3D microprinting solutions for highly efficient light coupling

Jörg Smolenski

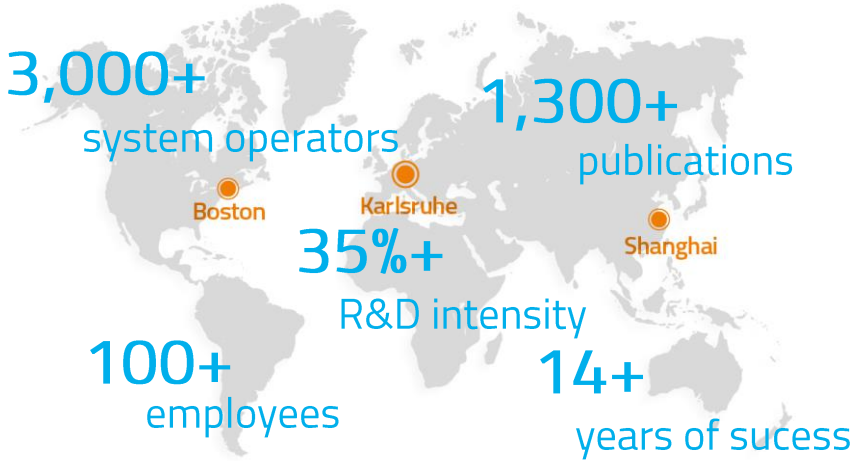
Business Development Manager

Nanoscribe GmbH & Co. KG

23. May 2022, EPIC OTM Co-packaged Optics

smolenski@nanoscribe.com

Nanoscribe worldwide in figures



The Key Enabling Technology

Download our Whitepapers

1 Two-Photon Polymerization (2PP)

2 Two-Photon Grayscale Lithography (2GL®)

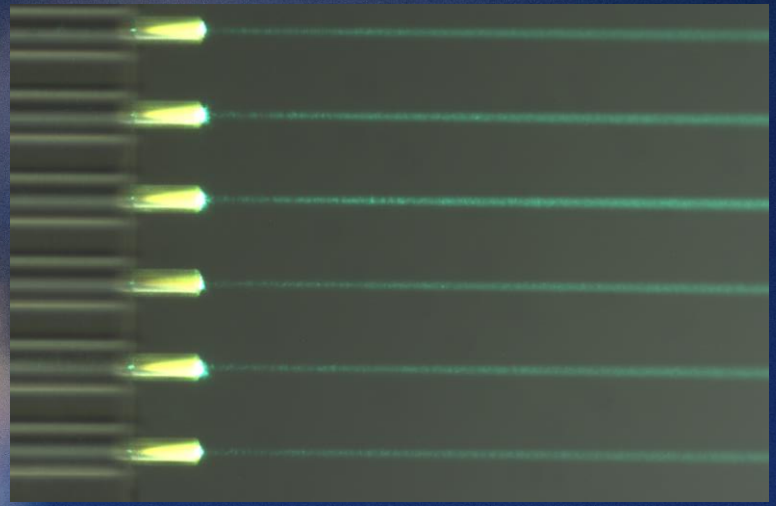
https://www.nanoscribe.com/en/whitepaper

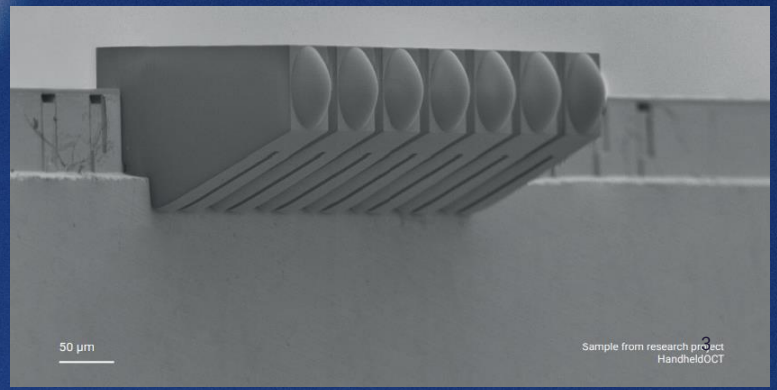
nanoscribe
A BICO COMPANY

Quantum X align

Connect to the photonic world

3D printed Free Space Microoptical Coupling

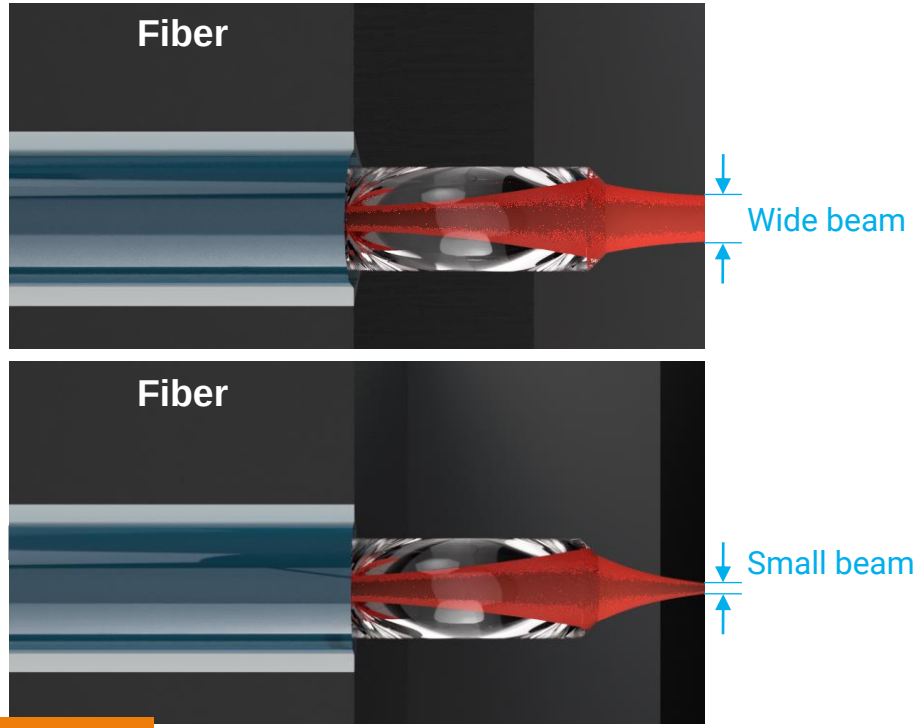




phix PHOTONICS ASSEMBLY

EPIC OTM Co-packaged Optics

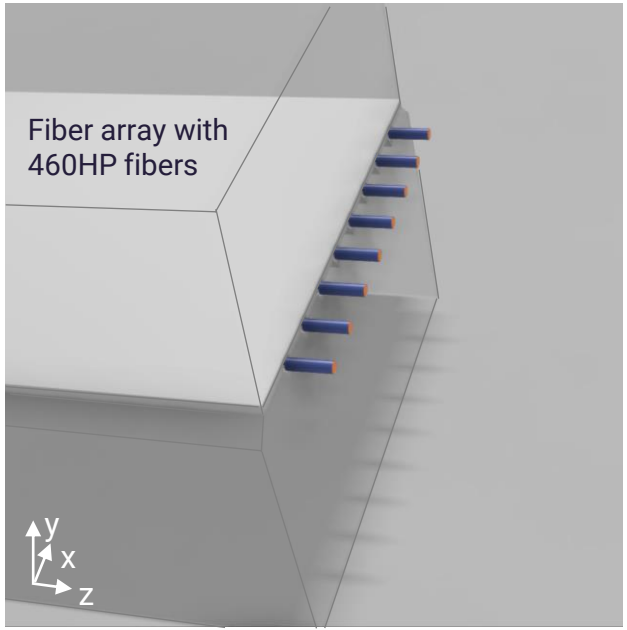
Application example – Printing on fibers
Tailored lensed fibers

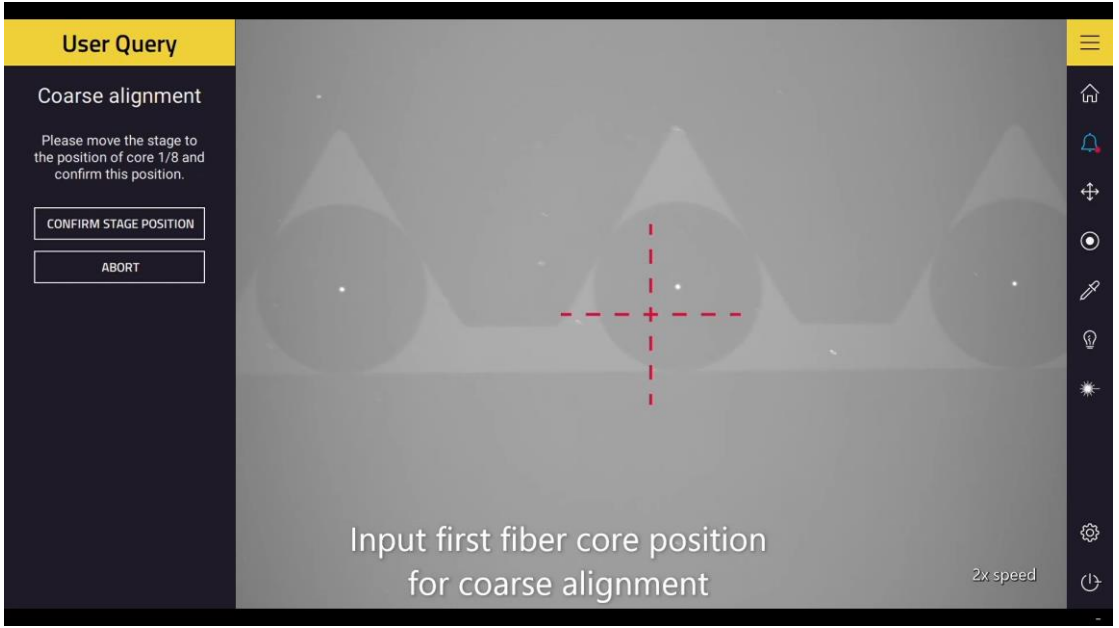


Beam expander for relaxed alignment tolerances in packaging

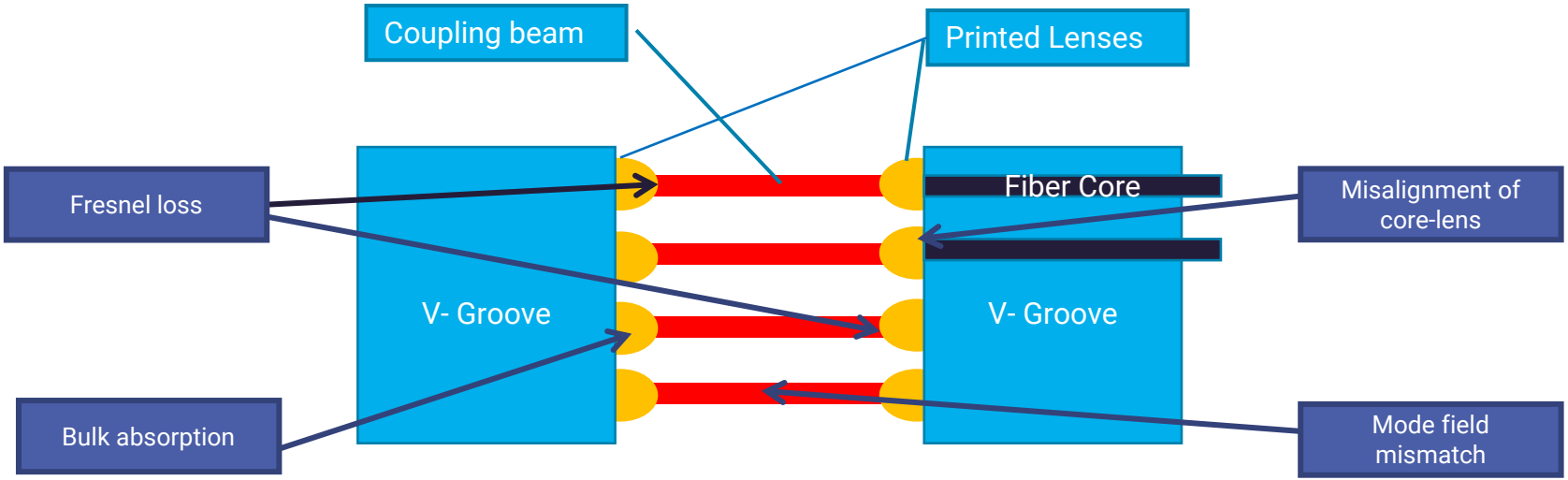
Focusing lenses for low loss direct coupling to tapered waveguides

Application example – Printing on fibers
Beam expander for 25 µm mode field diameter





Coupling losses: example for lensed fiber arrays – where do they occur?

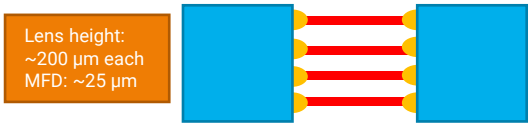


* the smaller the MFD at the fiber, the higher the losses due to misalignment
** Losses due to setup misalignment not depicted
Lens height: ~200 µm each
MFD: ~25 µm

Coupling losses - a rough estimation fro fiber to fiber
- Free space microoptic coupling enables losses below 1db

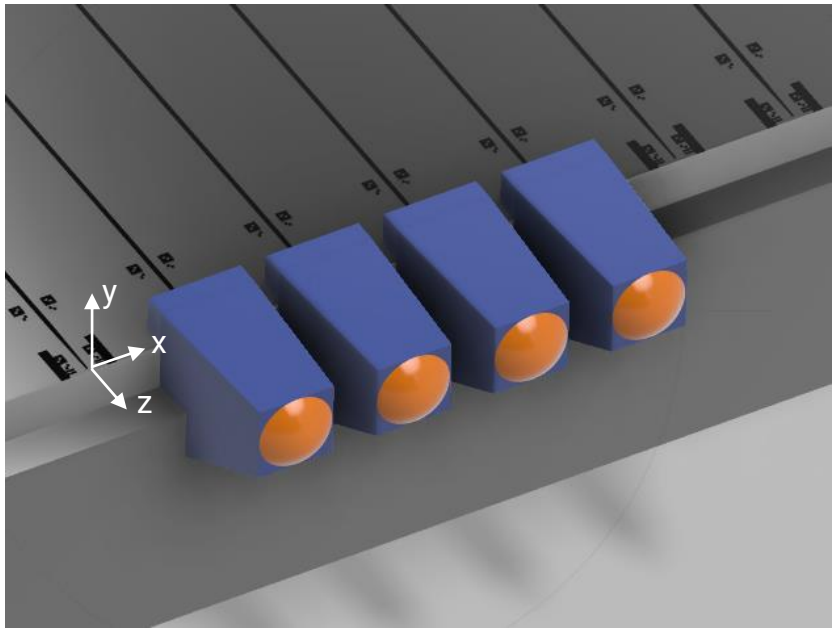
Loss type	Info	Fiber - Fiber
Fresnel reflection	*Losses:* ~4%(0.2 dB) per resist-air interface	~8% (~0.4 dB)
Bulk absorption / scattering	*Material dependent losses:* ~0.7% per 100 µm in **IP-S** (**1550 nm**)*	~3% (~0.15 dB)
Mode field mismatch	*Target:* <10% MFD mismatch	<1% (<0.05 dB)
Misalignment of core-lens	*Target:* <±500 nm**	**< 1%(1550 nm) - <14%(520 nm)** < 0.05 dB - <0.65 dB**
Misalignment of setup	*Packaging dependent*	?
	Minimum total loss	**~11% (~0.5 dB)**
	Total expectable fabrication-related losses* **	**~13–22% (~0.6 - 1.3 dB)**

- High precision 3D printed collimation lenses enable
  - reduced losses below down to 1 dB
  - tailored relaxed alignment of several µm



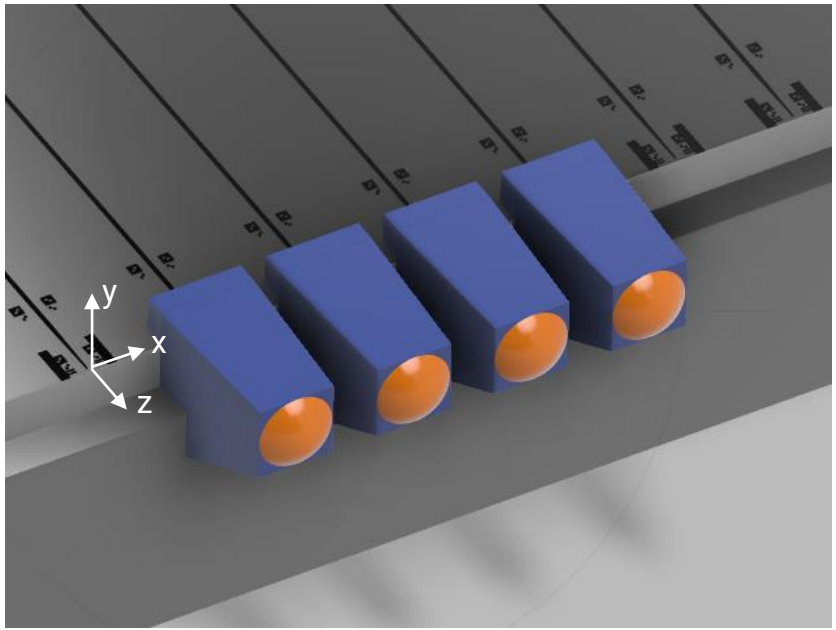
* first estimation, detailed measurements pending
** the smaller the MFD at the fiber, the higher the losses due to misalignment: SMF MFD for 1550 ~ 10.5µm; 520 nm ~ 3.5µm
*** Losses due to setup misalignment not included

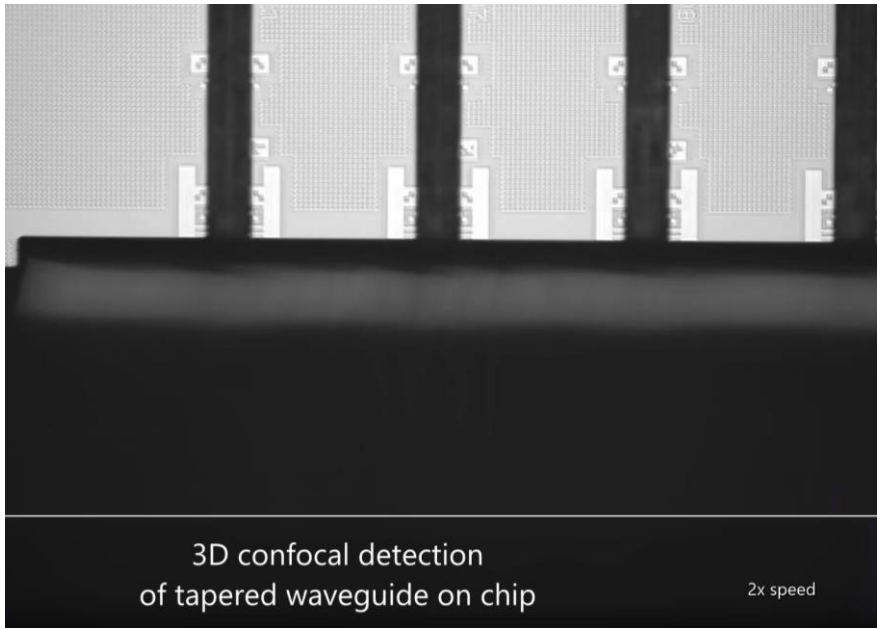
Next step – Printing on photonic chips
Example of beam shaping optics for 1060 nm



*Chip from HandheldOCT, *H2020-ICT-2019-2*

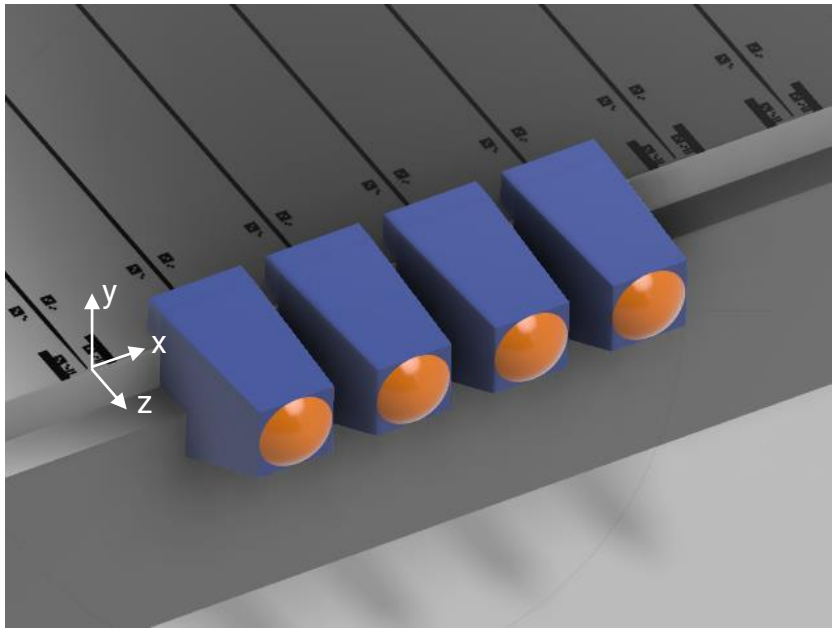
Next step– Printing on photonic chips
Example of beam shaping optics for 1060 nm

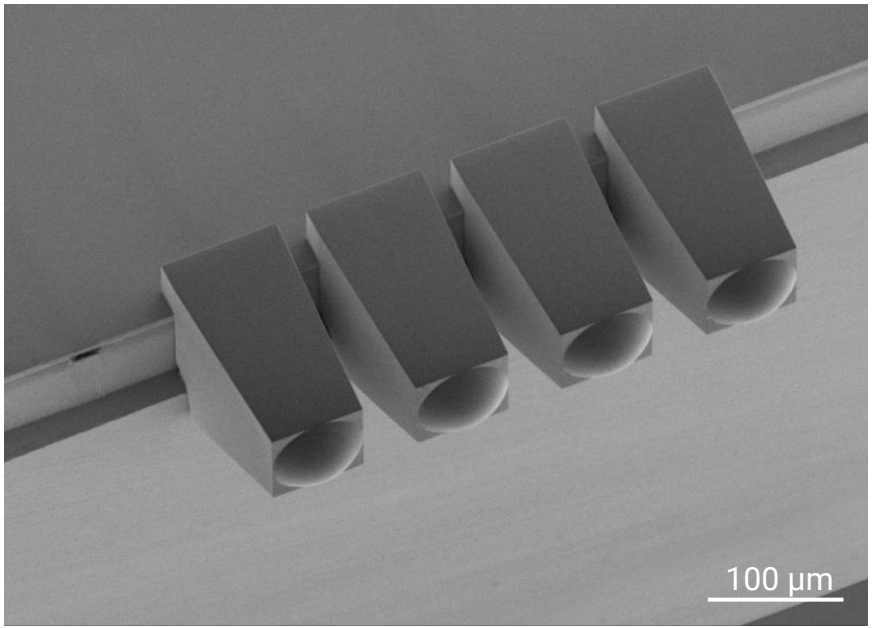




*Chip from HandheldOCT, *H2020-ICT-2019-2*

Application example – Printing on photonic chips
Beam shaping optics for 1060 nm

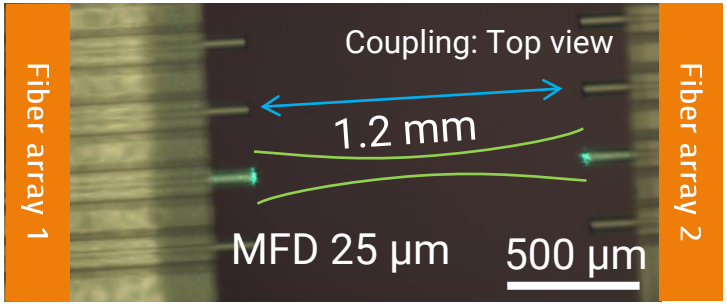




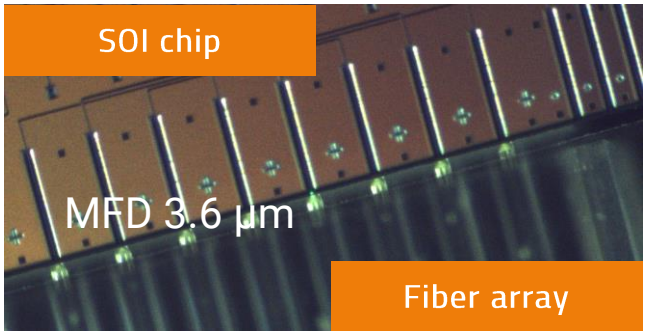
*Chip from HandheldOCT, *H2020-ICT-2019-2*

Example for printing on fibers
Losses with tailored lensed fibers

- **Beam expander for 532 nm wavelength**
  - Single mode coupling over 1.2 mm
  - 5 µm for 1 dB lateral alignment tolerance
  - **-0.7 dB per lens**, -0.3 dB Fresnel reflection

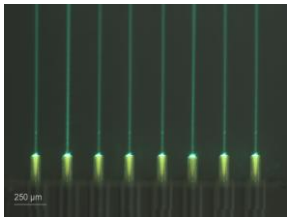


- **Focus lens for 1550 nm**
  - **-1.7 dB per coupling interface** for coupling to SOI tapered edge coupled waveguides

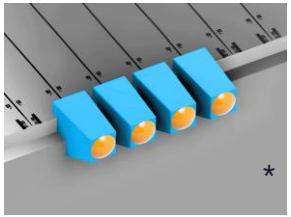


Quantum X align –
Dedicated tool for improved optical coupling

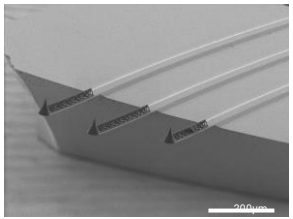
- Up to **100 nm** precise **lateral alignment** to waveguides with confocal module
- **Automatic printing** on fiber arrays & chips
- Enables **relaxed die alignment** tolerances of **few µm** and **reduced losses**



Printing on fibers
3D alignment to fiber core and emission direction



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

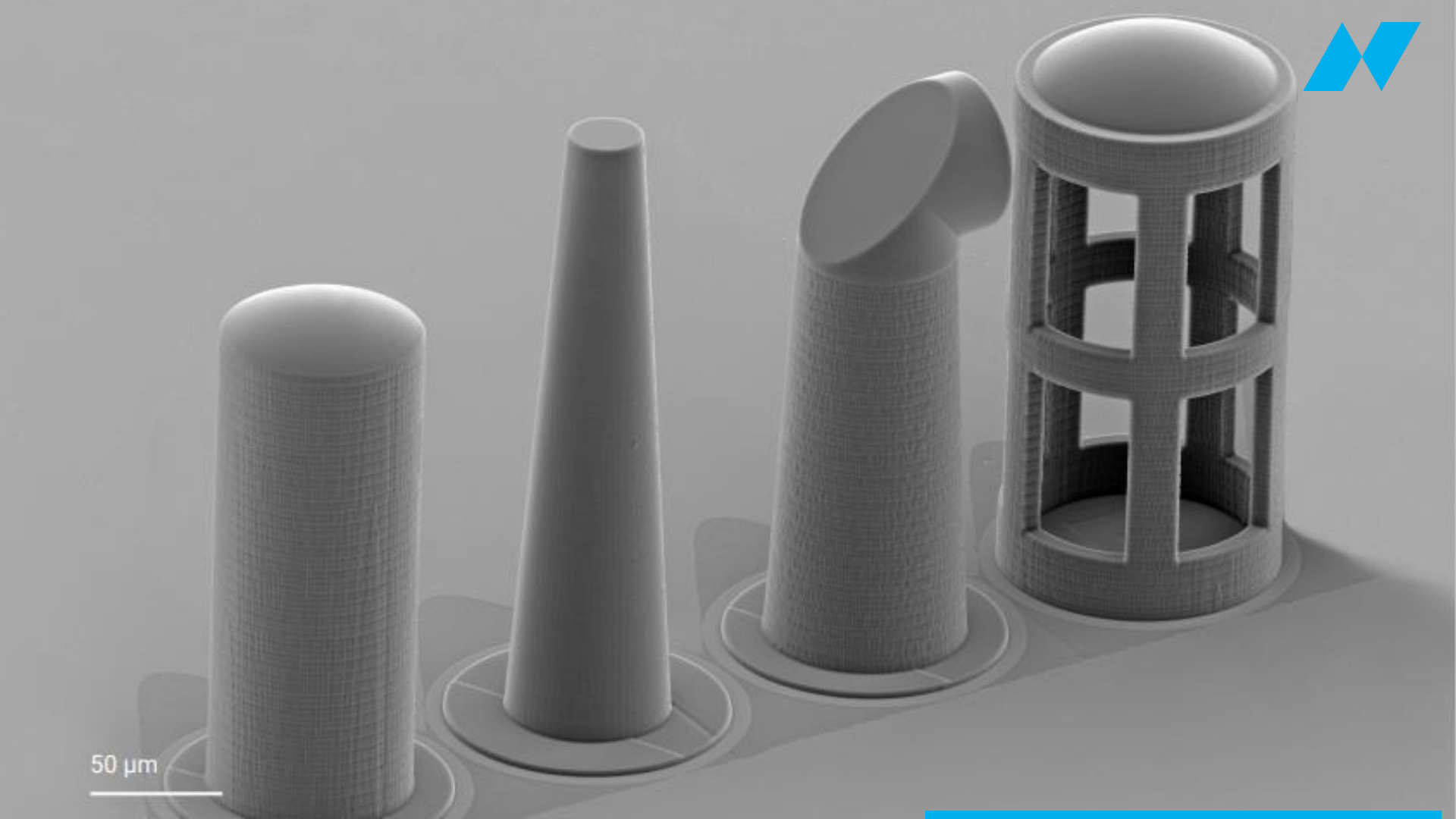


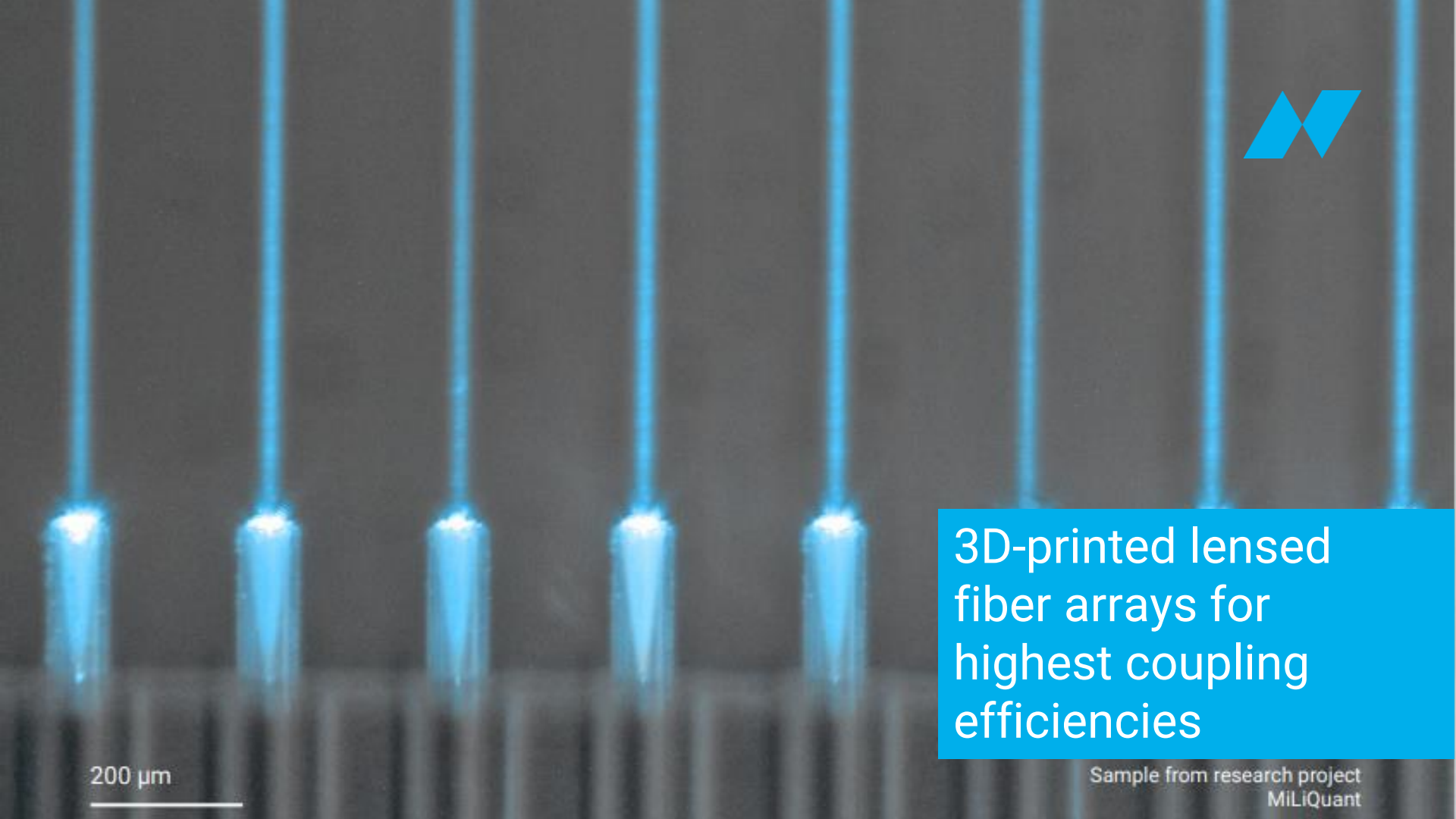
Printing on 3D topographies
3D alignment to topographical features

*Chip from HandheldOCT, *H2020-ICT-2019-2*

Get inspired

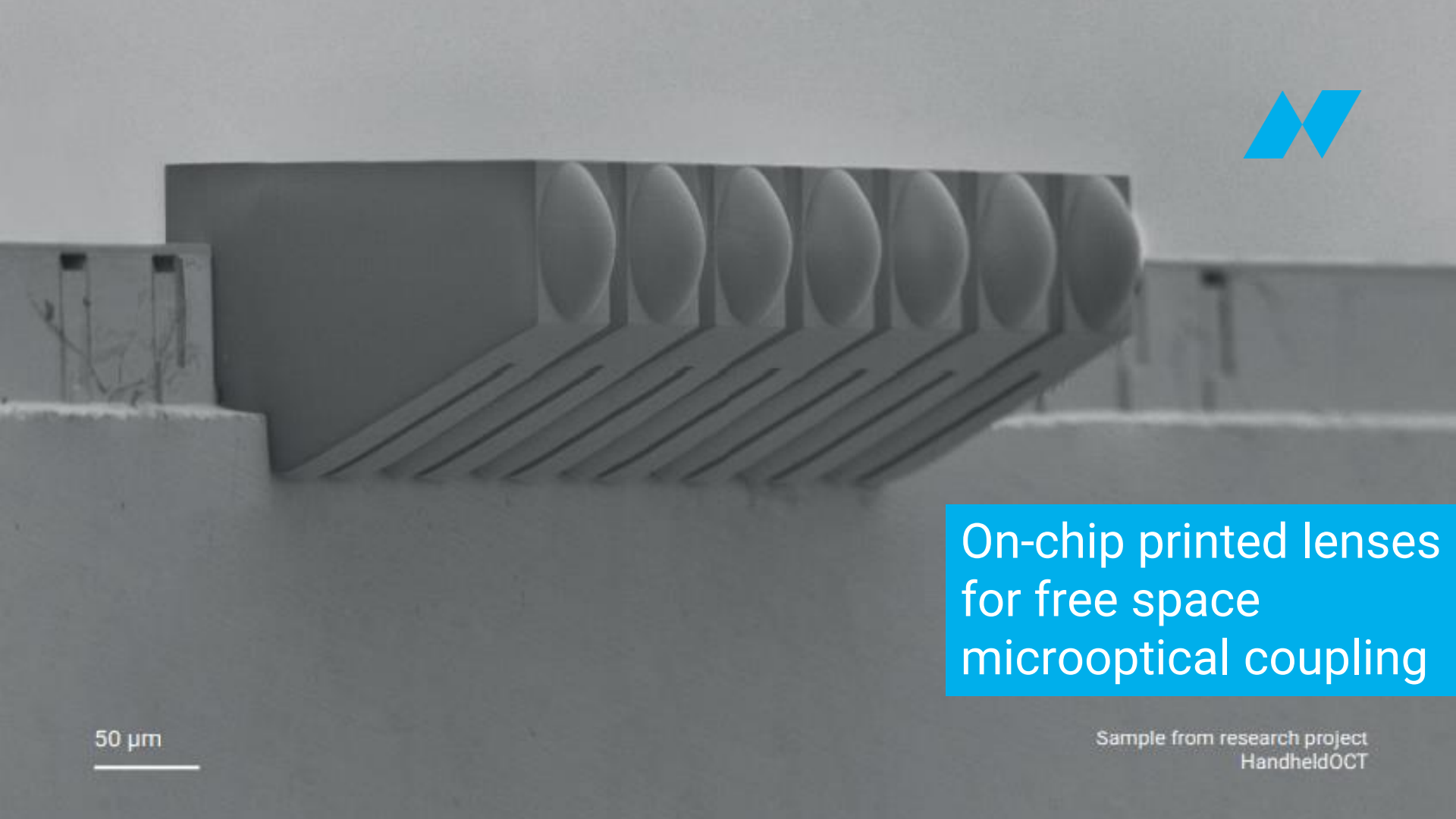
Application examples

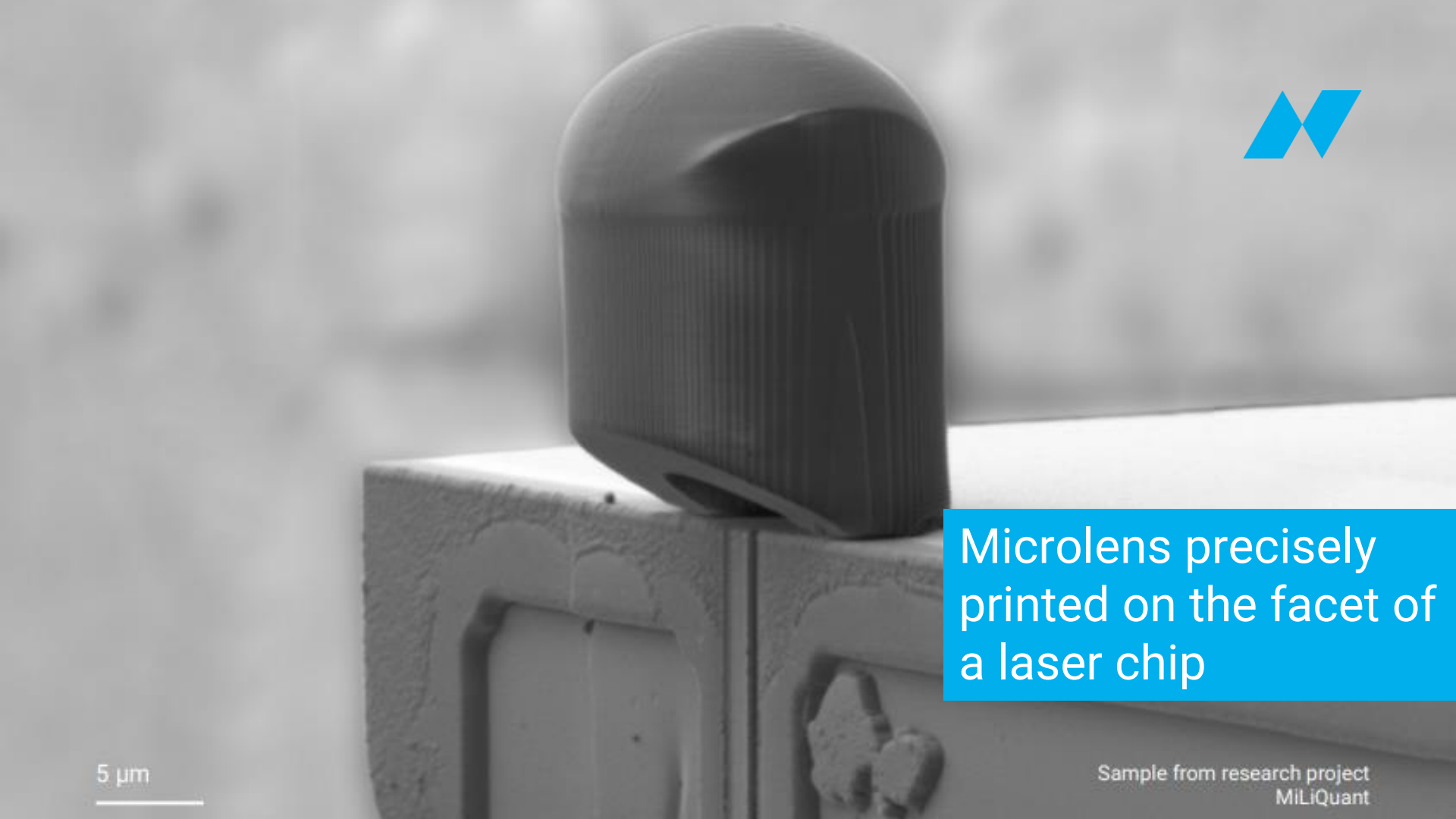

50 µm



3D-printed lensed fiber arrays for highest coupling efficiencies

Sample from research project MiLiQuant


On-chip printed lenses for free space microoptical coupling
50 µm
Sample from research project HandheldOCT

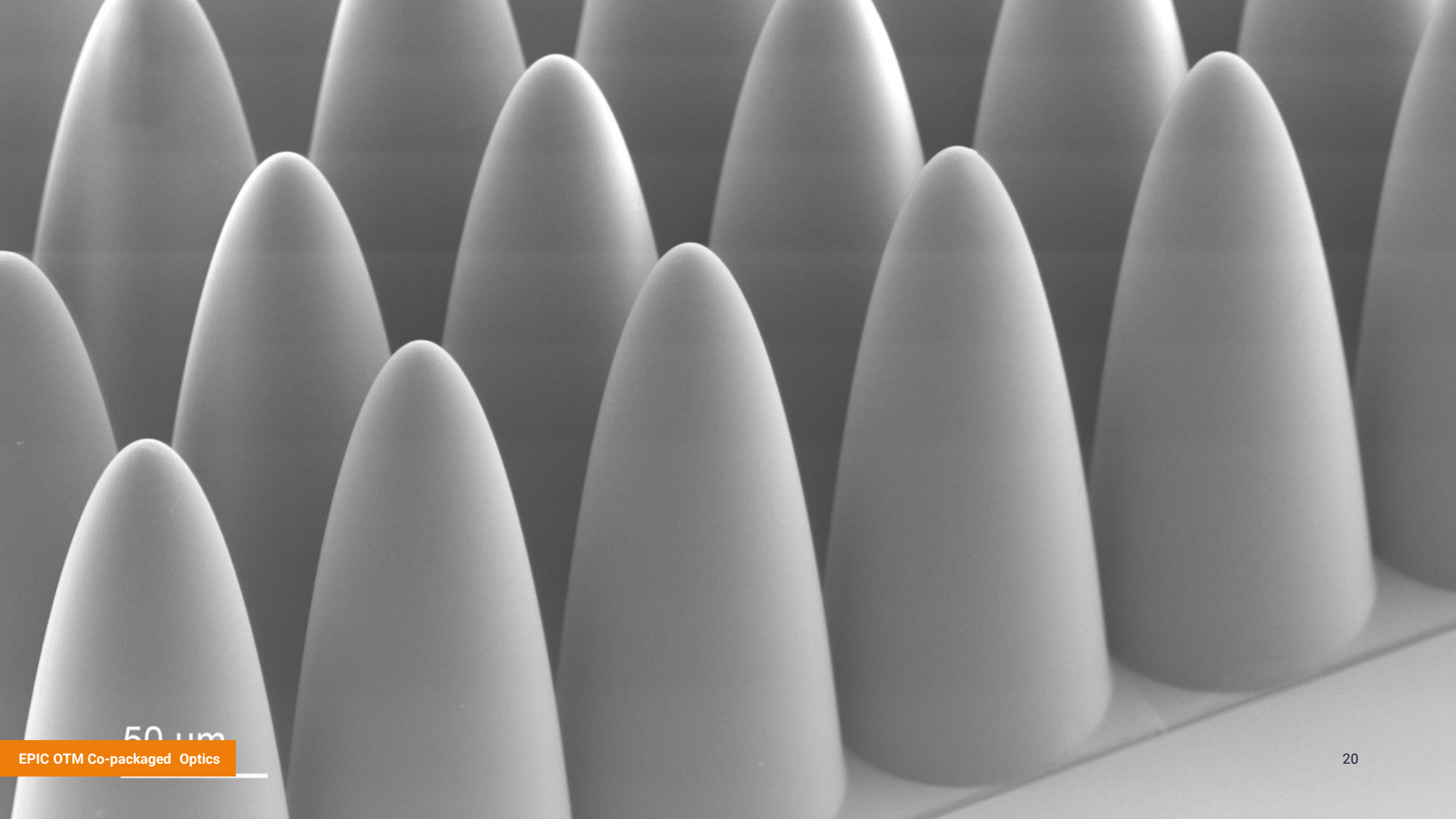


Microlens precisely printed on the facet of a laser chip

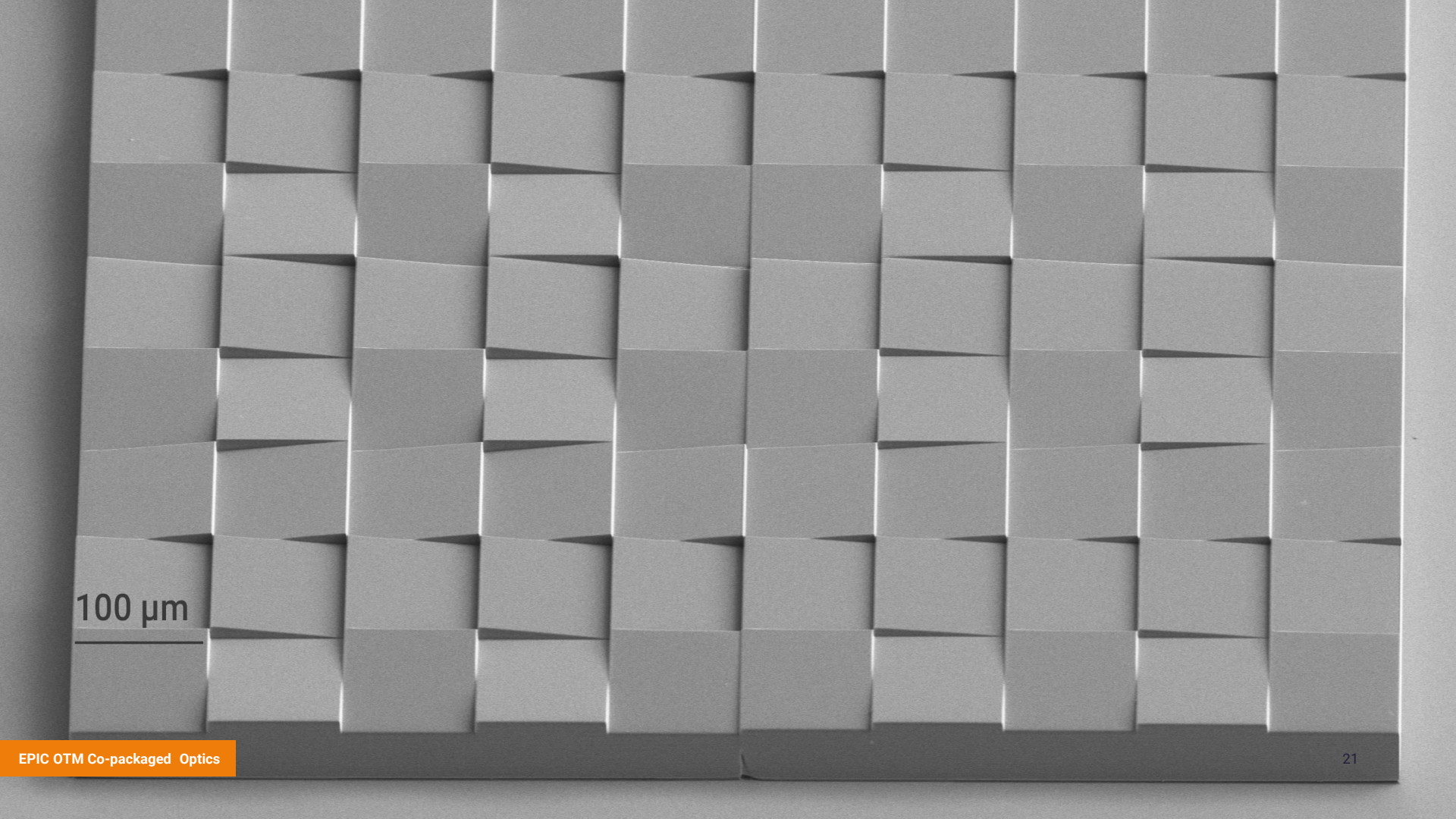
Sample from research project MiLiQuant

Hybrid lens 3D-printed on an optical fiber with diffractive elements

PRINTOPTICS



EPIC OTM Co-packaged Optics


100 µm

Thank you for your attention!

smolenski@nanoscribe.com

Check out our website
nanoscribe.com

Book an online
product demo
Get to know the
Nanoscribe Quantum X series

Check the feasibility
of your structure
Validate our
3D Microfabrication technology