



Fabrication of optical interconnects for PICs

Advanced low-loss coupling solutions made easy

Jörg Smolenski, Business Development Manager

16th of September 2024

EPIC Online Technology Meeting on Photonics Hybrid Integrated Circuits

15
YEARS Think big.
Print nano.



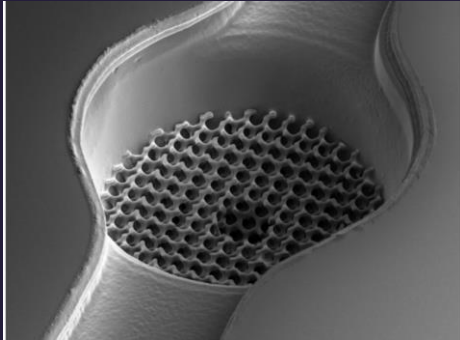
Company Facts & Figures

- ▶ 100+ employees
- ▶ 35% R&D intensity
- ▶ 4,000+ users
- ▶ 2,000+ publications
- ▶ HQ in Karlsruhe, Germany with >4,200 m² space
- ▶ Subsidiary Boston, US
- ▶ Subsidiary Shanghai, CN
- ▶ 15+ years of success

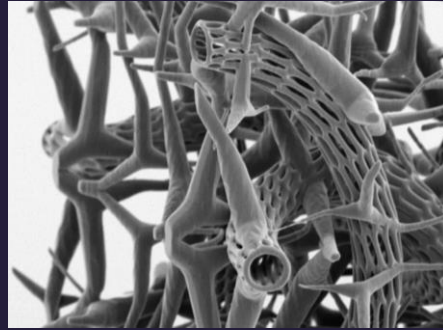
We empower cutting edge science & drive industrial innovations



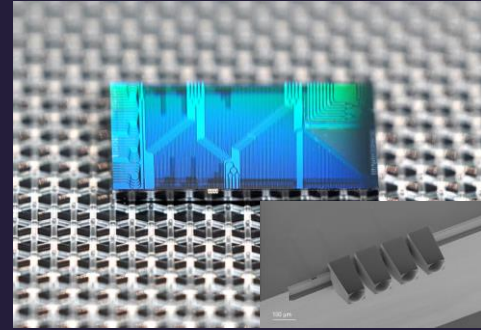
Life Sciences



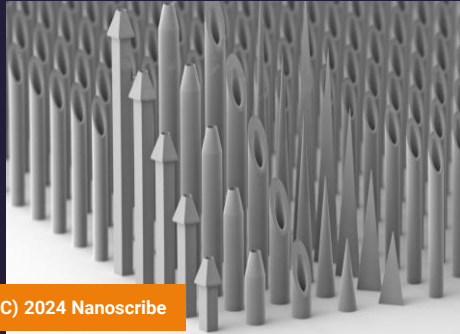
Microfluidics



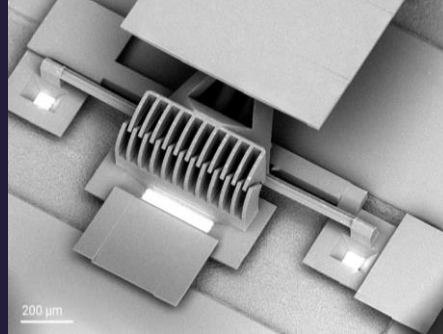
Photonic Packaging & PIC



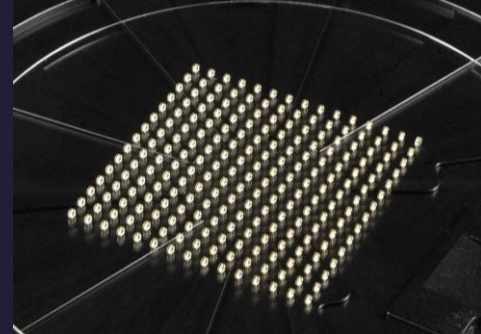
Microneedles

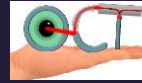


Materials Engineering & MEMS



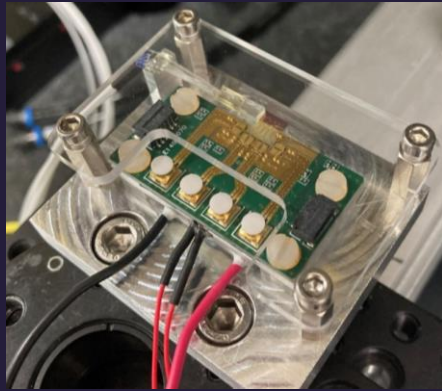
Microoptics



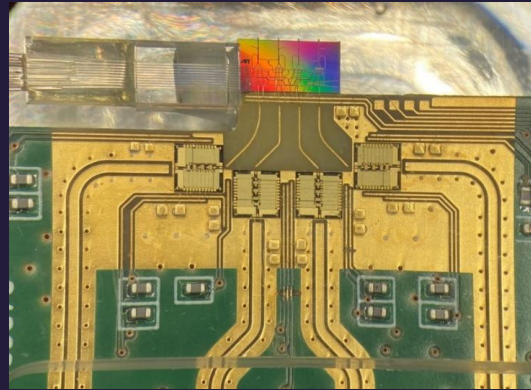


Integrated photonics

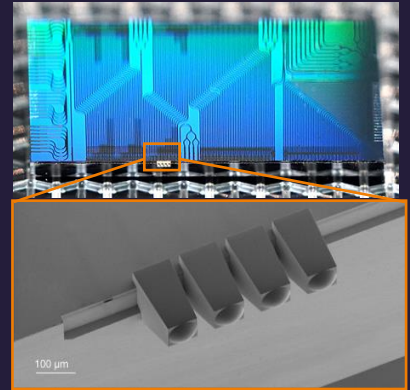
A compact packaged product based on different components



Packaged prototype



Fiber-PIC-EIC



PIC - Printed microoptics

▶ Printing of optical interconnects on

- any material (SiN, Si, SOI, GaAs, LNBO, ...) and
- any component (PIC, Laser, VCSEL, PIN, SM/MM/PM fiber...)

▶ Print fast: down to 2 sec / object

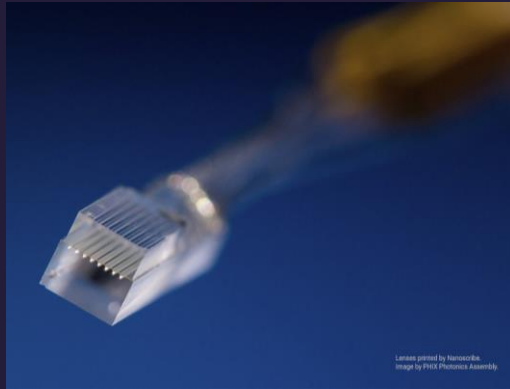
- ▶ Dedicated 3D Micro Printer: Quantum X align
- ▶ Supporting patent portfolio

Free-Space Microoptical Coupling (FSMOC)

Efficient light coupling solutions

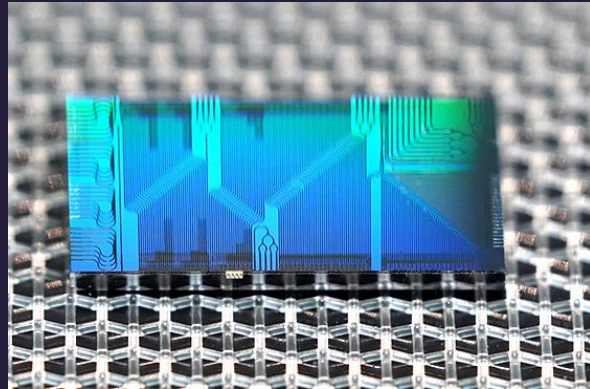


On fiber array



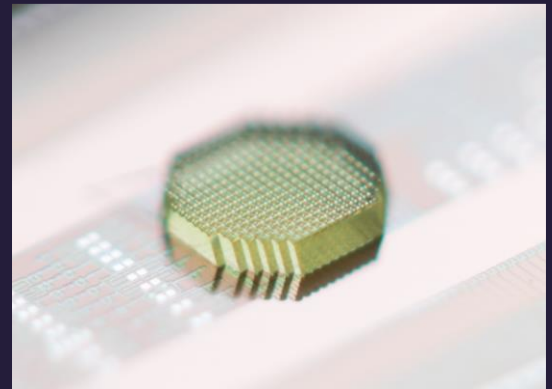
Microoptical elements on optical facet of fibers (fiber array)

On chip edge



Free-space microoptical couplers on chip edge (edge coupler)

On chip surface



Free-form microlenses for vertical coupling on chip surfaces (grating coupler)

Overview of Optical Coupling Challenges

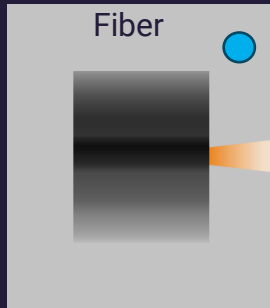
Large variety of substrates, interfaces and related MFDs



Fiber

3 – 10 μm MFD

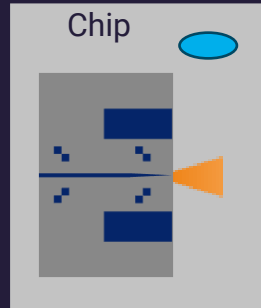
Circular cross section



Chip edge

0.5 – 3.0 μm MFD

Elliptical cross section

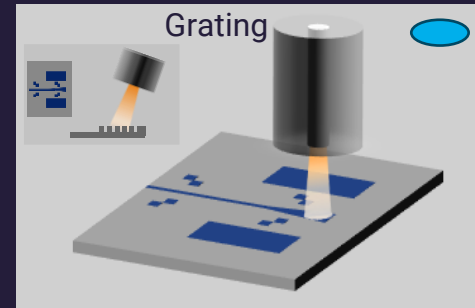


On chip surface

0.5 – 3.0 μm MFD

Elliptical cross section

Angled emission

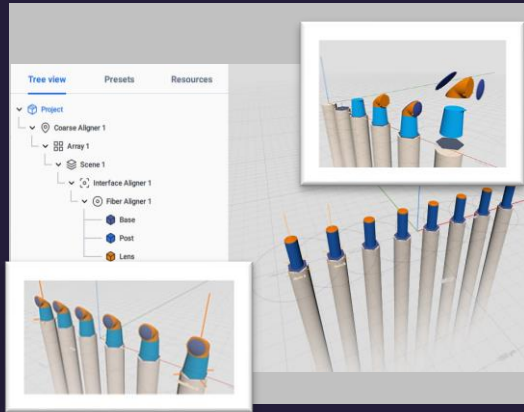


Fiber Arrays: Adapting the MFD and Numerical Aperture (NA)

Easy print set up, flexible designs, reliable results

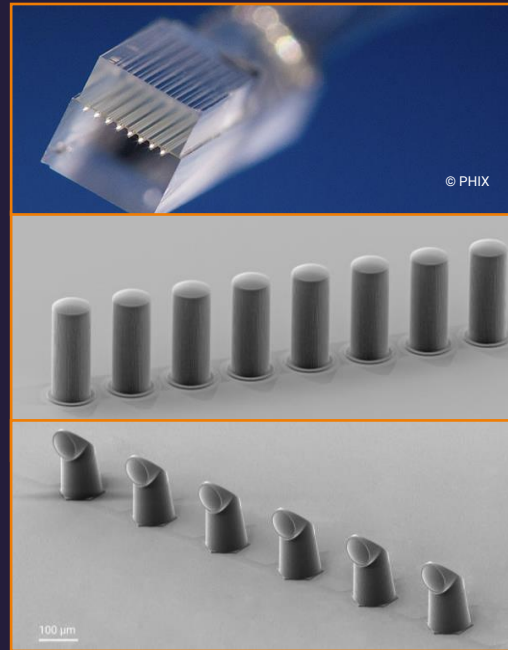


Workflow

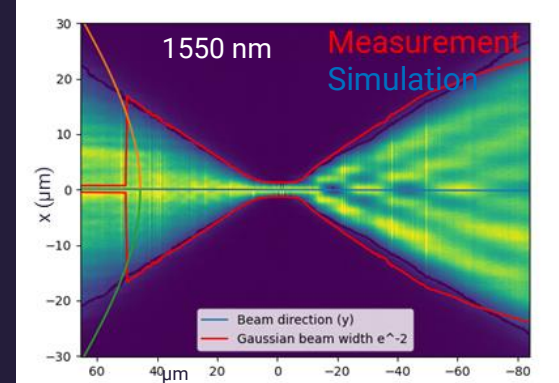


- ▶ Define lenses via formula or STL
- ▶ Align relative to fiber core
- ▶ Select process parameters
- ▶ Print & develop

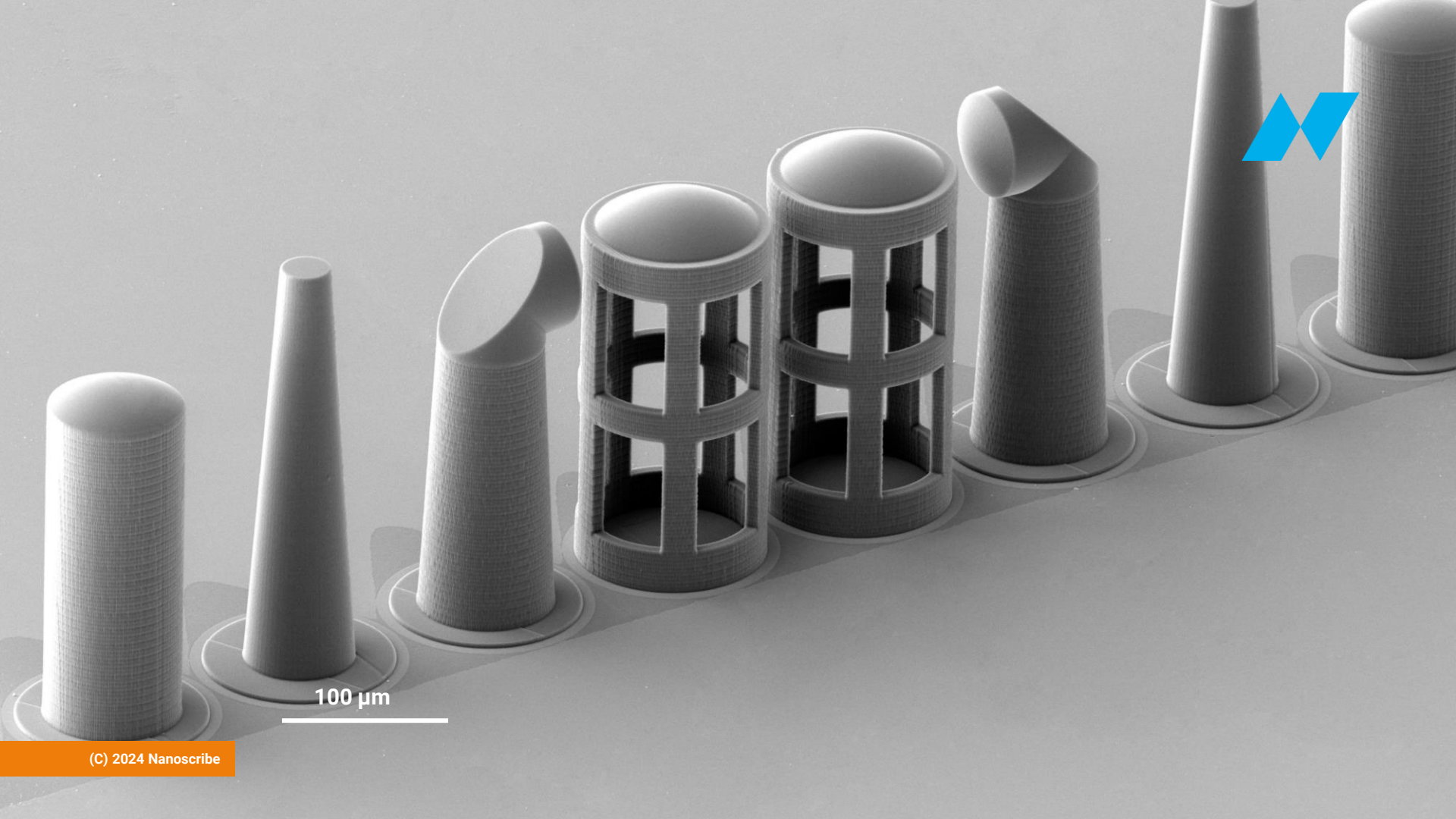
Results



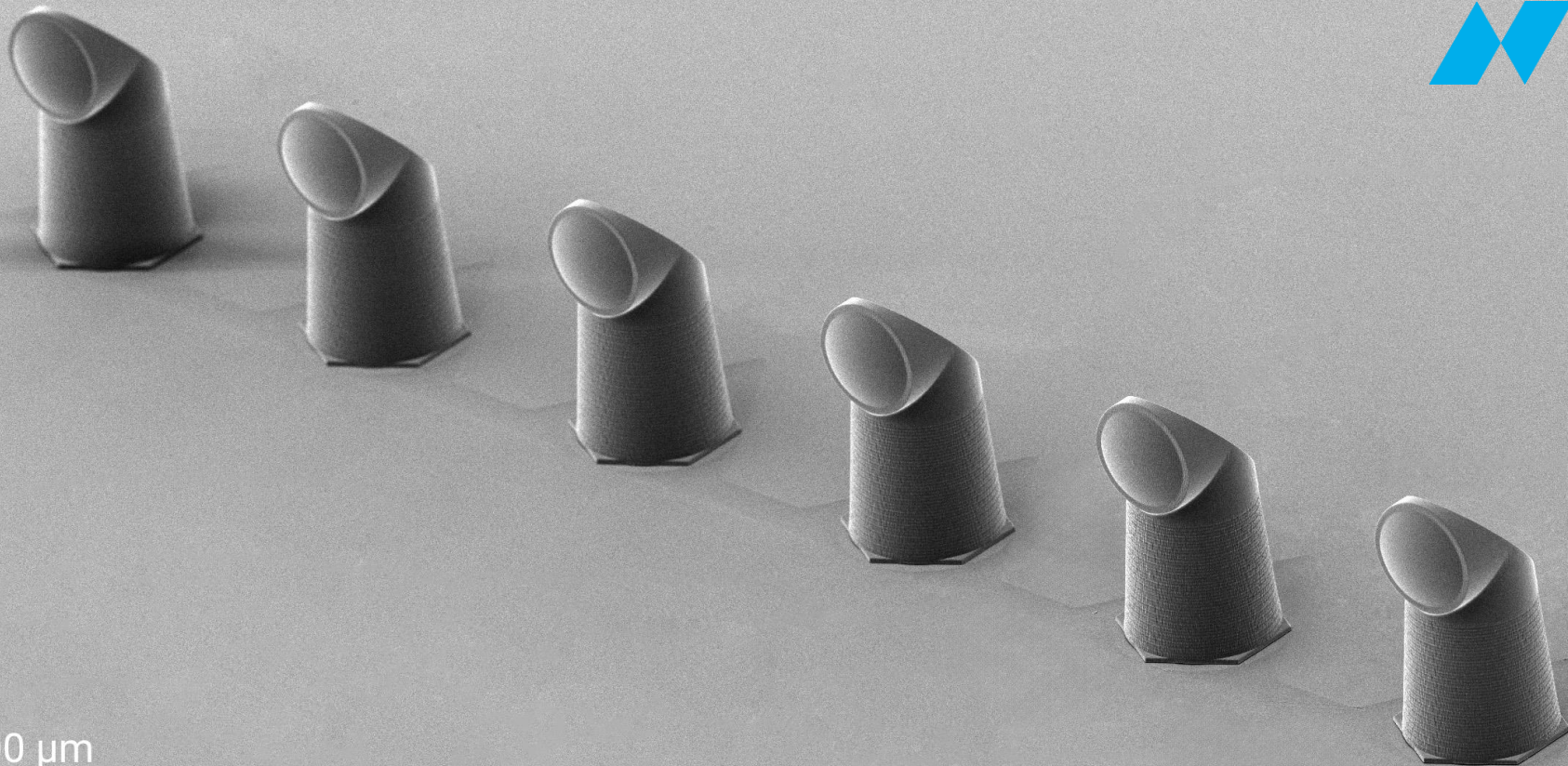
Characterization



Characteristic	Typ. Value
Shape accuracy	< 40 nm rms
Surface roughness	<5 nm
MFD repeatability	$\sigma = 16 - 23$ nm
Loss	0.5 - 0.8 dB
Print time	10 - 80 sec
Environmental	Thermal Shock -25°C to 85°C(1000 cycles); 85° C 85 %

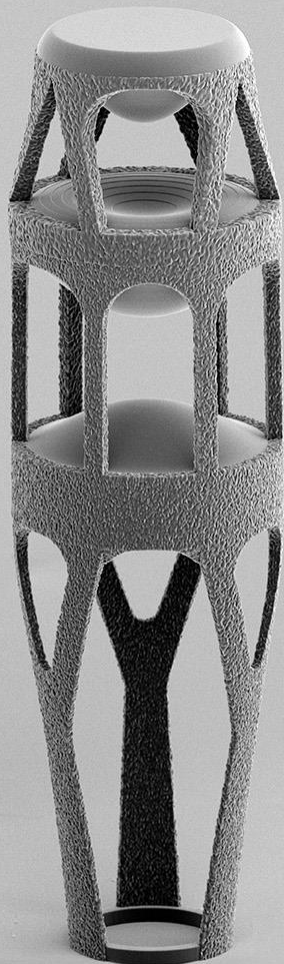


100 μm



100 μm

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printoptix



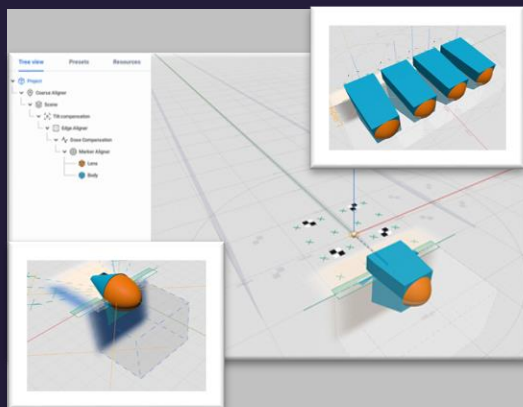


250 μm



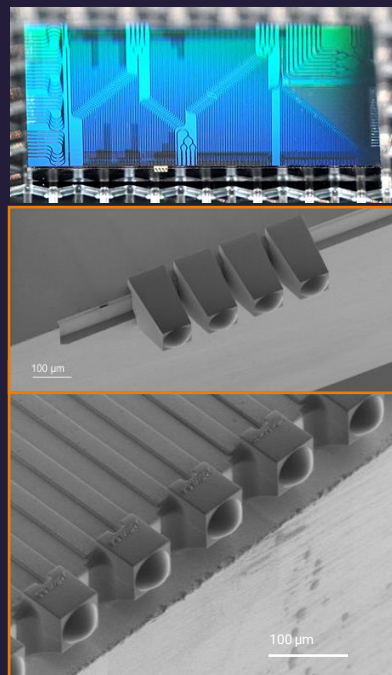
Microoptics on the Edge of a Chip: Shaping the beam from elliptical to round with low losses

Workflow

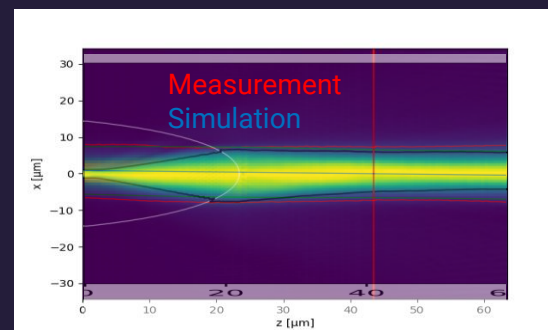


- ▶ Define lenses via formula or STL
- ▶ Align relative to marker and edge
- ▶ Select process parameters
- ▶ Print & develop

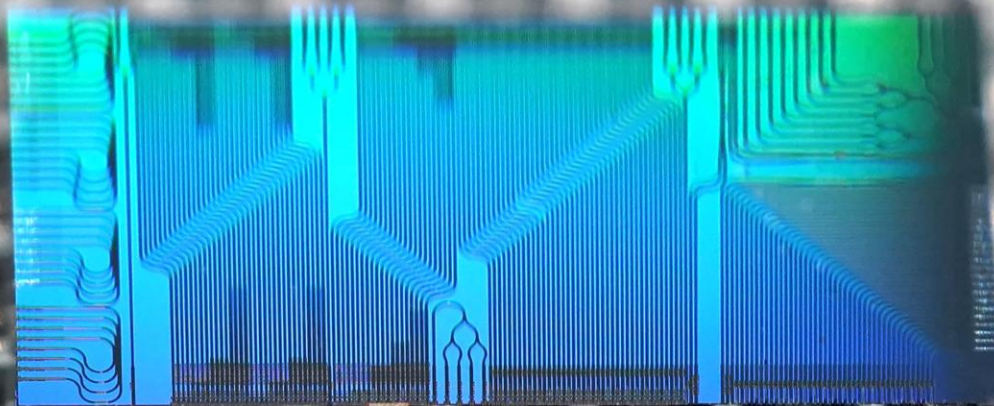
Results



Characterization

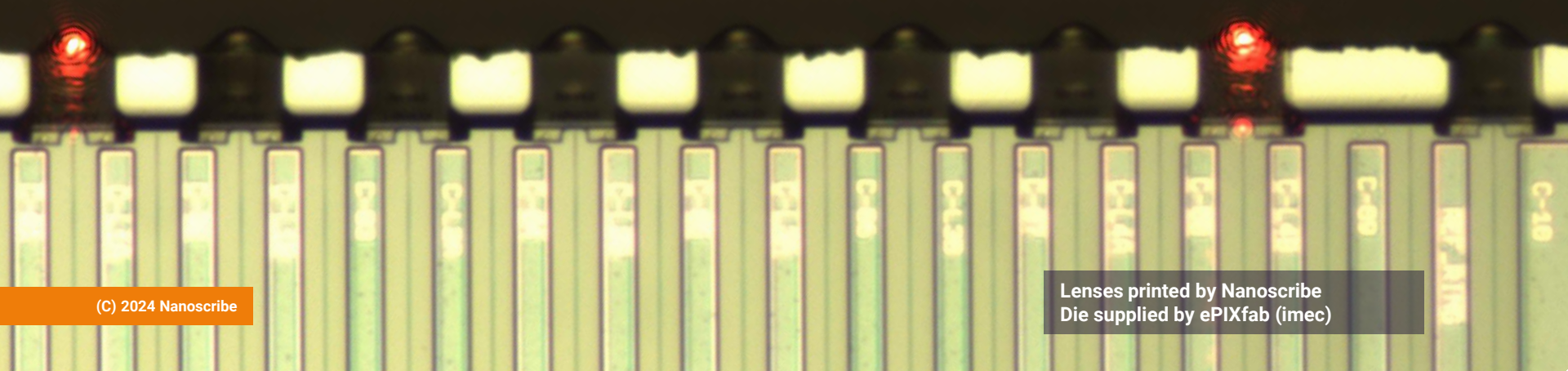


Characteristic	Typ. Value
Shape accuracy	< 40 nm rms
Surface roughness	<5 nm
MFD repeatability	$\sigma < 23$ nm
Loss	0.8 – 2.0 dB
Print time	90 - 280 sec
Environmental	Thermal Shock -25°C to 85°C(1000 cycles); 85° C 85 %



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Source: HH-OCT
Lenses Printed by Nanoscribe
Photonic chip fabricated by imec

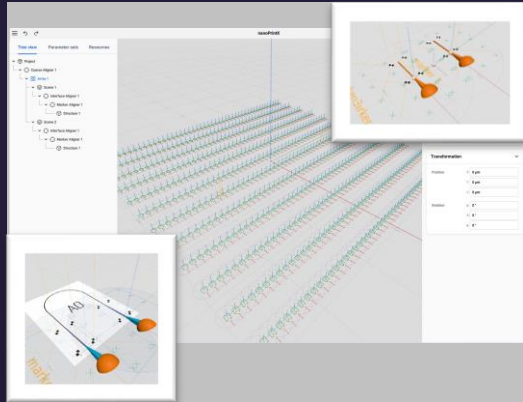


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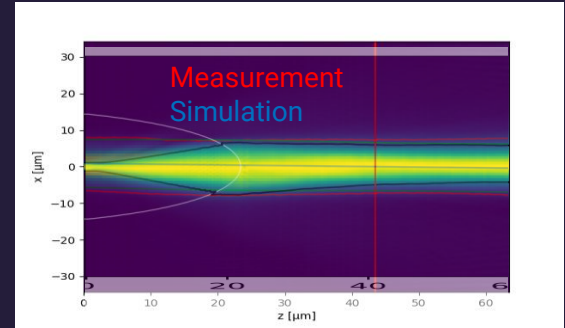
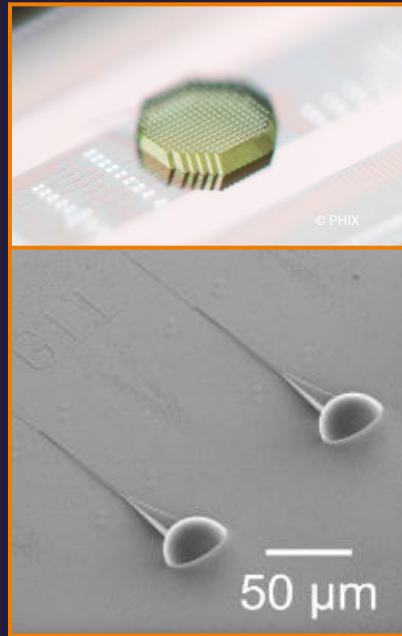
Lenses printed by Nanoscribe
Die supplied by ePIXfab (imec)

Vertical coupling on Chip

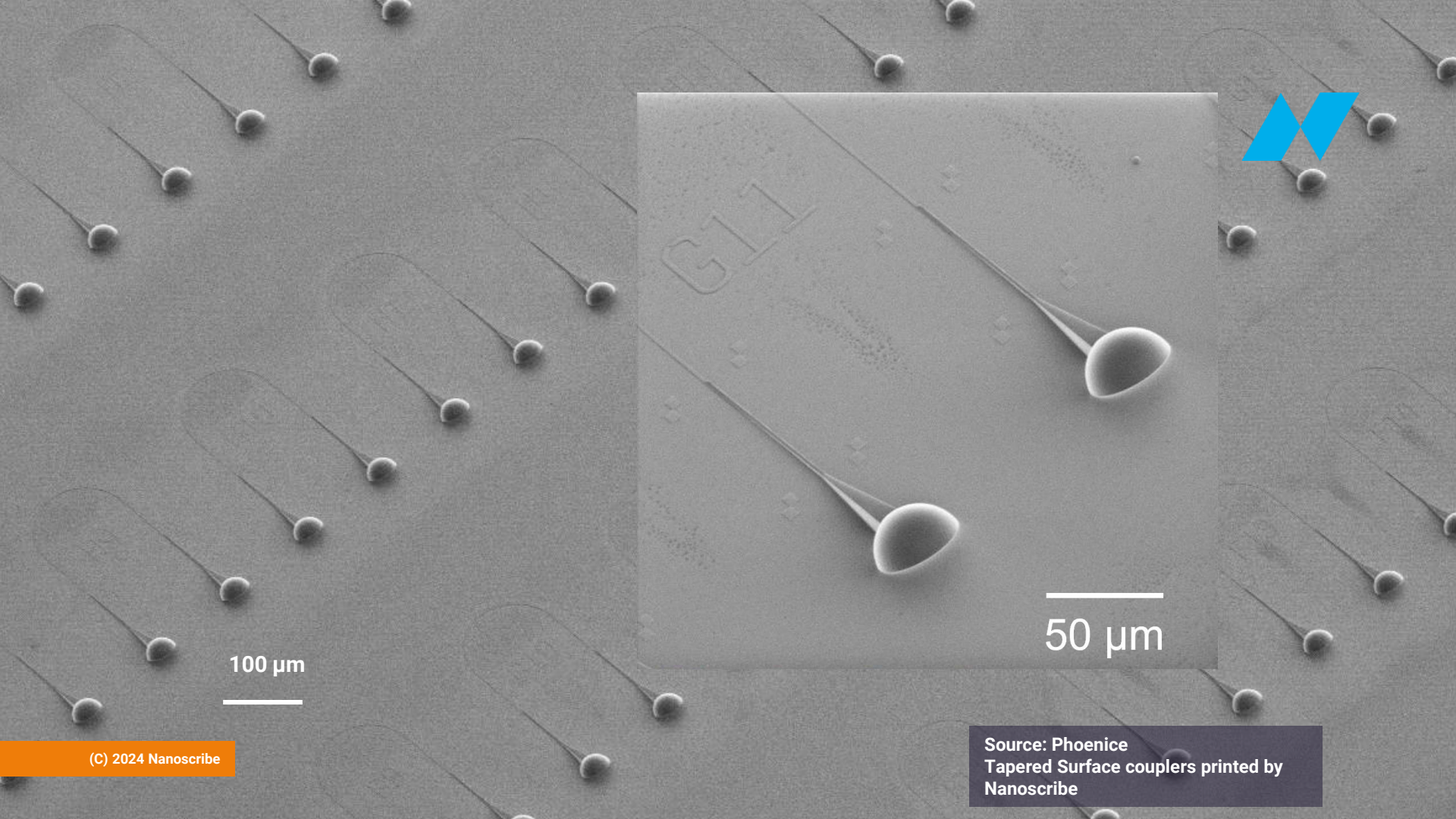
Flexible design enabling low loss (broadband) coupling



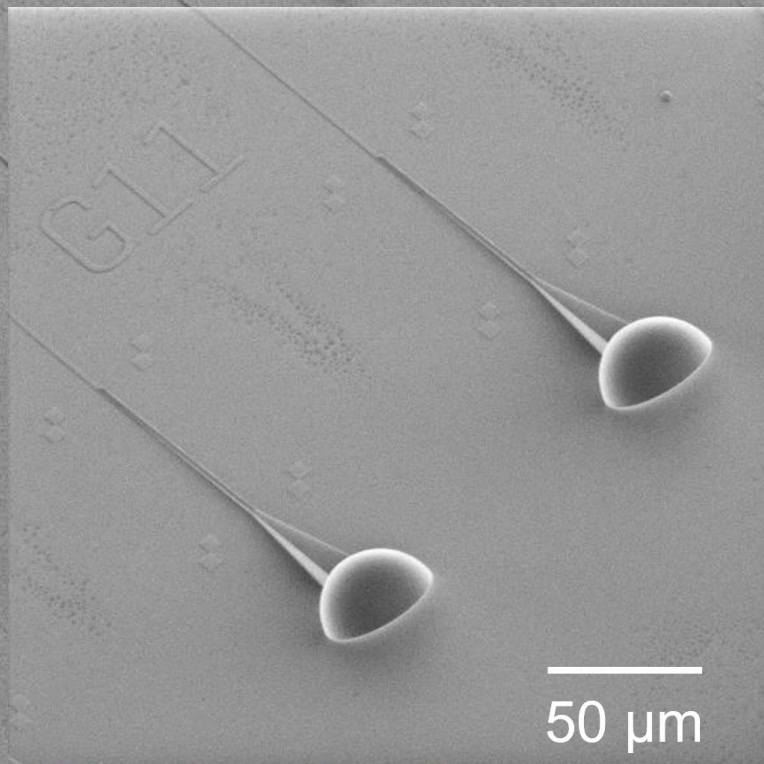
- ▶ Define structure via STL and array it
- ▶ Align relative to marker
- ▶ Select process parameters
- ▶ Print & develop



Characteristic	Typ. Value
Shape accuracy	< 40 nm rms
Surface roughness	<5 nm
MFD repeatability	σ <23 nm
Loss	0.8 – 2.0 dB
Print time	60 – 280 sec
Environmental	Thermal Shock -25°C to 85°C(1000 cycles); 85° C 85 %



100 μm



50 μm



OPTICAL INTERCONNECTS

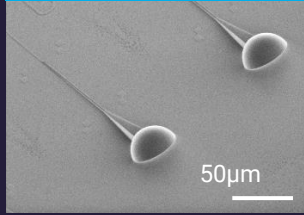
3D printed free space micro optics by 2GL® *



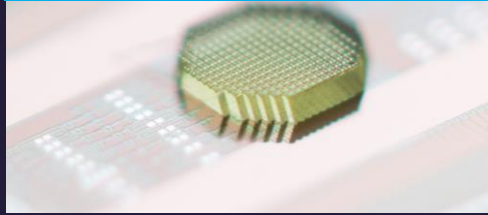
Scalable manufacturing of lensed fiber arrays



Wafer level printing



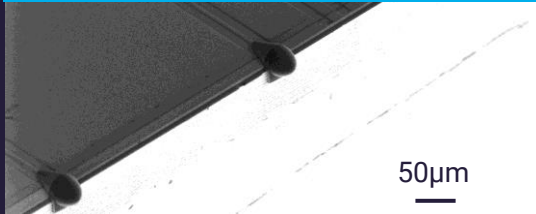
Fast prototyping and design check



Aligned mastering for NIL



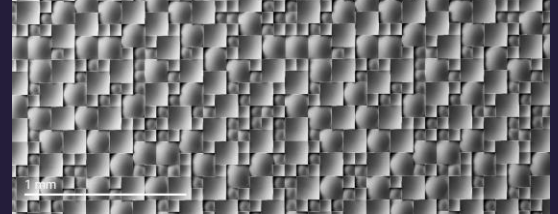
Aligned printing on different substrates



Wafer level printing of multilevel micro optics



Prototyping & Mastering of free form micro lens arrays MLA



What can we do for you and what can you do for us?



- ▶ Challenge us with your optical interconnect and packaging problems
- ▶ Join us at our Hands-on Training Session after ECOC

WELCOME
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EXPERIENCE CENTER

BOOK A
LIVE DEMO

EXCLUSIVE
TRAINING COURSE
Two-Photon Polymerization

September 26
Nanoscribe
Headquarters
Karlsruhe, DE

Content provided by Nanoscribe.
Image by PHIX Photonics Assembly.



Jörg Smolenski

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Web: nanoscribe.com

Thank you for your attention!

As the pioneer in 3D printing solutions for optics and photonics, we push the limits of photonics packaging. We deliver smart solutions to optical coupling challenges for best-in-class optical engineering and industrially mature innovations.

Validate our aligned 3D Microfabrication technology

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- ▶ Schedule an online / on-site demo
- ▶ Check the feasibility of your project