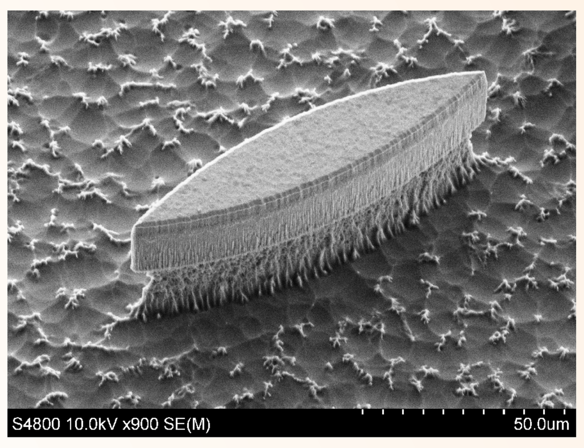






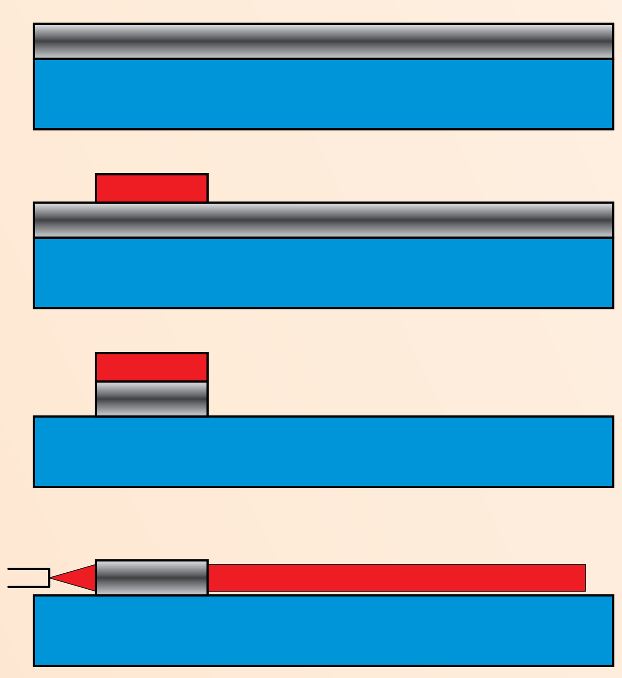




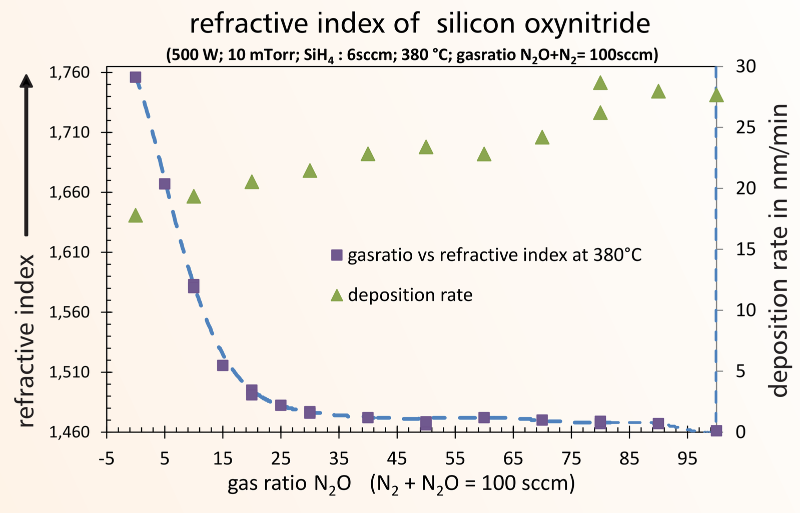


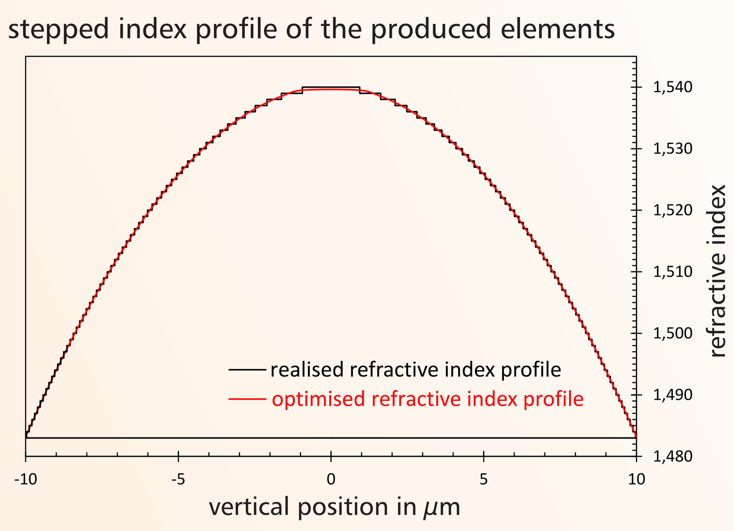
Technology and experimental results

Fabrication using semiconductor technologies

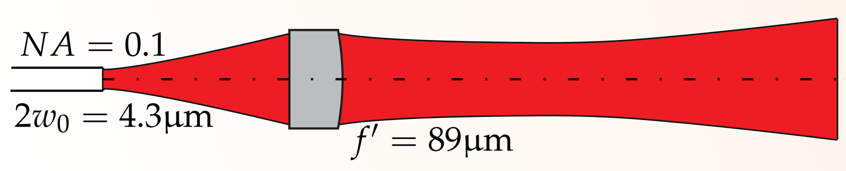


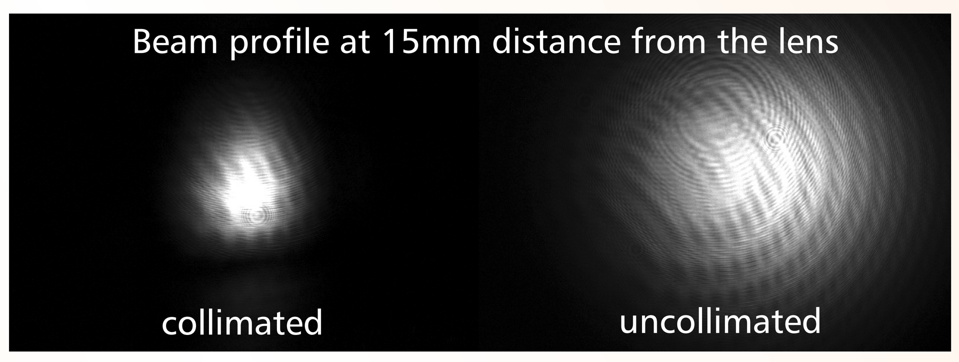
Achievable parameters
- Maximum height of the structures dependent on deposition time; structures with 30μm GRIN layer height realized
- Realized minimum feature size: 2 μm (DOE period)
- Possible refractive index range: 1,47-1,85

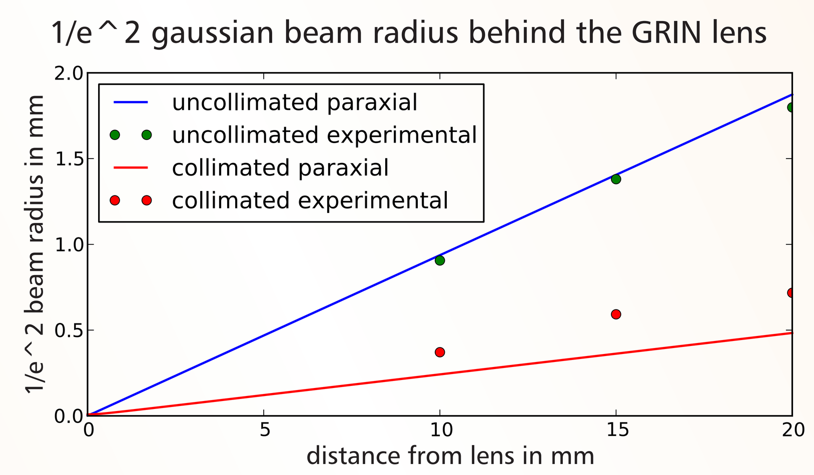




Experimental setup for laser beam collimation







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