

2 OCTOBER
2023



Micro-Optics for Medtech and Life Science

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Company History

SUSS MicroOptics SA

- Founded 1998
- Part of the SUSS MicroTec Group
- Refractive micro-optics
- Diffractive micro-optics
- Worldwide client base in data/telecom, metrology, semiconductor, instruments and life science

Neuchâtel, Switzerland



> 20 Years
of Micro-Optics FAB Experience



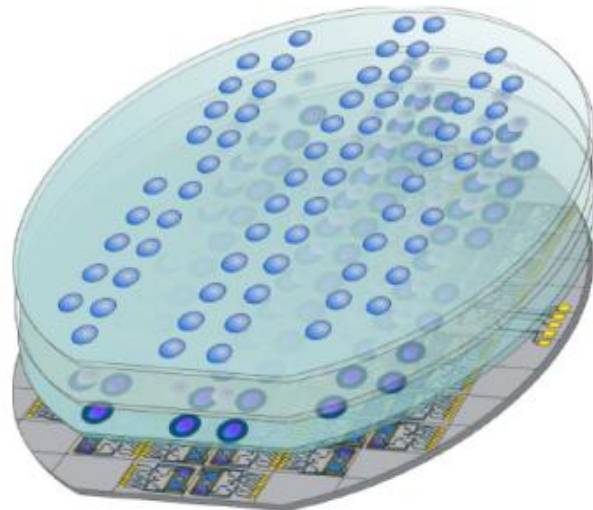
8" (200mm) Wafer Cleanroom Fab & Imprint Lithography Production

SUSS – Equipment and Micro-Optics



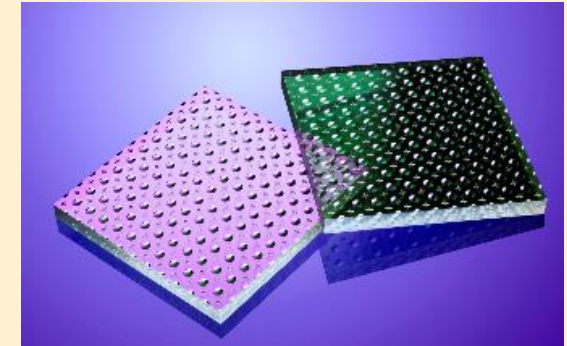
SUSS MicroTec SE (SMT)

- Global company (~260 M€ revenue, >1150 people)
- Lithography tools
- Wafer-level processing machines



SUSS MicroOptics SA

- Swiss company (>160 people), part of the SMT Group
- Micro-Optics chips & wafers
- Wafer-level processes & optics

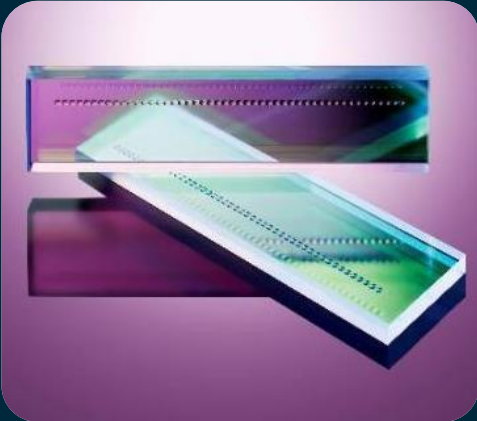


Products and Markets

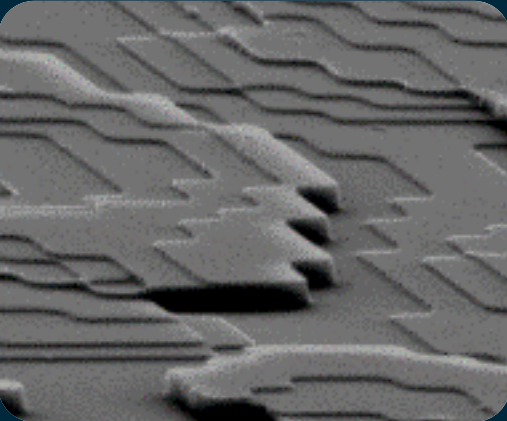
■ AUTOMOTIVE



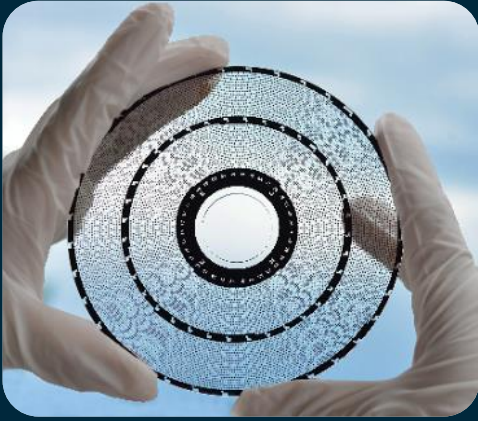
■ TELE/DATACOM



■ SEMICONDUCTOR



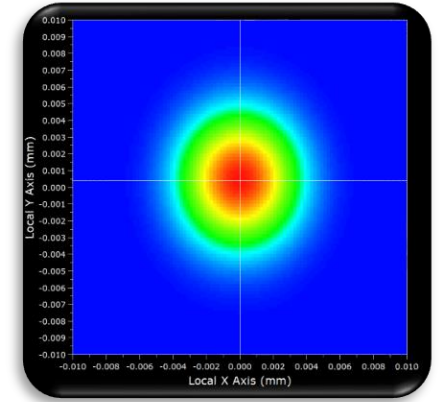
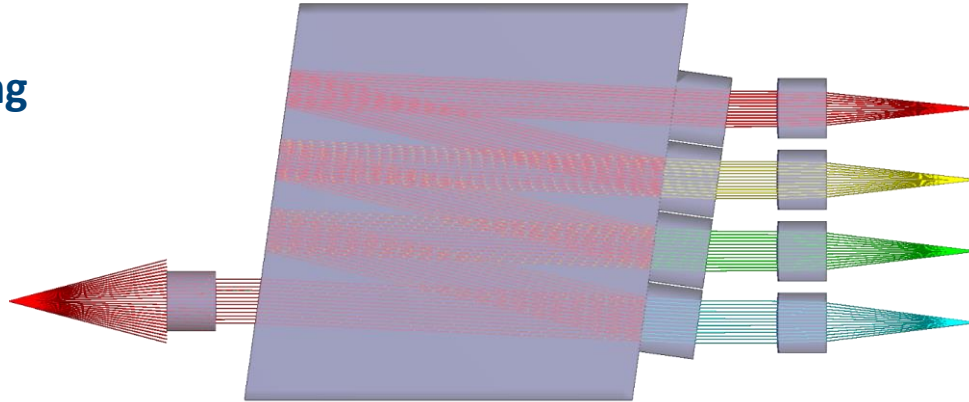
■ MEDICAL



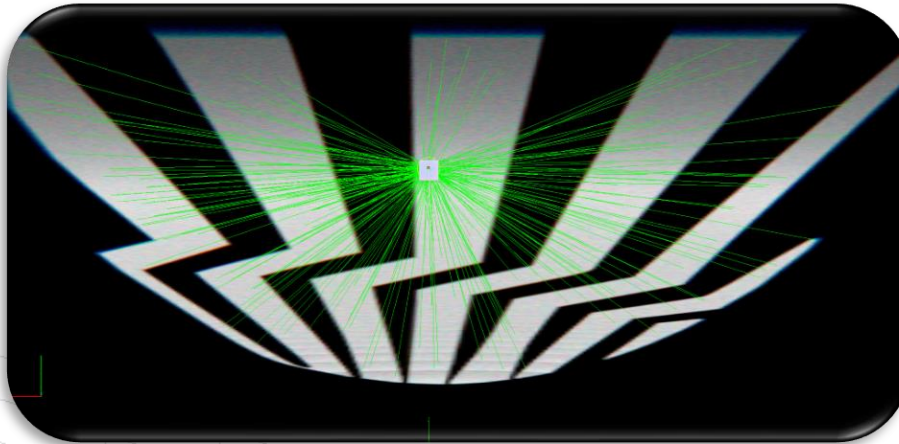
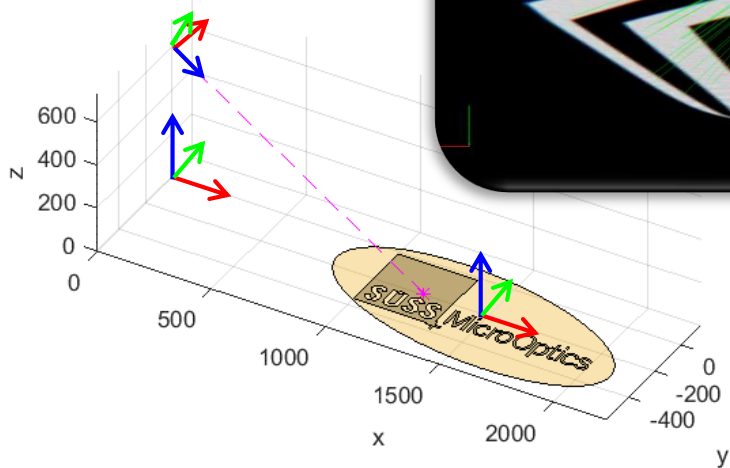
Optical Design Capabilities

- Ray tracing with massive parallel computing
- Billions of rays in minutes
- Physical optics & diffractive optics
- Tolerance simulations

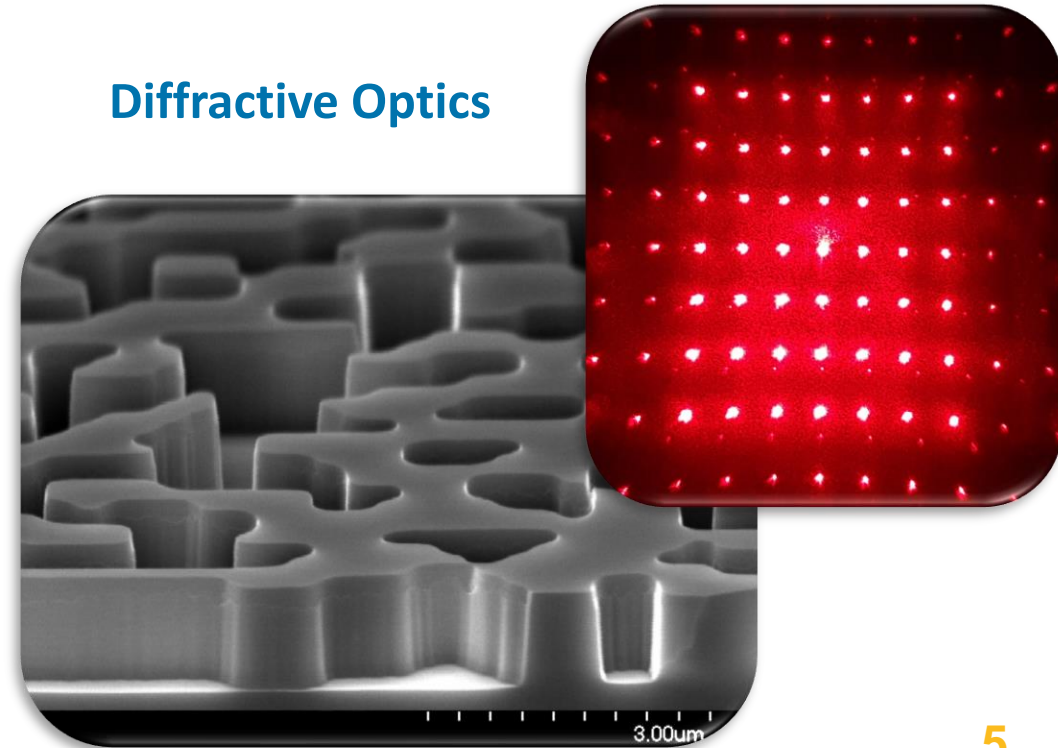
Fiber optics



Illumination

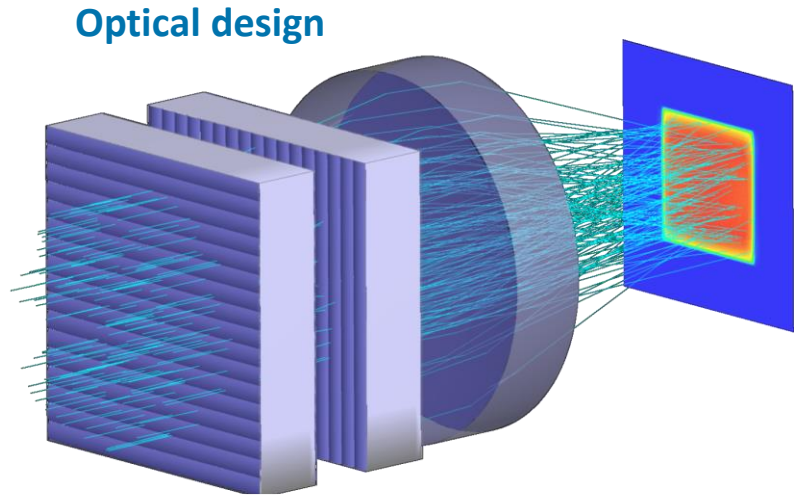
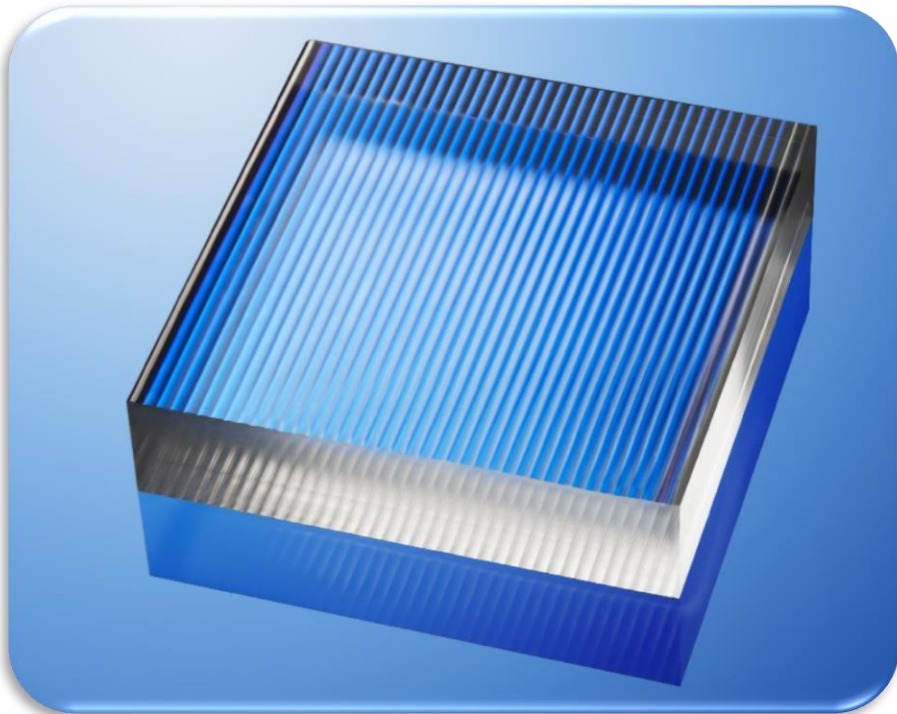


Diffractive Optics

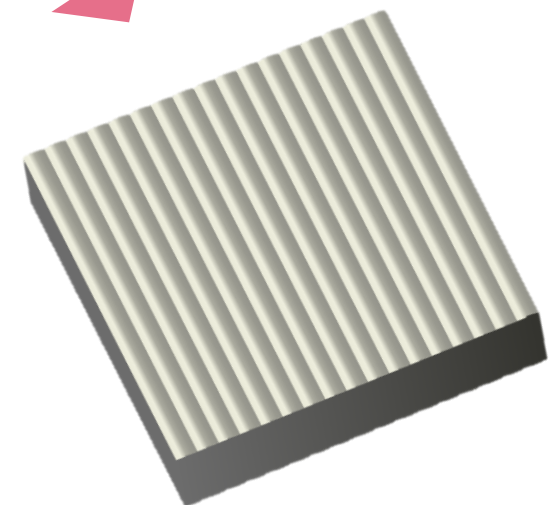


From Design to Product – Etched

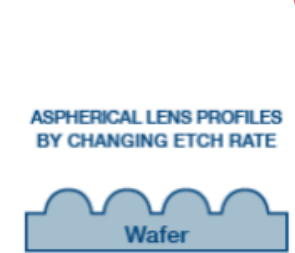
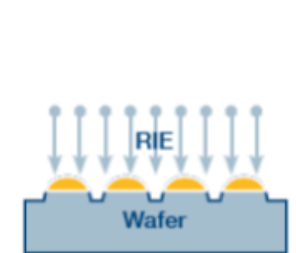
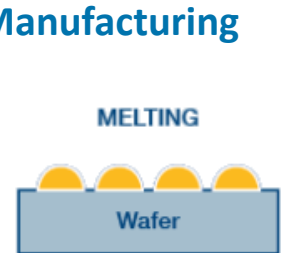
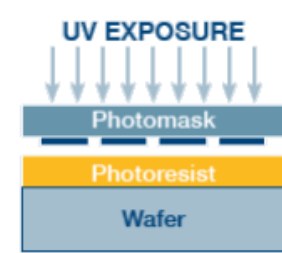
Flat Top – Cylindrical Lenses



CAD output

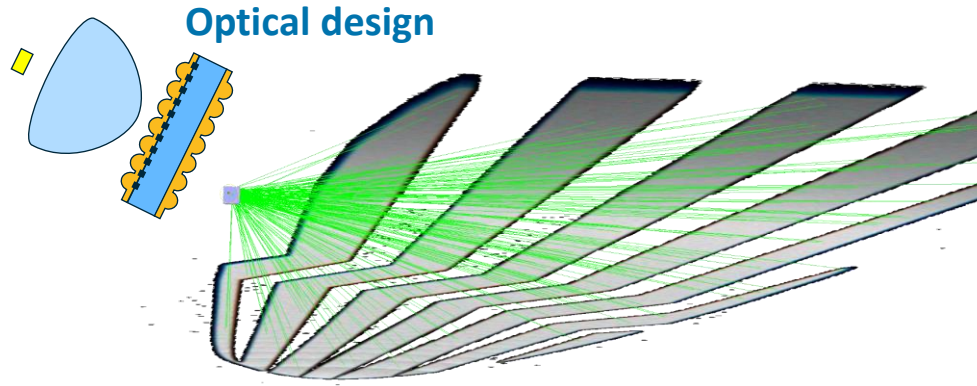
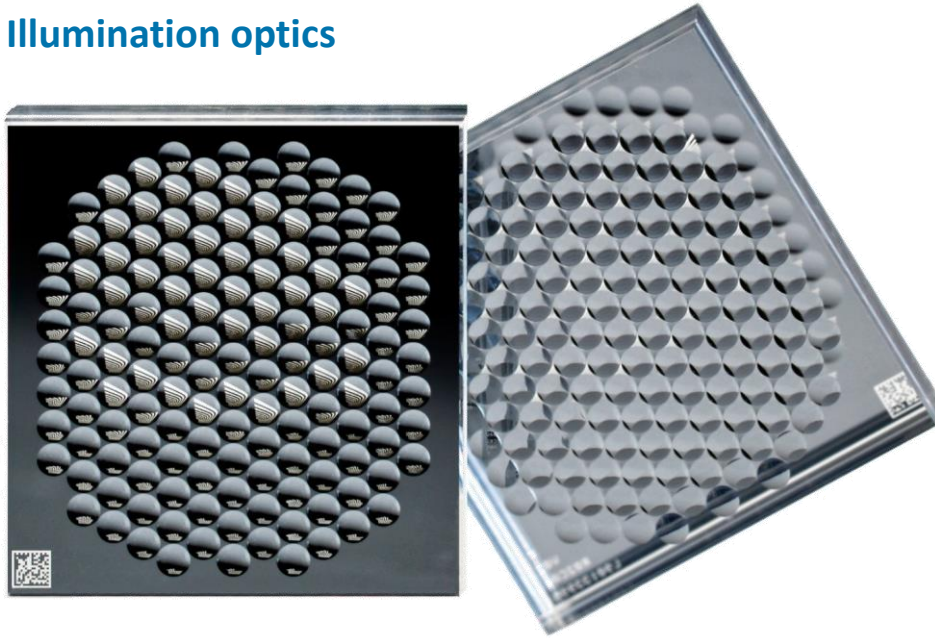


- Ray tracing and physical optics
- Tolerance simulations
- CAD Design
- Manufacturing constrains in design flow

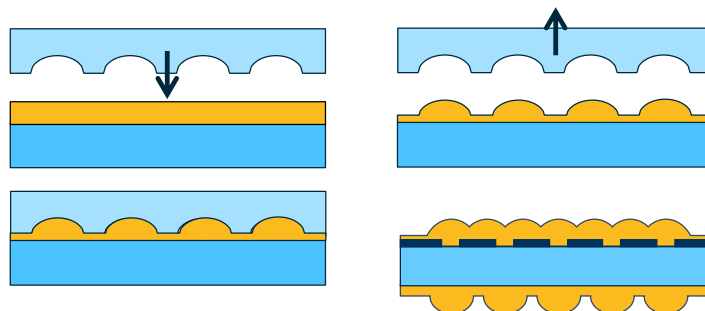


From Design to Product - Imprint

Illumination optics



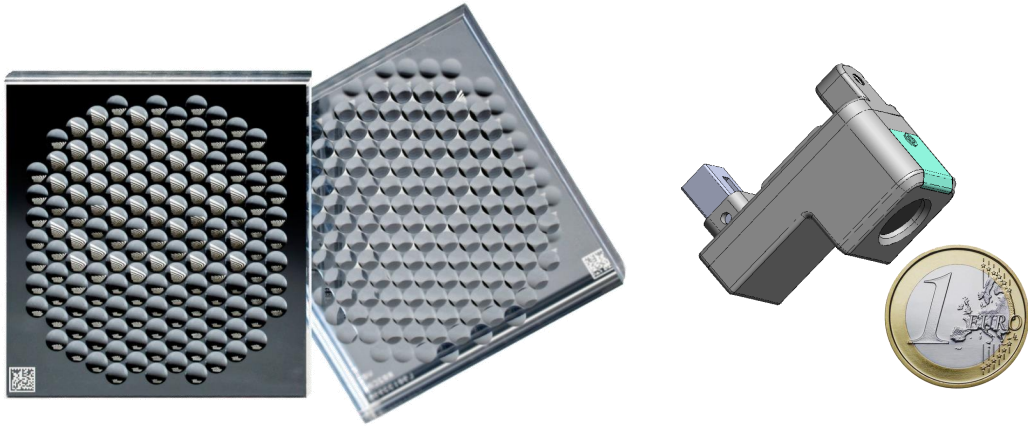
- Processing target design of client
- In-house algorithms & ray tracing
- CAD Design
- Manufacturing constrains in design flow



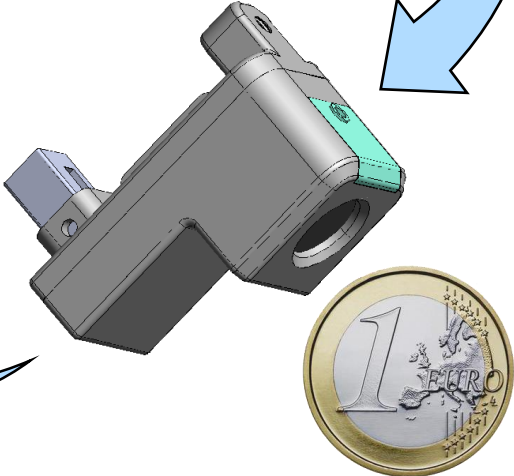
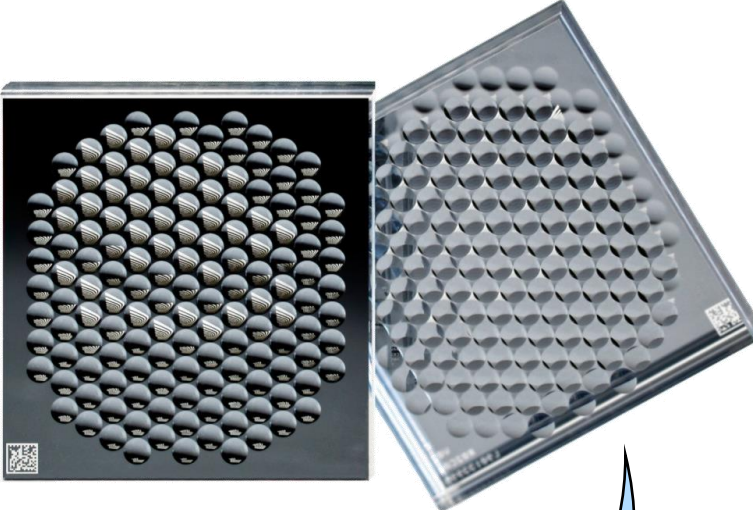
Manufacturing
Polymer-on-glass imprint



Automotive Lighting - Ultra-Compact Microprojectors And Headlamps

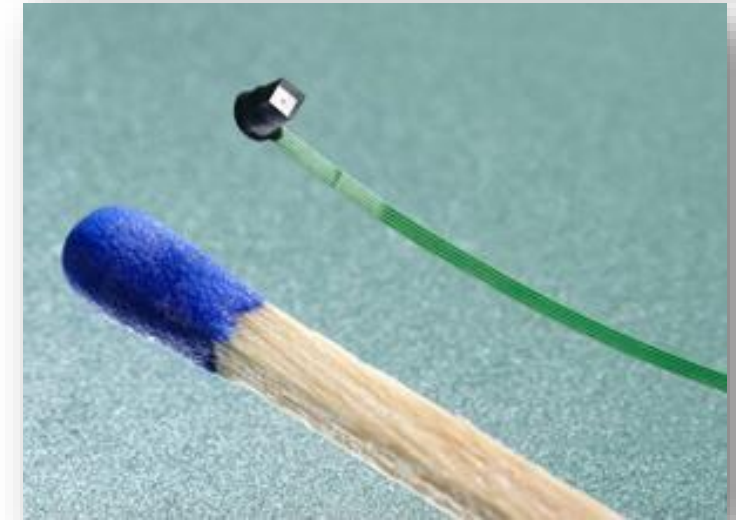
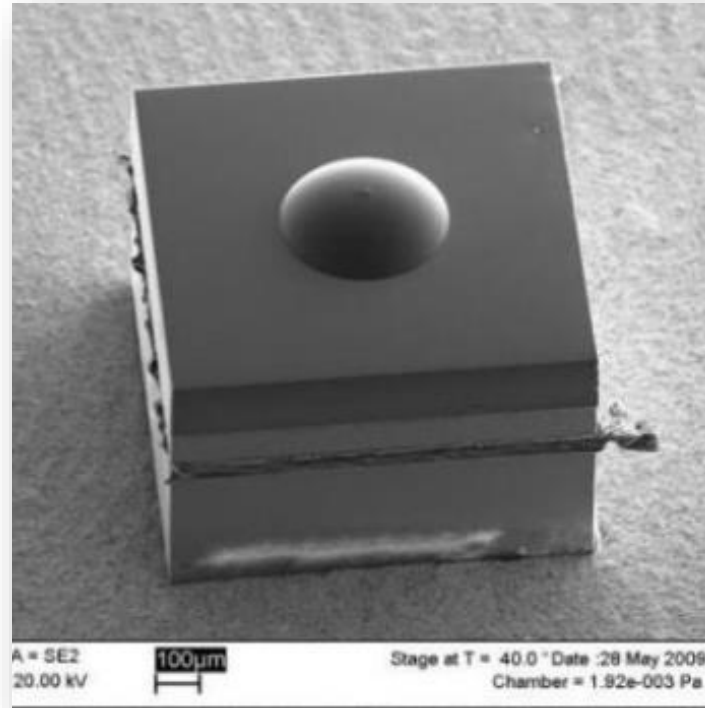
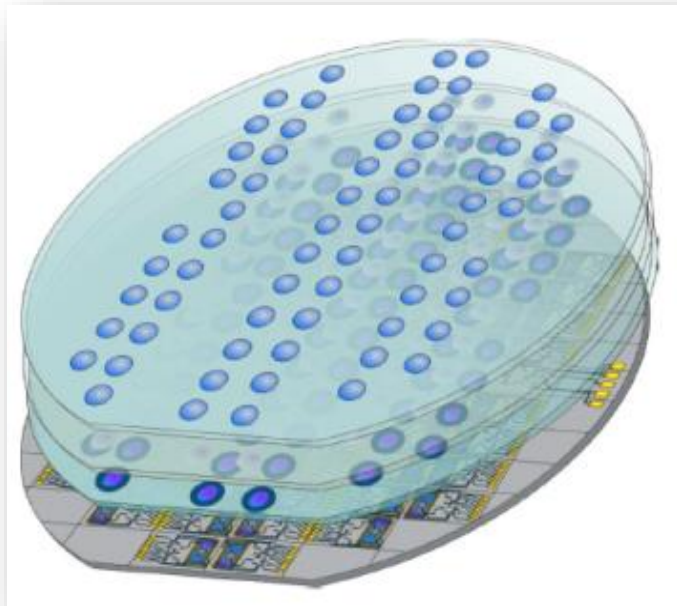


Ultra-Compact Microprojector

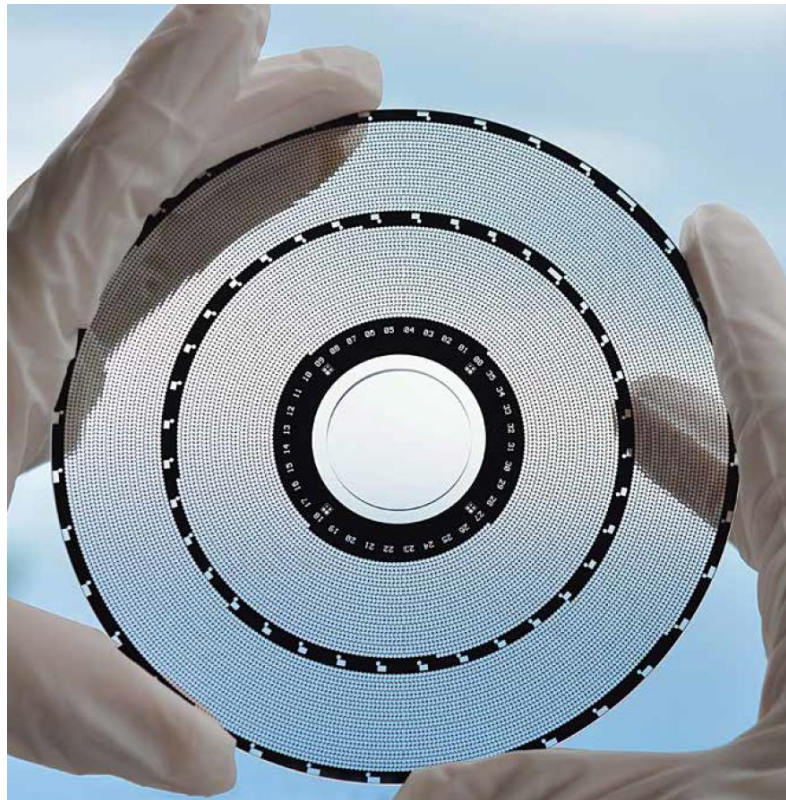


Imprint - Wafer-Level Micro-Optics – Endoscopes

- Microlens wafers
- Image-sensor wafers
- Wafer-level assembly
- Wafer-level singulation
- Disposable endoscopes



- Custom-made for confocal microscopy
- Low/No (auto)fluorescence fused silica substrate
- Highly uniform pinhole arrays
- Microlens arrays, aligned with pinholes
- In reflection or transmission
- Chromium or black chromium
- Disc diameter: ≤ 160 mm
- AR coatings



Nipkow Discs

High contrast images

Sharply focused images

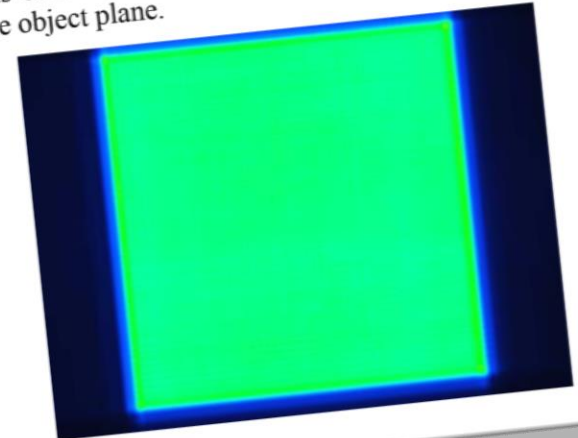
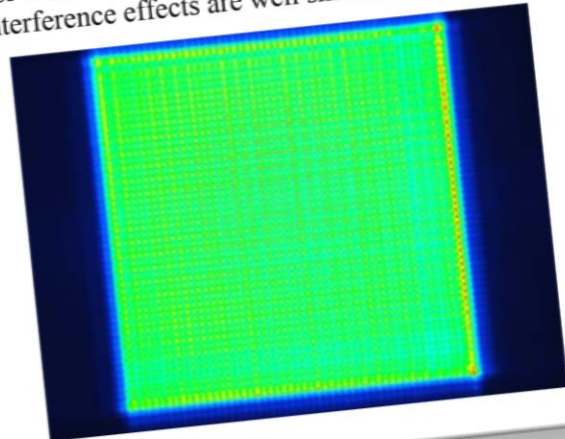
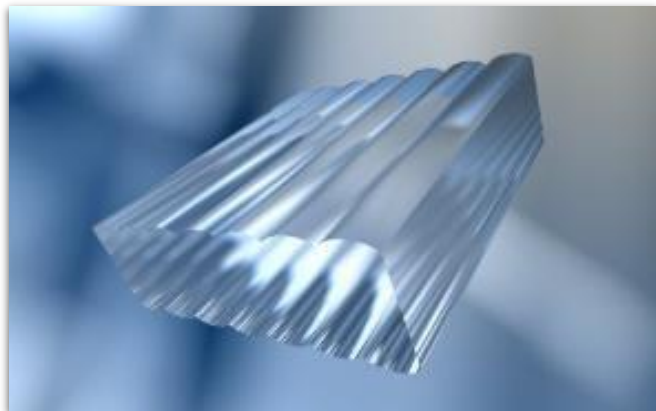
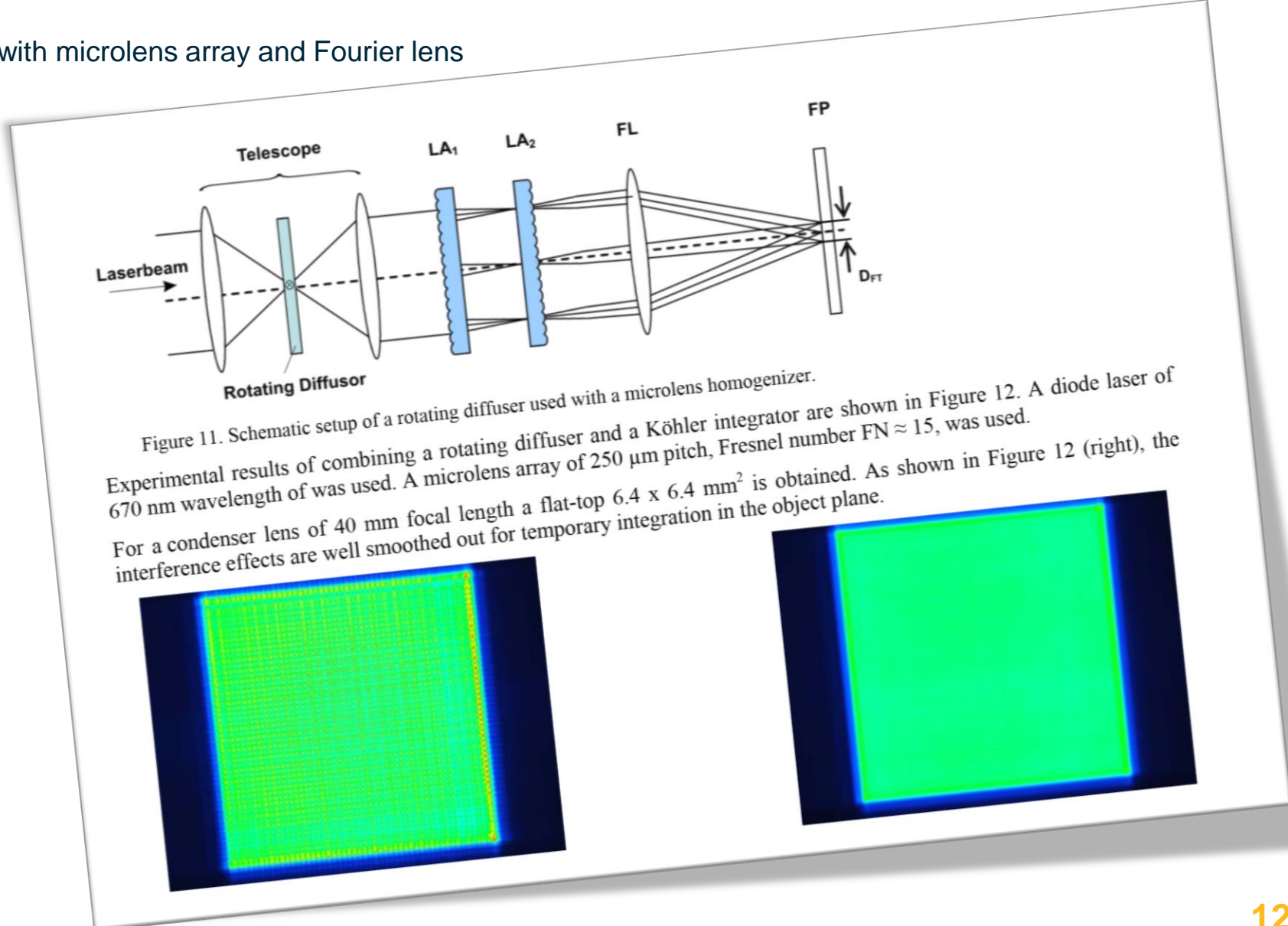
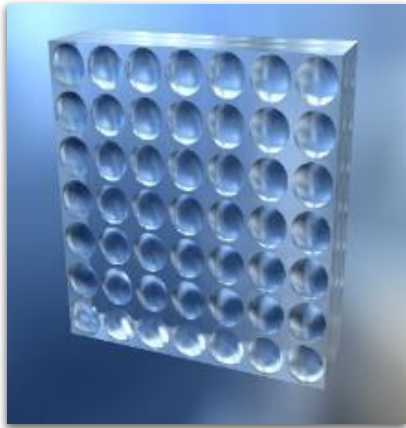
Custom design

Enhance system performance



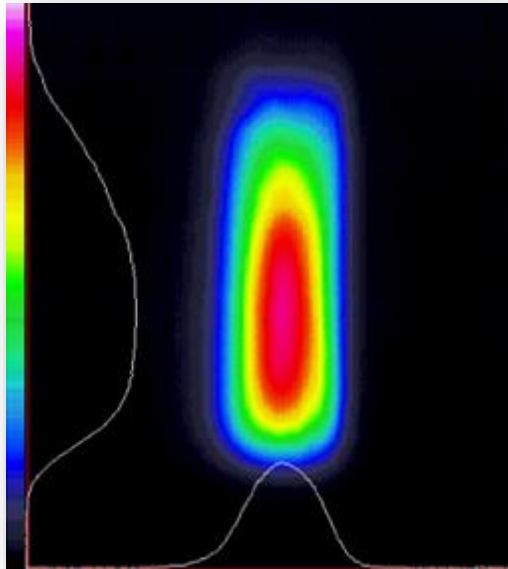
Beam Shaping Optics

“Classically” – Homogenizer configuration with microlens array and Fourier lens

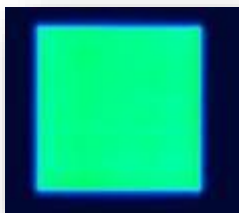
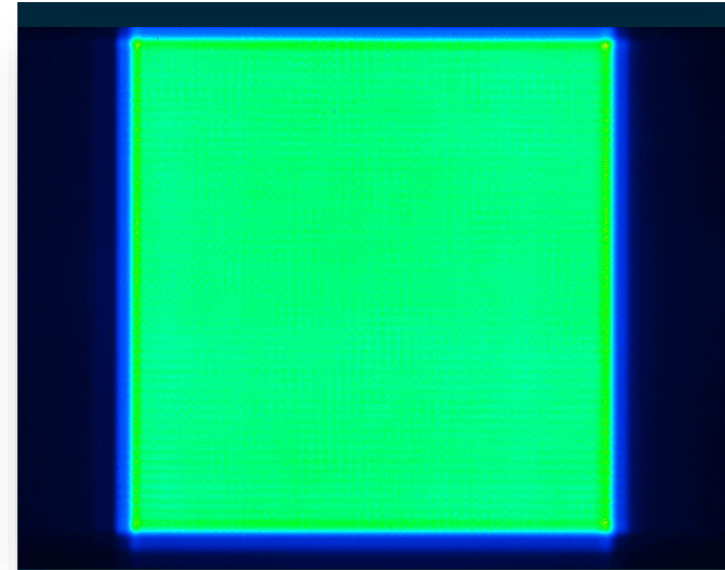


Laser Beam Shaping

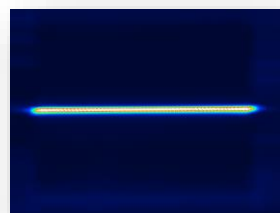
Arbitrary Laser Source



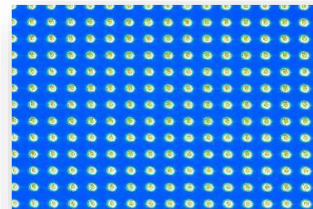
Flat-Top



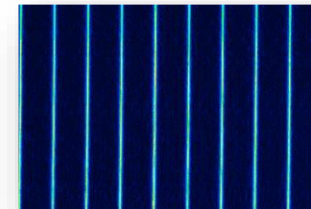
Flat-Top (2D)



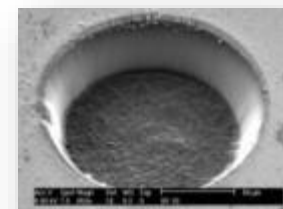
Flat-Top (1D)



Spot-Generator



Line-Generator

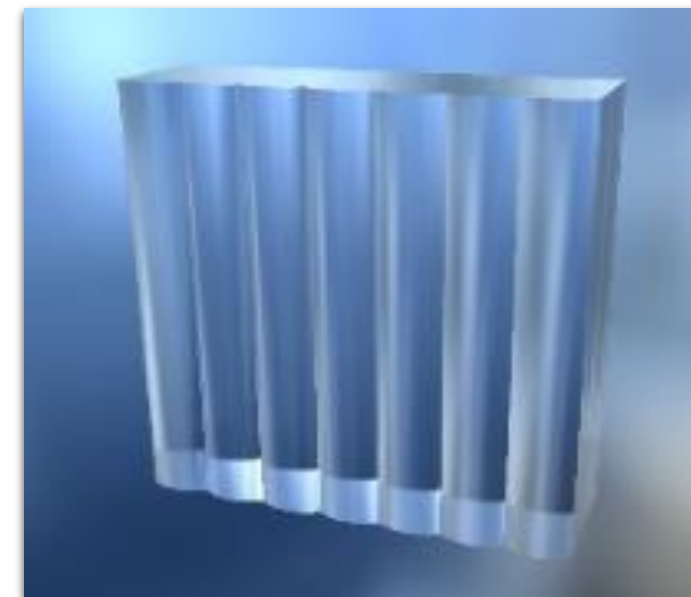
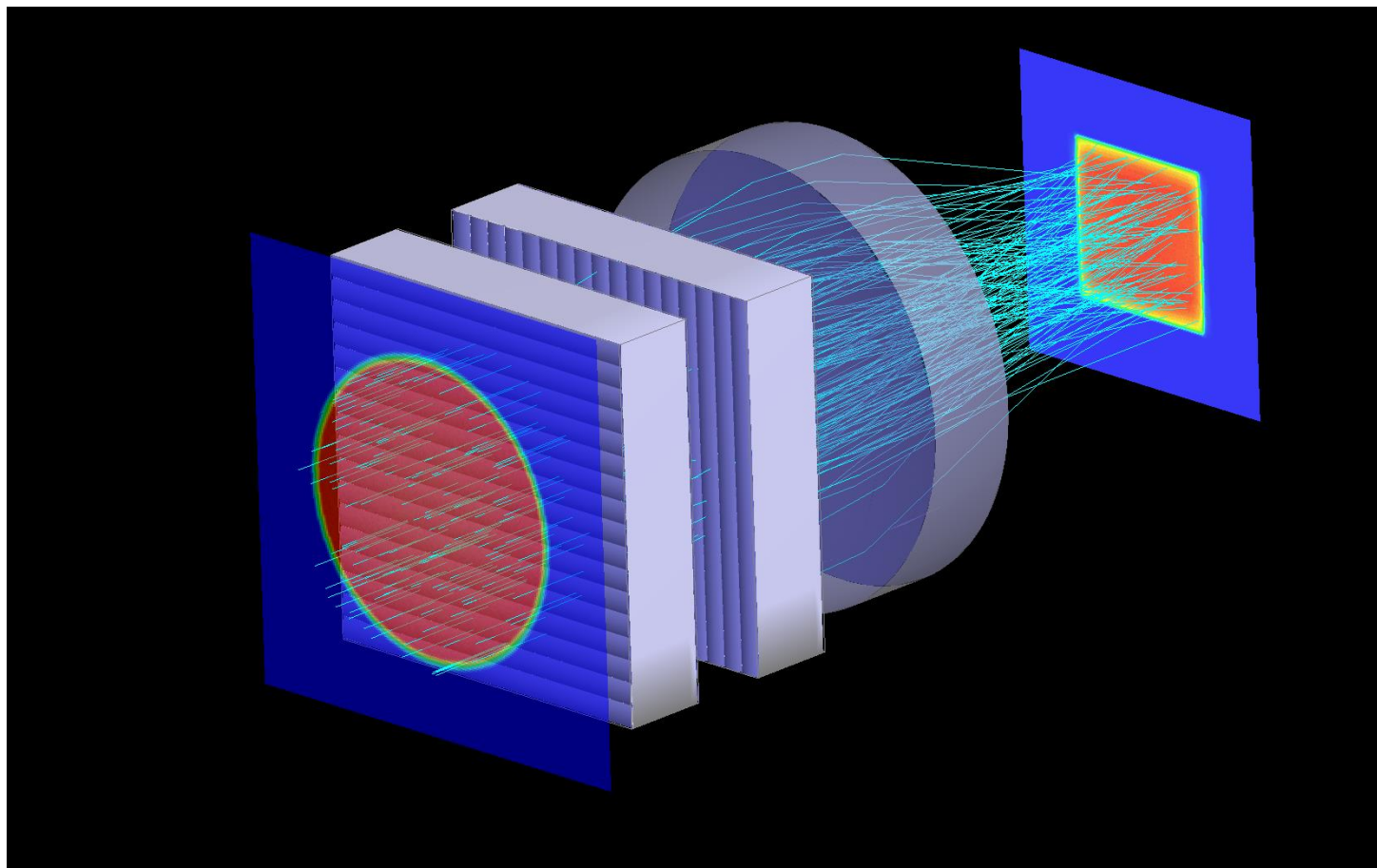


Ablation



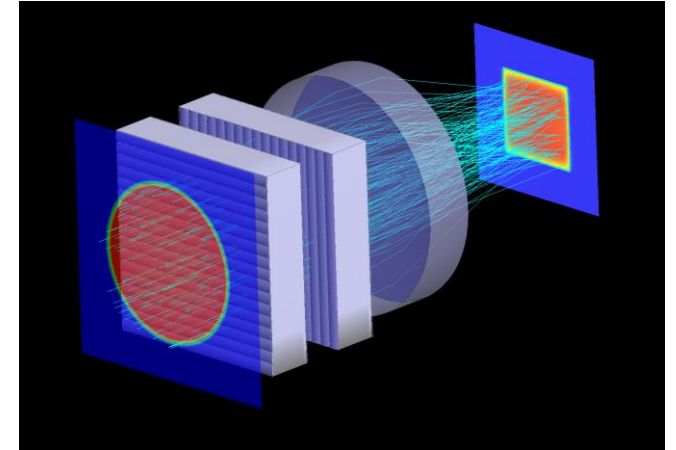
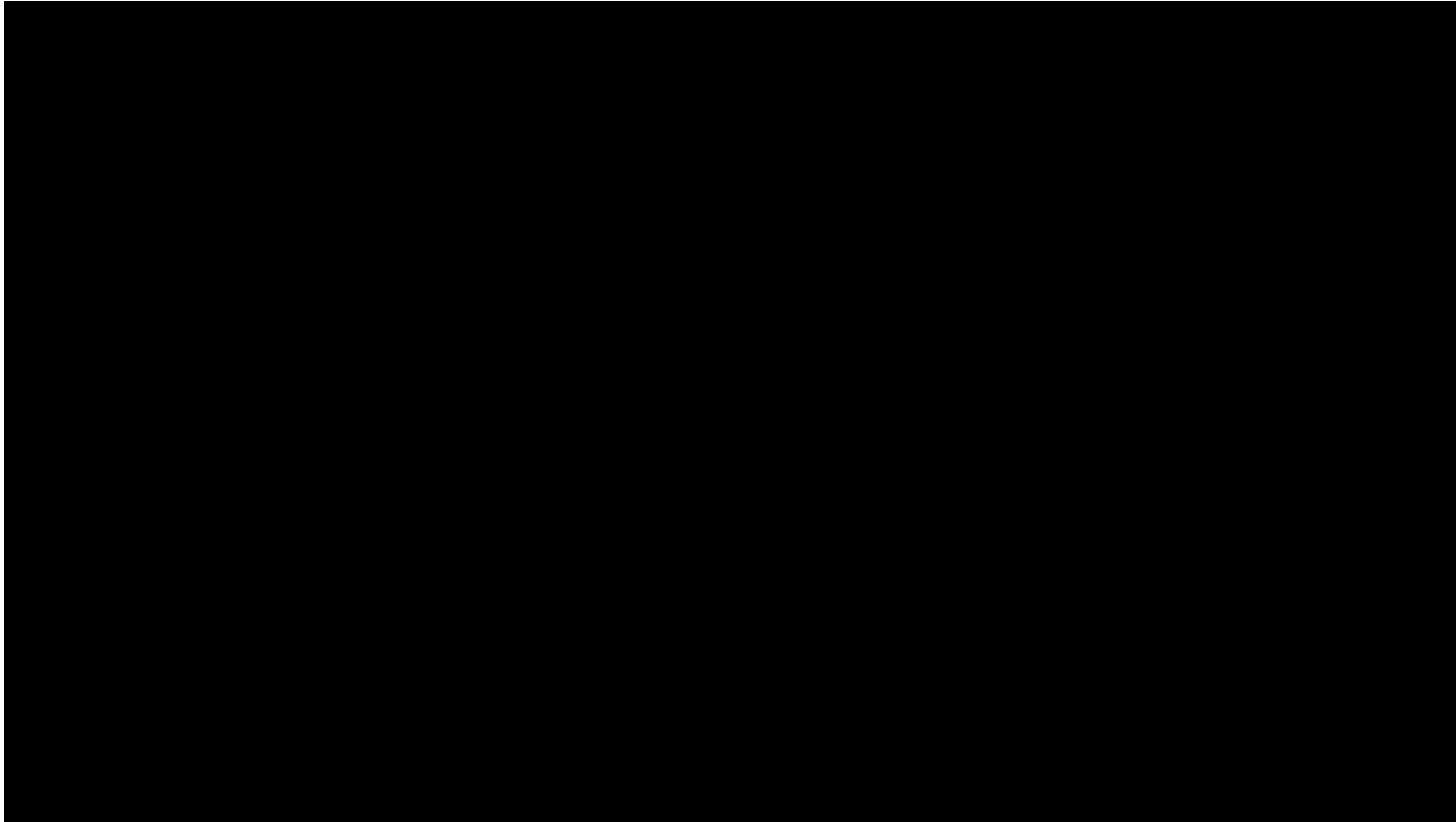
Beam Homogenizers and Flat Top – Simulation

Round-to-square Beam Shape Conversion – Two crossed cylindrical lens arrays



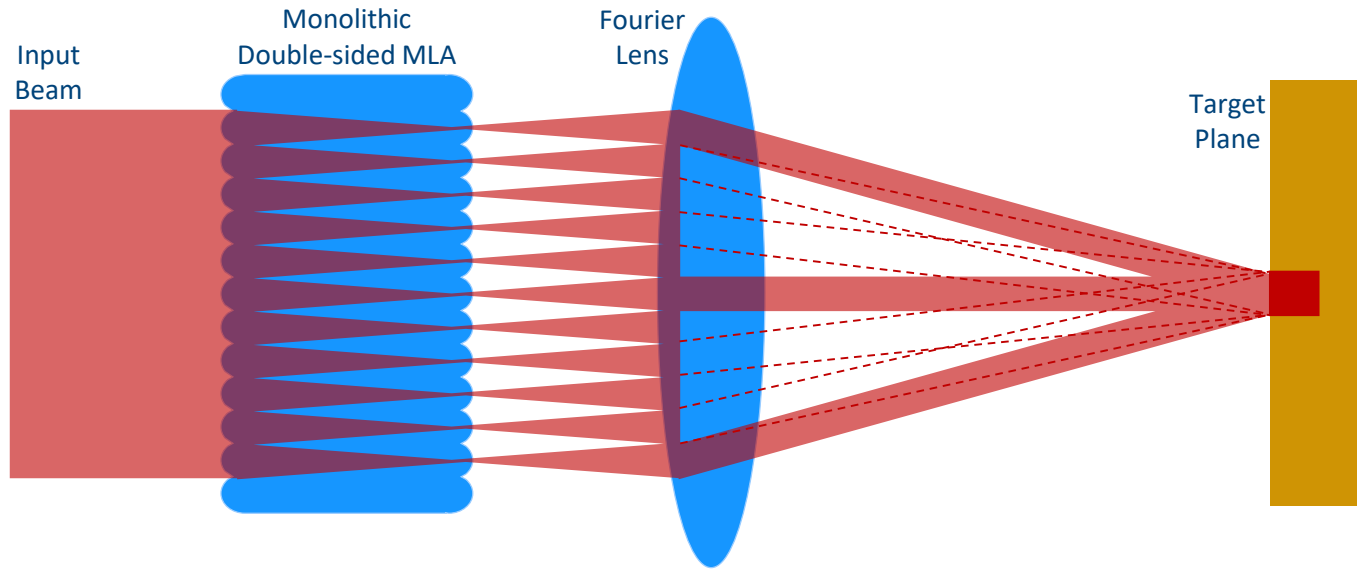
Beam Homogenizers and Flat Top – Simulation

Round-to-square Beam Shape Conversion – Two crossed cylindrical lens arrays

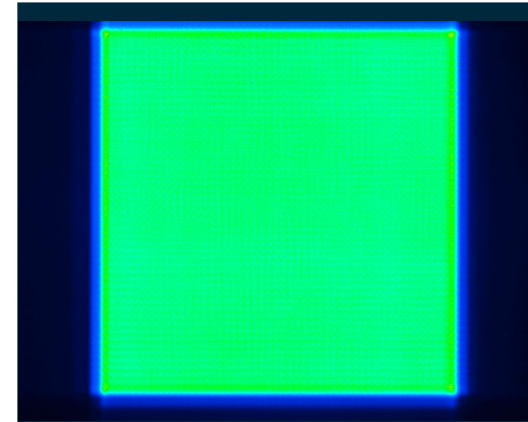


Beam Shaping Optics – Coherent vs. Incoherent Illumination

Homogenizer configuration with microlens array and Fourier lens

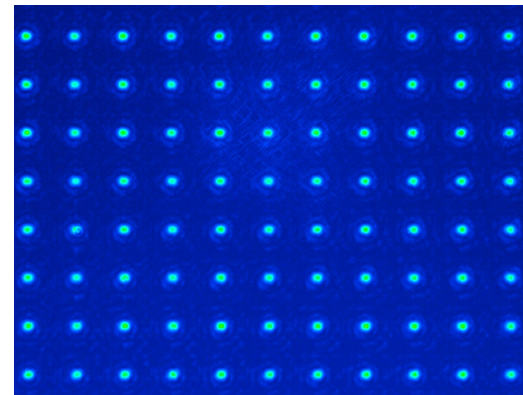


Incoherent superposition

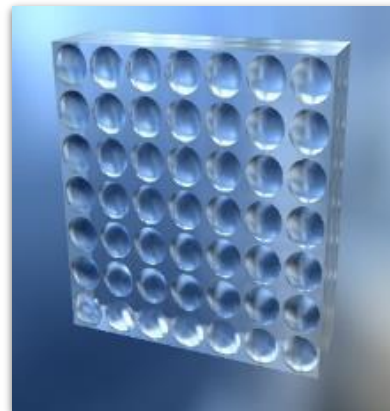
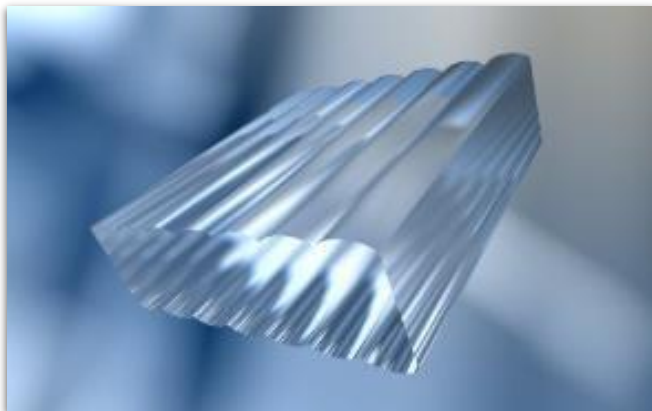
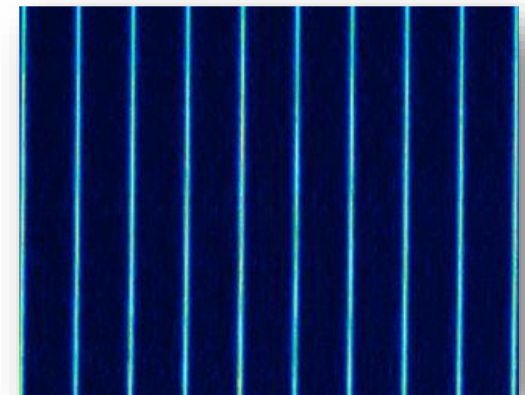


Coherent superposition

Spot generator

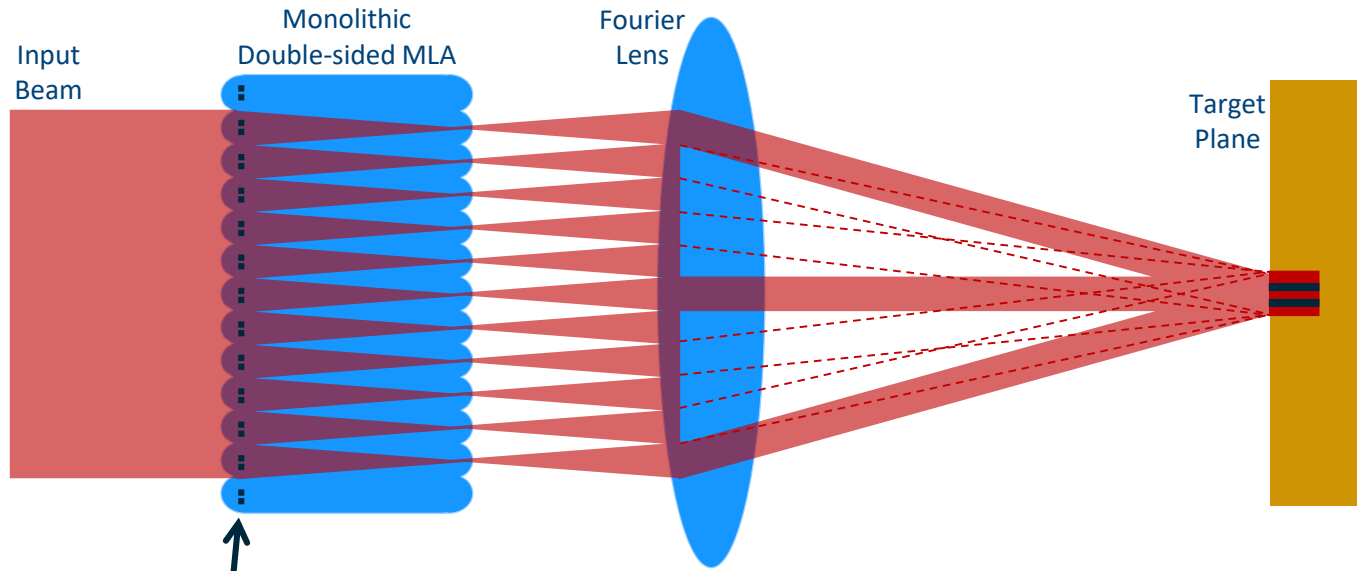


Line generator

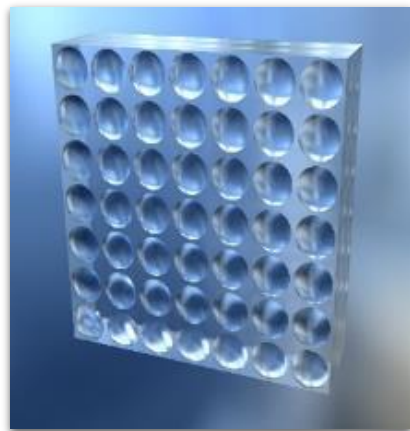


Beam Shaping Optics – Imaging Embedded Pattern

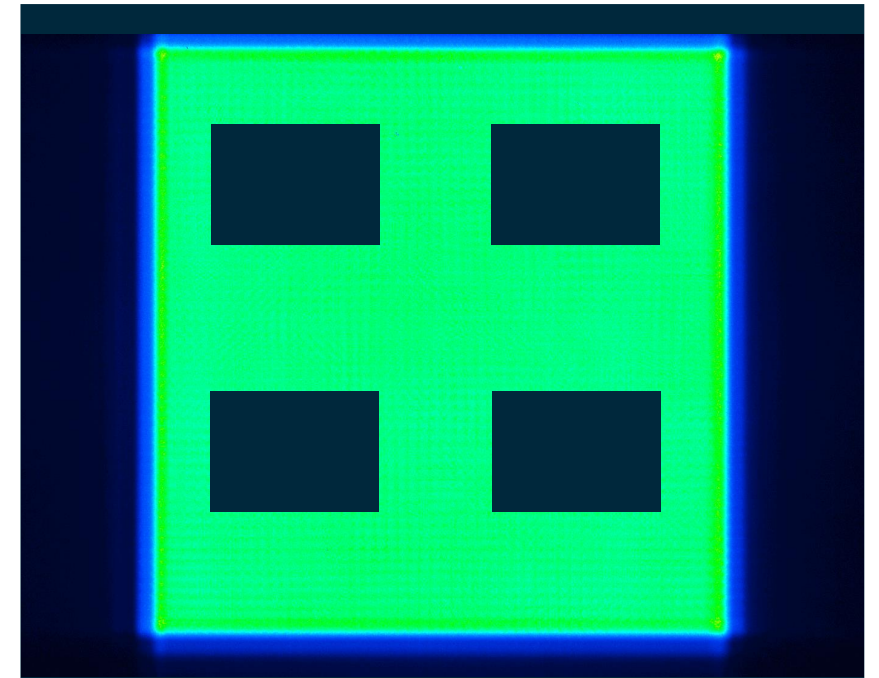
Homogenizer configuration with microlens array, **embedded pattern** and Fourier lens



Embedded mask / pattern



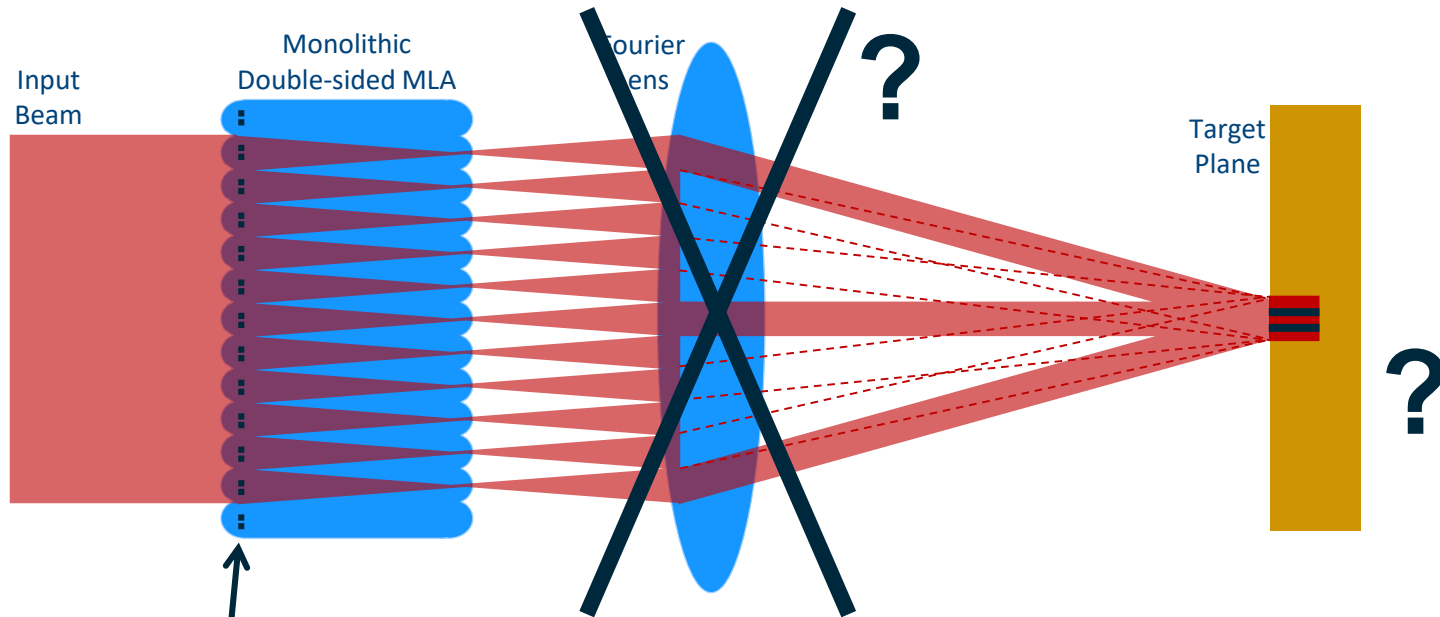
Incoherent superposition



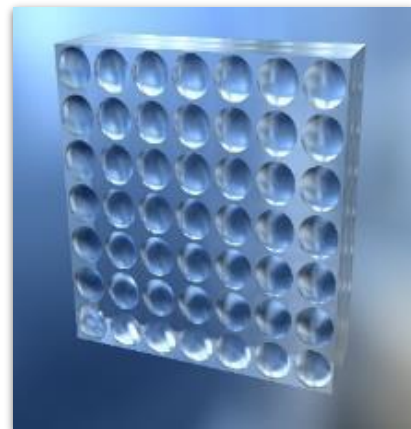
- Imaging of the embedded pattern
- Superposition of hundreds or thousands of images
- Best of two worlds: Homogenized pattern and illumination

Beam Shaping Optics – Imaging Embedded Pattern

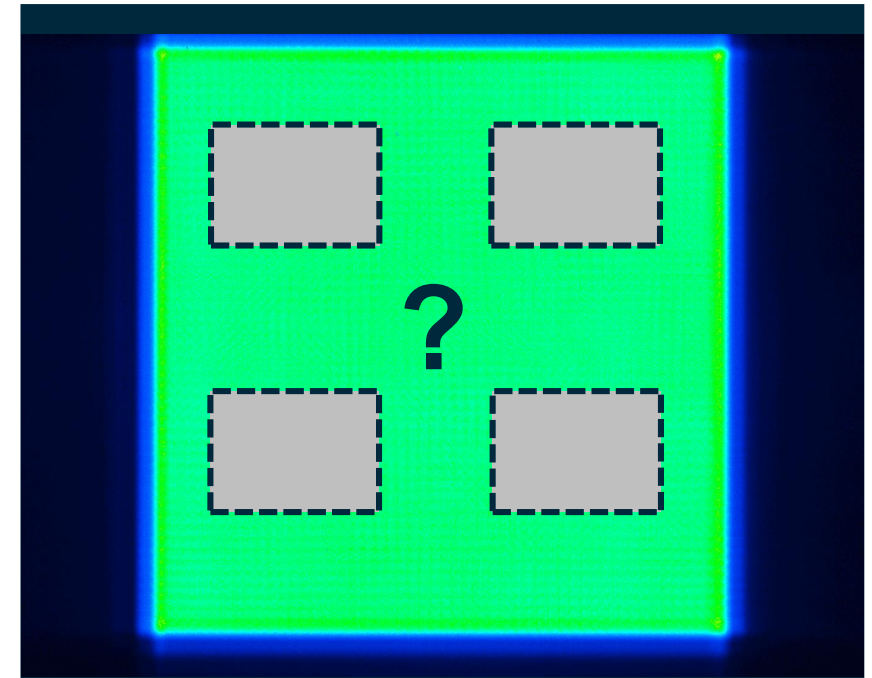
Homogenizer configuration with microlens array, *embedded pattern* and *without* Fourier lens ?



Embedded mask / pattern



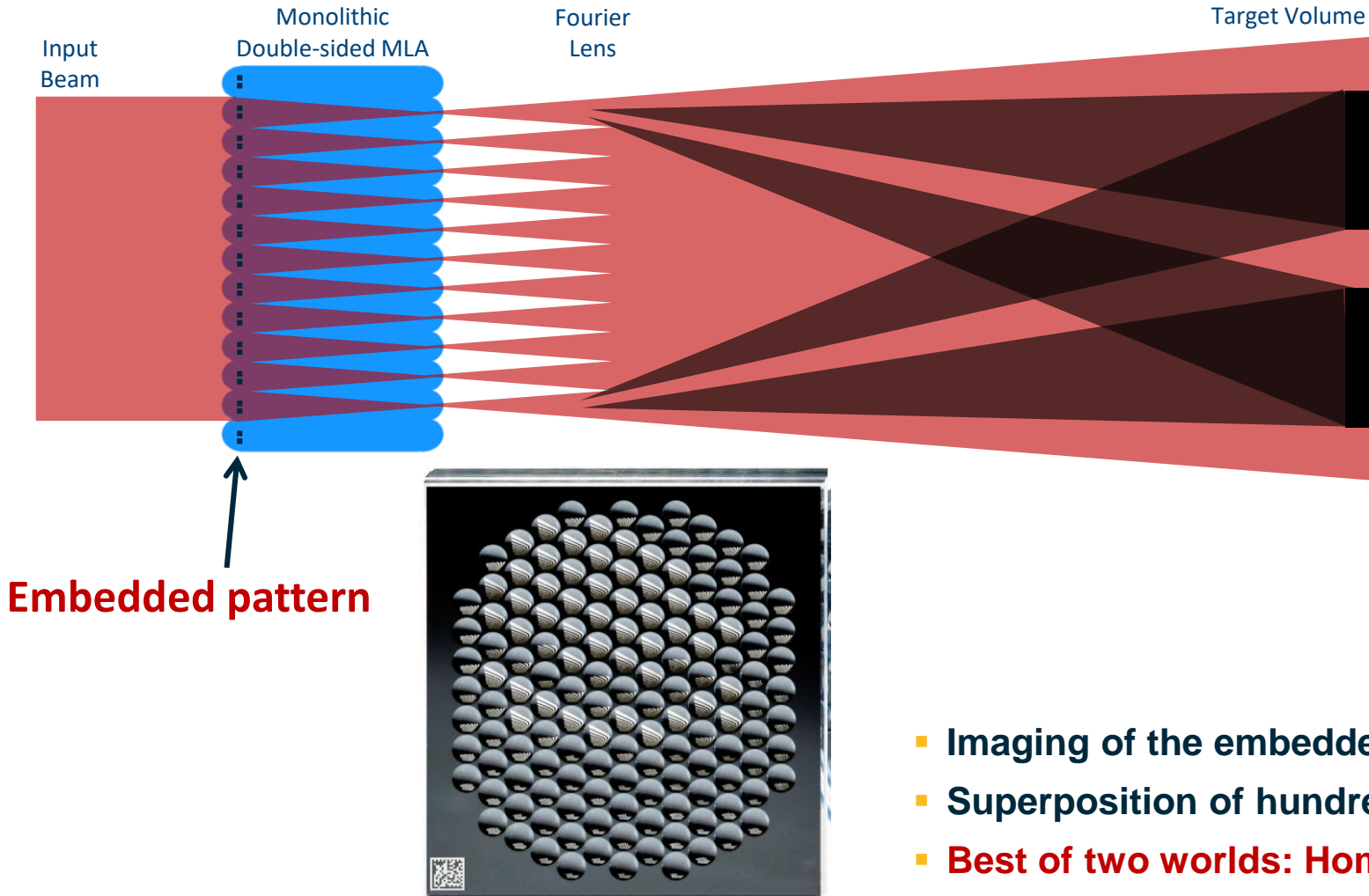
Incoherent superposition



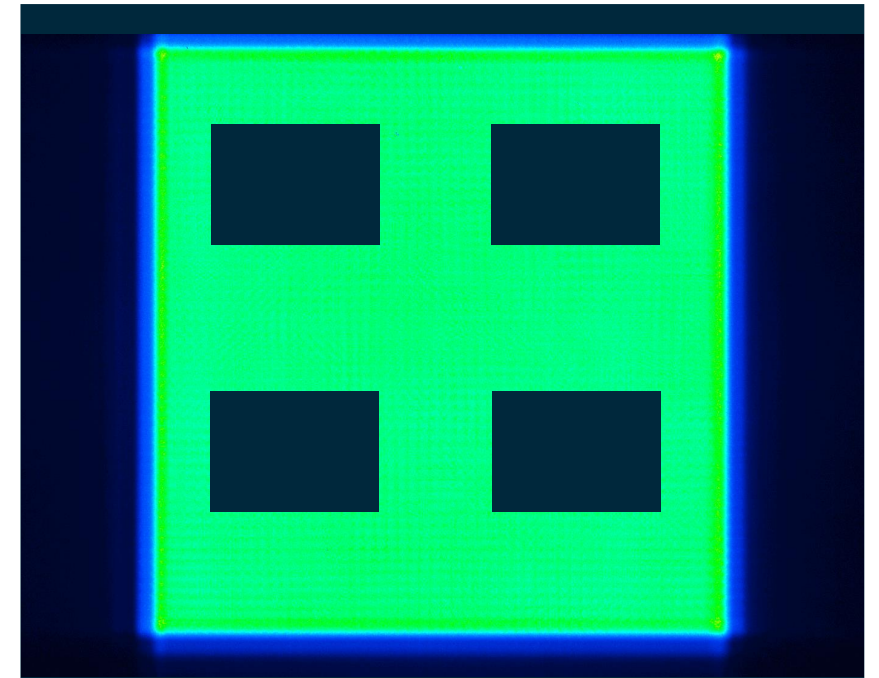
- Imaging of the embedded pattern
- Superposition of hundreds or thousands of images
- Best of two worlds: Homogenized pattern and illumination

Beam Shaping Optics – Imaging Embedded Pattern Into Farfield

Homogenizer configuration with microlens array and embedded pattern / **NO Fourier lens**



Incoherent superposition



- Imaging of the embedded pattern in the far field (= infinity)
- Superposition of hundreds or thousands of images (microchannels)
- **Best of two worlds: Homogenized pattern and illumination**

Micro-Optics in Intraoral Scanners

Microlens arrays for illumination and imaging

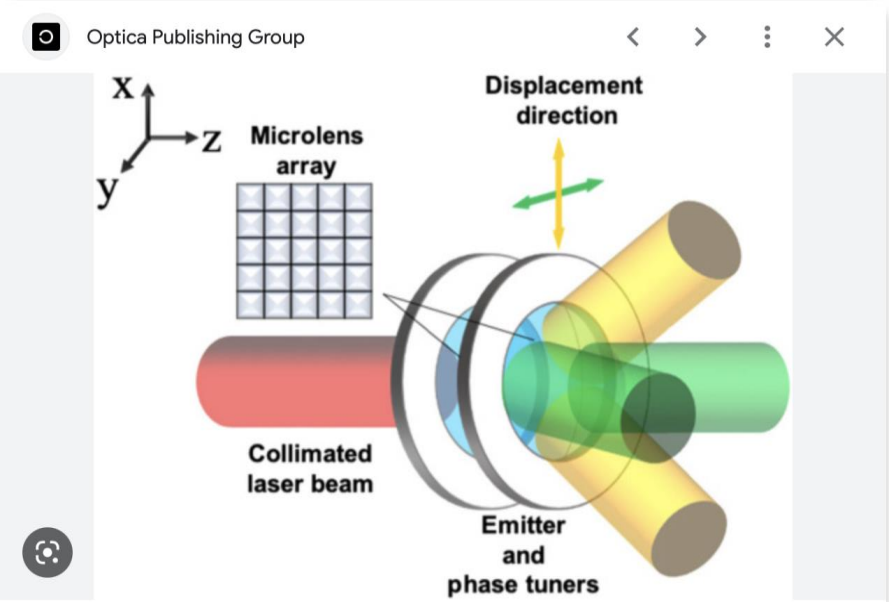
Google search: "intraoral scanner microlenses"

DL SPIE Digital Library scanner based on chromatic...
 ResearchGate light emitter is collimated ...
 MDPi Infrared Laser Beam Homogenizati...
 SPIE Digital Library novel device for dental i...

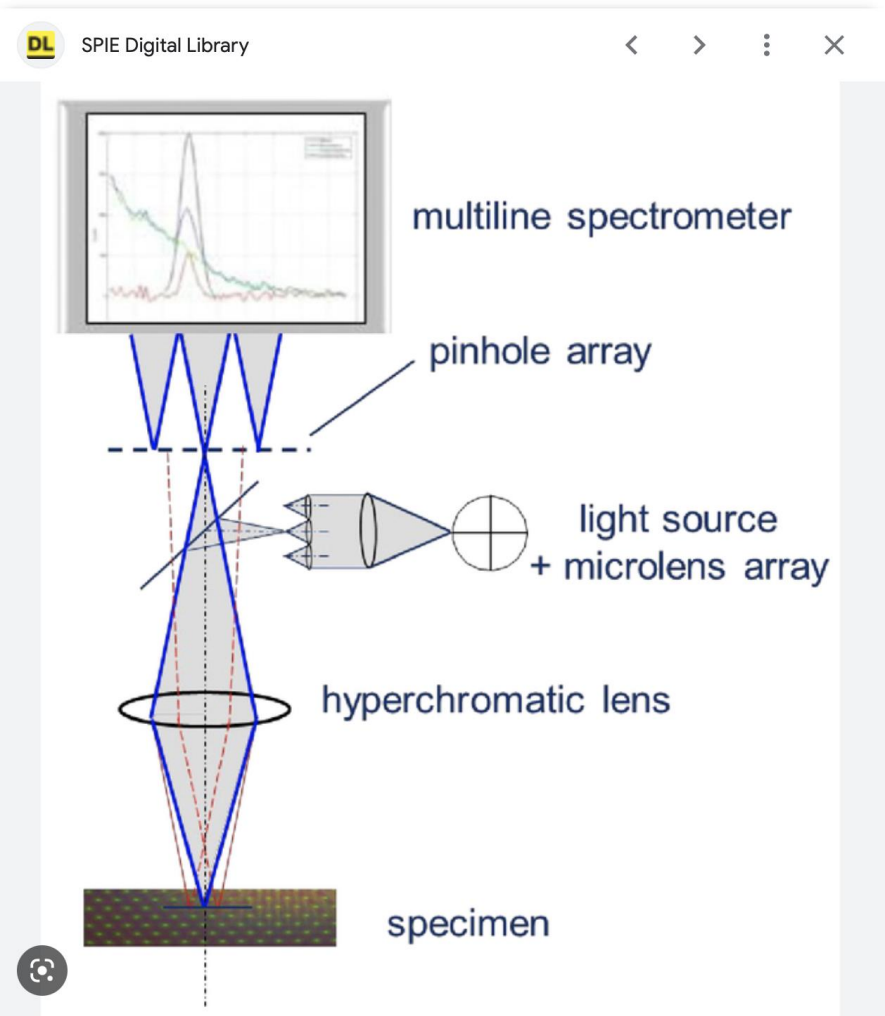
EurekaAlert! 3D printing renders ultr | EurekaAlert ...
 ResearchGate dental phantom using siMLAs ...

Optica Publishing Group microlens array scanner ...

Nature Self-assembly of amorphous calcium ...



Theory analysis and experimental demonstration of a microlens array scanner with Kepler structure
 Images may be subject to copyright. [Learn More](#) [Visit](#)



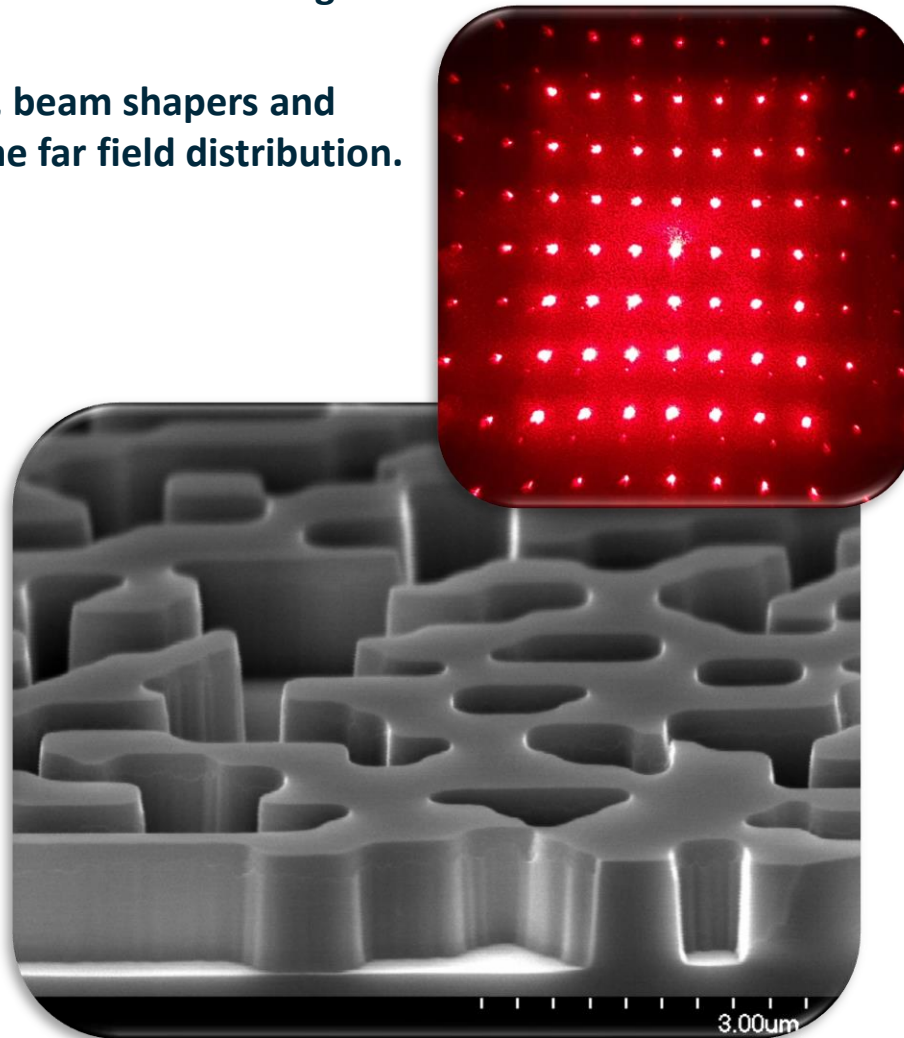
Development and verification of a novel device for dental intraoral 3D scanning using chromatic confocal technology.
[Visit](#)

Diffractive Optical Elements (DOE)

Diffractive optical elements (DOEs) are an interesting alternative in applications where MLAs do not offer enough design - freedom.

They are excellent beam homogenizers, beam shapers and spot generators and offer freedom in the far field distribution.

- Fused silica and silicon
- Binary and up to 16 levels
- Typ. overlay error < 70 nm
- Wavelength range: DUV to NIR
- Minimum feature size: 300 nm
- Efficiency up to 96%



Diffractive Optical Elements (DOE)

3D Sensing

Ophthalmology

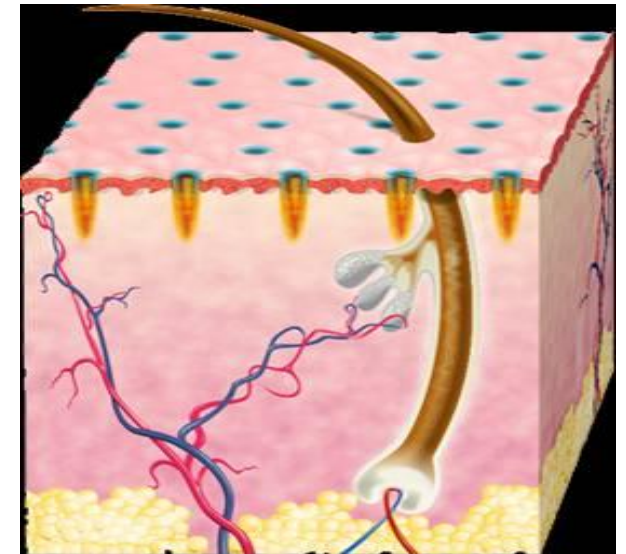
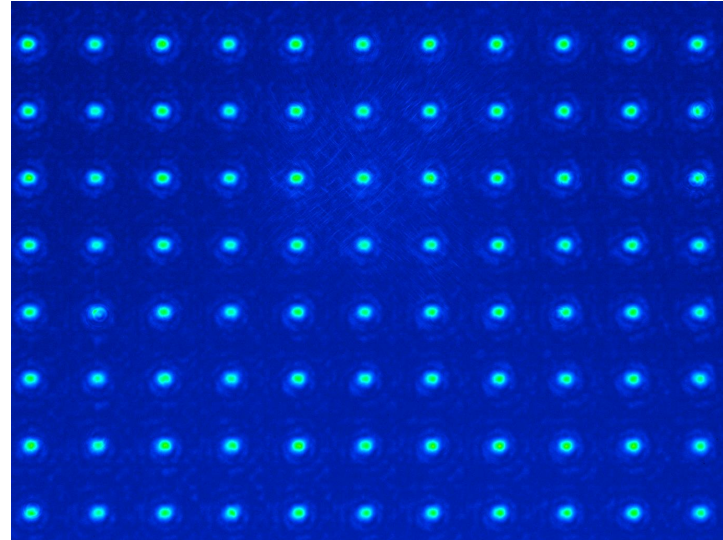
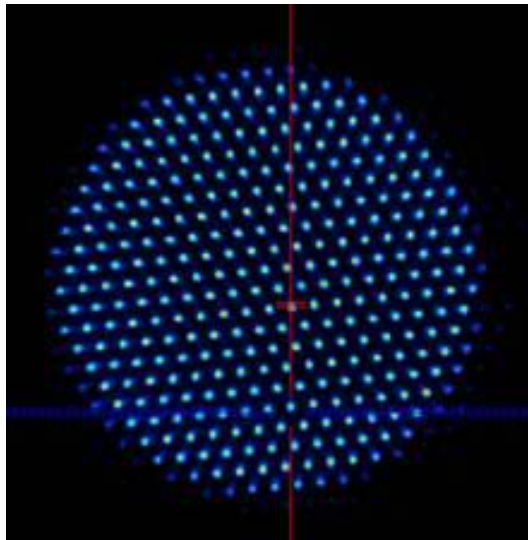
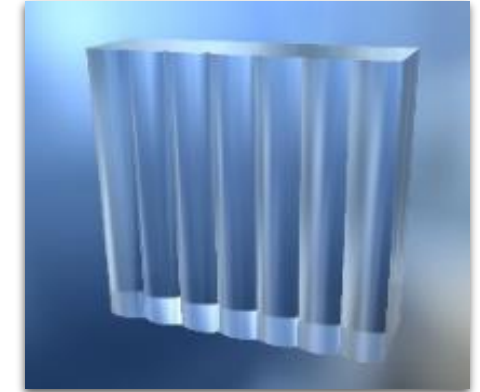
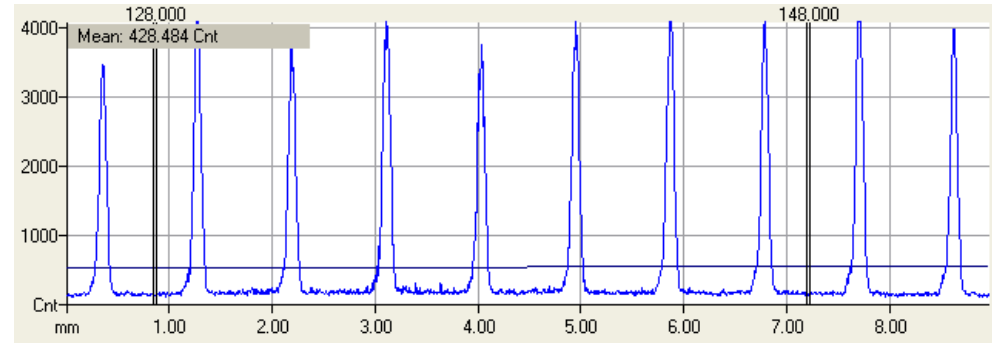
Structured Illumination

Skin treatment



Spot Generator for Medical Applications

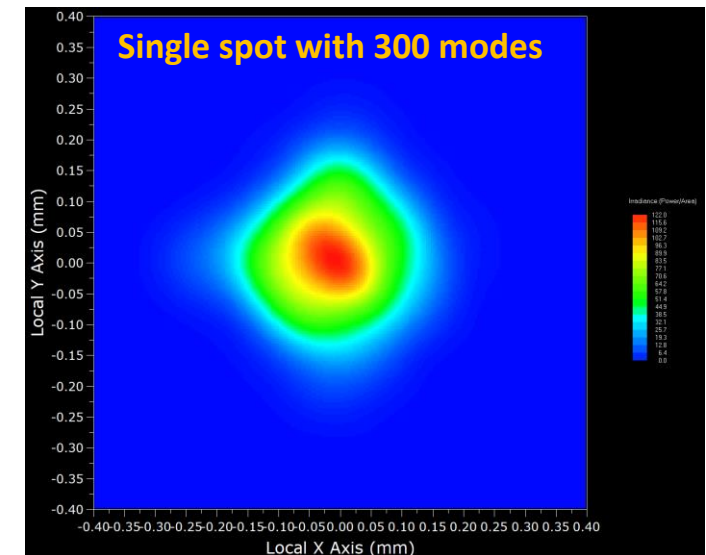
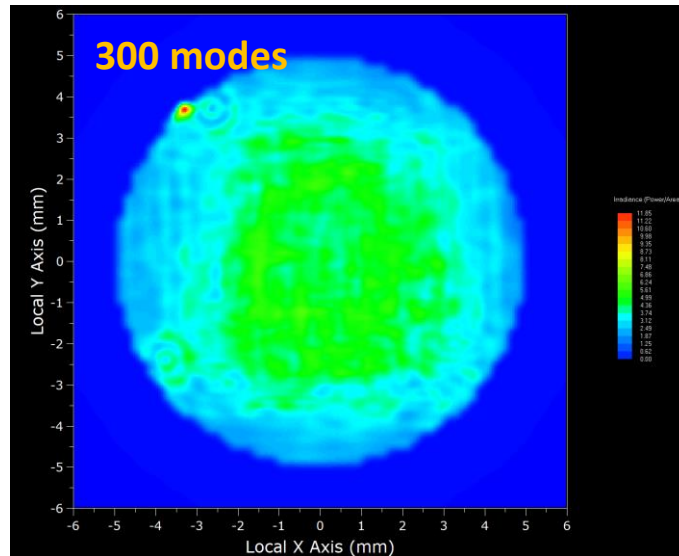
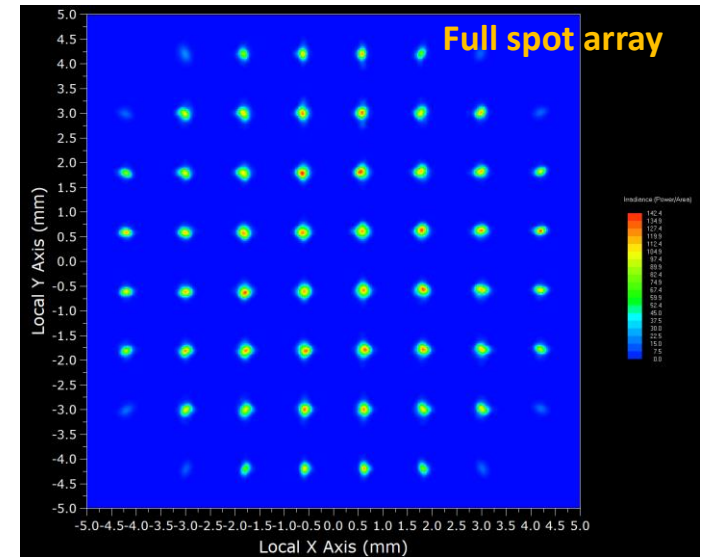
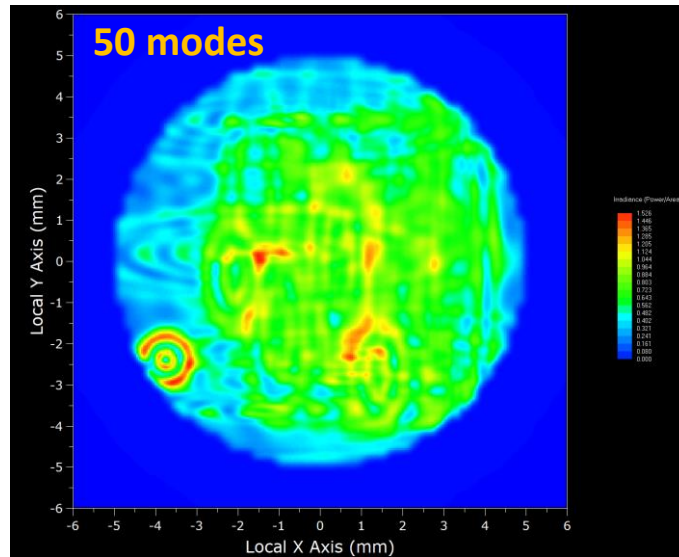
- Dermatology
- Hair removal
- Tattoo removal
- Pigment treatment
- Skin rejuvenation



Source: www.palomarmedical.com

Multimode Laser Source – Spot Array Simulation

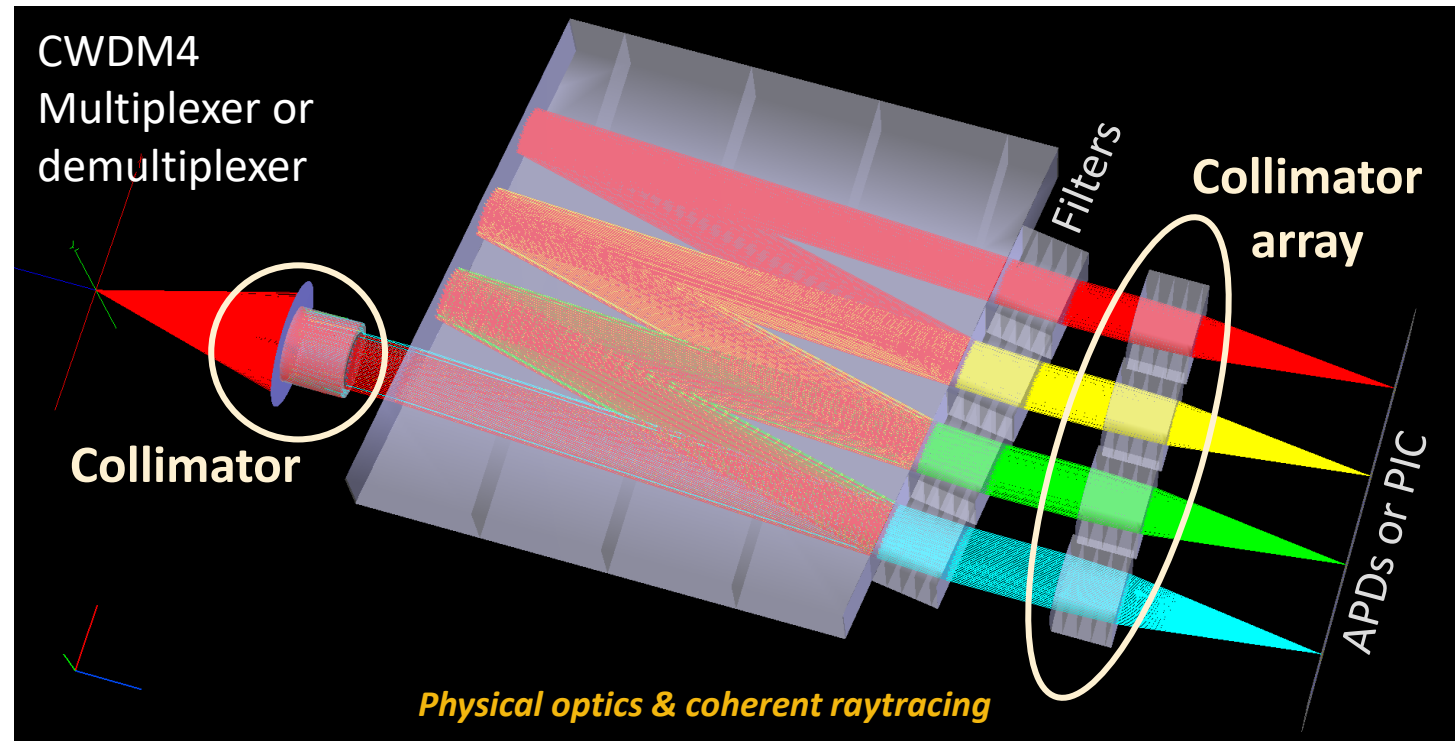
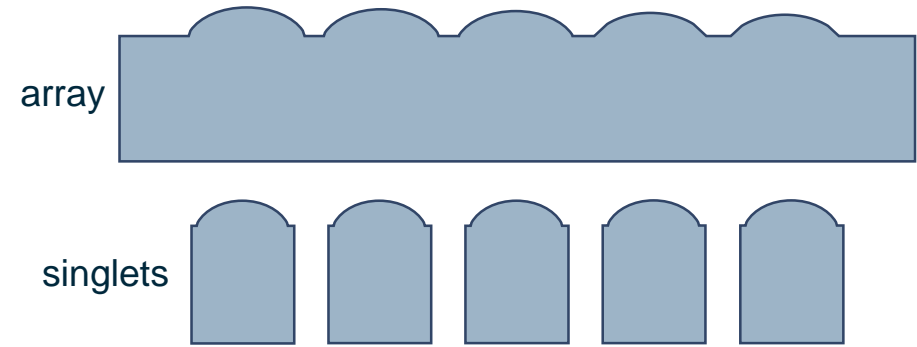
- NIR multimode source
- Simulation
- Number of modes = 50 and 300
- $M^2 \approx 20$
- Beam $\varnothing \approx 10$ mm
- Creating array of uniform spots



Singlets and Arrays for CWDM and Pluggables

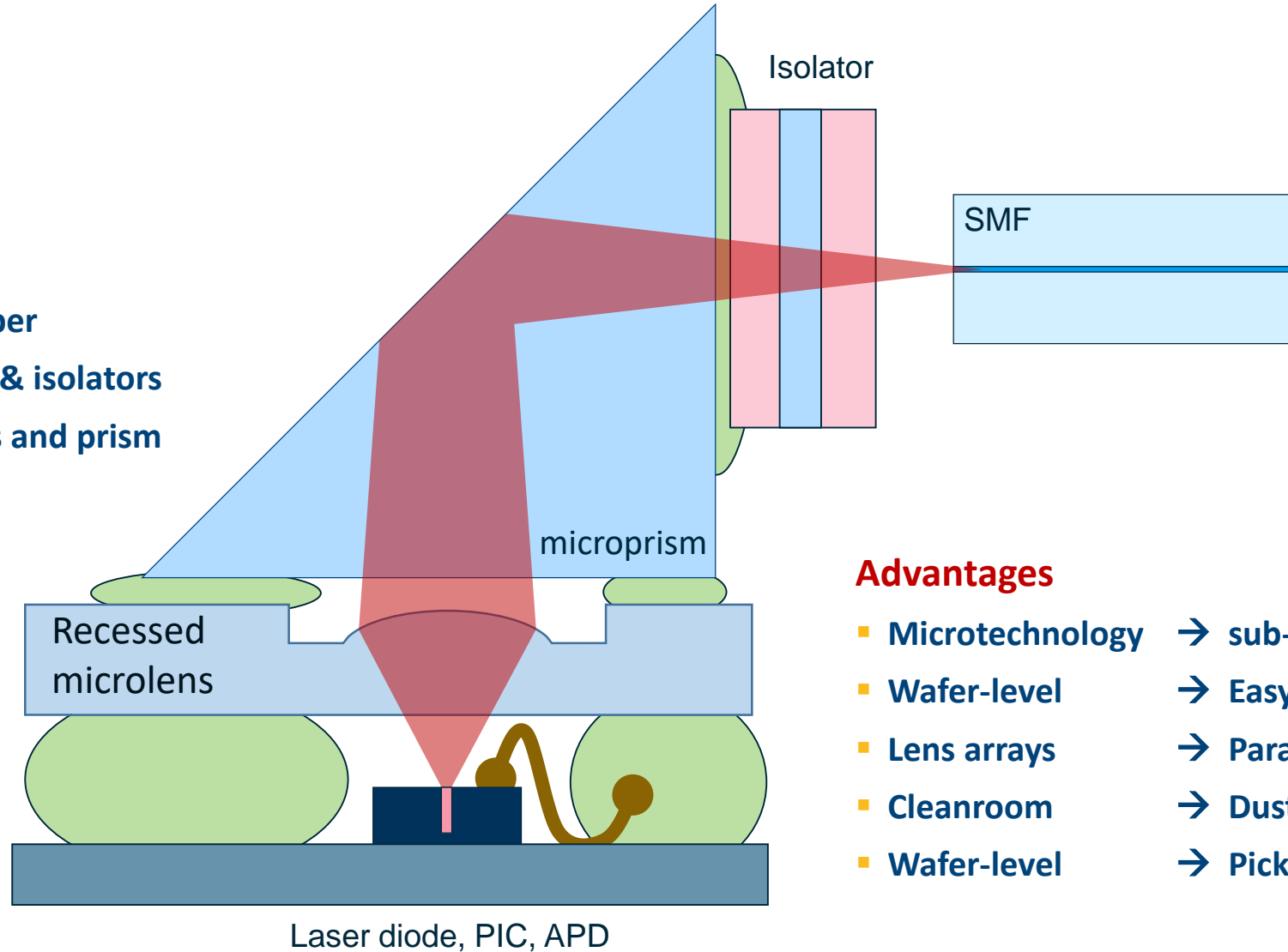
Collimating microlenses

- 1x4, 1x8 to 1xN lens arrays with perfectly aligned lenses
- Singlets <math> < 0.6 \times 0.6 \times 1 \text{ mm}^3 </math>
- Collimation & refocusing
- Large lens aperture for large beam size and long distance



Recessed Microlenses for Stacking Optics – Packaging

- **Stacking**
 - Microprisms
 - FACs & SACs
 - Isolators
 - Silicon photonics (PIC)
- Flat area for vacuum gripper
- Flat base for microprisms & isolators
- Defined gap between lens and prism



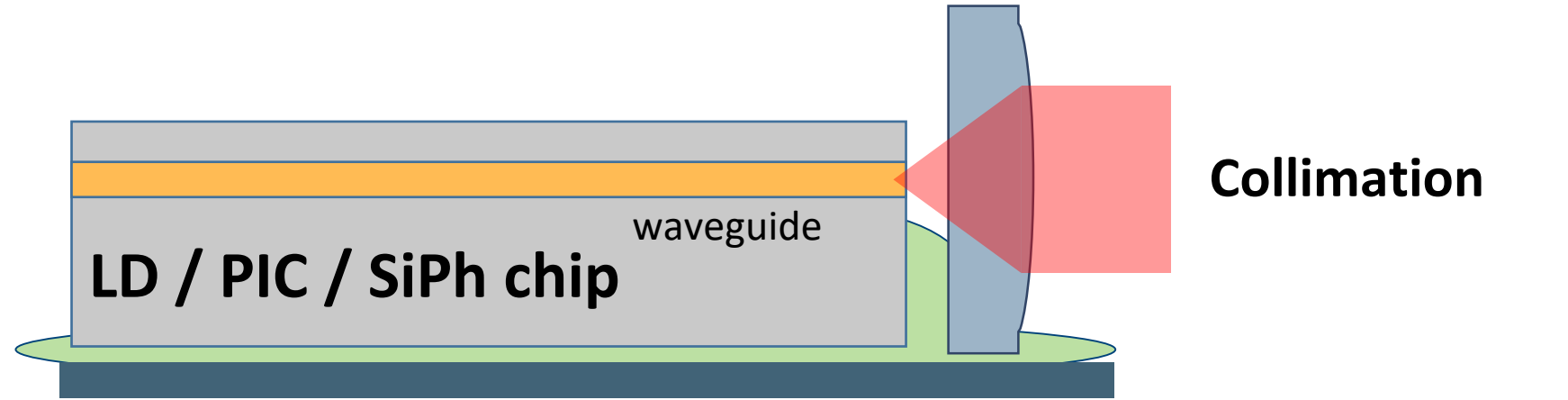
Advantages

- Microtechnology → sub- μm precision of fiducials
- Wafer-level → Easy metrology for volume
- Lens arrays → Parallelization
- Cleanroom → Dust-free surfaces
- Wafer-level → Pick & place handling

Microlenses for Silicon Photonics with Edge Emitters

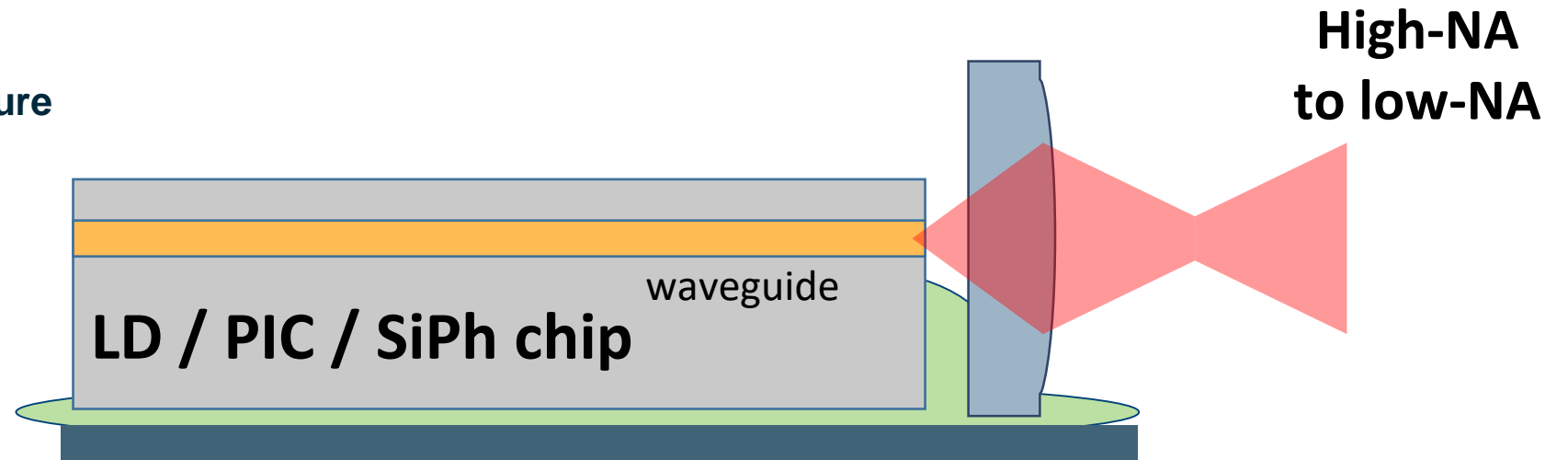
Collimation Micro-Optics

- Very compact
- Adapted to PIC layout
- Sub- μm precision



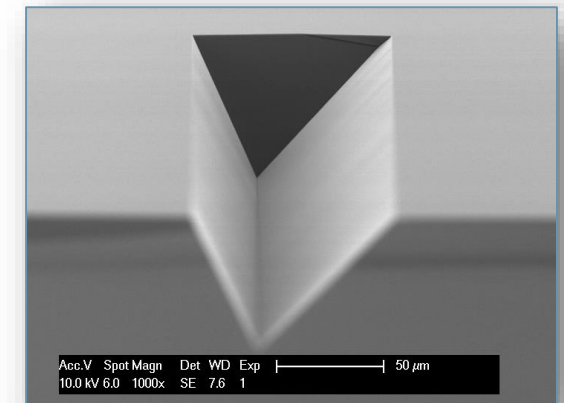
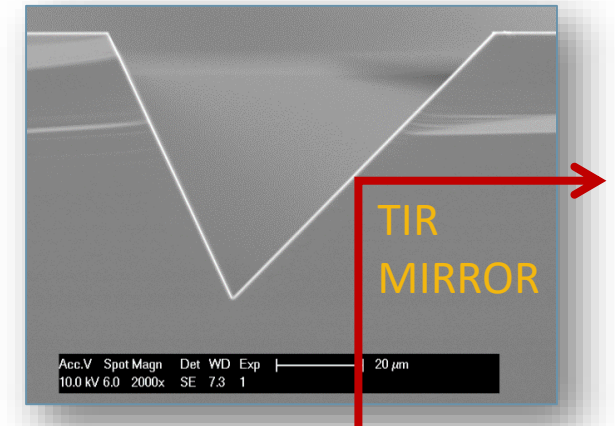
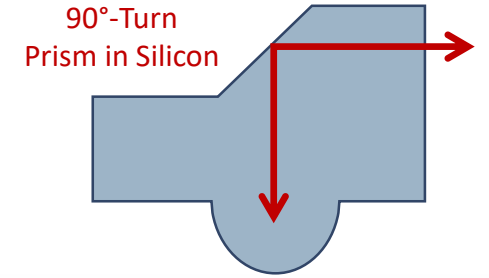
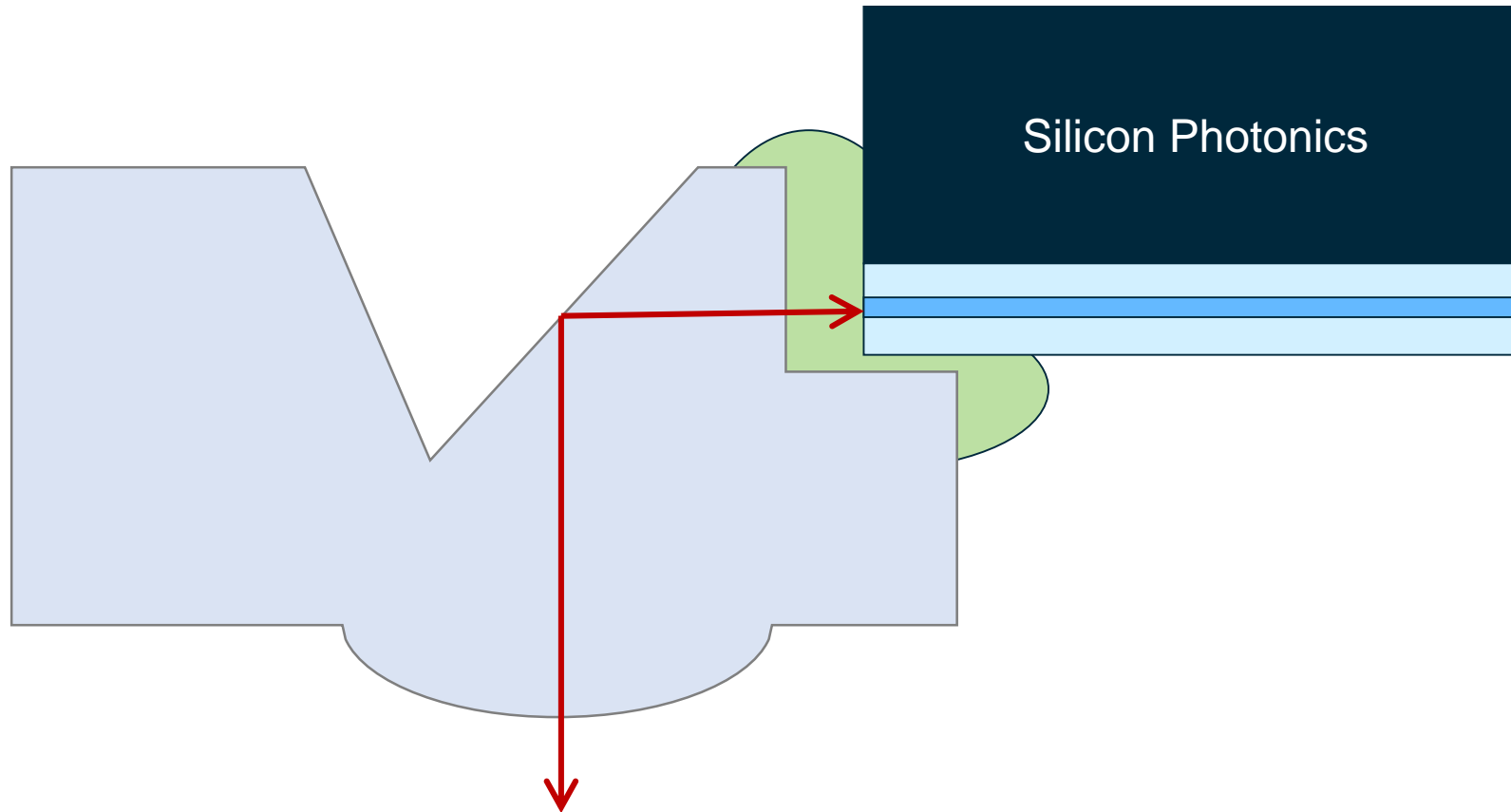
Adaptation of Numerical Aperture

- Tunable to PIC mode field
- Tunable to NA of output
- Adapted to PIC layout
- Sub- μm precision



Prism with Integrated Microlens – “Calm the Waves” along the Shoreline

- Monolithic prism and lens
- Collimation optics & re-focusing optics
- Simple interface to PIC or fiber



Opportunities

- Fits in the smallest space
- Large depths of field
- Works at gracing incident
- Large design freedom for pattern
- Dynamic imaging of patterns

Challenges (during development and ramp-up)

- Manufacturing tolerances for high volume
- 100% functional testing
- *Intuitive* understanding of the image generation
- Predicting patterns appearance accurately
 - Diffraction
 - Channel superposition at very short distances

Thank you!

