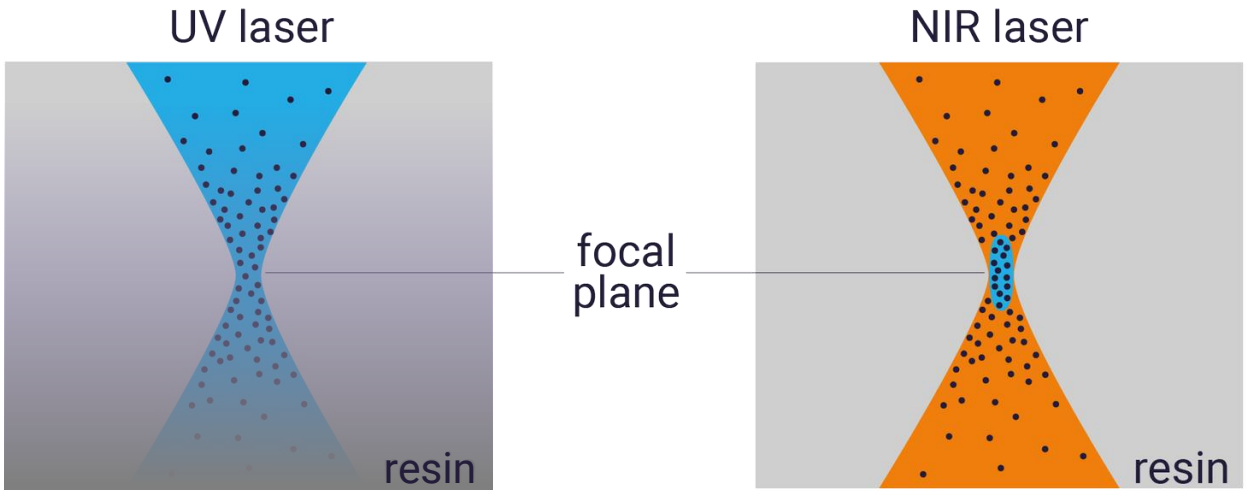
nanoscribe
A BICO COMPANY

Additive Manufacturing for Industrial Micro-optics Production

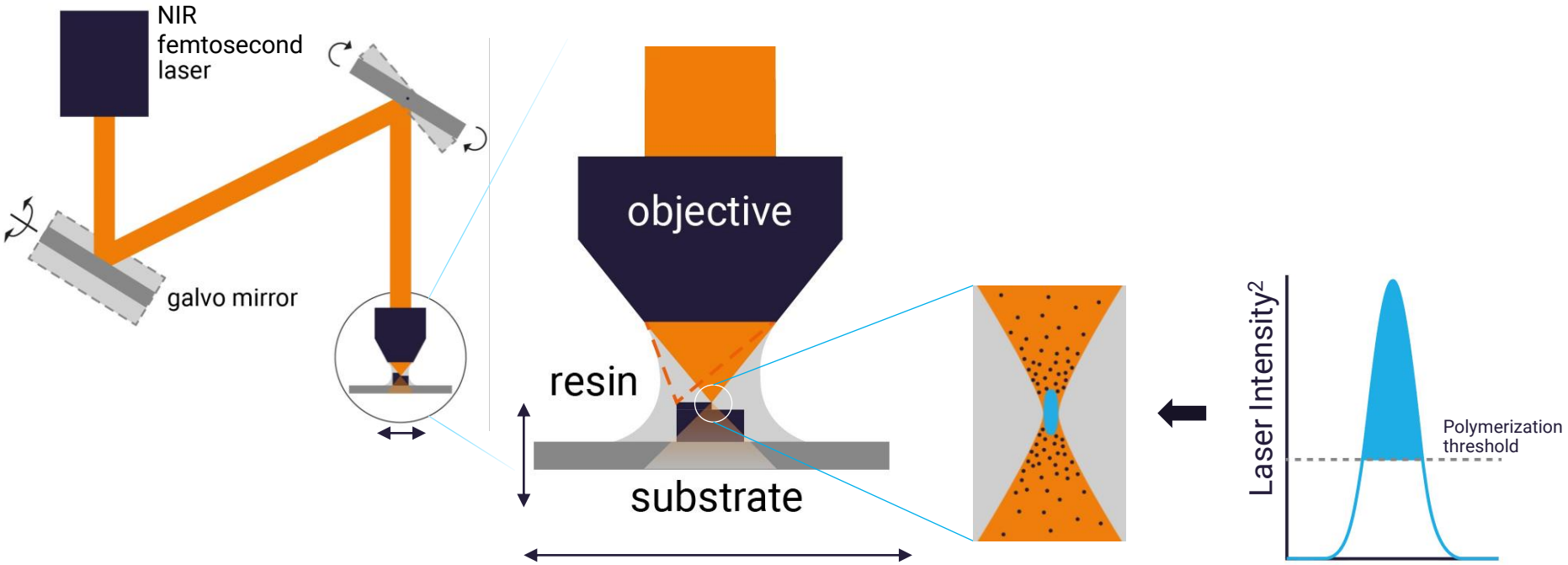
Dr. Michael Thiel

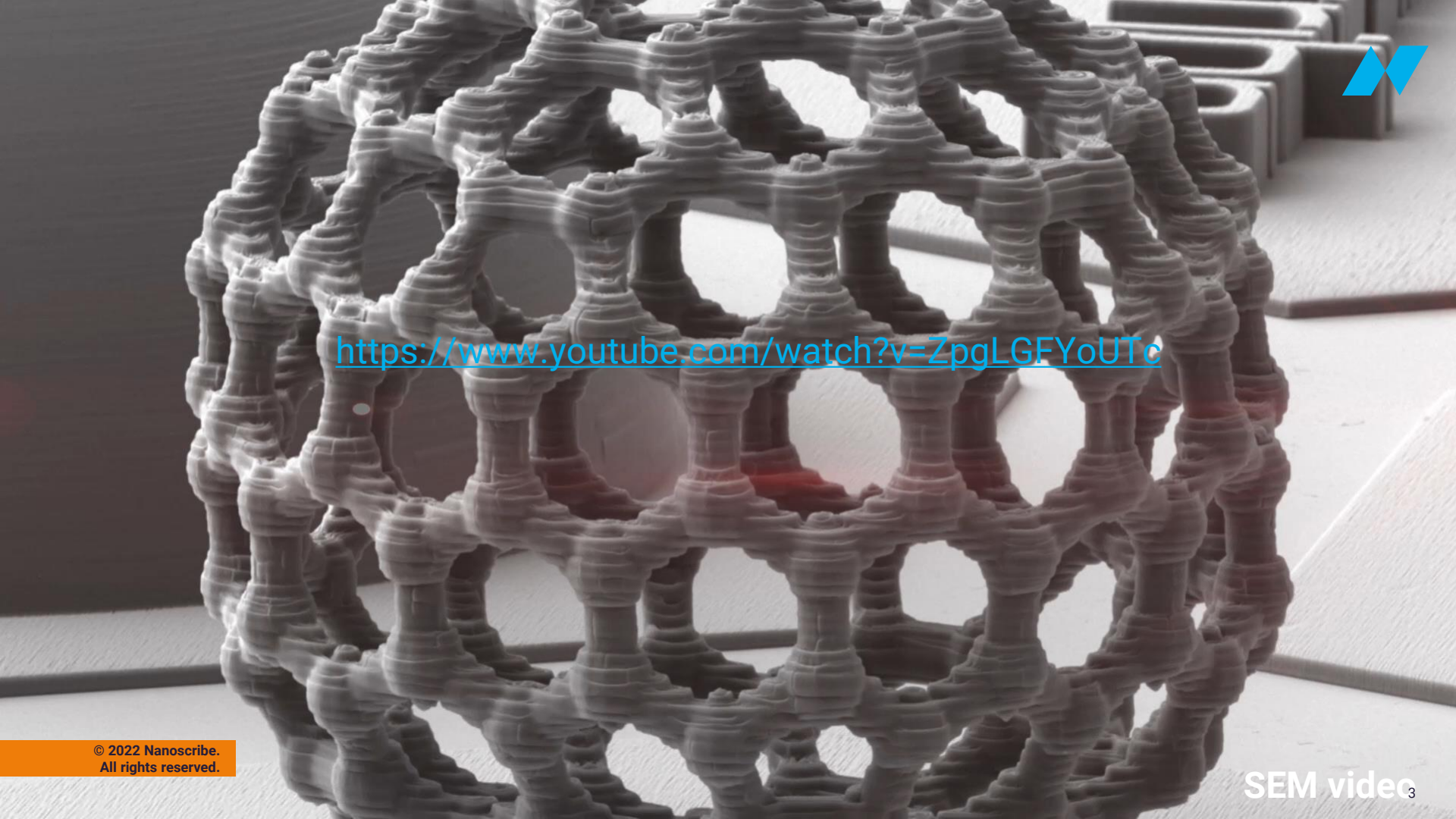
Co-Founder, Nanoscribe (Germany)

Technology basics
Two-Photon Polymerization (2PP)



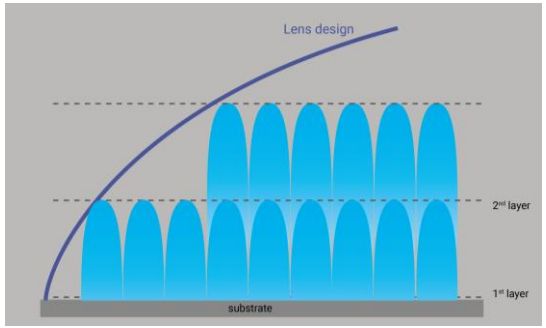
Technology basics
Two-Photon Polymerization (2PP)

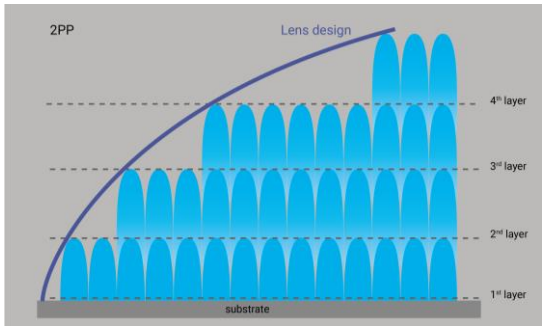


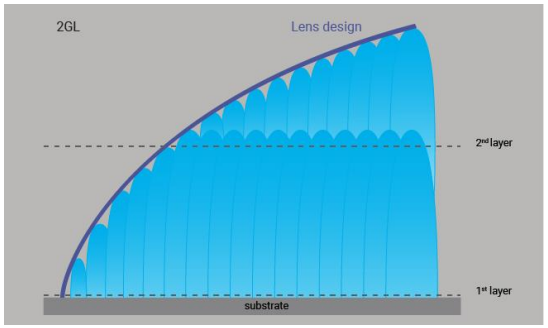


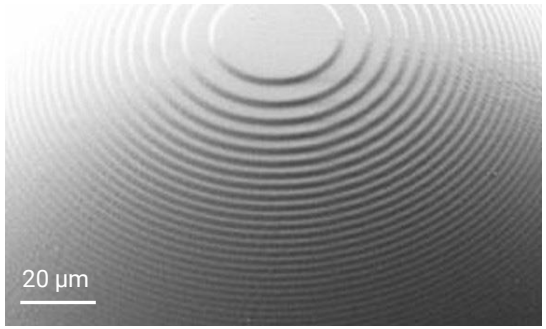
SEM video

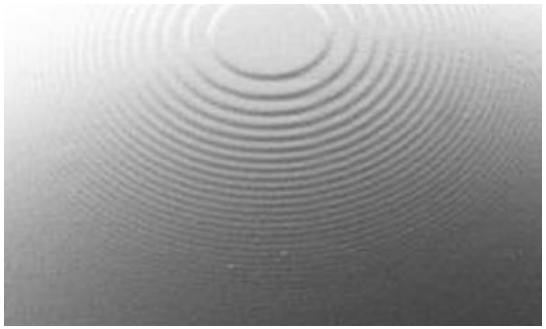
Challenge in high-precision 3D printing
Staircasing vs. printing speed

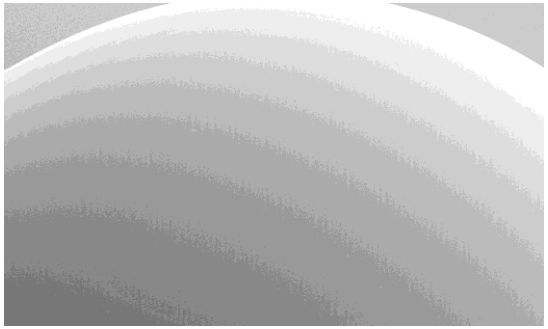












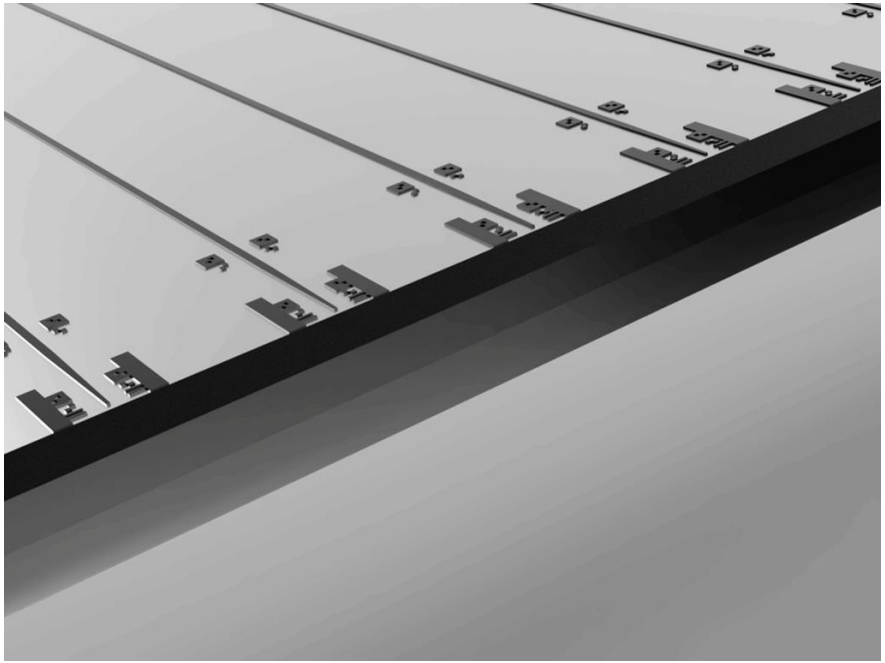
2PP with coarse slicing

2PP with fine slicing

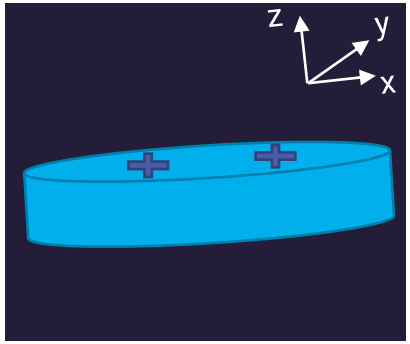
2GL® with coarse slicing

Print on-chip
Confocal module for 3D alignment

- Confocal module
- 3D topography measurements and automatic alignment
- 3D alignment precision down to 100 nm (lateral)
- Print onto surfaces or facets of photonic chips

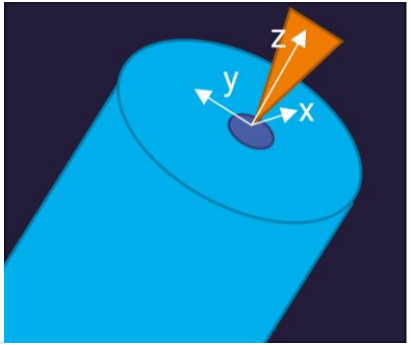


Application examples



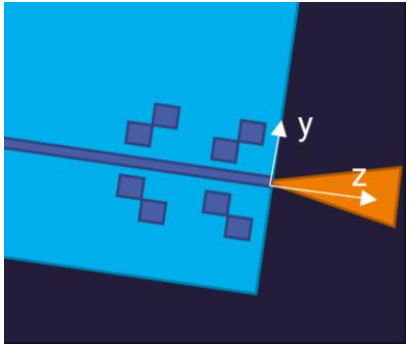
Printing on wafers

3D alignment to flat wafers or topographies on wafers



Printing on fibers

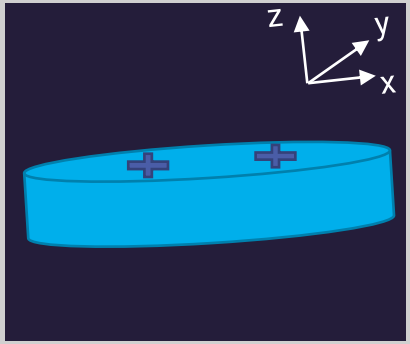
3D alignment to fiber core and emission direction



Printing on photonic chips

3D alignment to on-chip markers, waveguides etc.

Application examples



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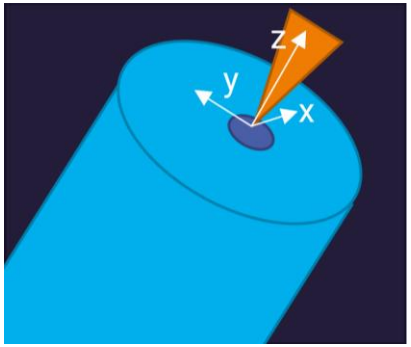
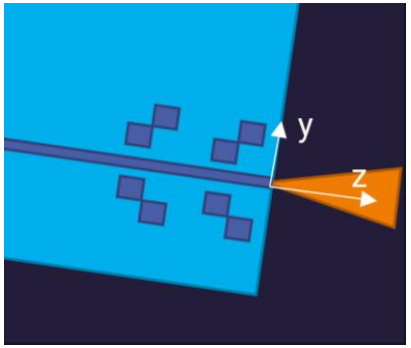


Printing on fibers

3D alignment to fiber core and emission direction



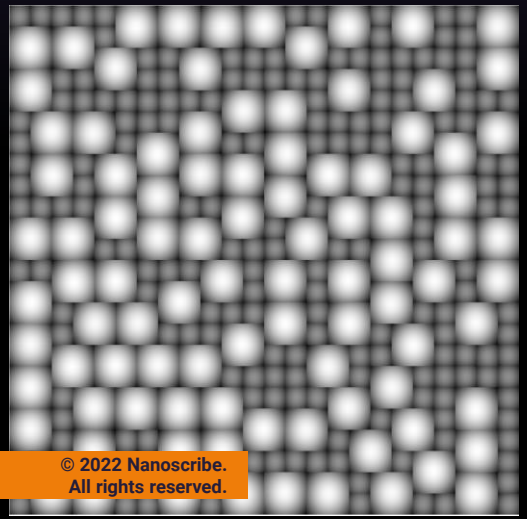
Printing on photonic chips

3D alignment to on-chip markers, waveguides etc.

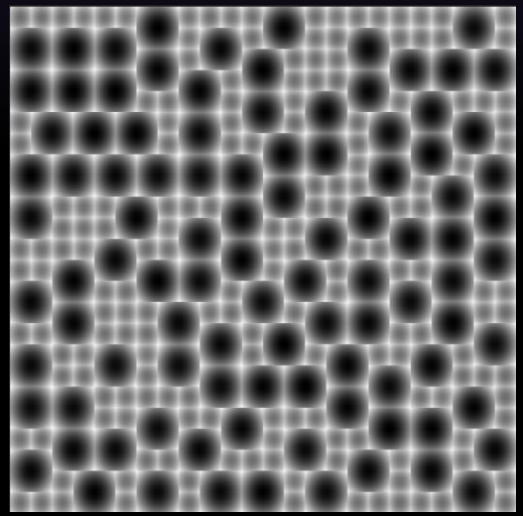
Refractive beam diffuser based on random MLA

- Design files exported to grayscale 16-bit PNG images with a pixel size of 200nm
- Base unit 1.8 mm wide was repeated in a 3x3 array to create a 5.4 mm diffuser.

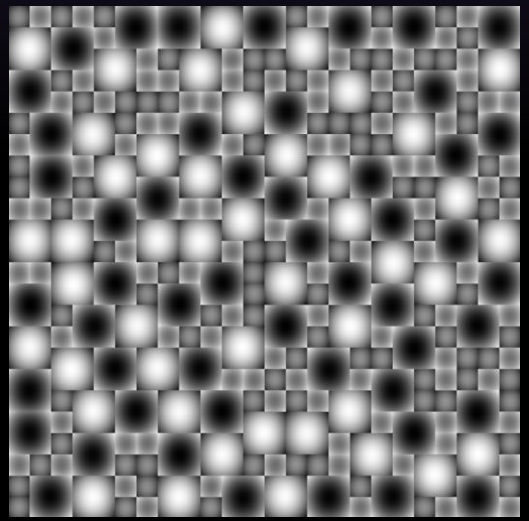
Convex (standard)

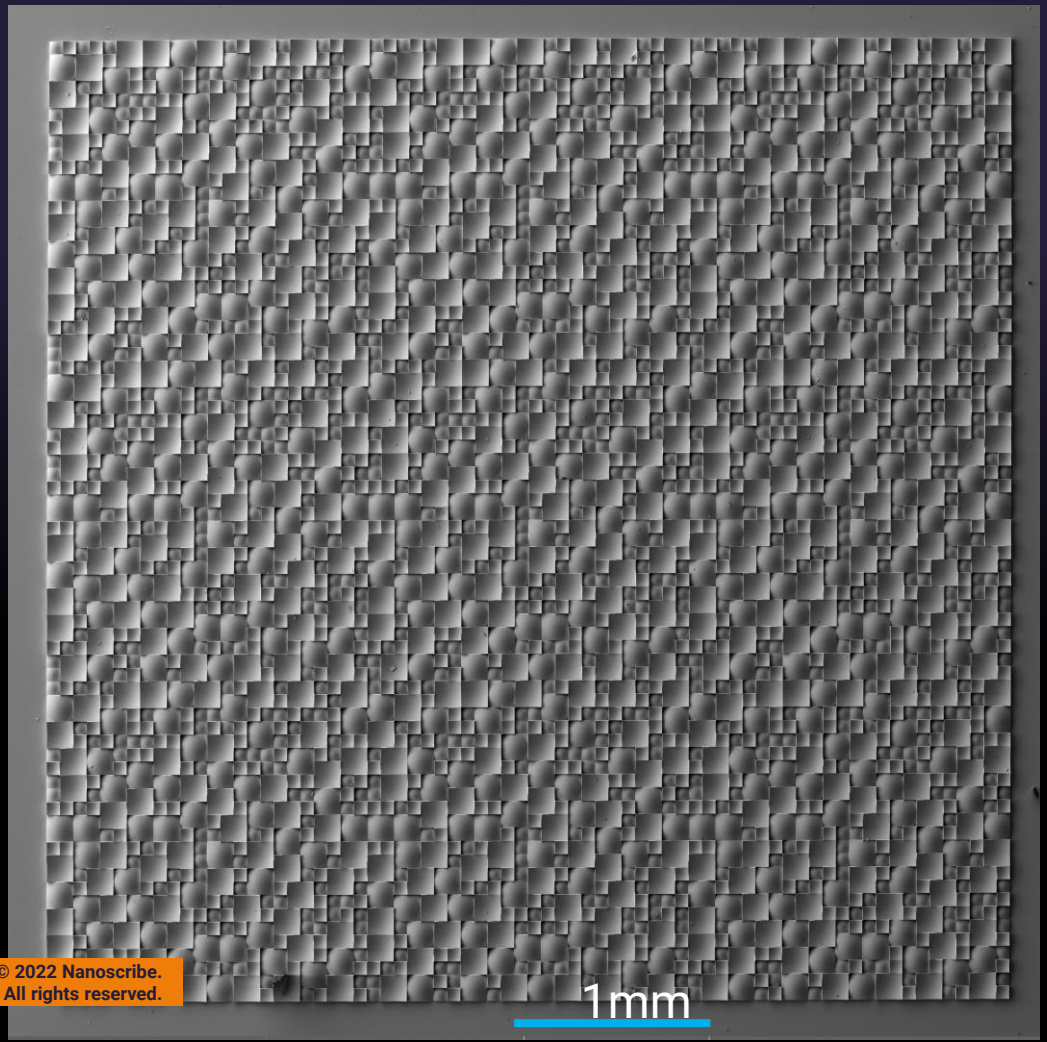


Concave 1.8 mm (base unit)

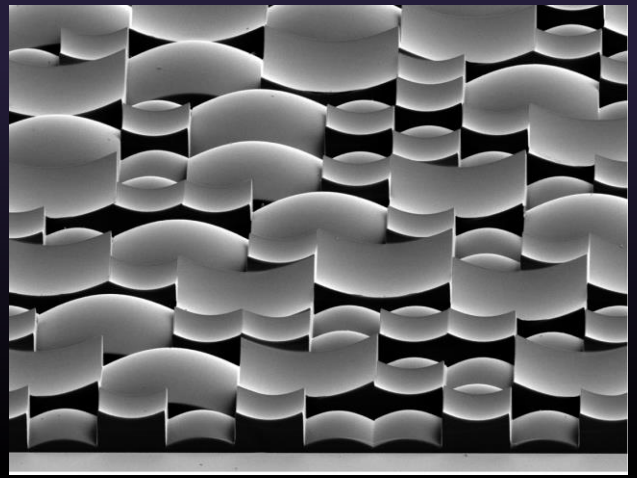


Mixed





Tilt corrected sample

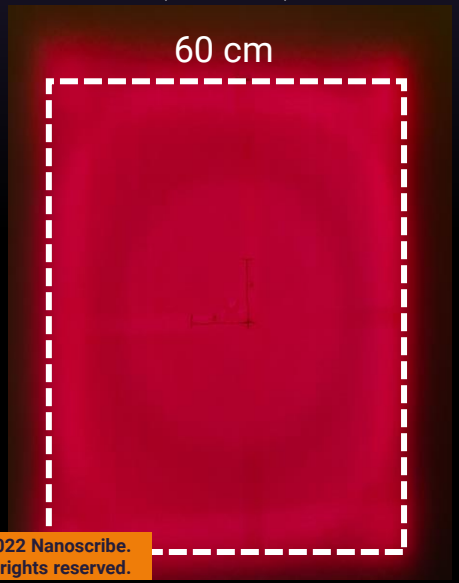


Very uniform patterning accuracy over extensive areas
5.4 mm by 5.4 mm

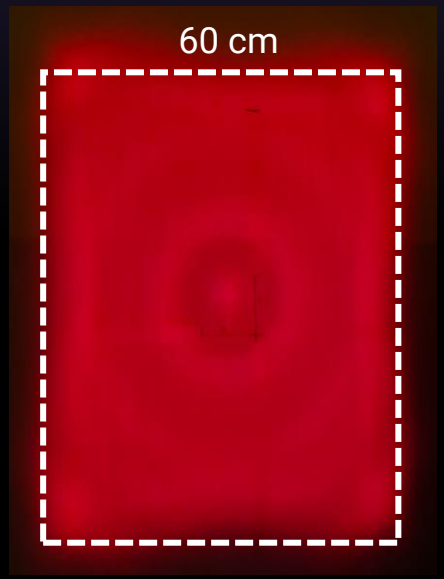
Refractive beam diffuser based on random MLA

- Experimental results

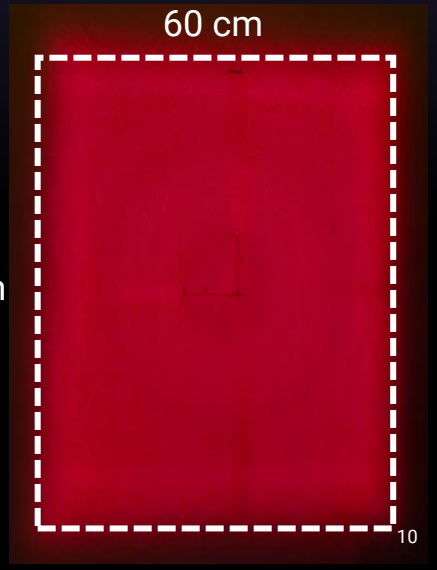
Convex (standard)



Concave



Mixed



Replication processes
From polymer master to small series production

- MLA polymer master

- Nickel shim

- Micro injection molded replica
- Hot embossed replica

- PDMS mold

- Nanoimprinted replica

- MLA negative polymer master

- Direct hot embossed replica

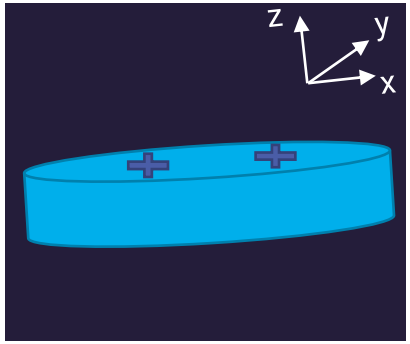
Replication processes
Injection Molding

- Beam homogenizer
- Injection molded replica
- Sprue and runner still attached
- Produced by our partner kdg

Replication processes
Nanoimprint Lithography

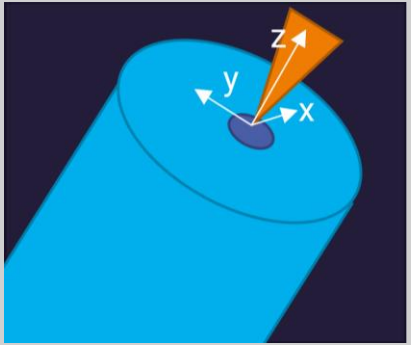
- 8” wafer replication
- Nanoimprint lithography
- Produced by our partner EV Group

Application examples



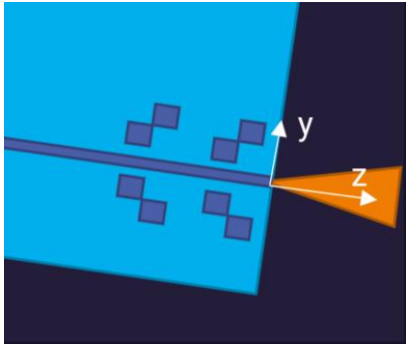
Printing on wafers

3D alignment to flat wafers or topographies on wafers



Printing on fibers

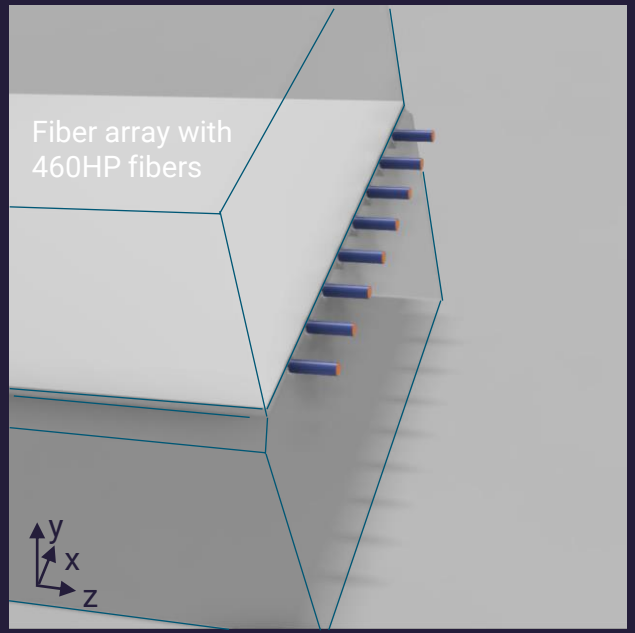
3D alignment to fiber core and emission direction

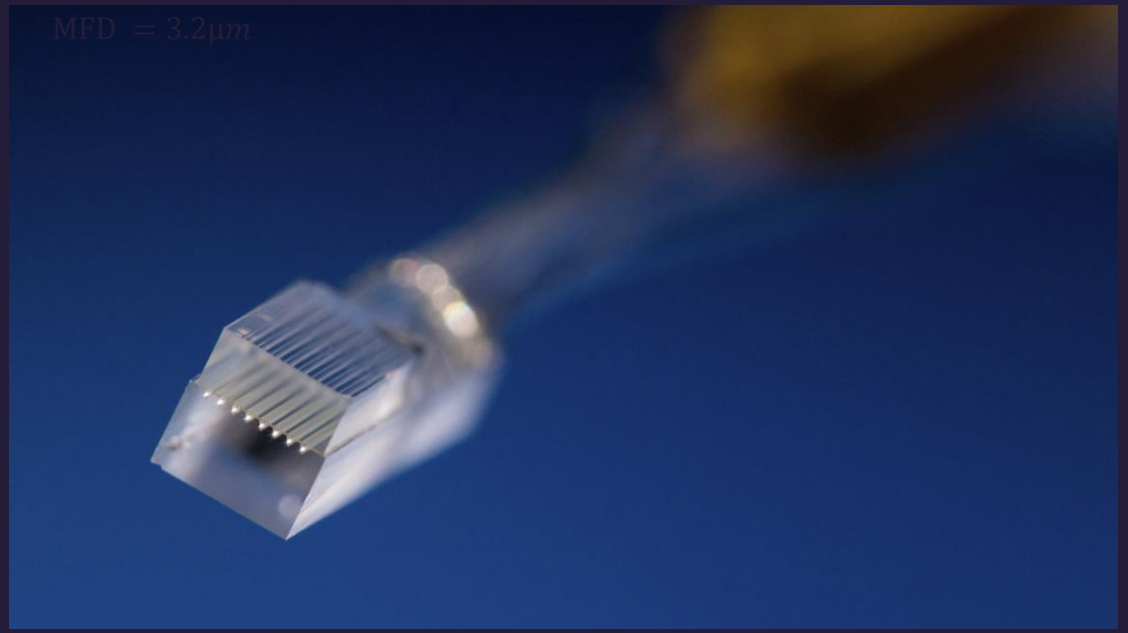


Printing on photonic chips

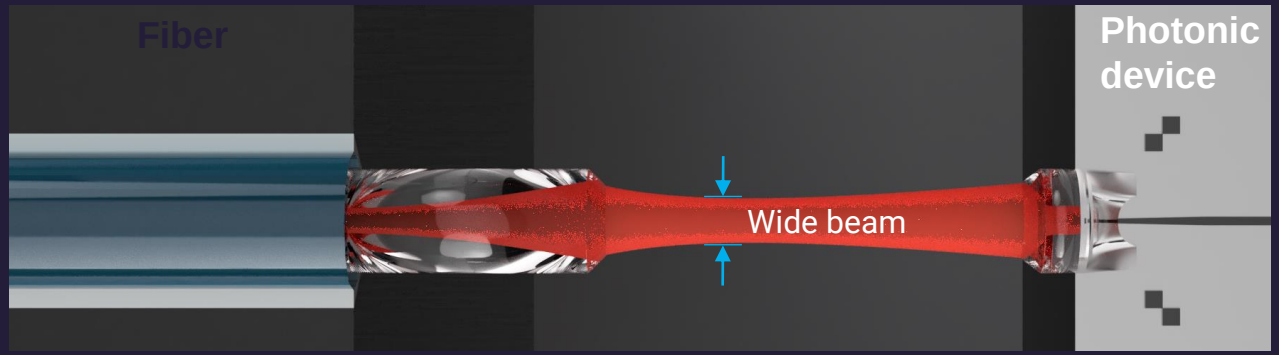
3D alignment to on-chip markers, waveguides etc.

Printing on fibers: Printing process

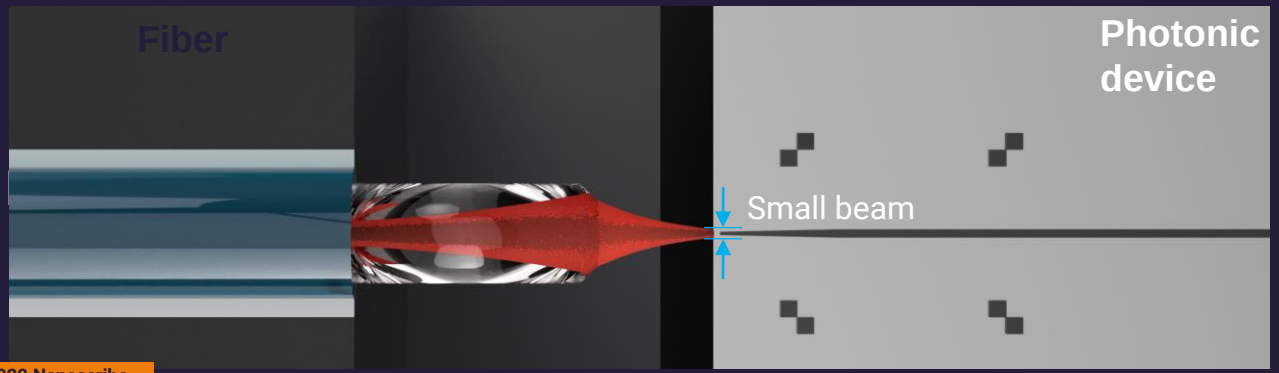




Application example – Printing on fibers
Tailored lensed fibers

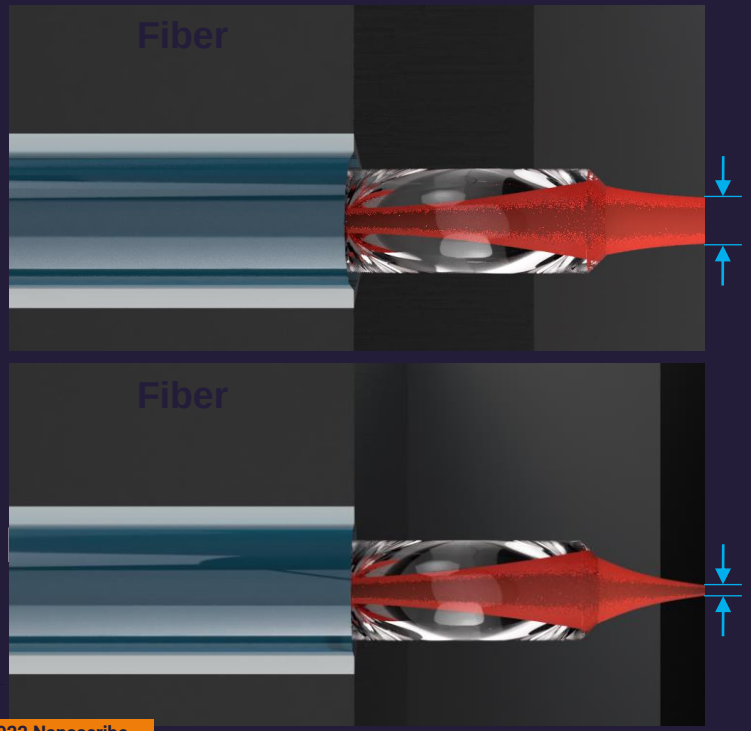


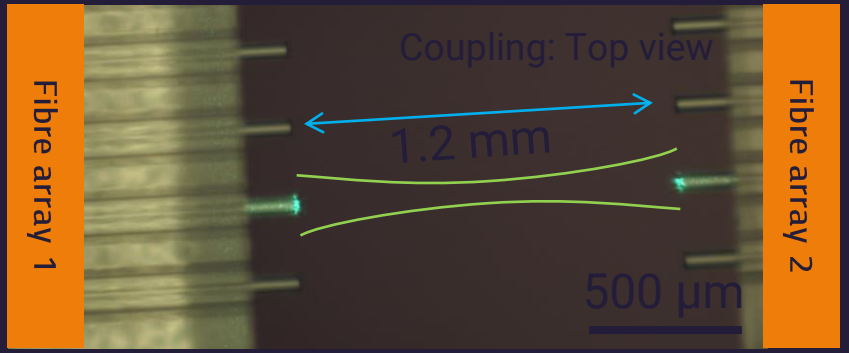
Beam expander for relaxed alignment tolerances in packaging

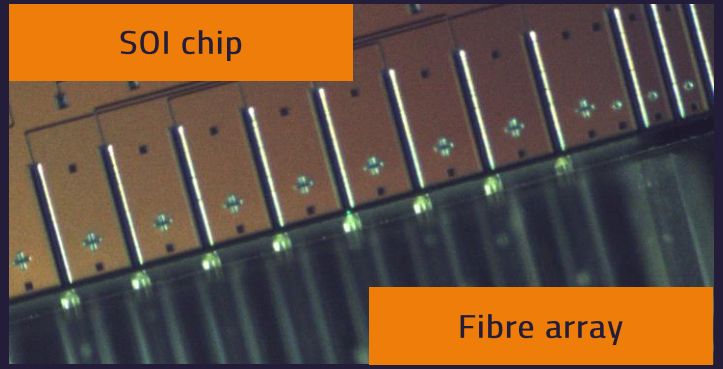


Focusing lenses for low loss direct coupling to tapered waveguides

Application example – Printing on fibers
Tailored lensed fibers







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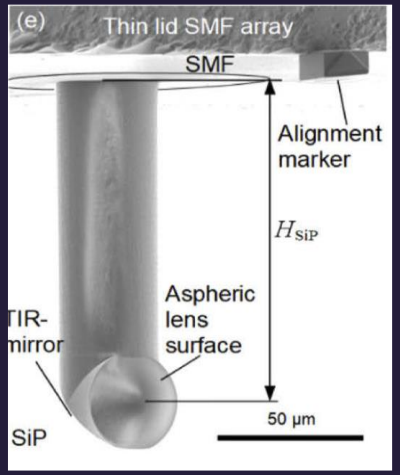
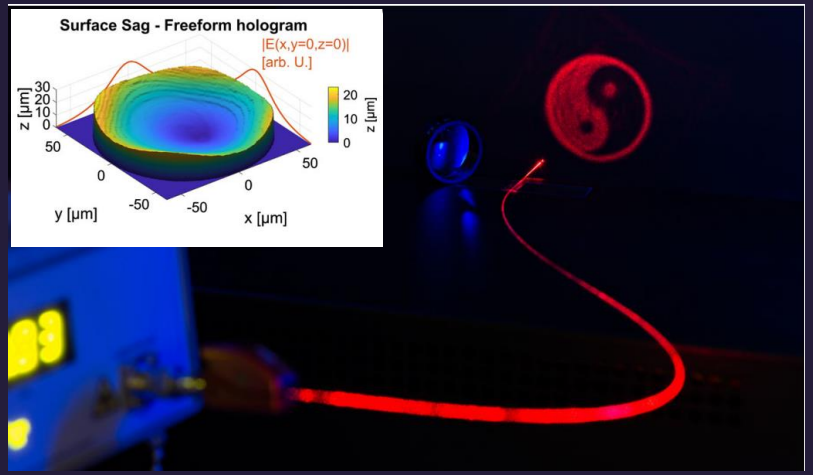
Other application examples – Printing on fibers

Optical probes for wafer-level testing of PICs



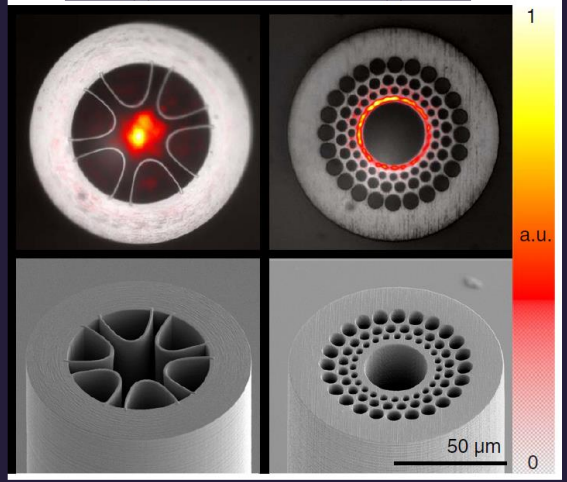
M. Trappen *et al.*, *Optics* [illegible] 2020).

Tailored micro-optical freeform holograms for integrated complex beam shaping



S. Schmidt *et al.*,Optica 7, 1279-1286 (2020)

3D printed waveguides based on photonic crystal fiber designs

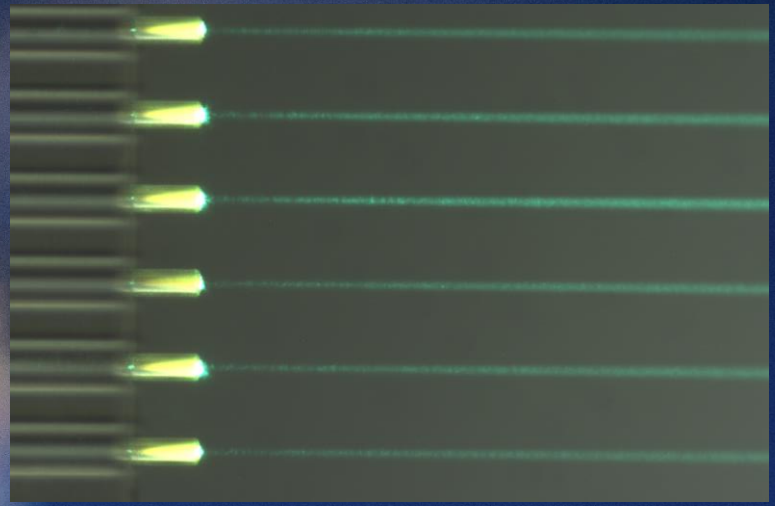


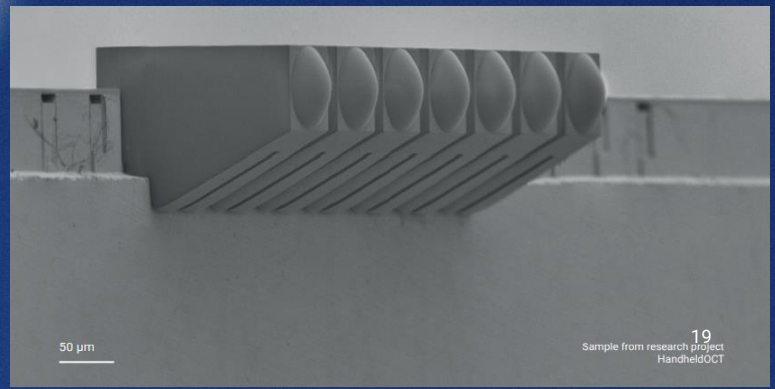
A. Bertoncini *et al. Optica* 7, 11 (2020).

Quantum X align

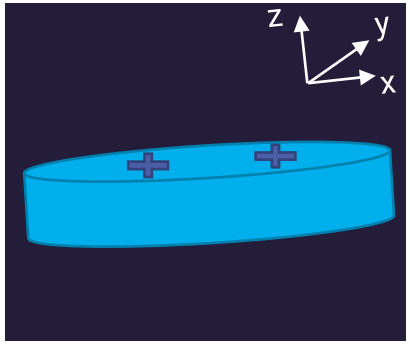
Connect to the photonic world

3D printed Free Space Microoptical Coupling





Application examples



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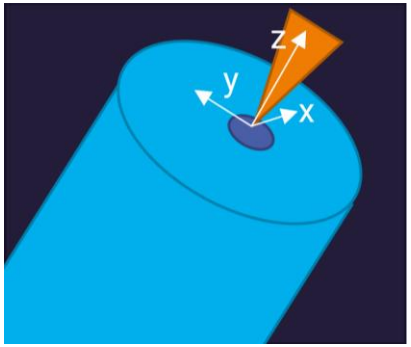

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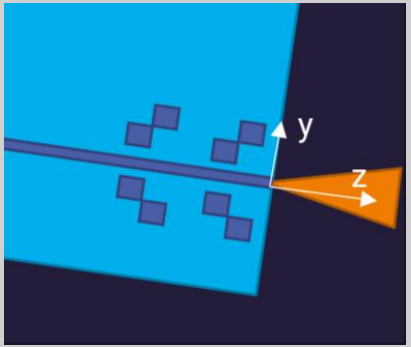

Printing on photonic chips

3D alignment to on-chip markers, waveguides etc.

Handheld Optical Coherence Tomography

HandheldOCT (#871312, H2020-ICT-2019-2, ICT-05-2019)

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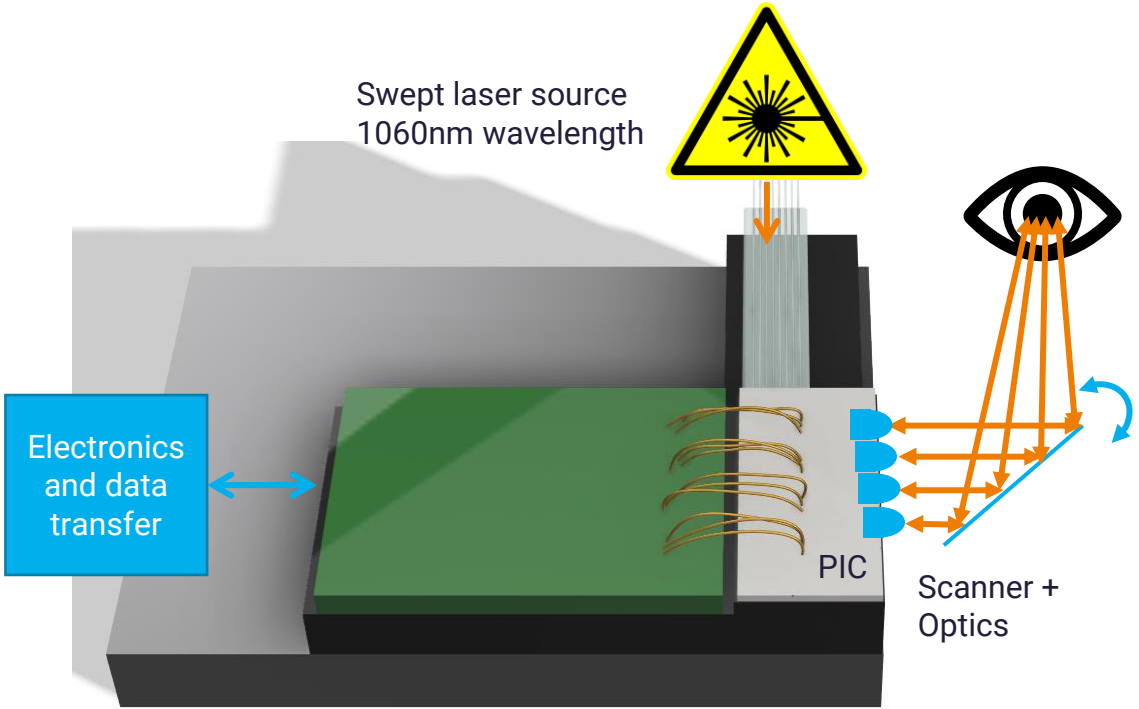
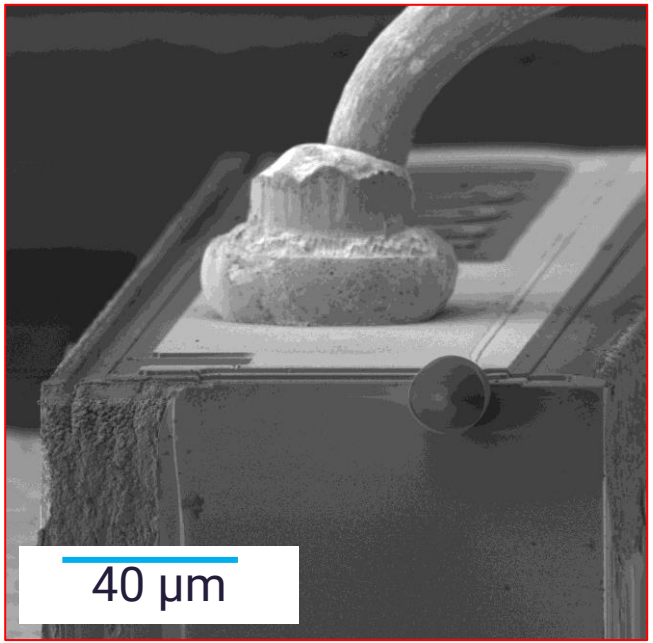
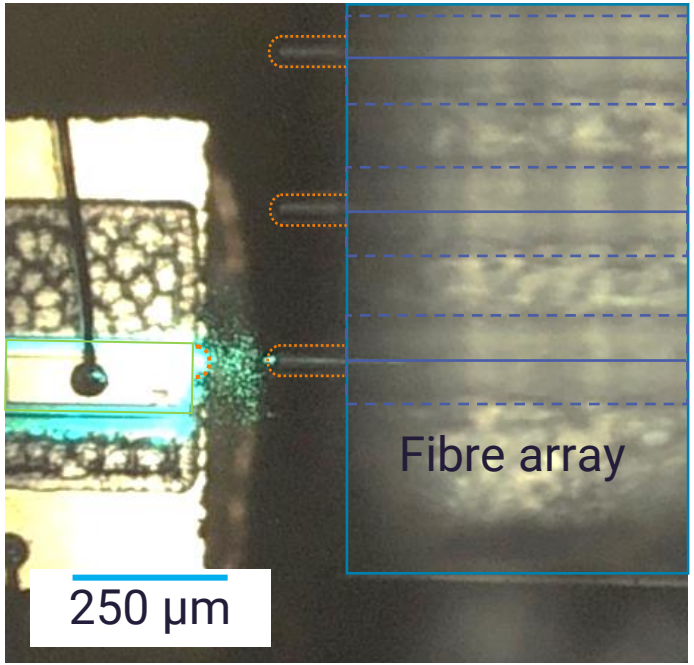


Miniaturized laser sources for quantum applications (MiLiQuant)

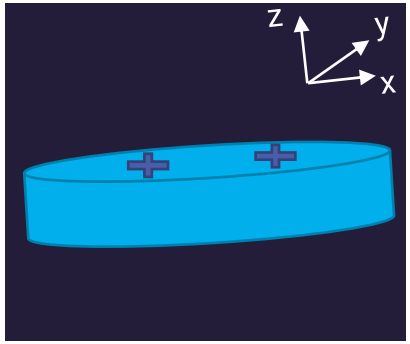
Bundesministerium für Bildung und Forschung





QANT BOSCH ZEISS UNIVERSITÄT PADERBORN JGU JOHANNES GUTENBERG UNIVERSITÄT MAINZ

Application examples



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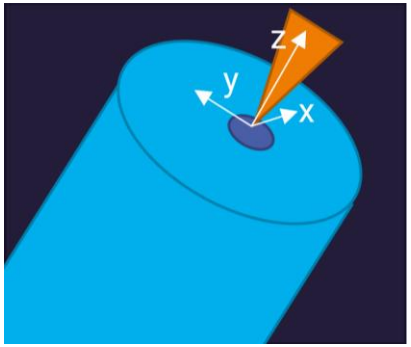

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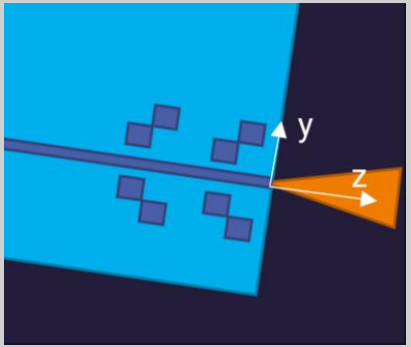
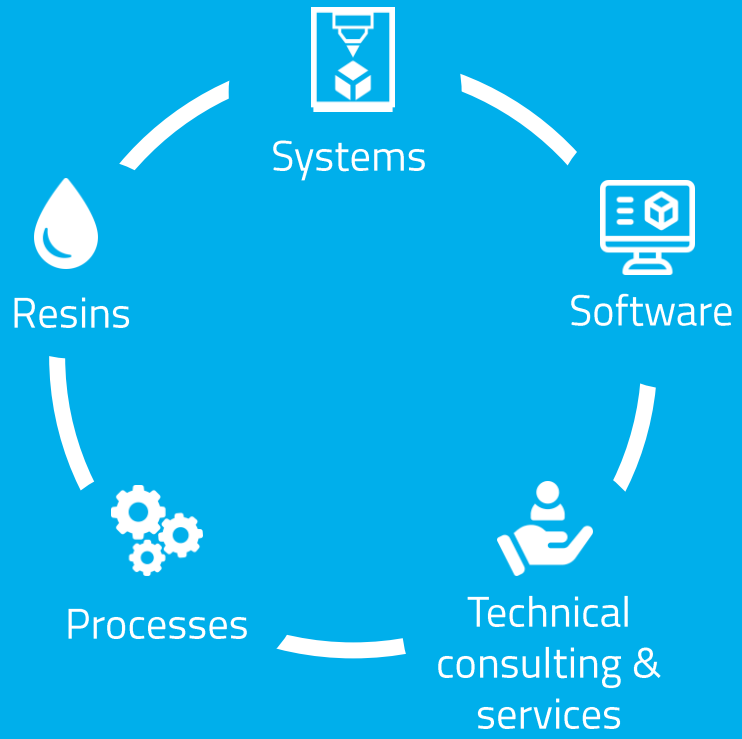


Printing on photonic chips

3D alignment to on-chip markers, waveguides etc.



We offer
a constantly evolving
microfabrication ecosystem
for your individual needs.

High Precision Microfabrication Systems
Product lines

- **Quantum X align**
- **Quantum X bio**
- **Quantum X shape**
- **Quantum X**
- **Photonic Professional GT2**

https://www.youtube.com/watch?v=fd3j8udOseI

New

PRISM AWARDS FINALIST

New

"Best in class 3D printer with nanoprecision alignment system"

"The world's most accurate 3D bioprinter"

"Fastest and most accurate 3D printer in class"

"World's first 2GL ® Two-Photon Grayscale Lithography system"

"The most field-proven high-precision 3D printer for fundamental innovations"

The Key Enabling Technology

https://www.nanoscribe.com/en/register

Download our Whitepapers

1 Two-Photon Polymerization (2PP)

2 Two-Photon Grayscale Lithography (2GL®)

Thank you for your attention!

Dr. Michael Thiel

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Validate our 3D microfabrication technology

Qualities of IP Photoresins

- Rapid 2.5D and 3D Microfabrication
- Excellent shape accuracy and mechanical stability
- Very good substrate adhesion
- Software recipes for various IP resins

Especially designed for Two-Photon Polymerization