Integrated Hybrid GRIN Lenses

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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
- Beam shaping for integrated laser diodes
- Efficient coupling structures between integrated optics and free space
- High transmittance

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

Technology and experimental results

Fabrication using semiconductor technologies
- Deposition of a LPCVD film (SiO2/SiON)
- Electro-patterning of nickel structured by UV-lithography
- Fluorine-based ICP RIE deep etching
- Separation and testing of the optical elements

Achievable parameters
- Maximum height of the structures dependent on deposition time; structures with 50um GRIN layer height realized
- Realized minimum feature size: 2µm (DOE period)
- Possible refractive index range: 1.47-1.85

Achievable parameters
- Possible refractive index profile: $n(y) = n_0 + n_1|y| + n_2|y|^2 + n_3|y|^3 + \ldots$
- Realized minimum feature size: 2µm (DOE period)

Experimental setup for laser beam collimation

Beam profile at 15mm distance from the lens

Collimated

Uncollimated

1/e² 2 gaussian beam radius behind the GRIN lens

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: $n(y) = n_0 + n_1|y| + n_2|y|^2 + n_3|y|^3 + \ldots$
- Element shape determined by 2D-profile of the lithographic mask

Direction 2: Parallel to the substrate
- Etching process with perpendicular, optical quality side walls

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

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References


Wafer-level optics

Wafer-level optics with a huge variety of shapes

Variety of diffractive and refractive shapes

variable GRIN-profile

References


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