



Miniaturizing LIDAR with Micro-Optics

Microlenses for Silicon Photonics and 3D-Sensing

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SUSS MicroOptics SA



20 Years
of Micro-Optics FAB Experience



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

- **Founded 1998**
- **Part of the SUSS MicroTec Group**
- **>160 people in 2023 in Switzerland**
- **Refractive microoptics**
- **Diffraction microoptics**
- **Worldwide client base in data/telecom, metrology, semiconductor, instruments**



SUSS MicroTec signs agreement to sell the MicroOptics division to Focuslight Technologies

Garching, November 8, 2023 – SÜSS MicroTec SE signed an agreement today for the sale of its Swiss subsidiary SUSS MicroOptics SA and the division by the same name to Focuslight (HK) Investment Management Co. Ltd., a subsidiary of the Shanghai (China) listed company Focuslight Technologies Inc. The transaction is expected to be completed in the first quarter of 2024 and is subject to pending approvals.



FOCUSLIGHT
Never stop exploring

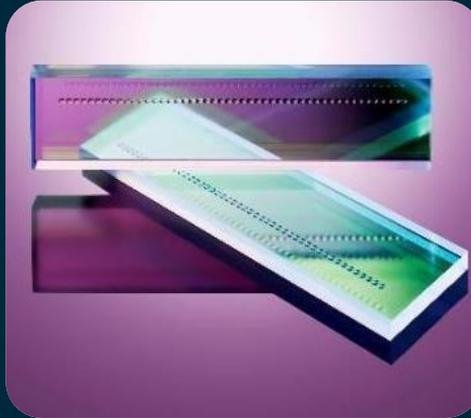
<https://www.suss.com/en/investor-relations/press-releases/corporate/suss-microtec-signs-agreement-to-sell-the-microoptics-division-to-focuslight-technologies/2632859>

Products and Markets

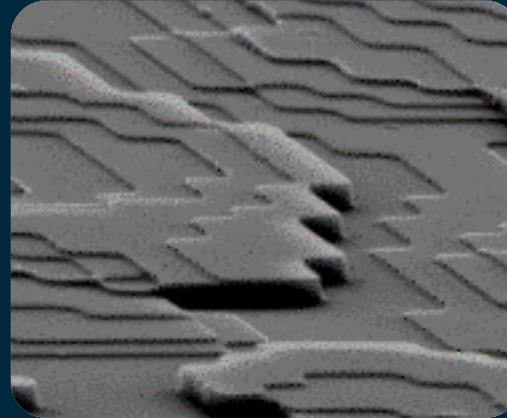
■ AUTOMOTIVE



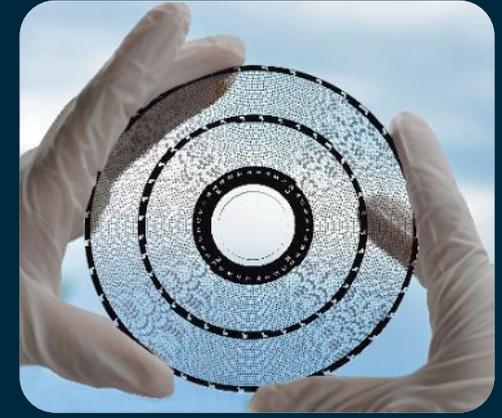
■ TELE/DATACOM



■ SEMICONDUCTOR



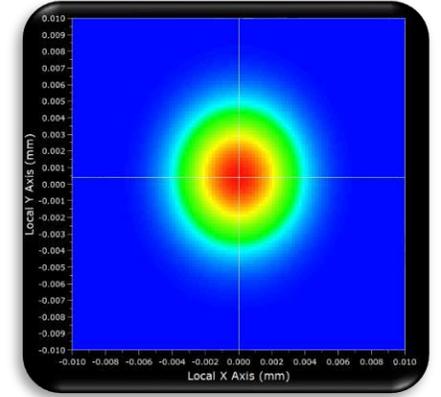
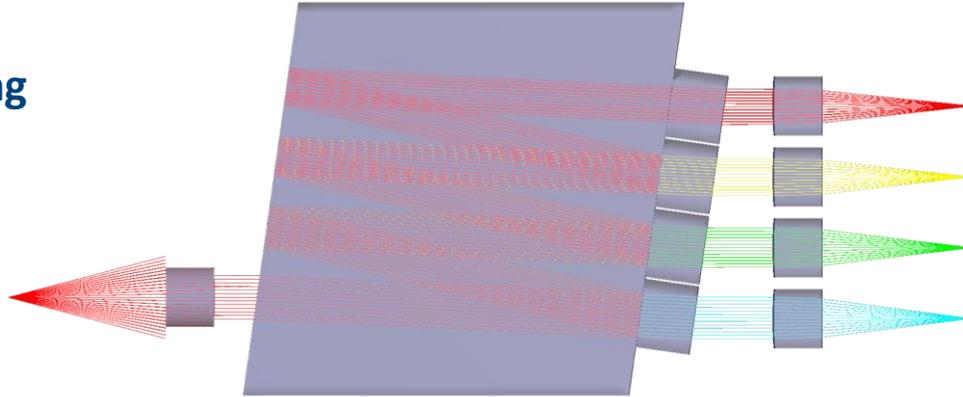
■ MEDICAL



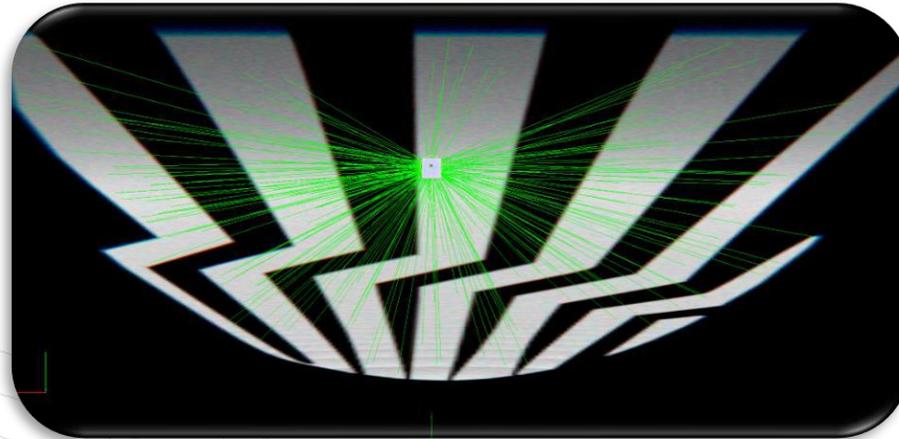
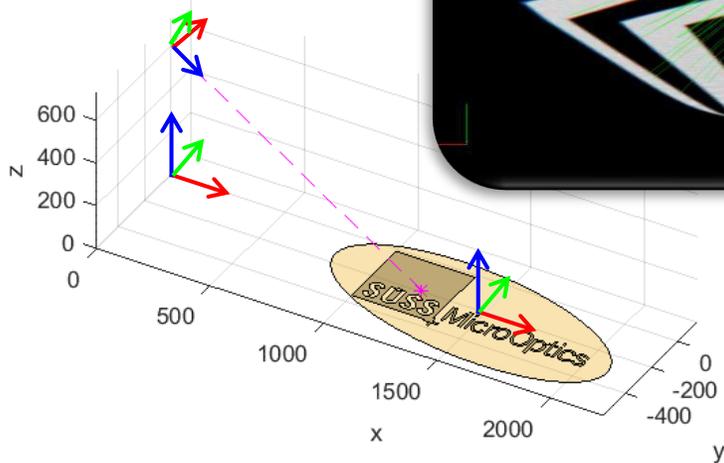
Optical Design Capabilities

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

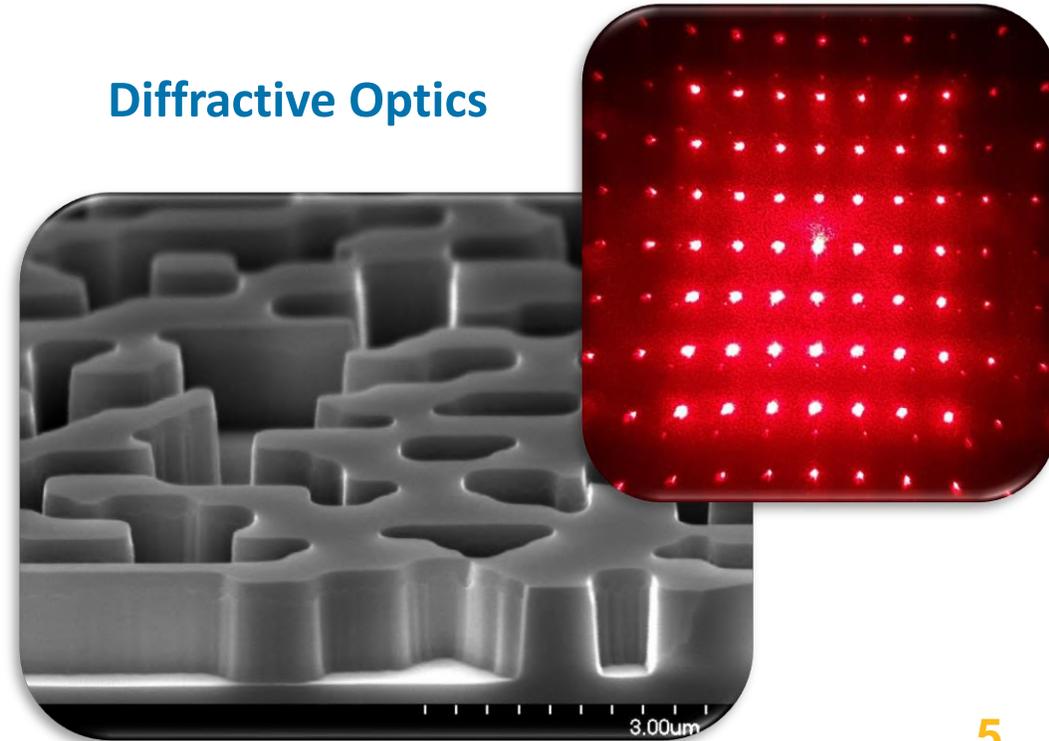
LD, PIC, APD, and Fiber optics



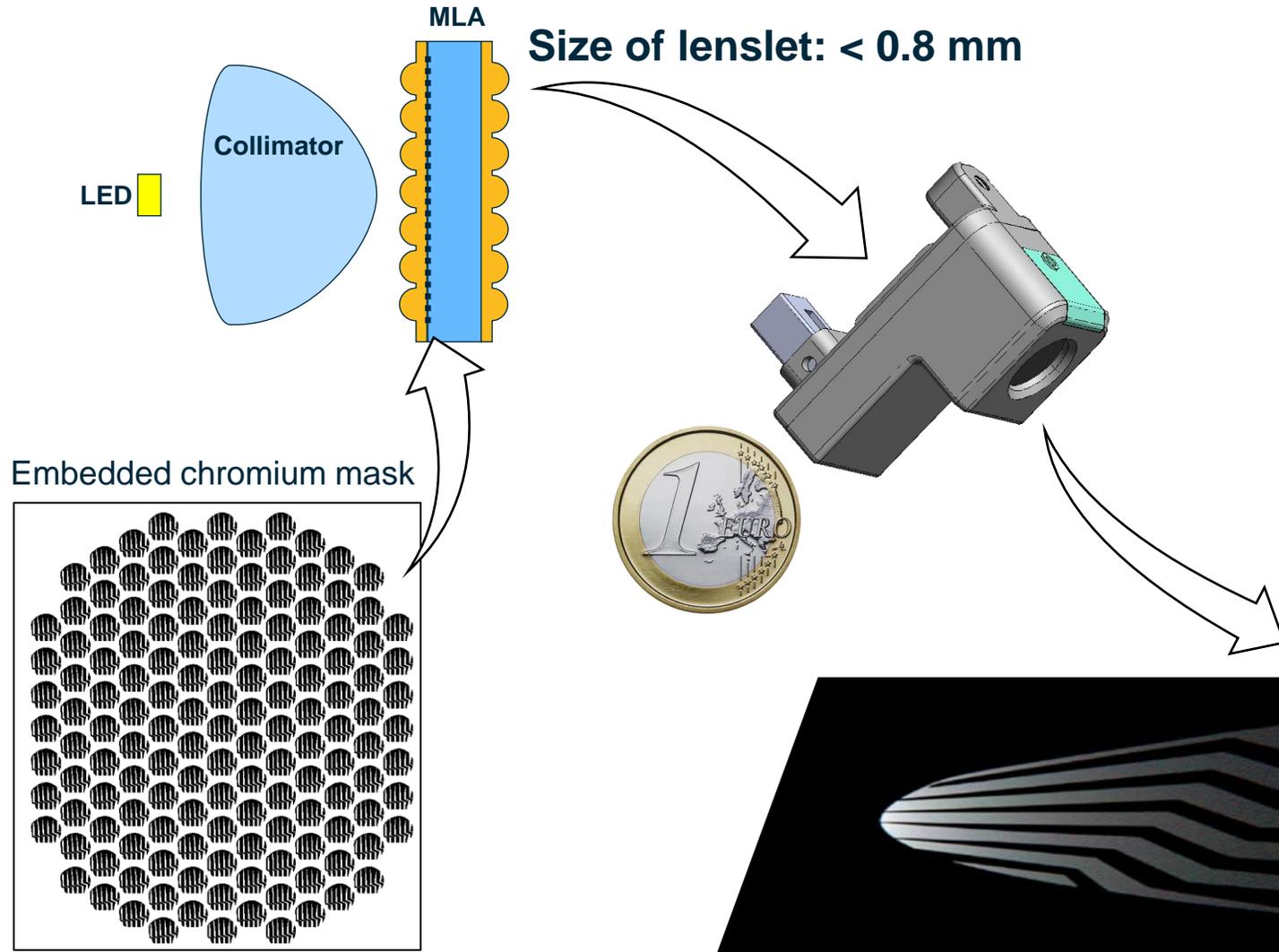
Illumination



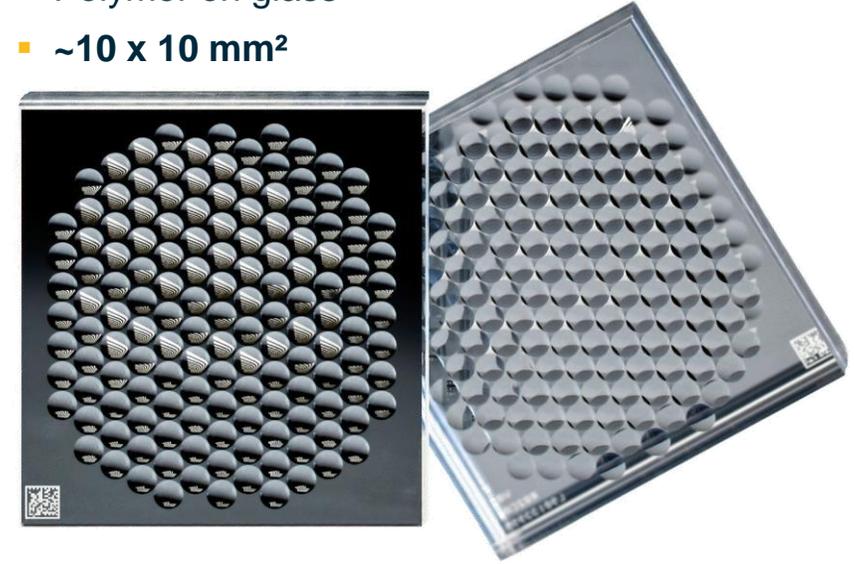
Diffractive Optics



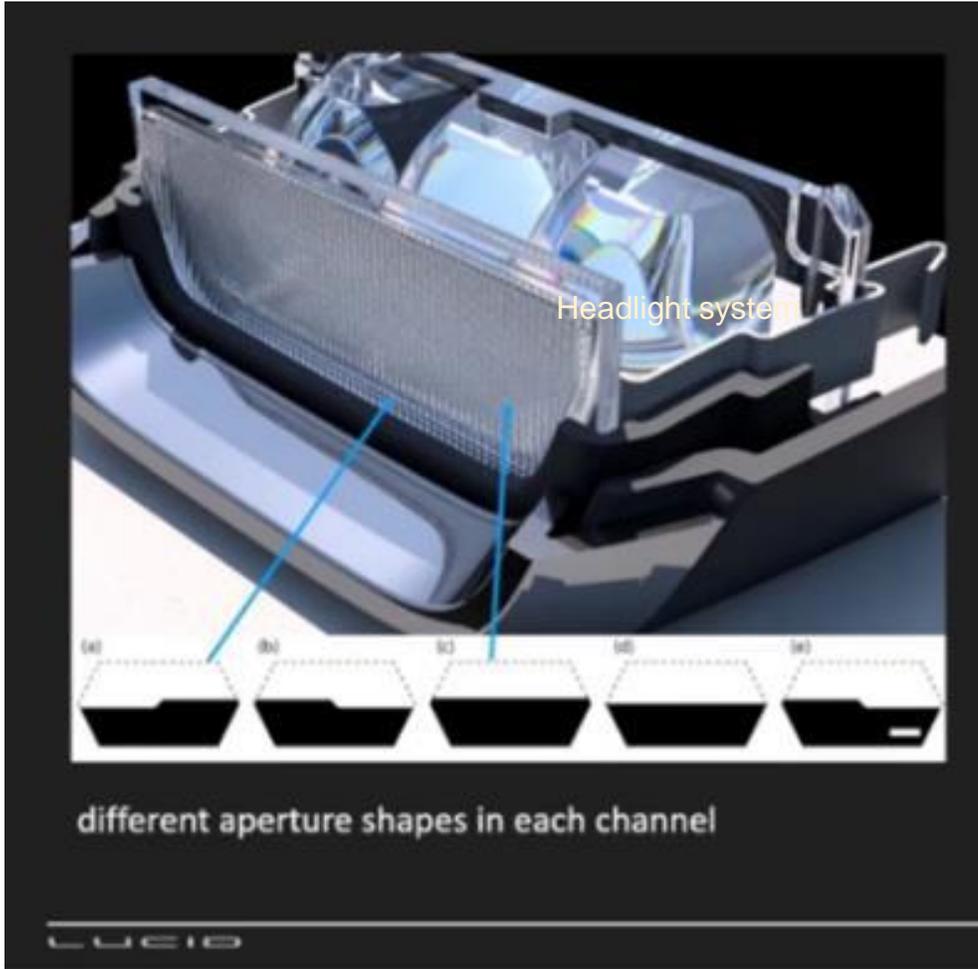
Ultra-Compact Microprojector



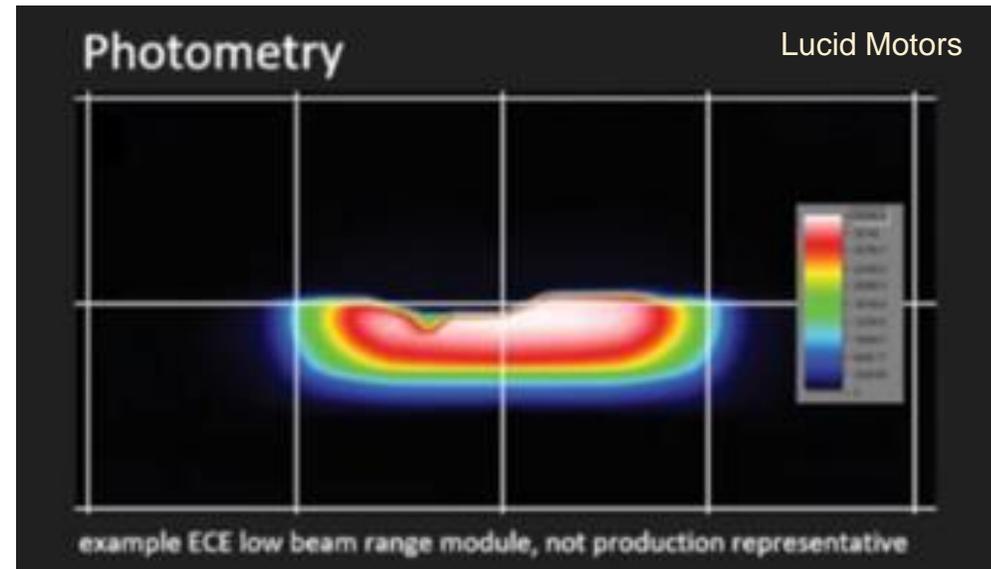
- Imprinted microlens array (MLA)
- Polymer on glass
- $\sim 10 \times 10\text{ mm}^2$



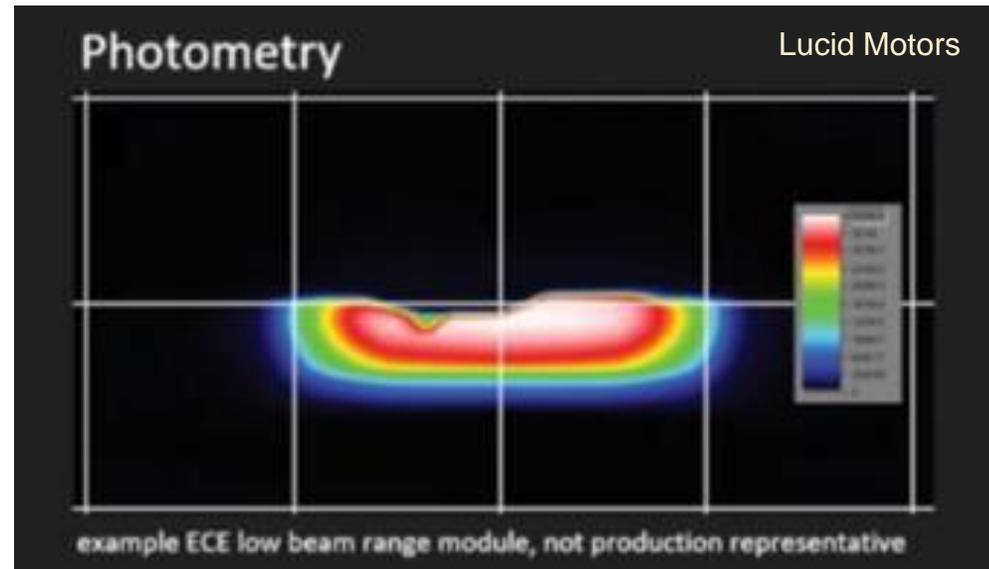
Automotive Lighting - Ultra-Compact Microprojectors And Headlamps



Lucid Motors



Automotive Lighting - Ultra-Compact Microprojectors And Headlamps



Our Products and Markets

LIDAR

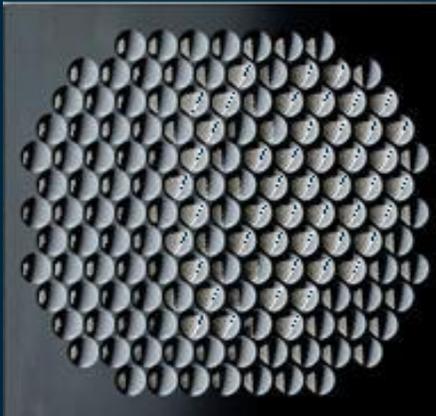
Silicon Photonics

LIDAR

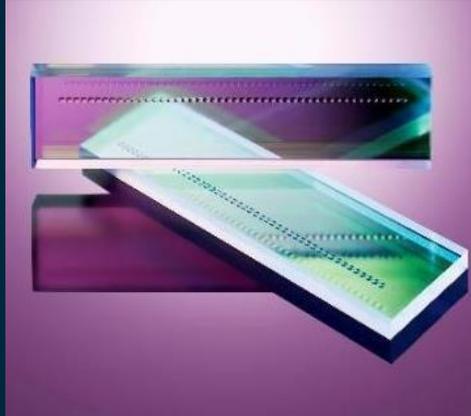
Illumination & 3D Sensing

Light Carpet & Headlamps

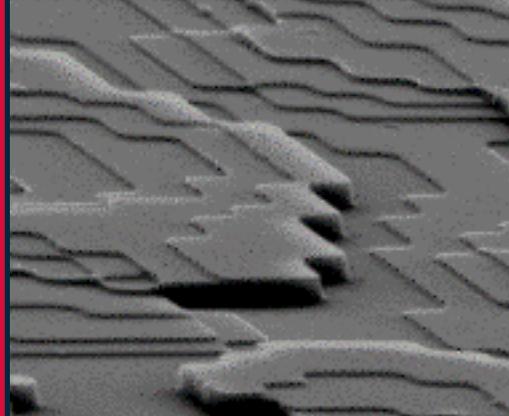
■ AUTOMOTIVE



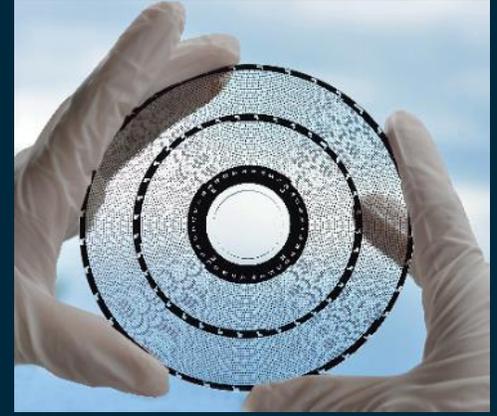
■ TELE/DATACOM



■ SEMICONDUCTOR

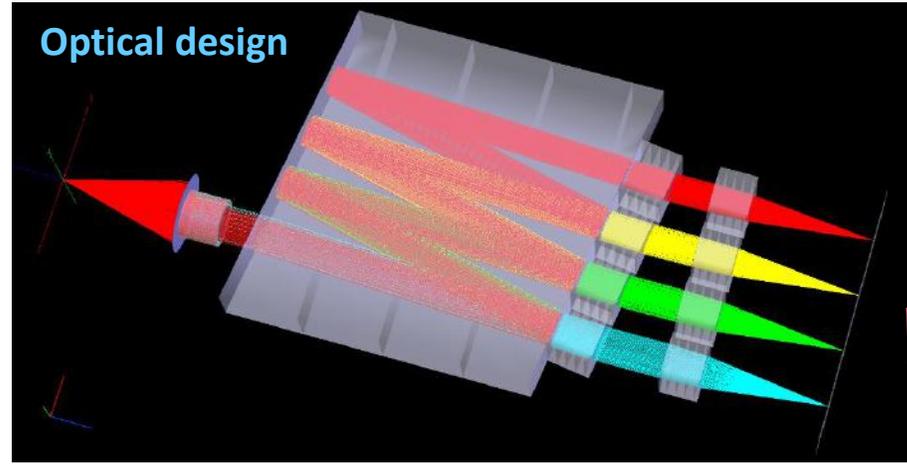
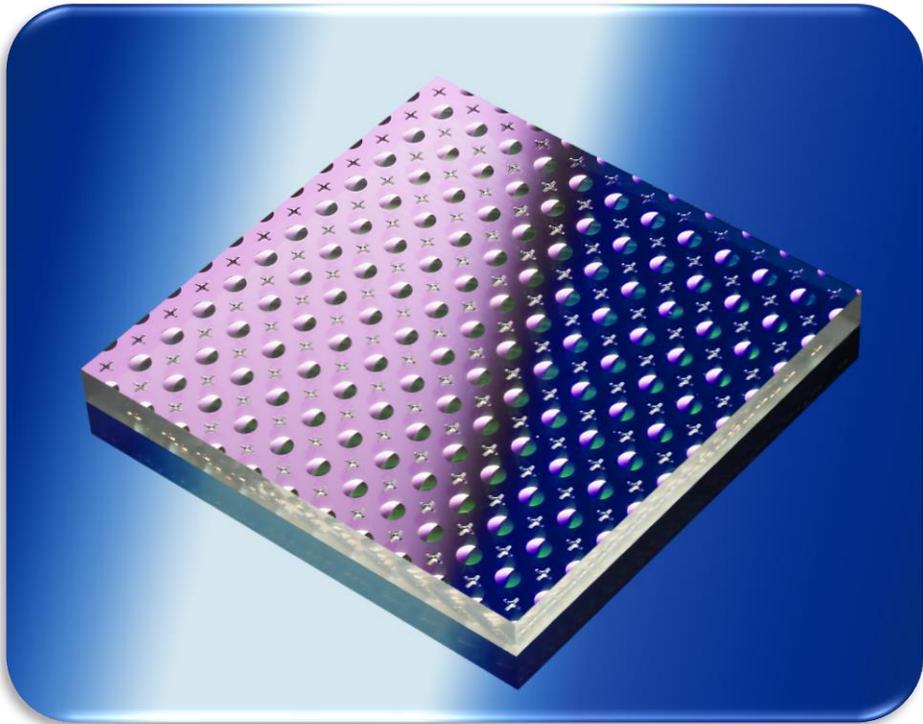


■ MEDICAL



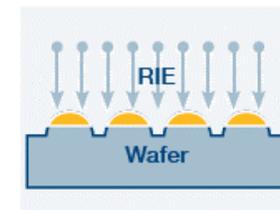
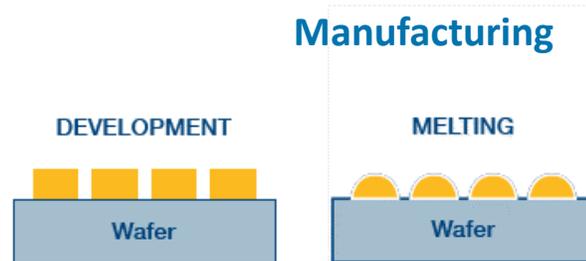
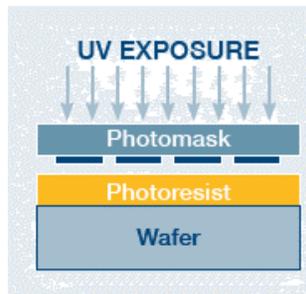
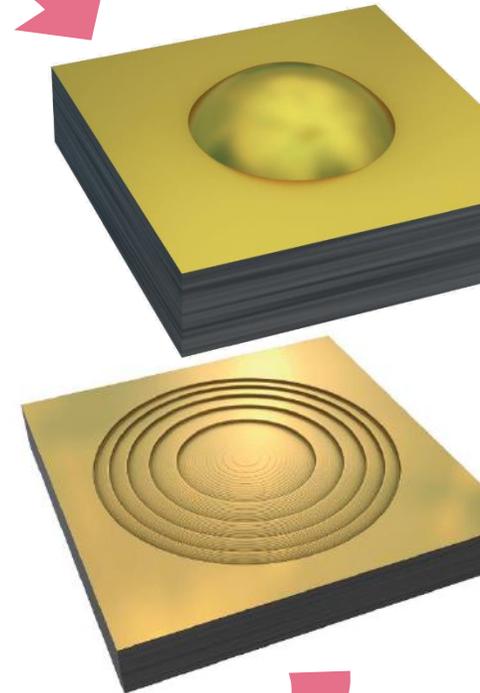
From Design to Product – Etched

Collimator-Lens Array



- CAD output
- Refractive
 - Diffractive

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



LIDAR System Where Micro-Optics can Miniaturize

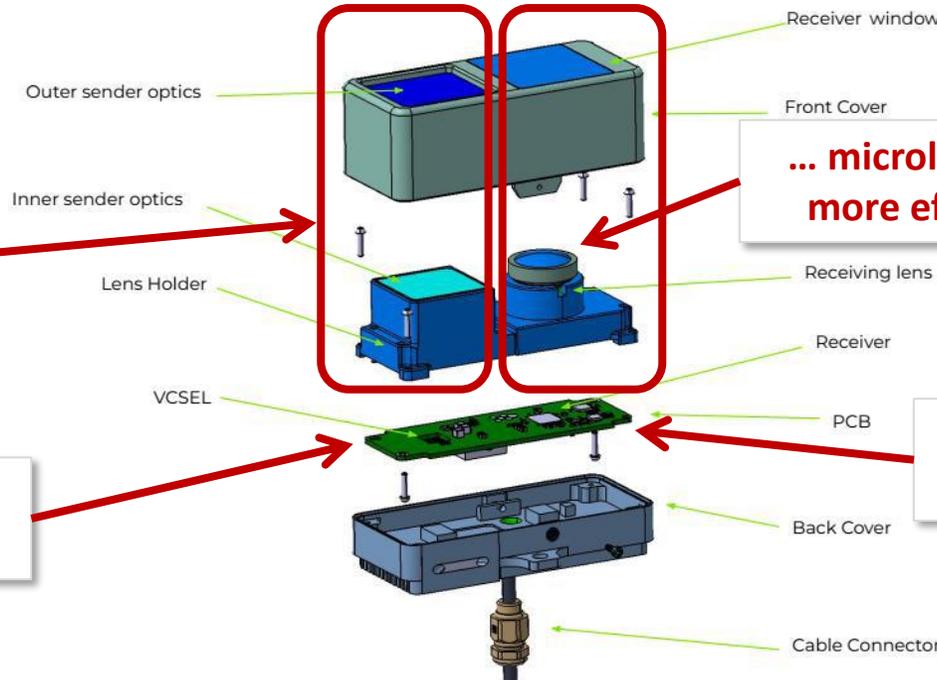
- LIDAR is ...
- ... Illumination
- ... Beam steering & scanning
- ... Receiving & Sensing

Potential applications for micro-optics ...

... microoptics for beam shaping

... microlenses for LASER collimation

Near Field Lidar Setup

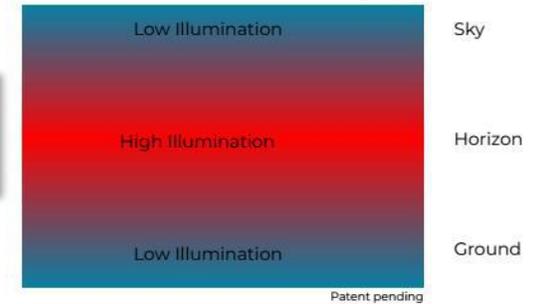


... microoptics for diffusers and beam shaping

... microlenses for more efficiency

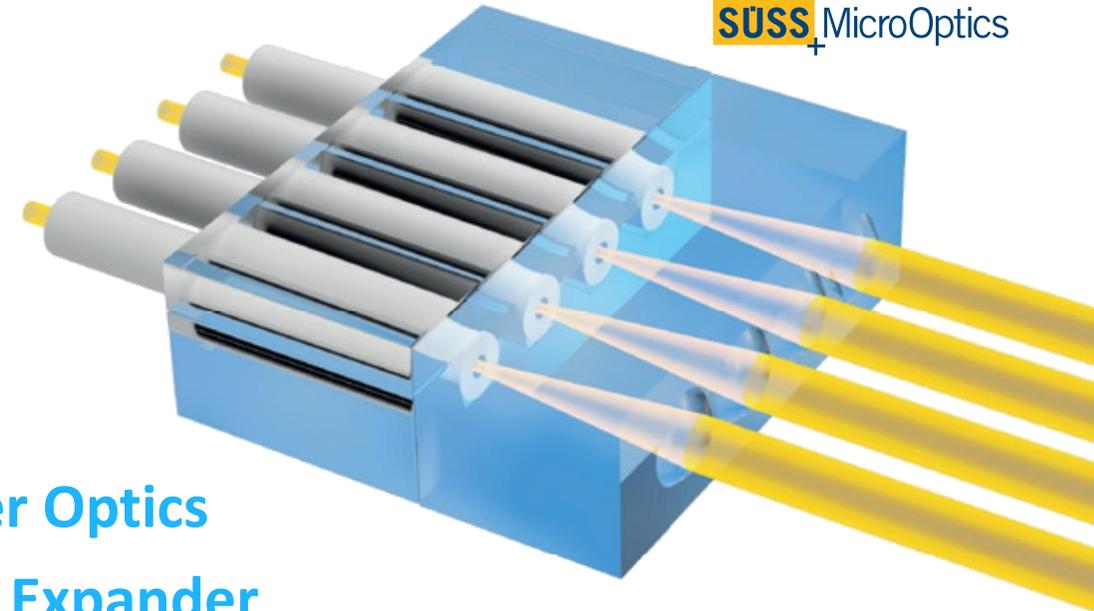
... micro-optics for detectors (SPAD)

Illumination distribution for automotive purpose

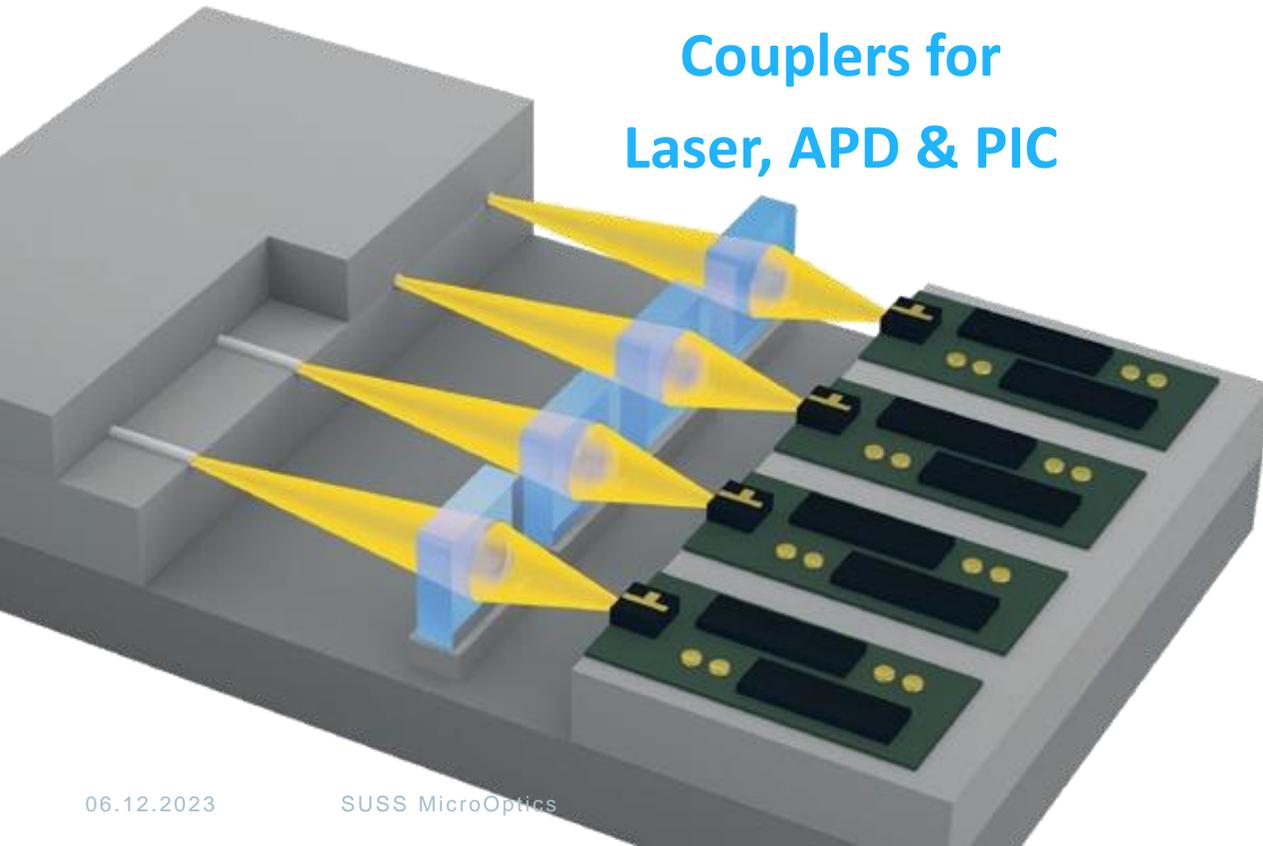


Micro-Optics in Data/Telecom Applications

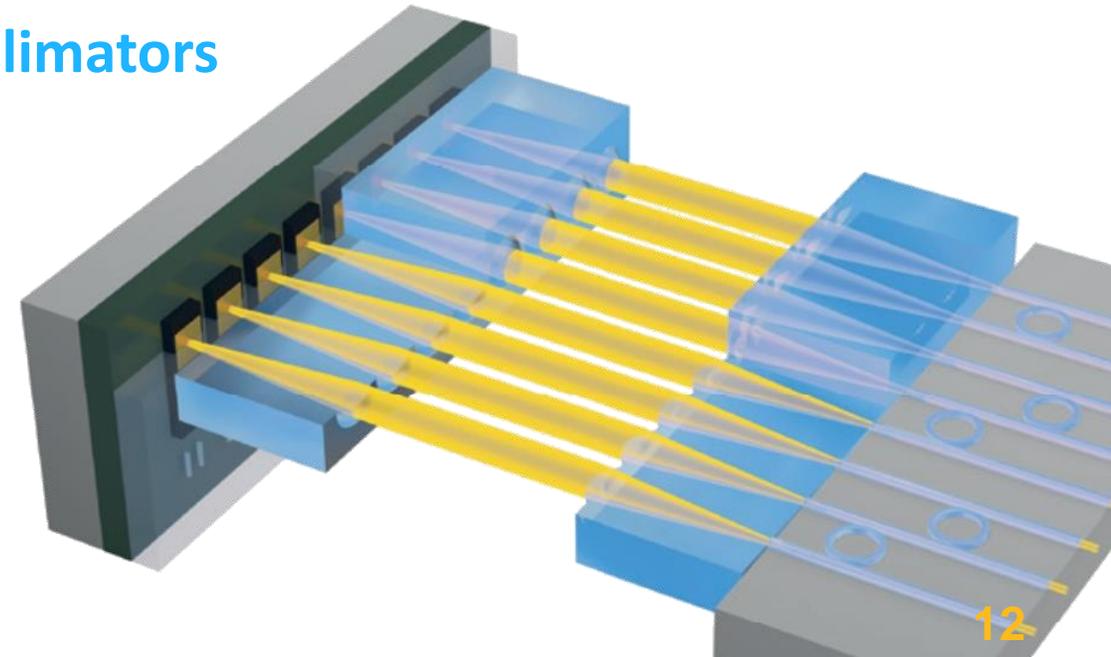
- Collimation & refocusing
- Large port counts with perfect alignment
- Pitch: 82 μm , 127 μm , 250 μm , 500 μm , 750 μm , ... custom pitch
- Arrays and singlets < 0.6 x 0.6 x 1 mm³



Couplers for
Laser, APD & PIC



Fiber Optics
Beam Expander
Collimators

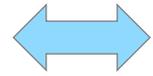


Silicon Photonics ... for Transceivers ... and LIDAR

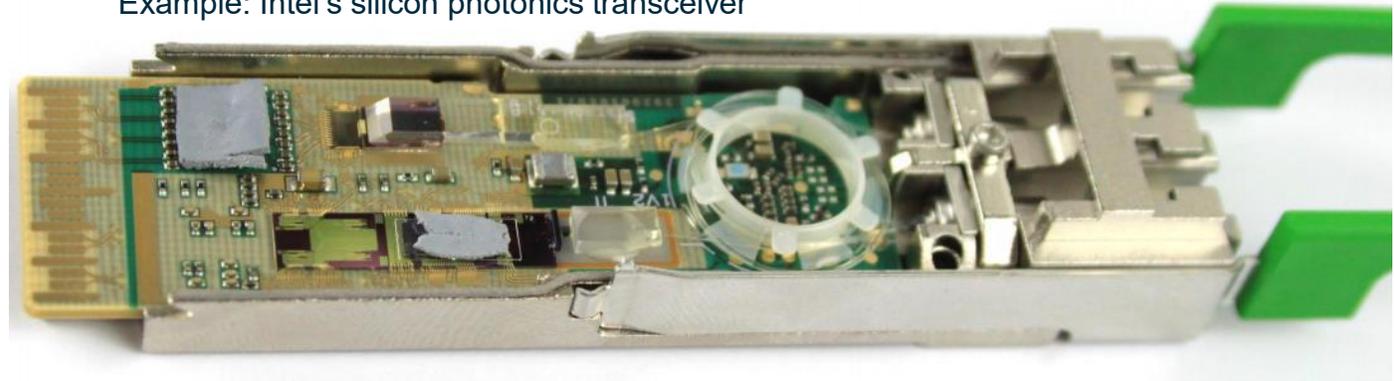
“Optical engine”

- Silicon Photonics (PIC)
- Fiber array
- Microlens arrays
- Microprisms

Example: Intel's silicon photonics transceiver

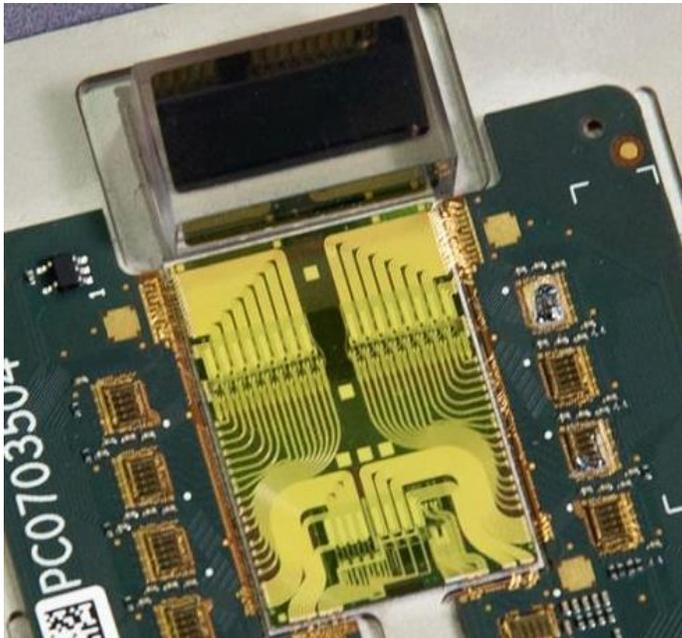


Electrical interface



Optical signals

MobilEye (Intel)



SILC



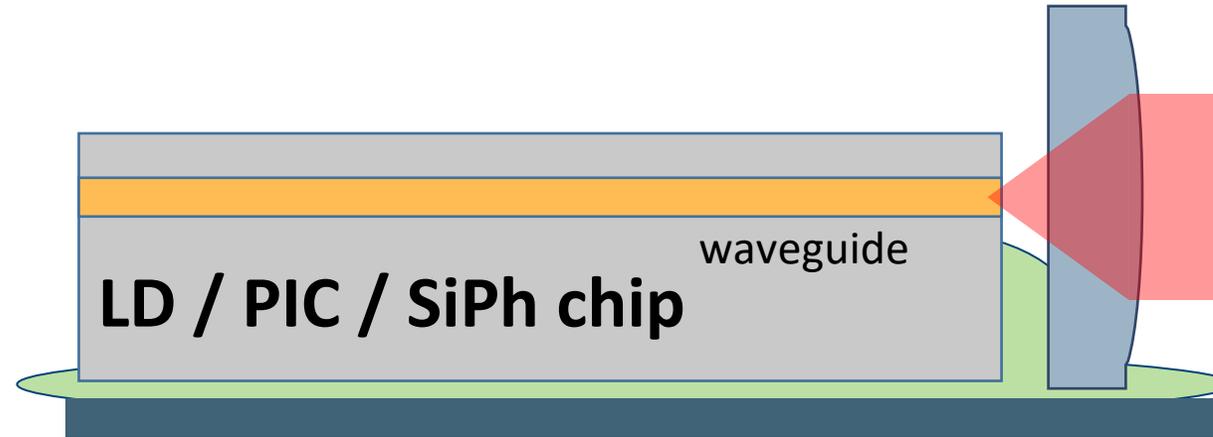
SCANTINEL



Microlenses for Silicon Photonics with Edge Emitters

Collimation Micro-Optics

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

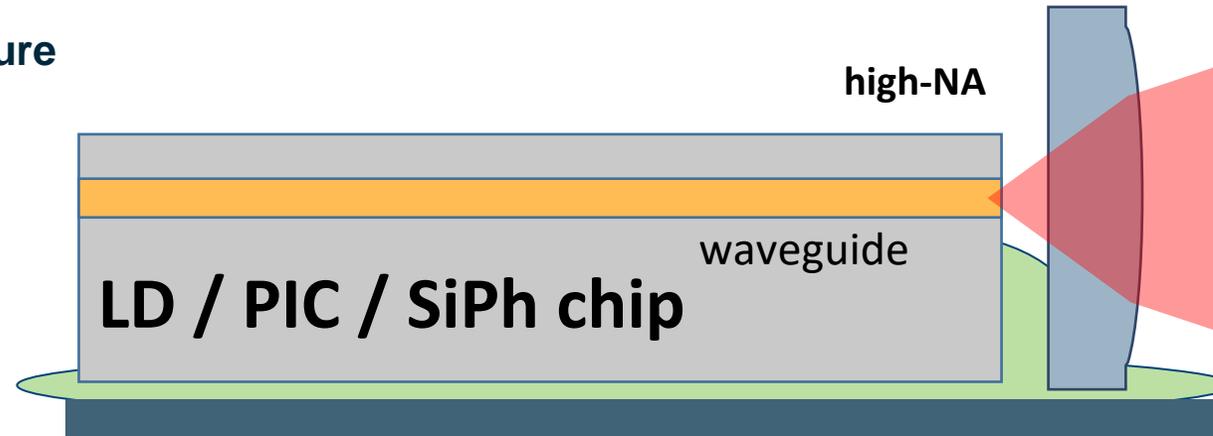


Micro-optics for ...

Collimation
and re-focusing

Adaptation of Numerical Aperture

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

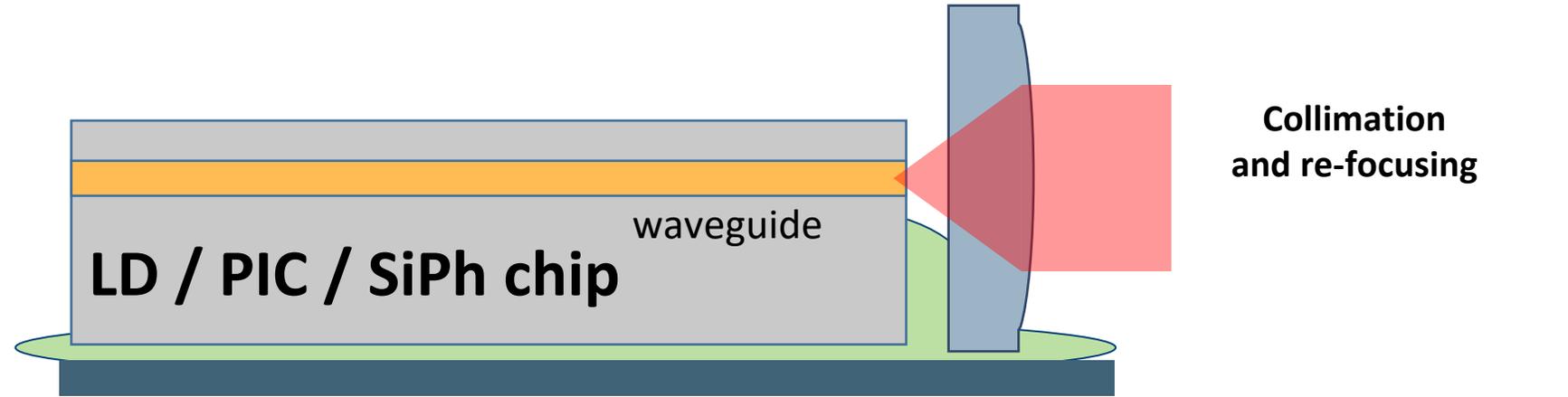


low-NA
divergence

Microlenses for Silicon Photonics with Edge Emitters

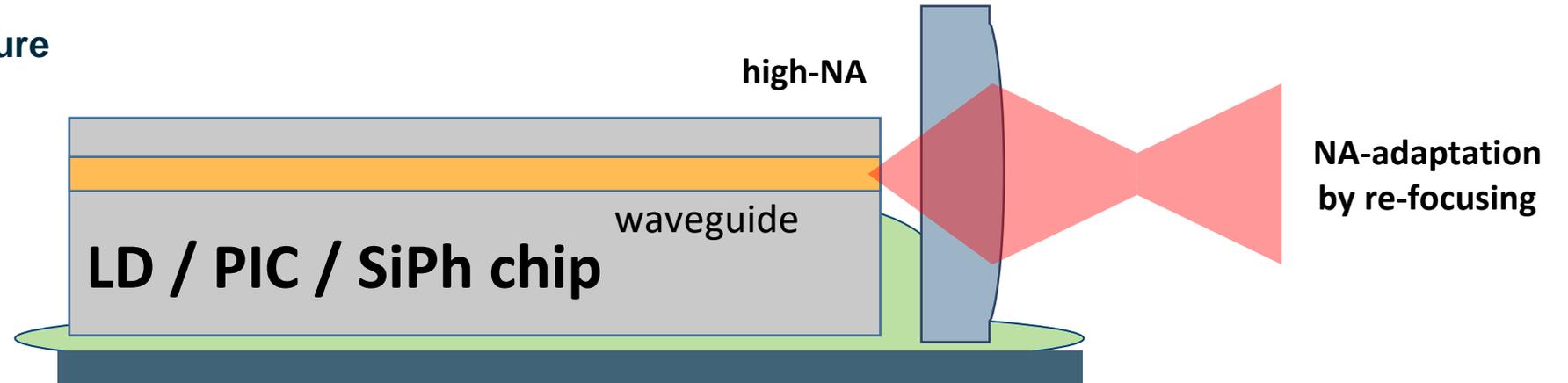
Collimation Micro-Optics

- Very compact
- Adapted to PIC layout
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Adaptation of Numerical Aperture

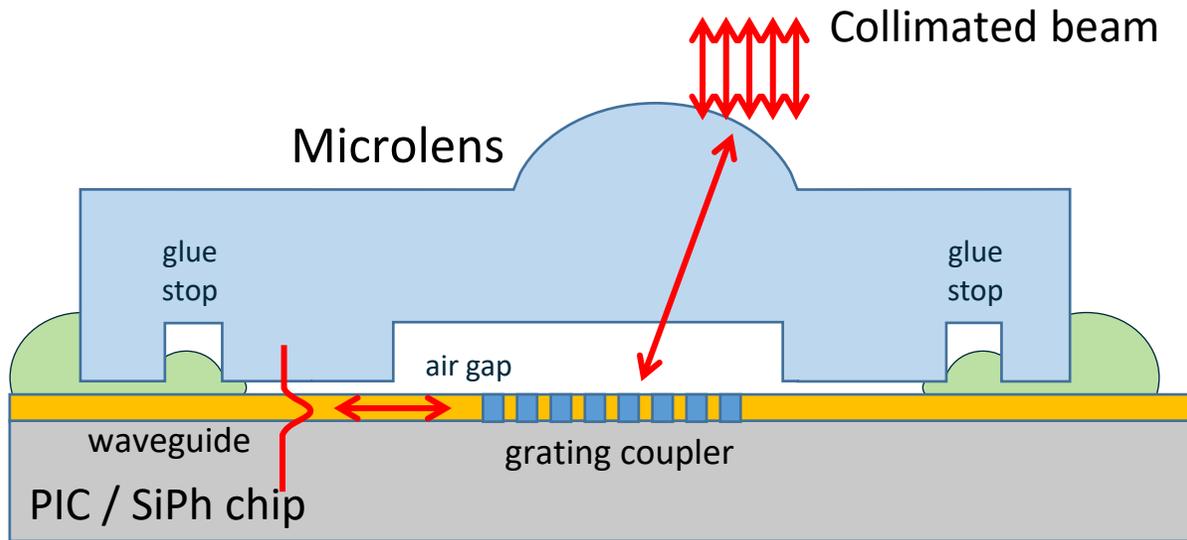
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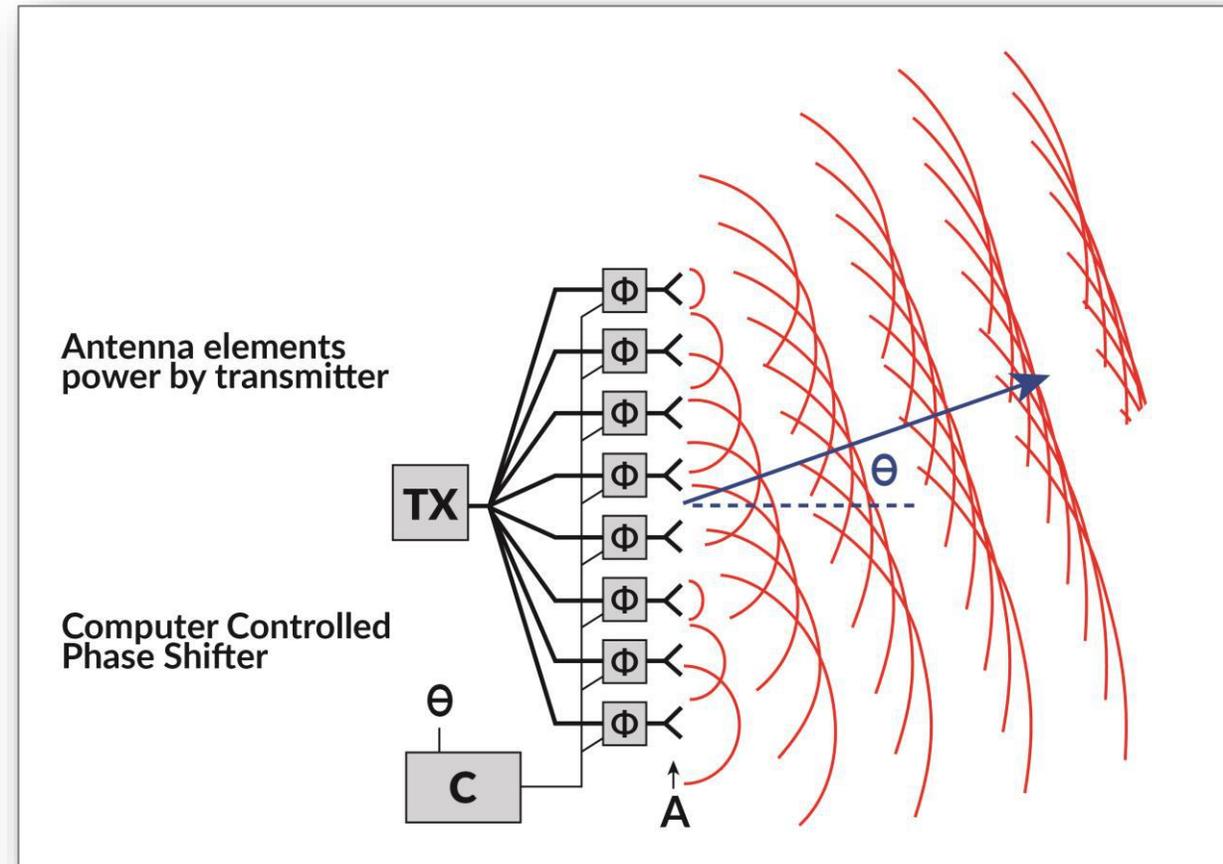
Microlenses for Silicon Photonics with Grating Couplers / OPA

Collimation Optics

- Front side
- Packaging features
- Off-axis microlens for tilted beam



Optical Phase Array (OPA) for Beam Steering

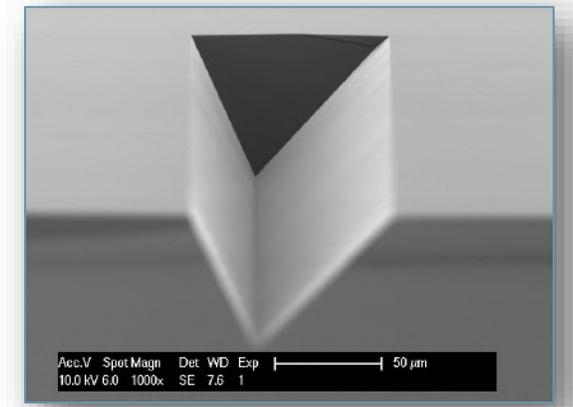
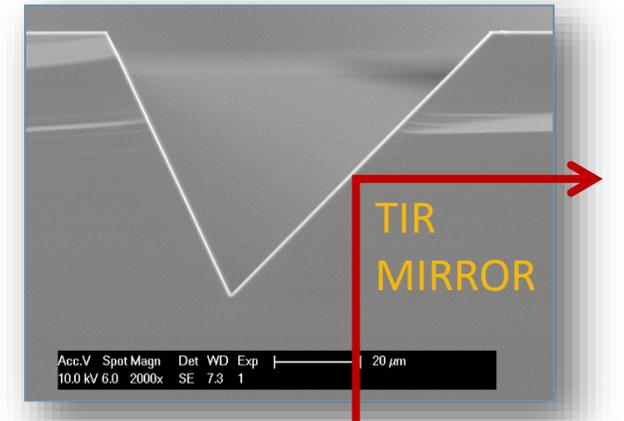
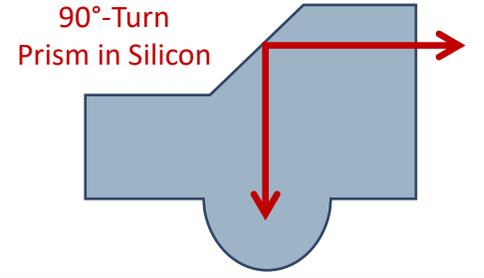
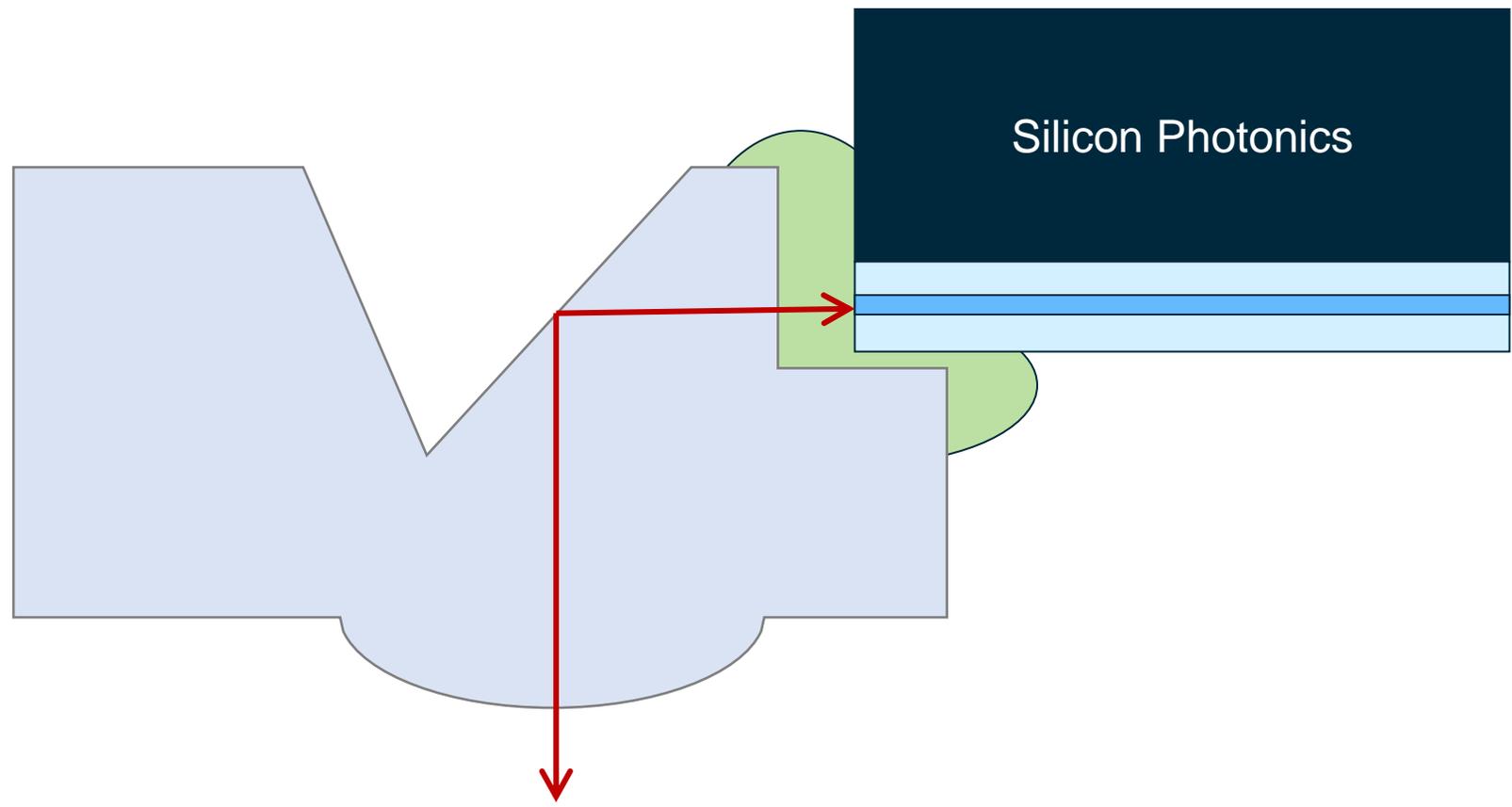


<https://www.eetimes.com/quanergy-optimizes-optical-phased-array-lidar/#genecy-interstitial-ad>

<https://go.abiresearch.com/lp-demystifying-lidar-iot-and-automotive-applications>

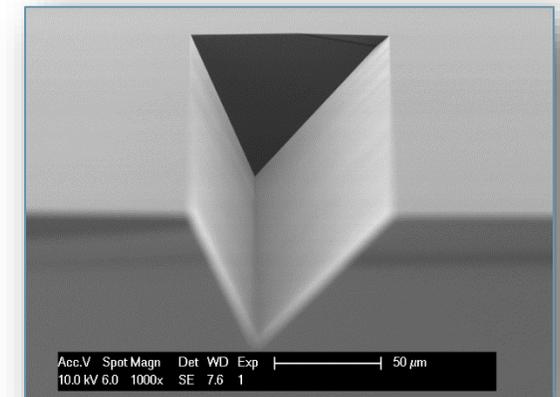
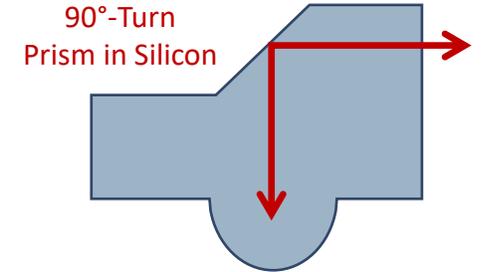
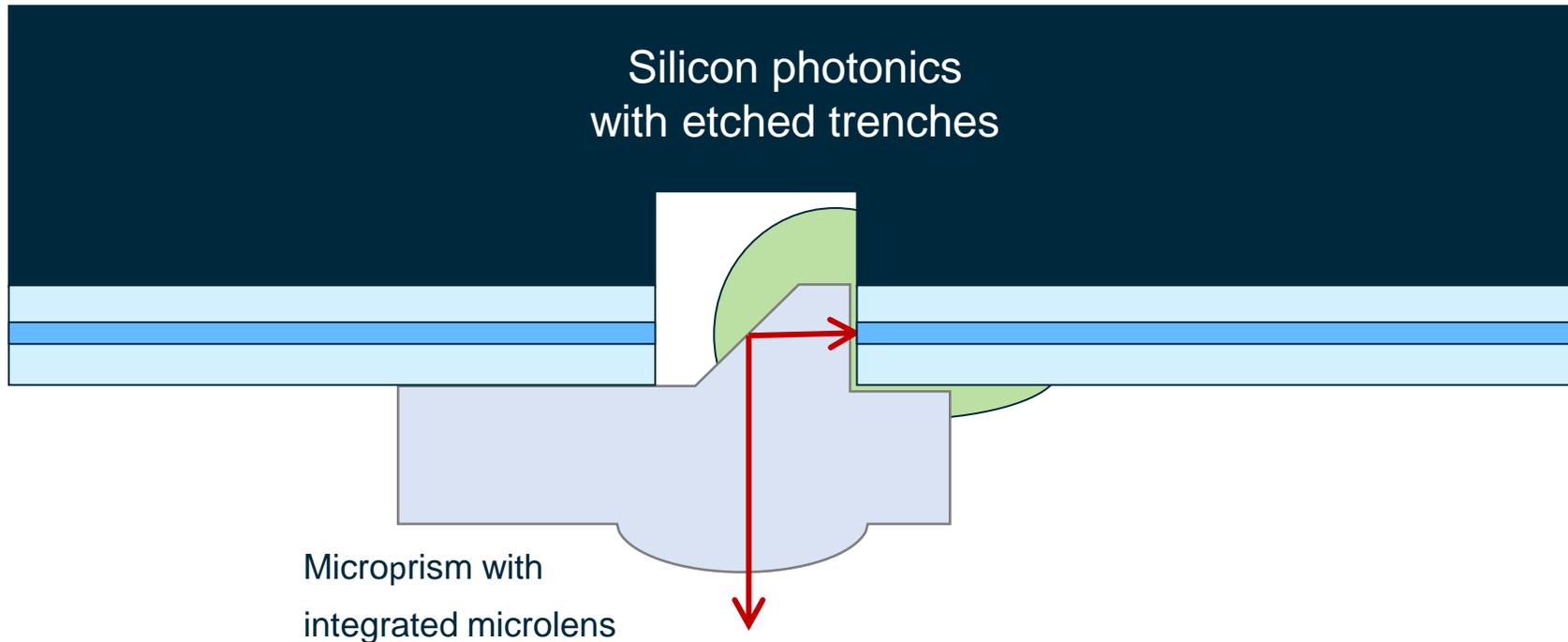
Prism with Integrated Microlens – “Calm the Waves” along the PIC Shoreline

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

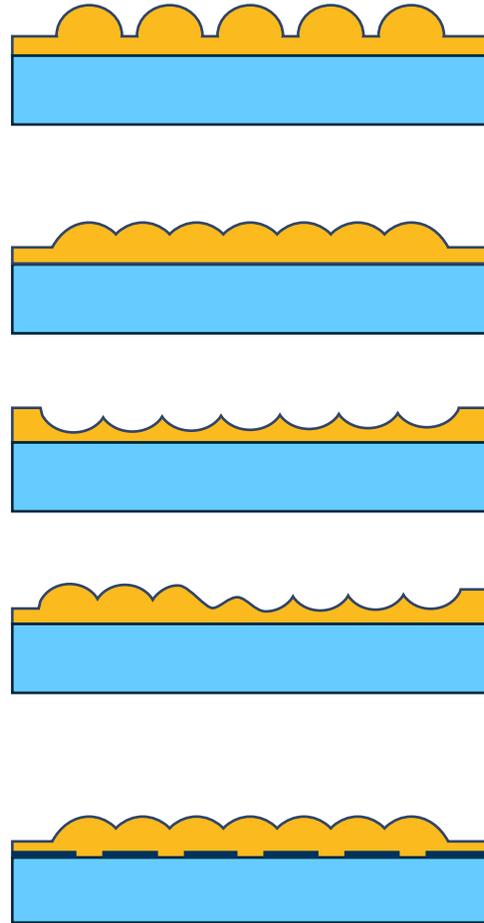
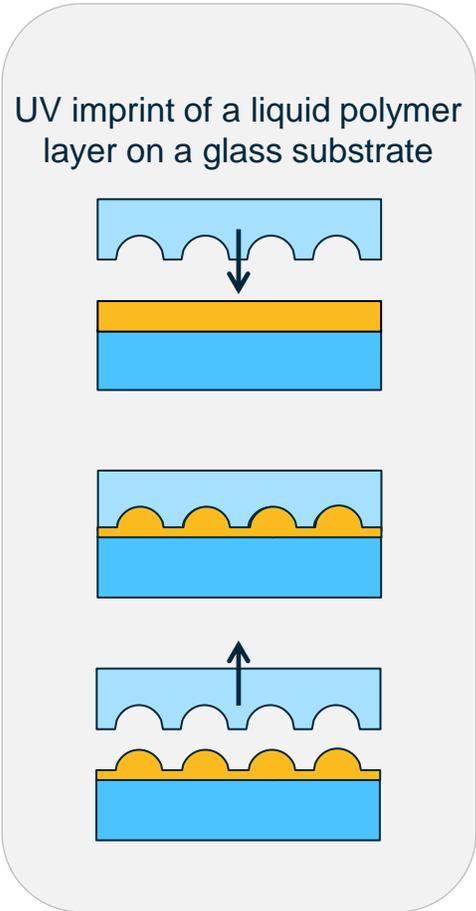


Prism with Integrated Microlens – Future High Level of Integration

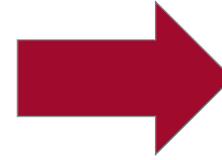
- Monolithic prism and lens
- Collimation optics & re-focusing optics
- Simple interface to PIC or fiber
- “Drop-In Prism” → *Chip-to-wafer technology ... in development*



Imprinted Microlenses – Wafer-Level – Double-sided



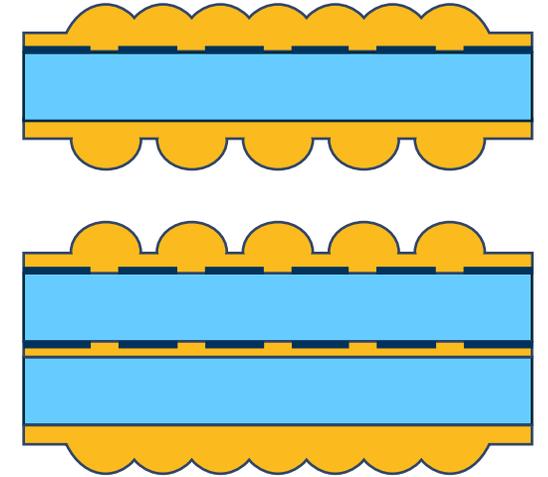
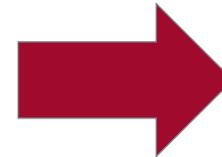
Front- and Backside Optics



Double-sided MLAs

Precisely aligned

Embedded apertures

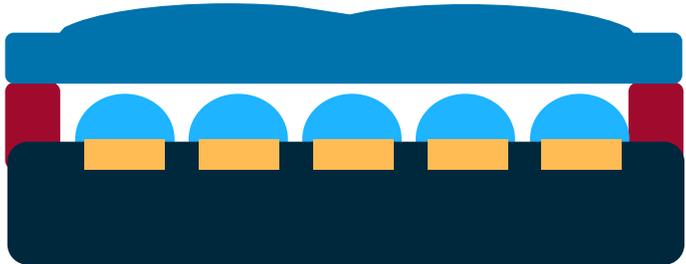
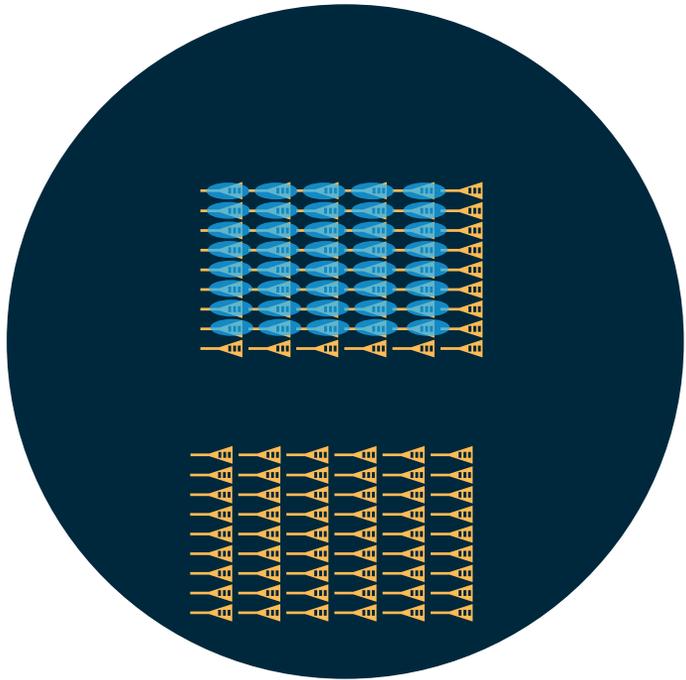


Wafer Level Micro-Optics for Integrated Optics, VCSELs, SPADs, ...

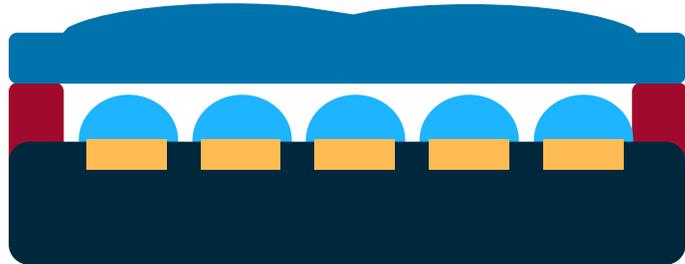
■ Silicon Photonics @1310 nm, @1550 nm

■ Lasers, VCSELs in the NIR

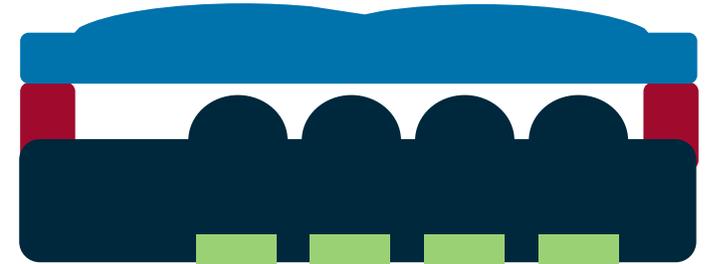
■ Photodetectors (SPAD, PD, ...)



Wafer-Level Micro-Optics ... for beam steering

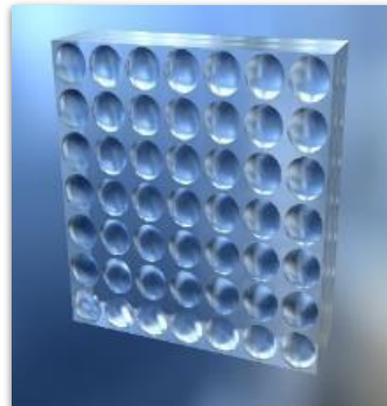
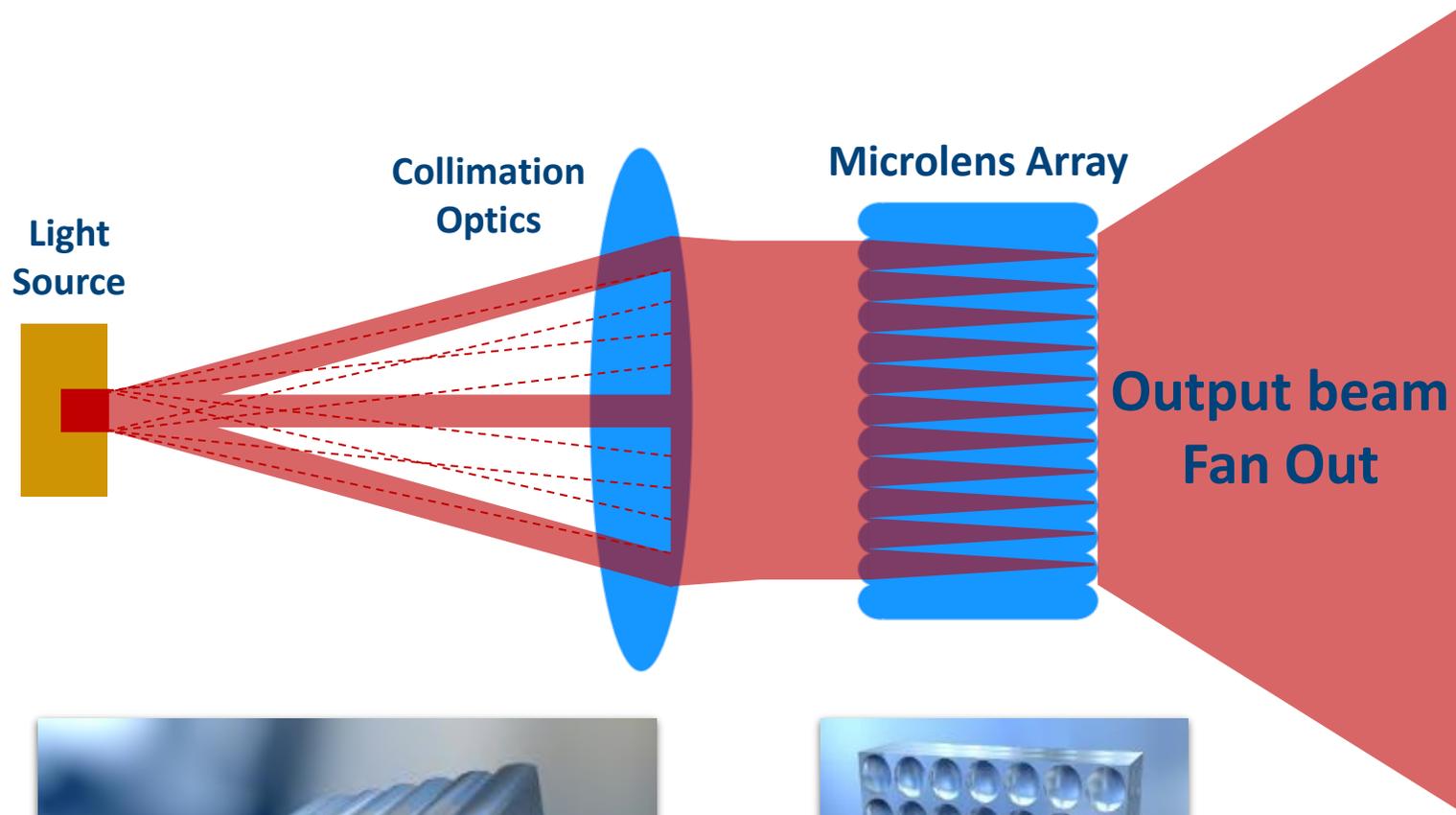


... for collimation

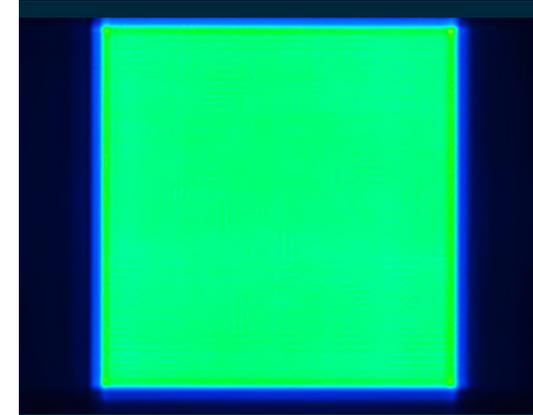


... for fill factor enhancement

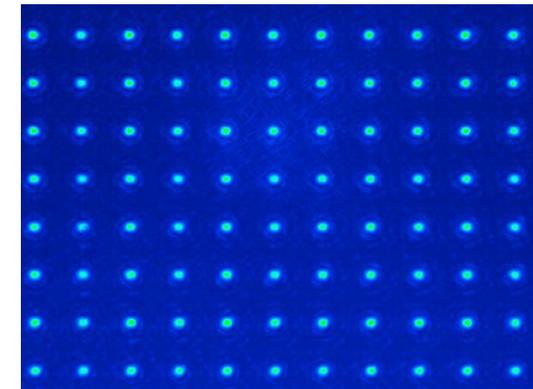
Beam Shaping Optics – Diffusers and Homogenizers



Incoherent superposition



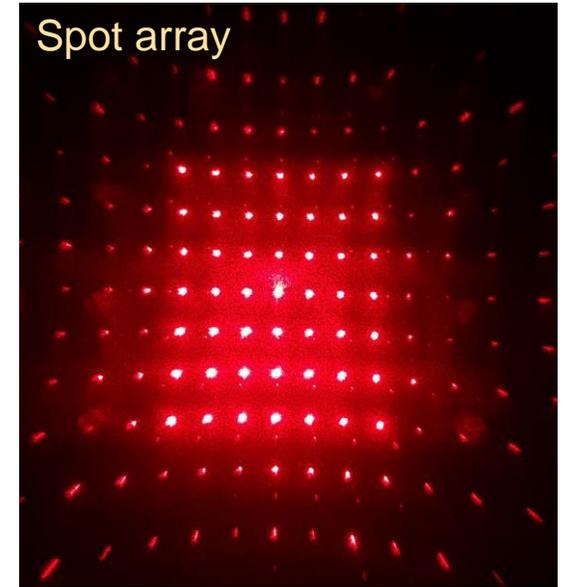
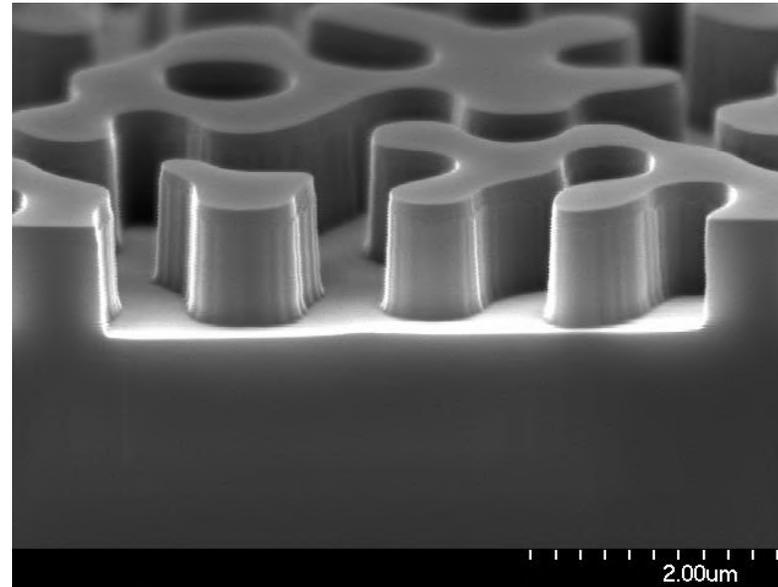
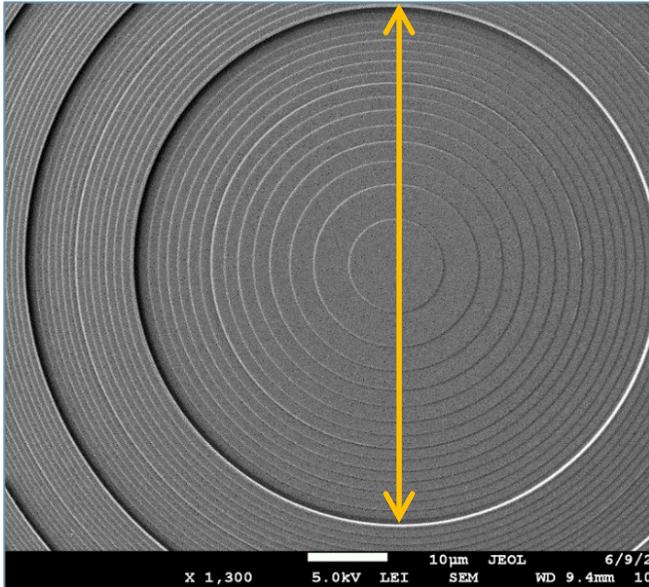
Coherent superposition



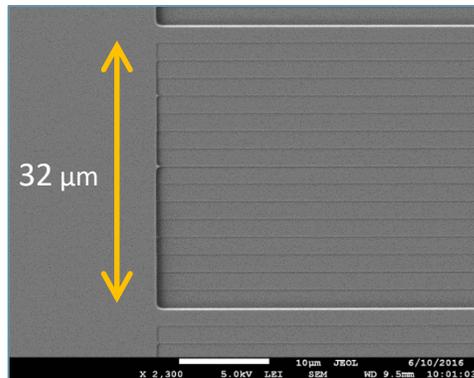
Sources:
www.blz.org, Johannes Wangler (CZ SMT)
www.palomarmedical.com

Diffractive Fiber Collimators and Beam Shapers

DOE Lens in Silicon for 1.55 μm , 350 nm resolution



16-Level Grating >96% diffraction efficiency



- Stepper technology
- Different radii or curvature in different directions
- No gaps between the lenses
- Partial lenses for off axis optics
- Design support available

Advantages of Micro-Optics ... Made in a Semicon Foundry

- Custom solutions → Micro-optics offers quick & precise solutions
- Wafer-level production → High volume, high reproducibility
- Microtechnology → sub- μm precision
- Functional testing → Wafer-level handling
- Large lens arrays → Unique optical performance and parallelization

Challenges

- LiDAR is a relatively “independent” photonics community
- Many “newcomers” with long development times

Thank you!

