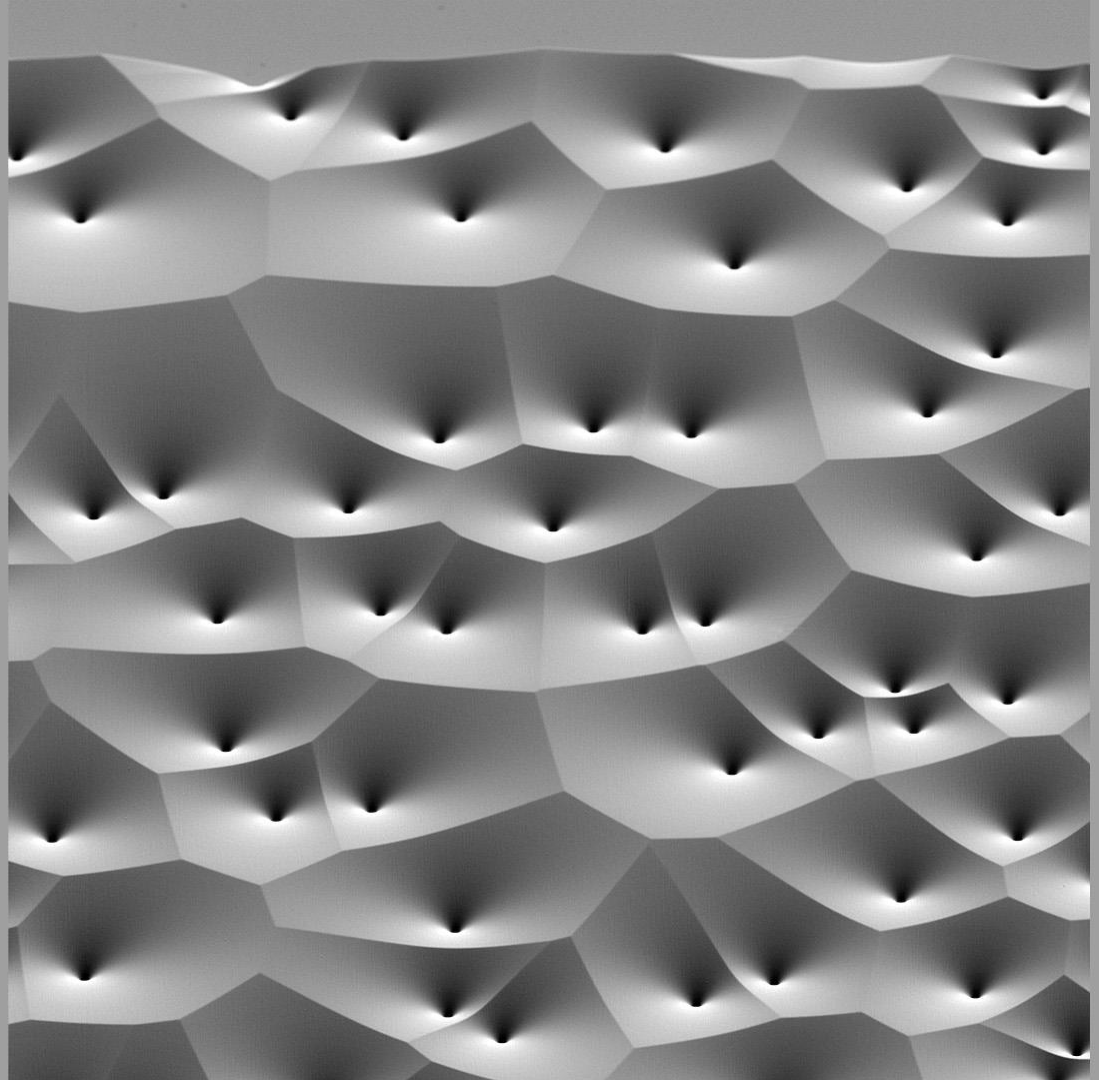

100 µm

nanoscribe
A BICO COMPANY

15 YEARS Think big. Print nano.

From Mastering to Aligned Printing – Enabling Photonics Systems Production with 2GL

Jörg Smolenski, Business Development Manager

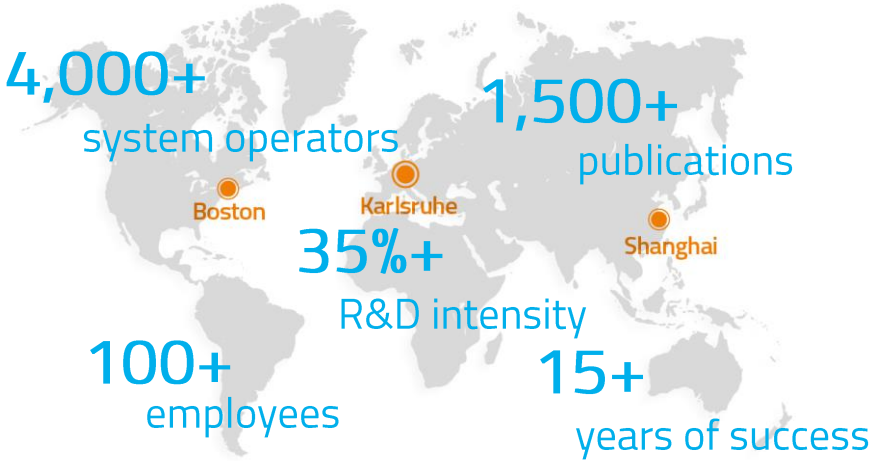
November 14th, 2023

EPIC Technology Meeting on Microelectronics & Photonics – Two Sides of One Coin

Company & Products

We offer 3D microfabrication solutions at the interface between **Lithography** and **Additive Manufacturing**. This results in **aligned 3D printing** capabilities e.g. on chip, on fiber, in wells and in microfluidic channels with **optical quality surfaces**.

Nanoscribe worldwide in figures



Systems
Quantum X product line

- Quantum X shape

"Fastest and most accurate 3D printer in class"

- Quantum X align

PRISM AWARDS FINALIST

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

- Quantum X bio

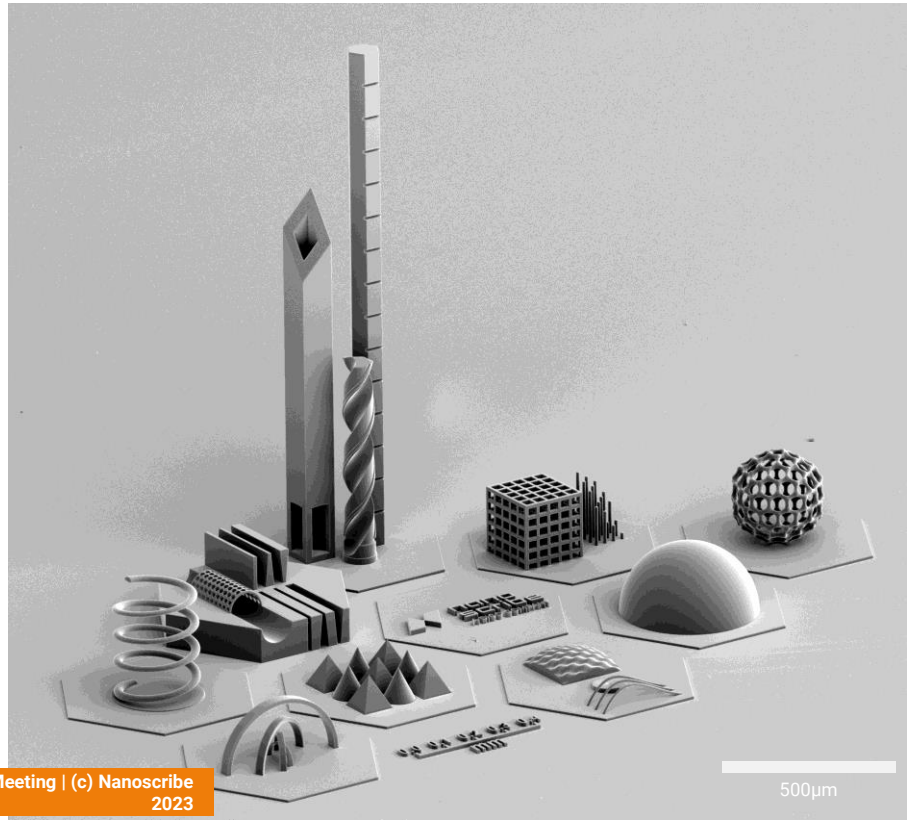
2022 R&D 100 WINNER

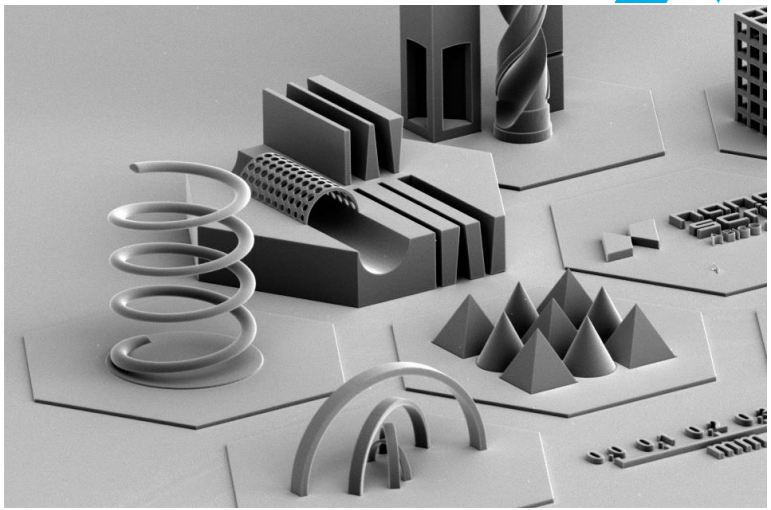
"The world's most accurate 3D bioprinter"

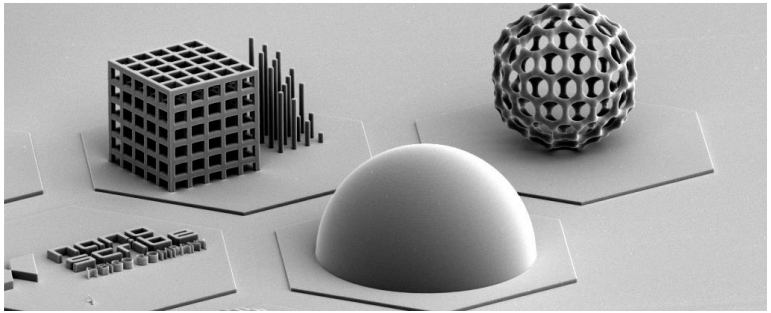
- Quantum X

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

Technology: Two-Photon Grayscale Lithography (2GL®)







Technology: Two-Photon Grayscale Lithography (2GL®)

2PP vs. 2GL®, SF
Height = 125µm

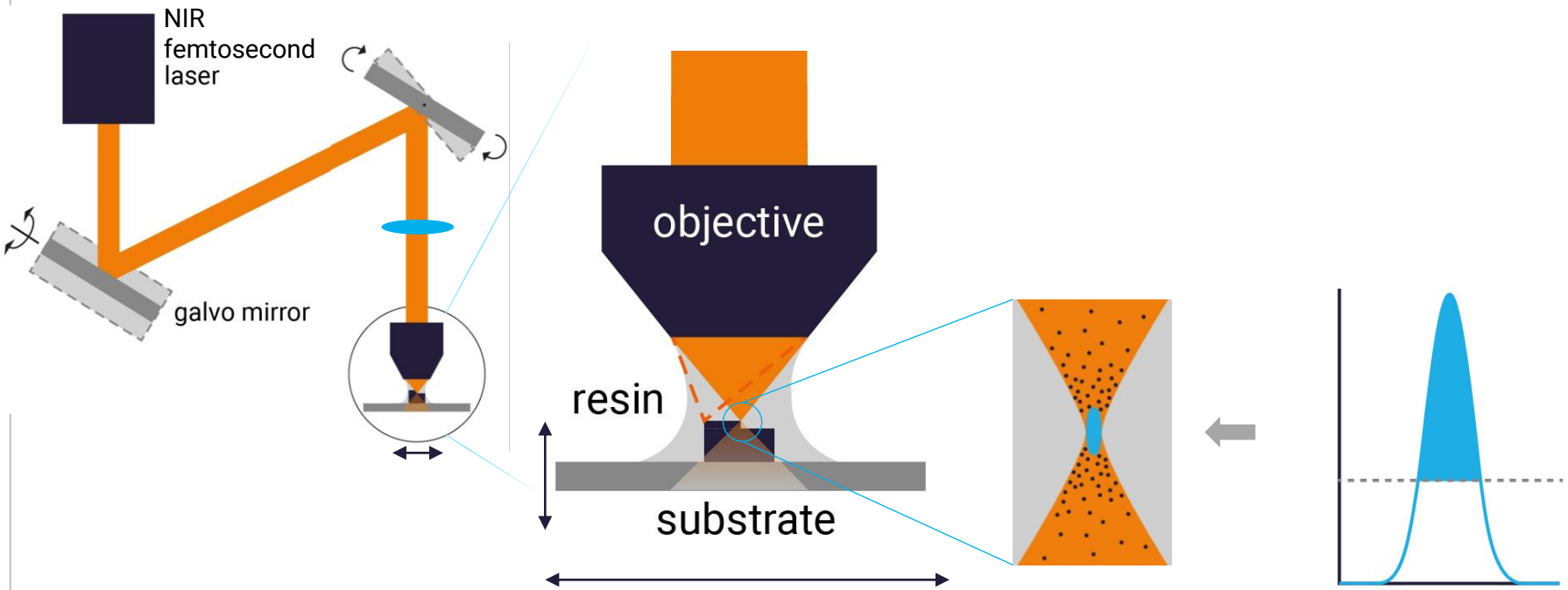
2PP vs. 2GL®, MF
Height = 250µm

2PP vs. 2GL®, LF
Height = 1250µm

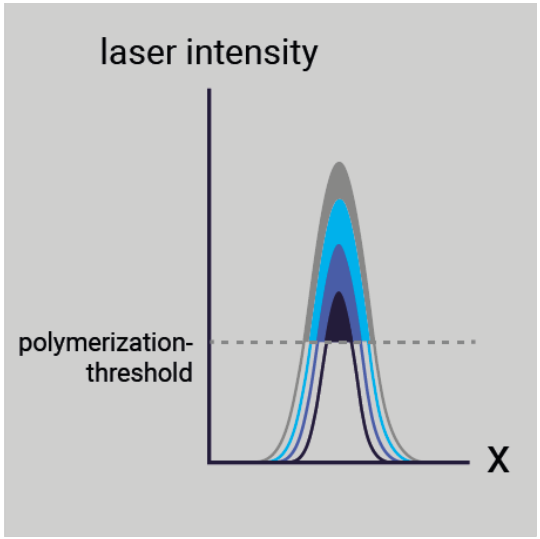
2PP vs. 2GL®, XLF
Height = 2500µm

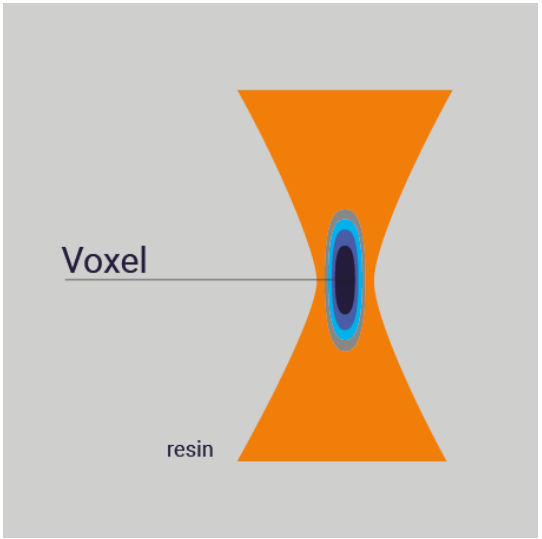
Technology

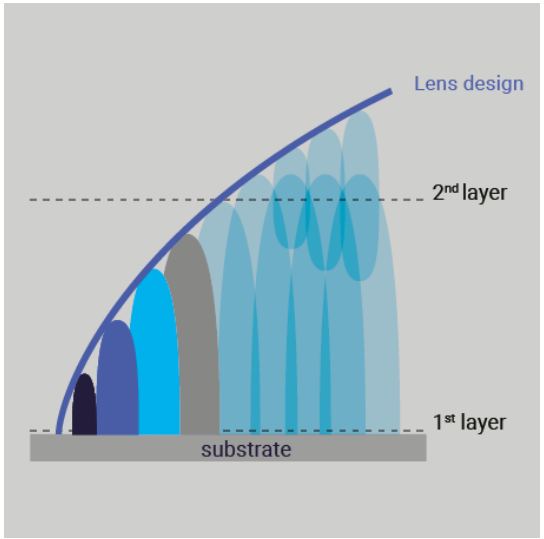
Technology: Two-photon polymerization (2PP)



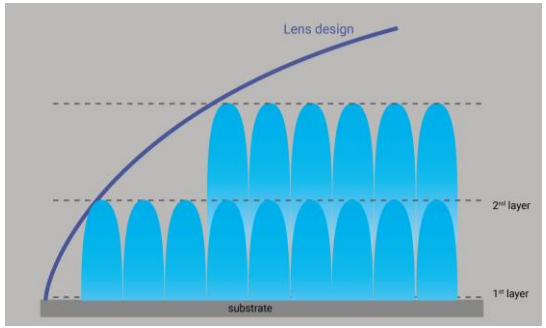
Two-Photon Grayscale Lithography - 2GL®
Dynamic voxel height tuning

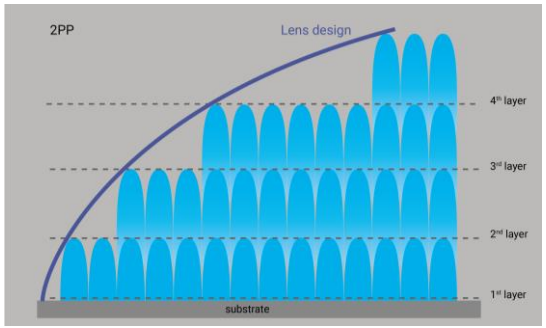


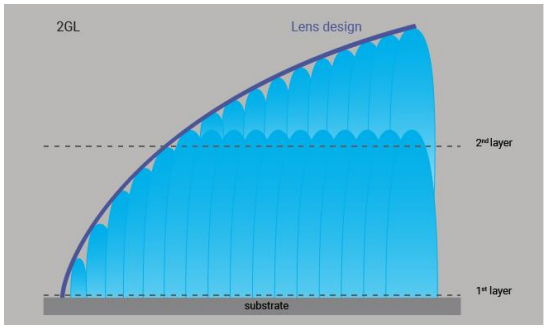


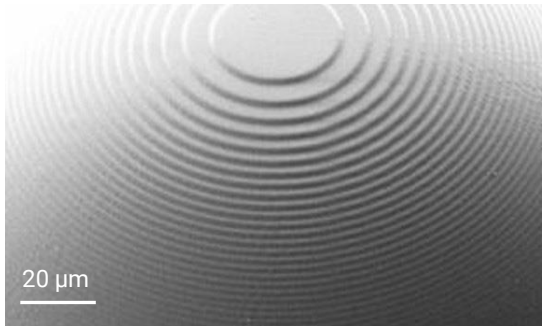


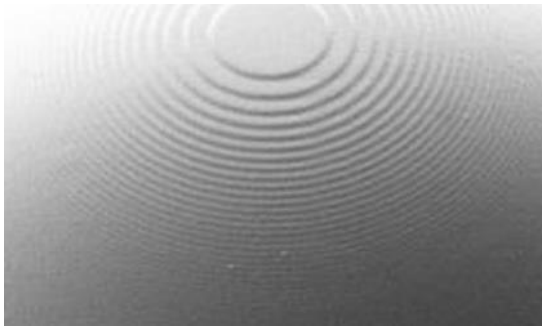
Technology: Two-Photon Grayscale Lithography (2GL®)

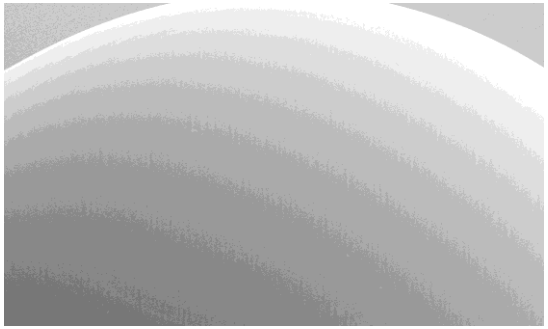












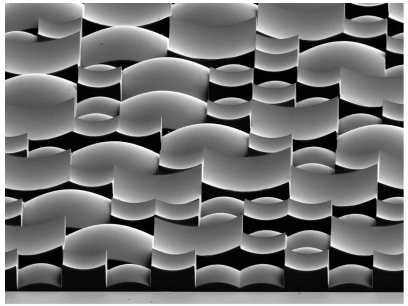
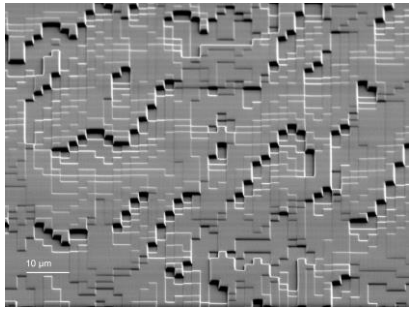
ith coarse slicing

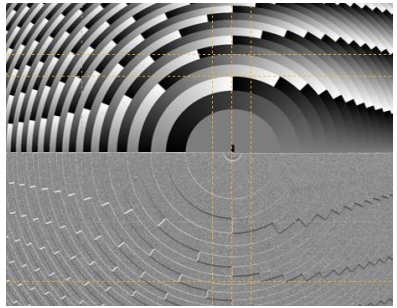
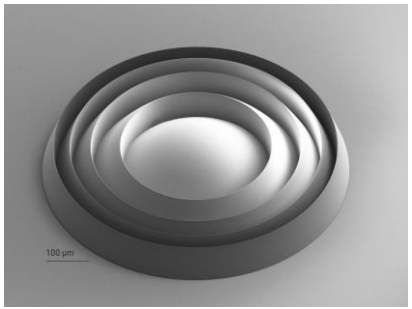
2PP with fine slicing

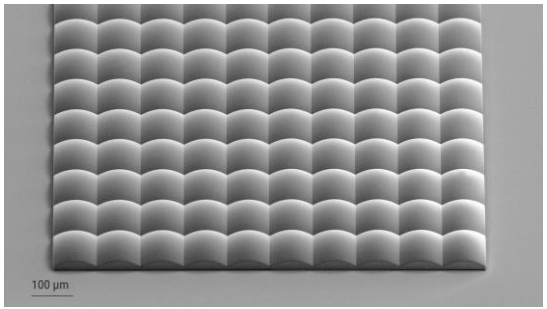
2GL® with coarse slicing

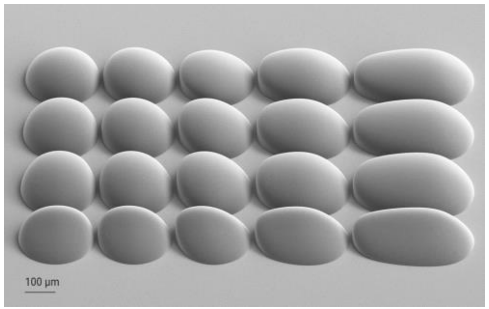
From Mastering to Aligned Printing

2.5D microoptics made by 2-Photon Polymerization (2PP)
Fresnel lenses, hybrid lenses, micro lens arrays, DOEs

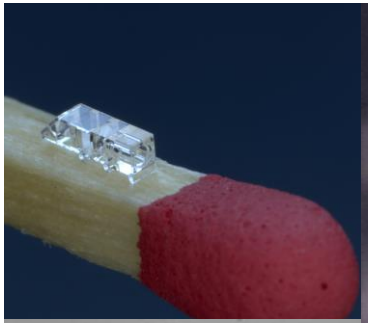


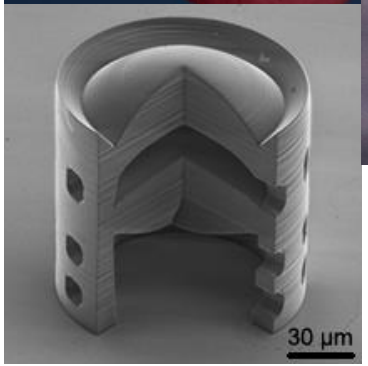


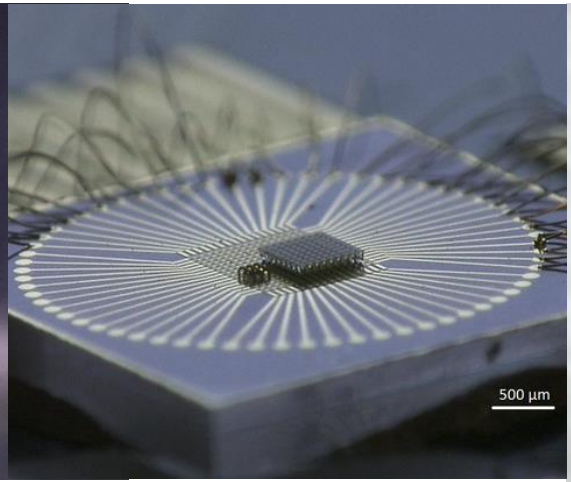
- few 10’s to 100’s µm to mm diameters of up to cm² area

3D microoptics made by 2PP
Specialized microoptical designs

PRINTOPTIX



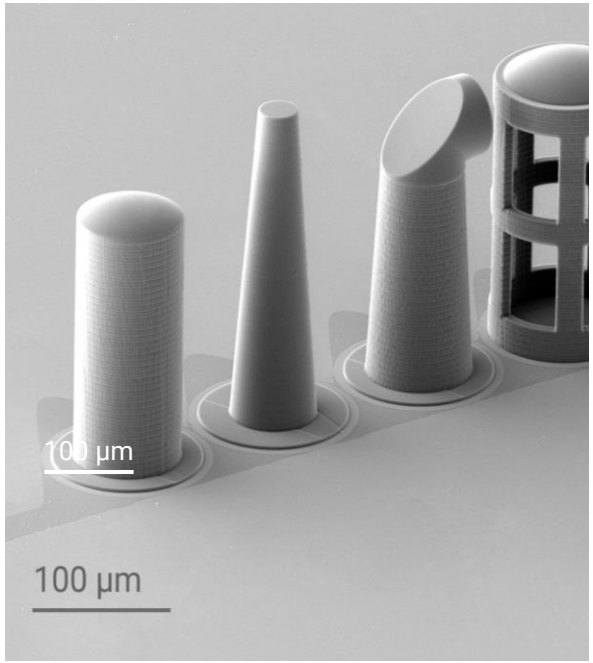


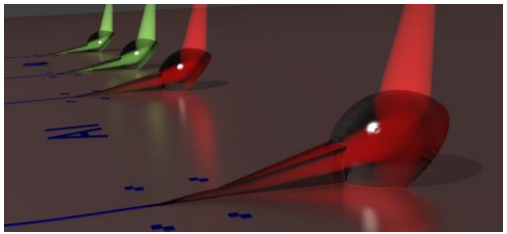


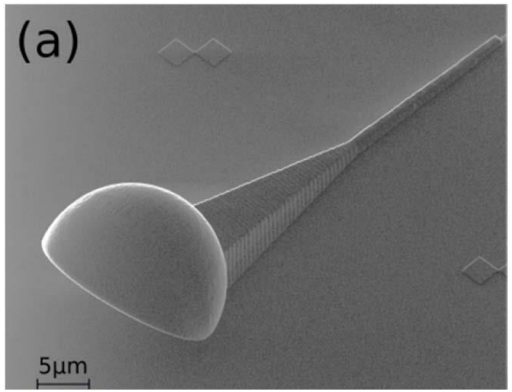
- Compact freeform lens optical systems
- Design, print, coat, measure, iterate
- Process optimization

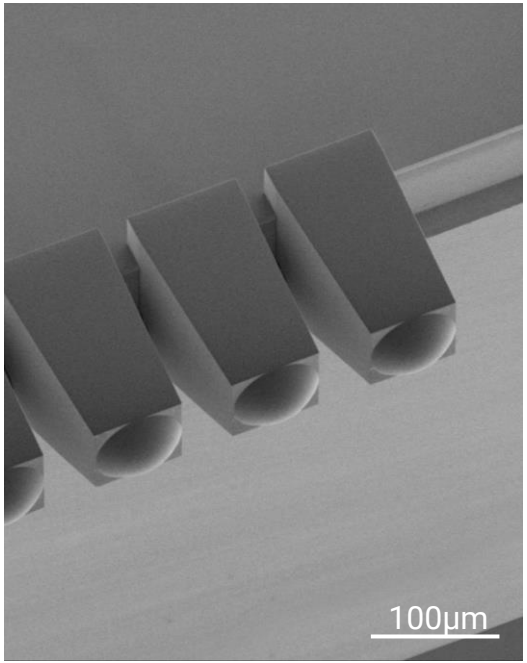
Images supplied by: Printoptix GmbH, https://www.printoptix.com/, Dr. Simon Thiele

3D microoptics made by 2PP
Beam shaping for efficient surface and edge coupling







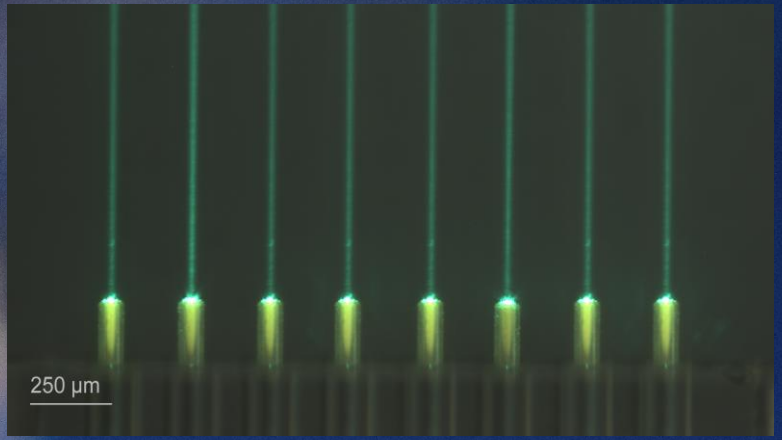


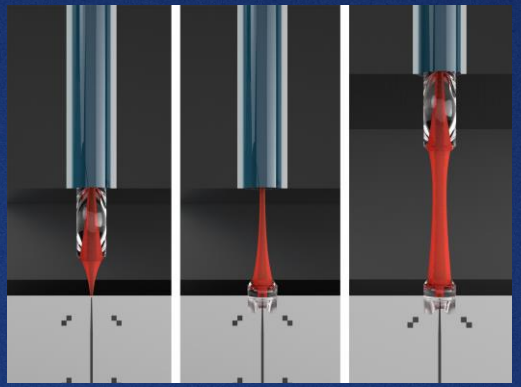
Gehring, Helge et al., "Broadband out-of-plane coupling at visible wavelengths", *Optics Letters,* 44.20 (2019)

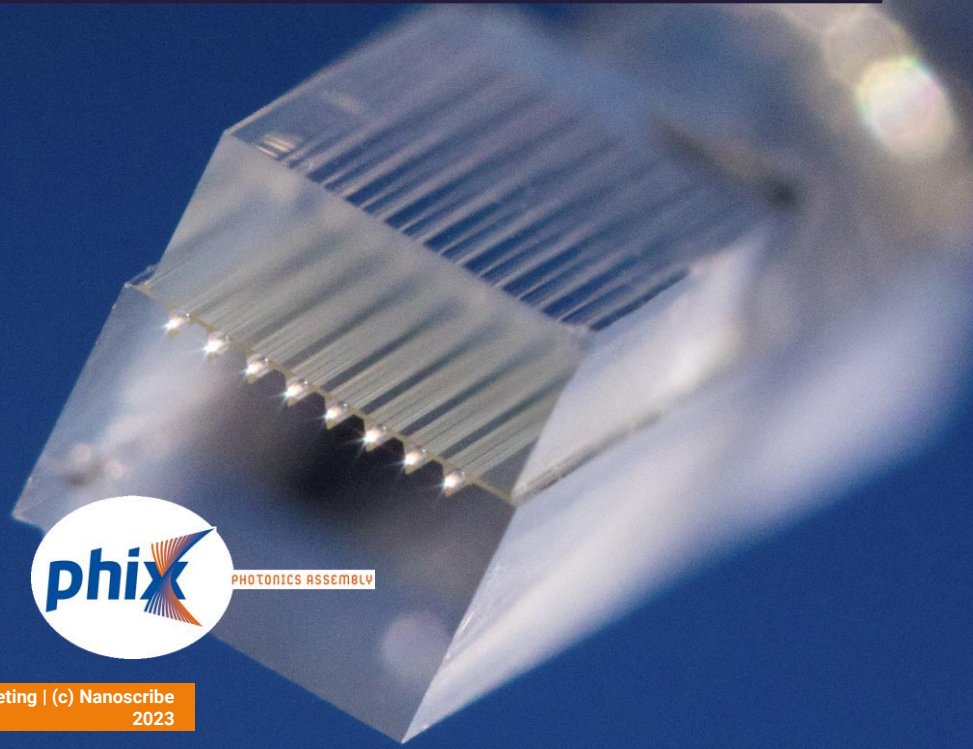
Summary

Connect to the photonic world

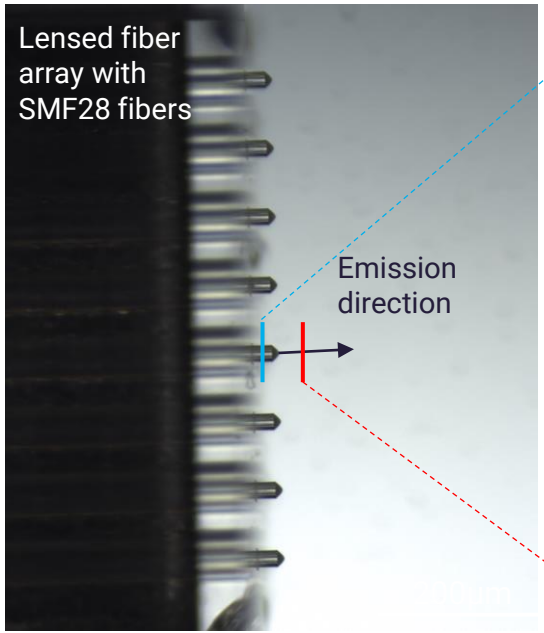
3D printed Free Space Microoptical Coupling

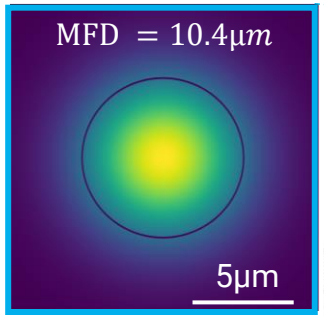


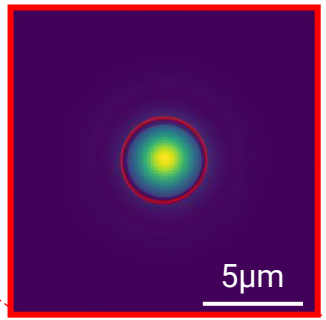


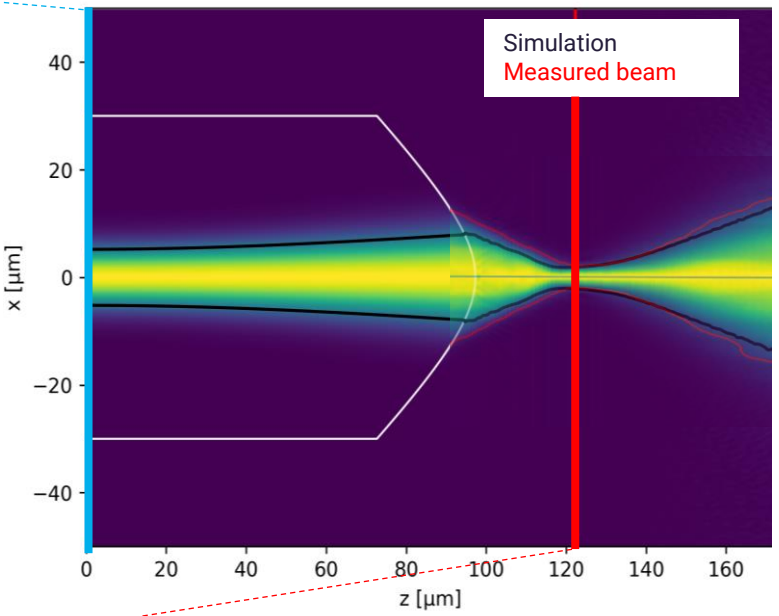


3.6µm MFD focus lens for 1550nm



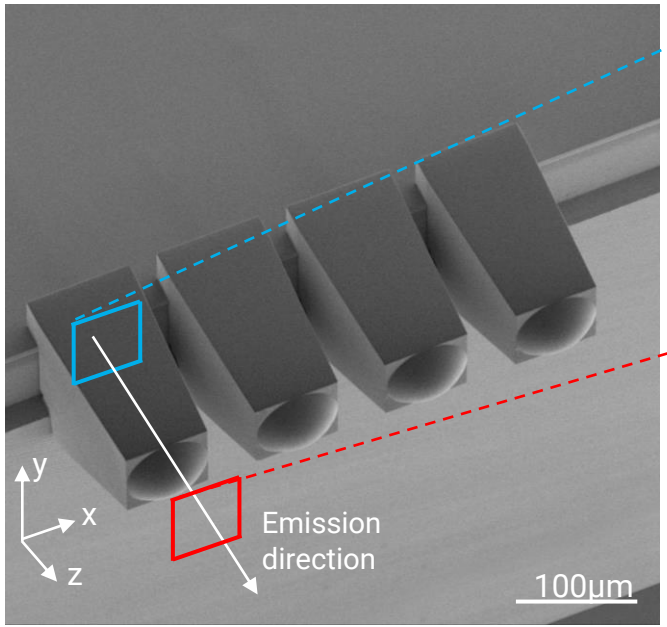


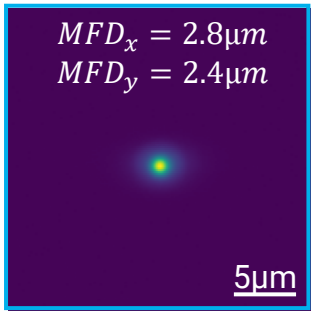


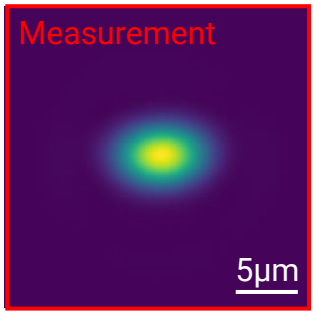


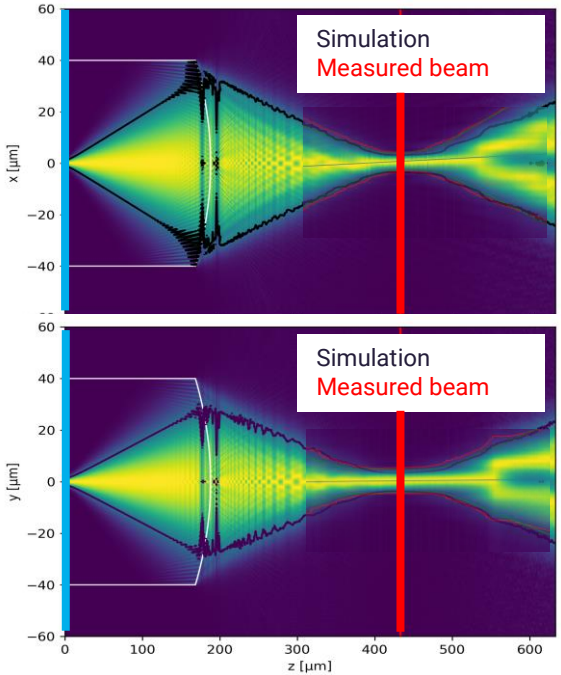
Simulation
Measured beam

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





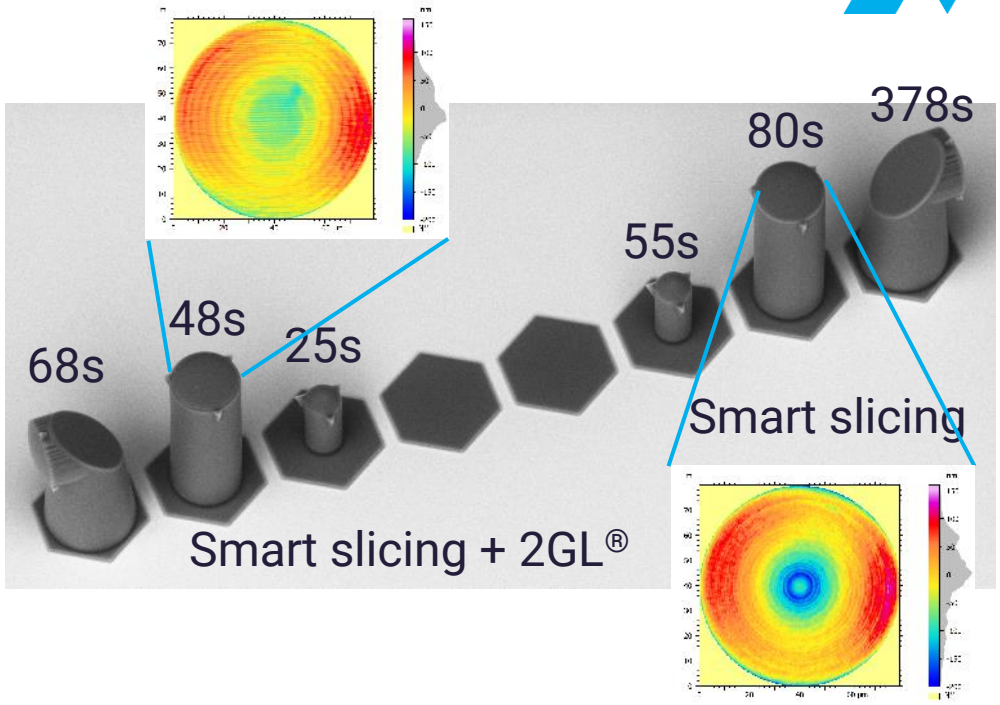




Sample from research project
HandheldOCT, imec SiN

Printing process:
Smart slicing + 2GL®

- **Smart** slicing
  vs. **fine** slicing:
  3.5x faster (for periscope)
- **Smart + 2GL** slicing
  vs. **fine** slicing:
  20x faster (for periscope)
- **Smart + 2GL** slicing
  vs. **smart** slicing:
  RMS error (shape): 41.7 nm
  vs. 58.5 nm



Enabling Massproduction

Replication processes
From polymer master to series production

- MLA polymer master

- Nickel shim

- Micro injection molded replica
- Hot embossed replica

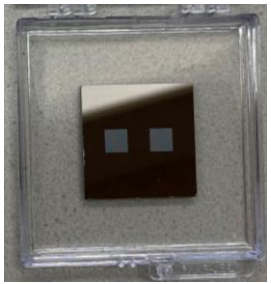
- Soft mold

- Nanoimprinted replica

- MLA negative polymer master

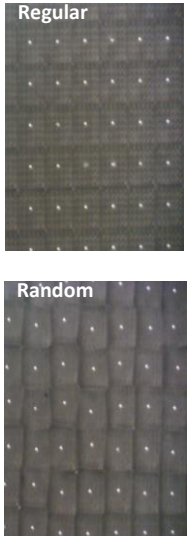
- Direct hot embossed replica

Replication Process IM
Injection Molding (IM) with KDG

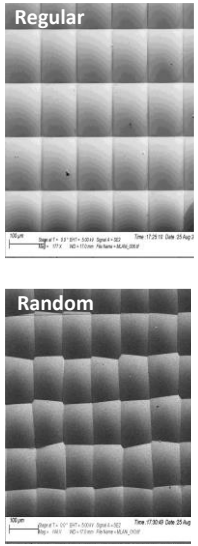


2GL Master
on glass substrate

Tool-insert
Nickel shim



Microscopic
images

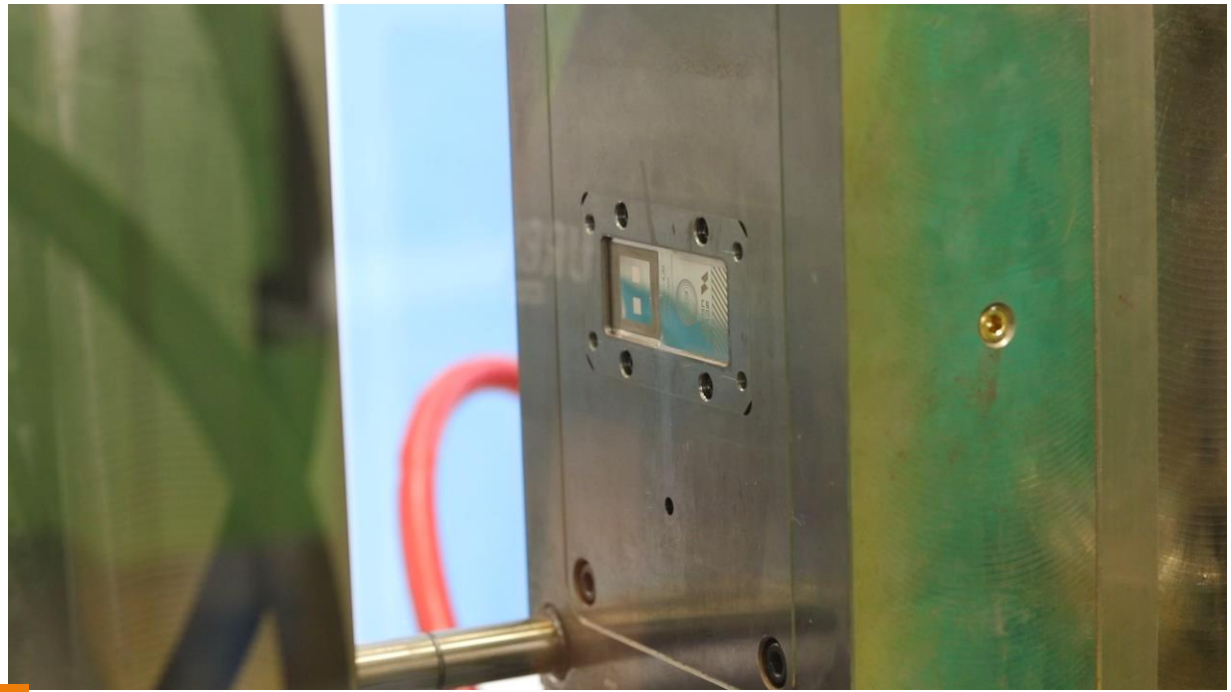


SEM images

Tool-insert
with engraving

PMMA-molded
part

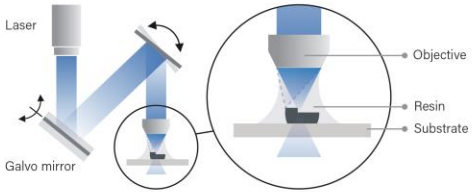
Replication Process IM
Injection Molding (IM) with KDG



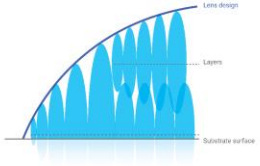
NIL Replication processes
From polymer master to small series production

Nanoscribe Quantum X

Single Die Mastering & Prototype by 2GL

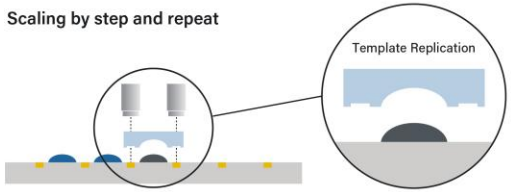


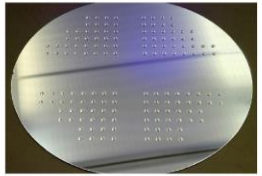
2GL voxel tuning



EVG®770 NT

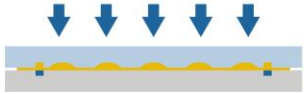
Scaling by step and repeat



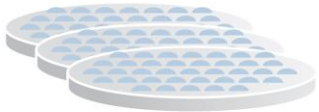


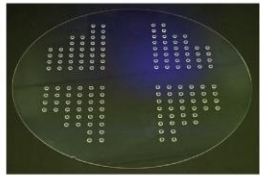
EVG®7300

UV Nanoimprint Lithography



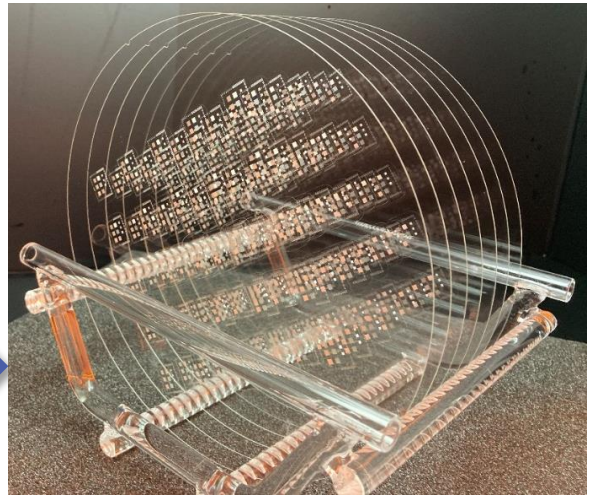
Mass Production

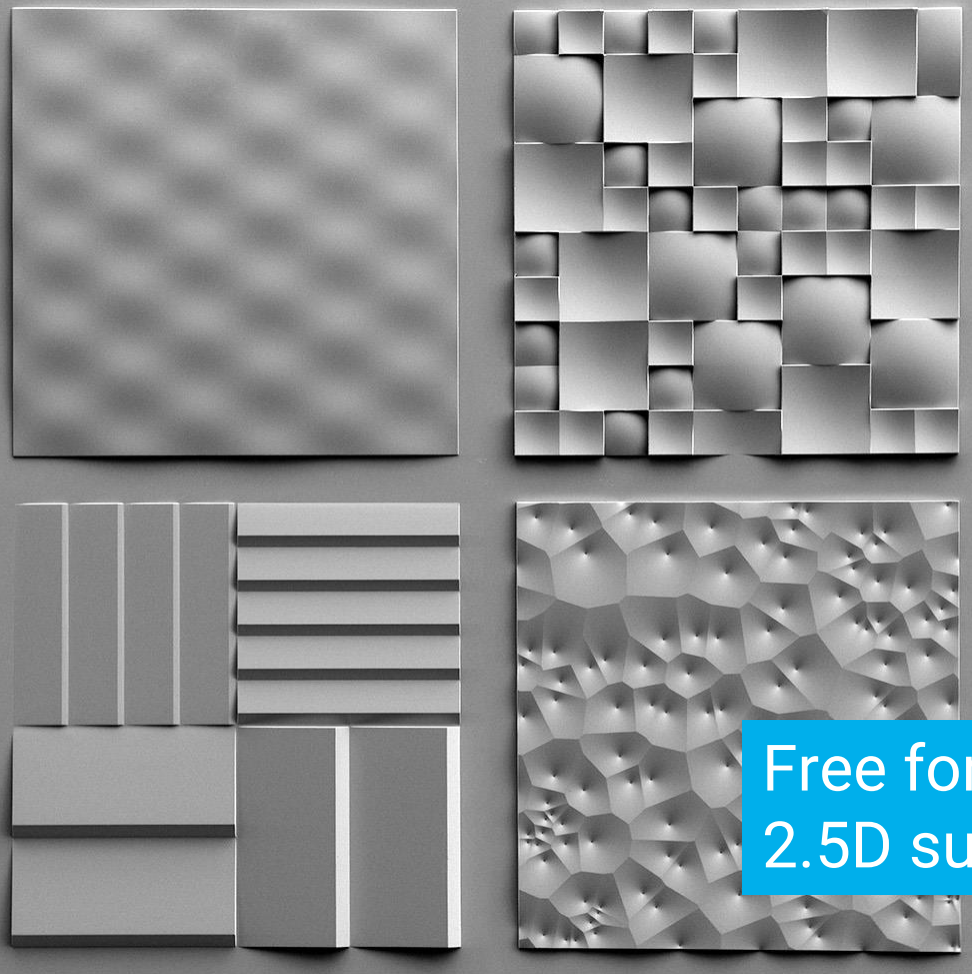




Nano Imprinting
Process Flow

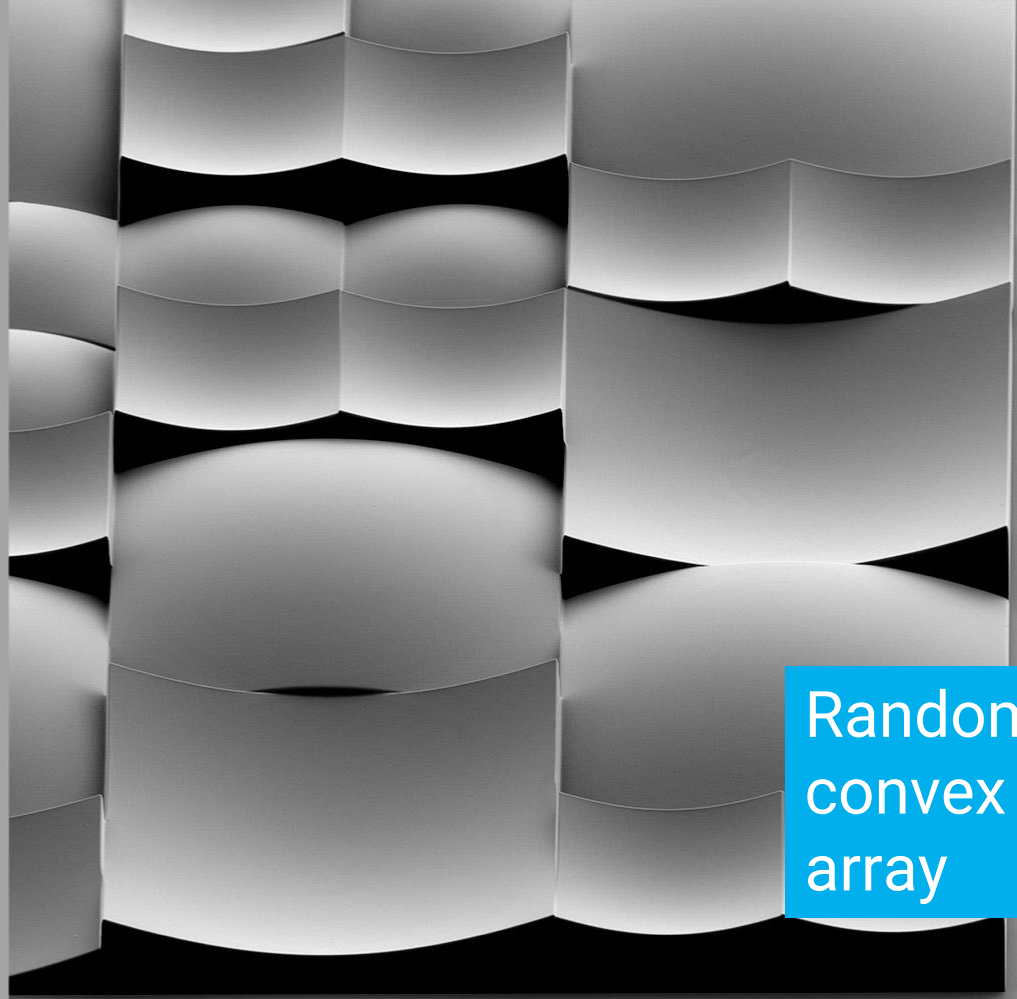
From single Master via S&R to Imprint





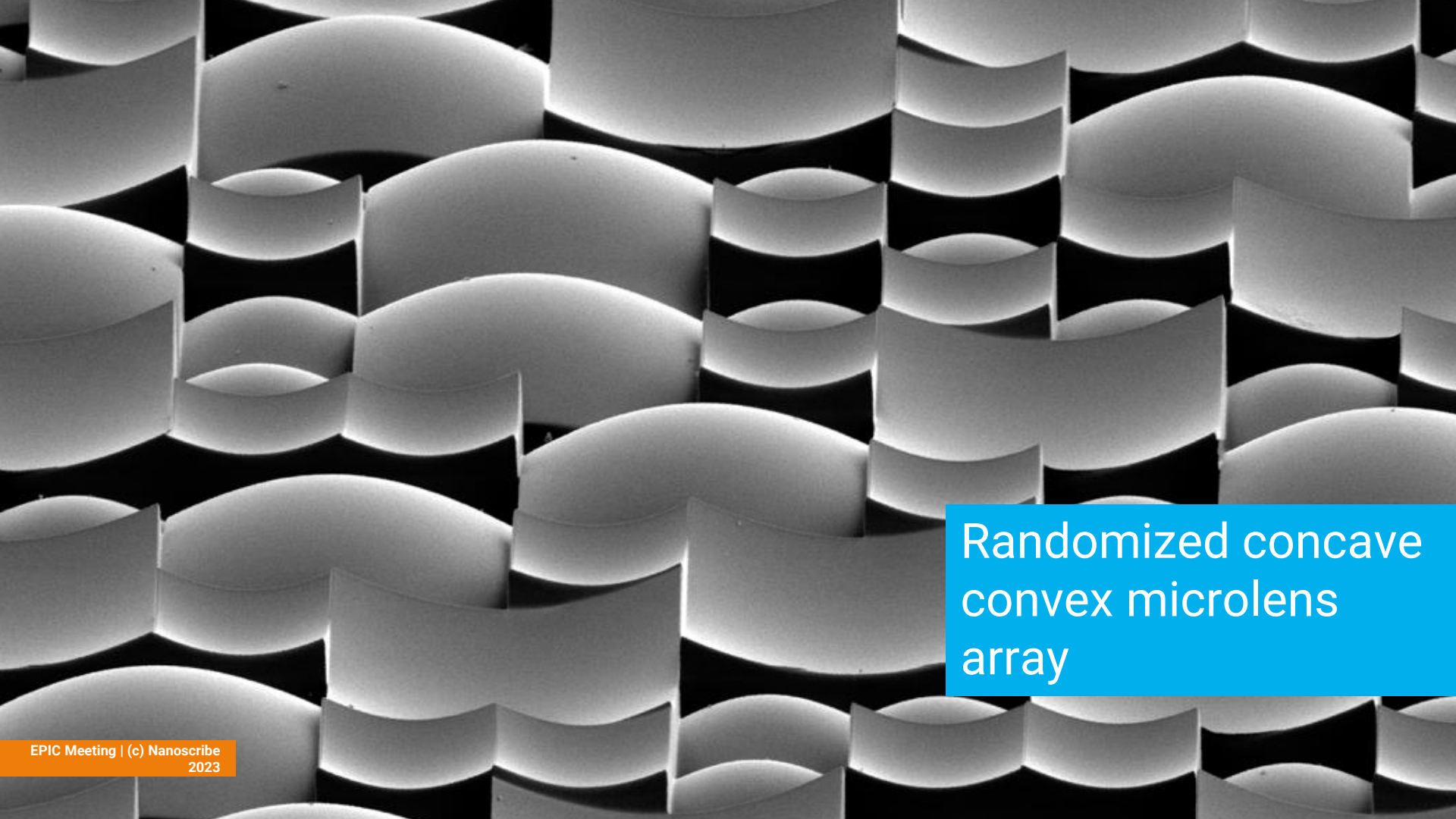
Free form
2.5D surfaces

500 µm

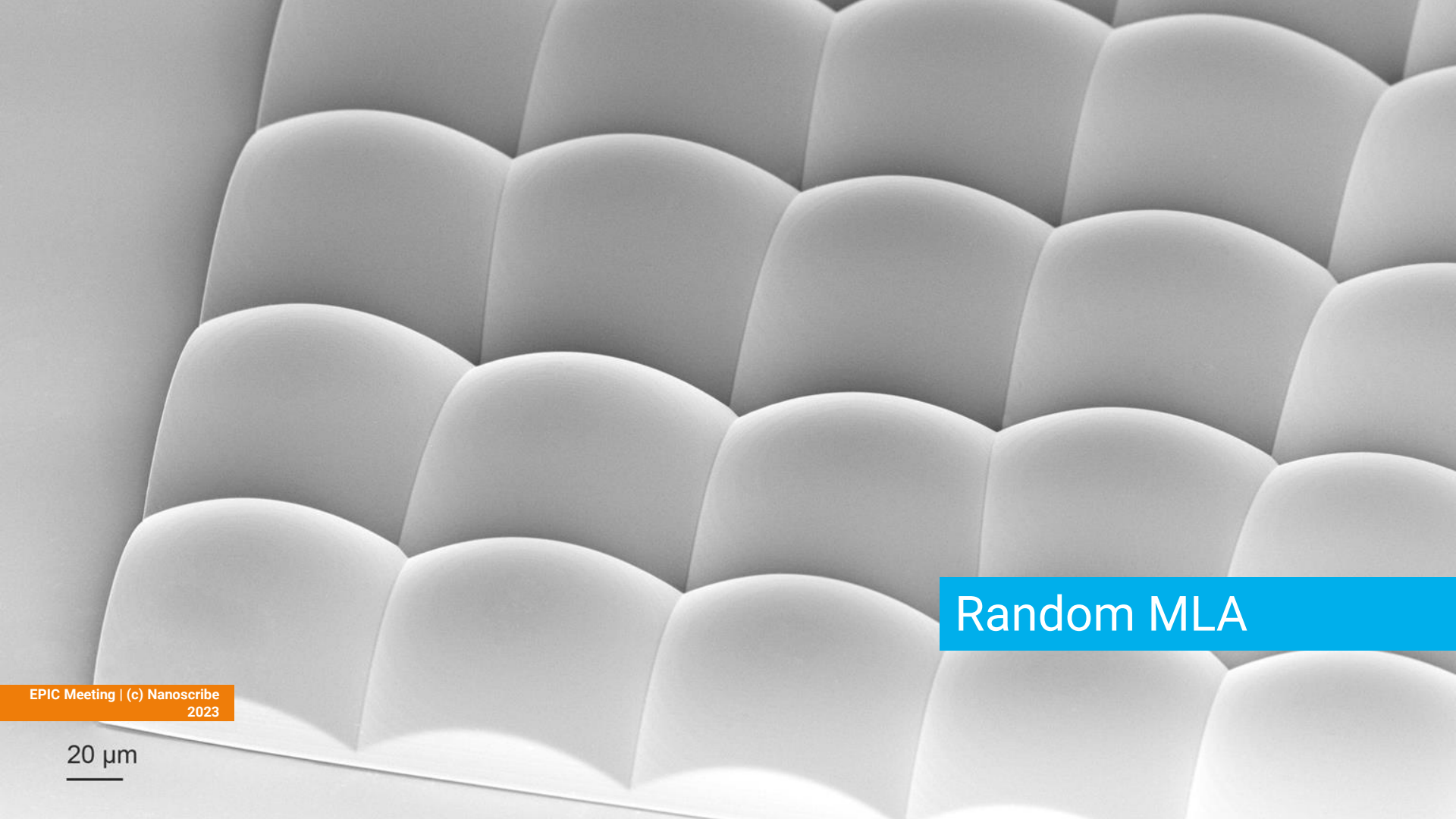


Randomized concave convex microlens array

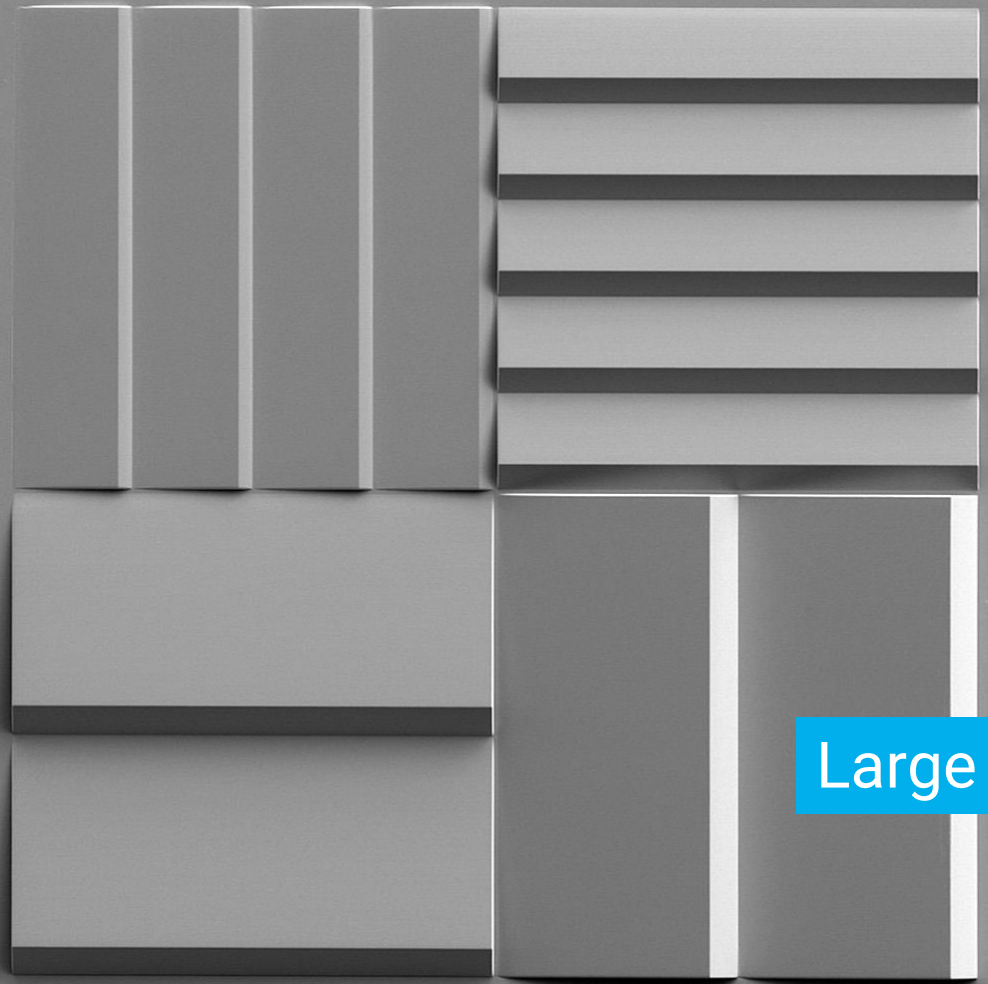
100 µm



Randomized concave convex microlens array

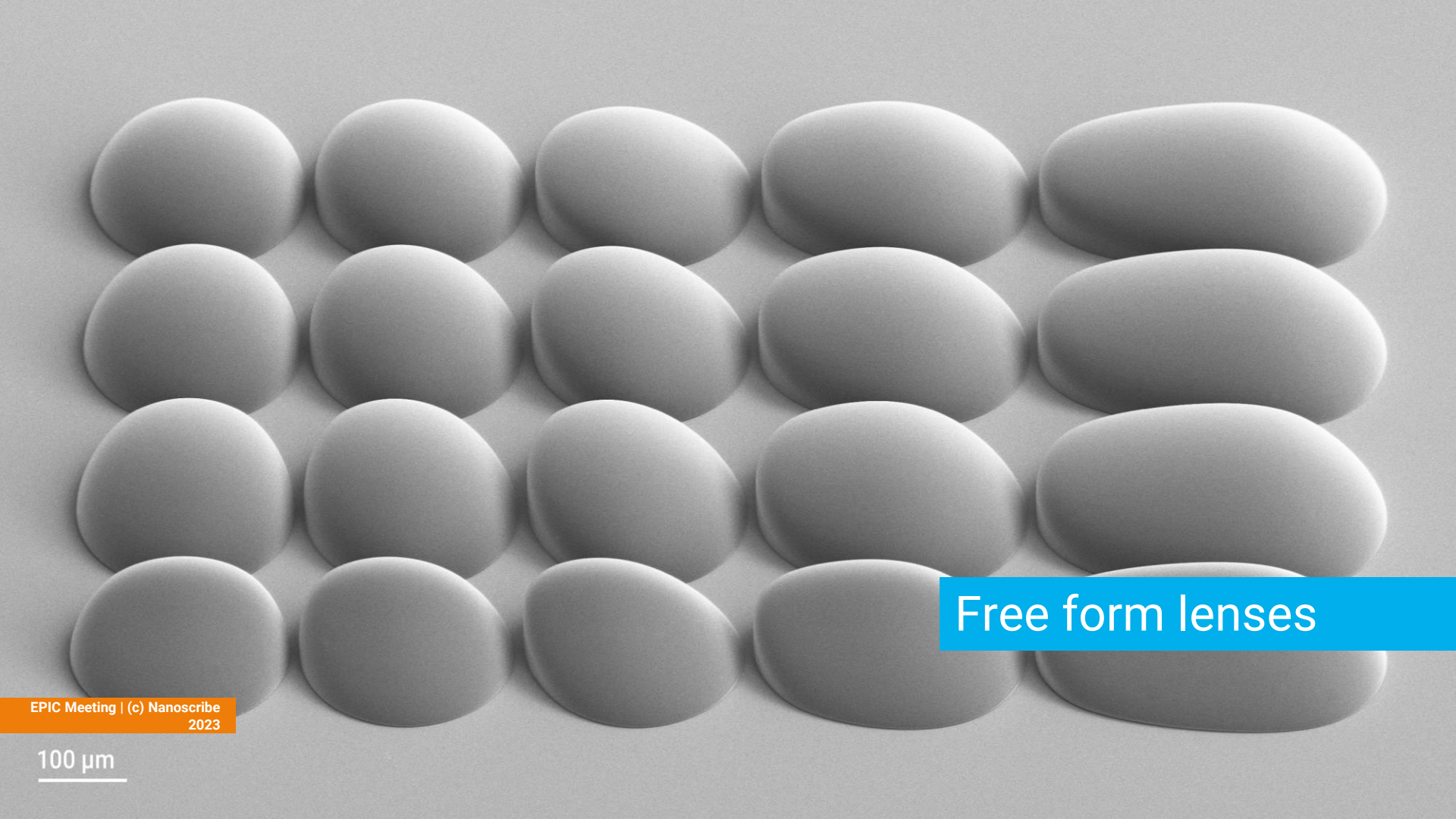


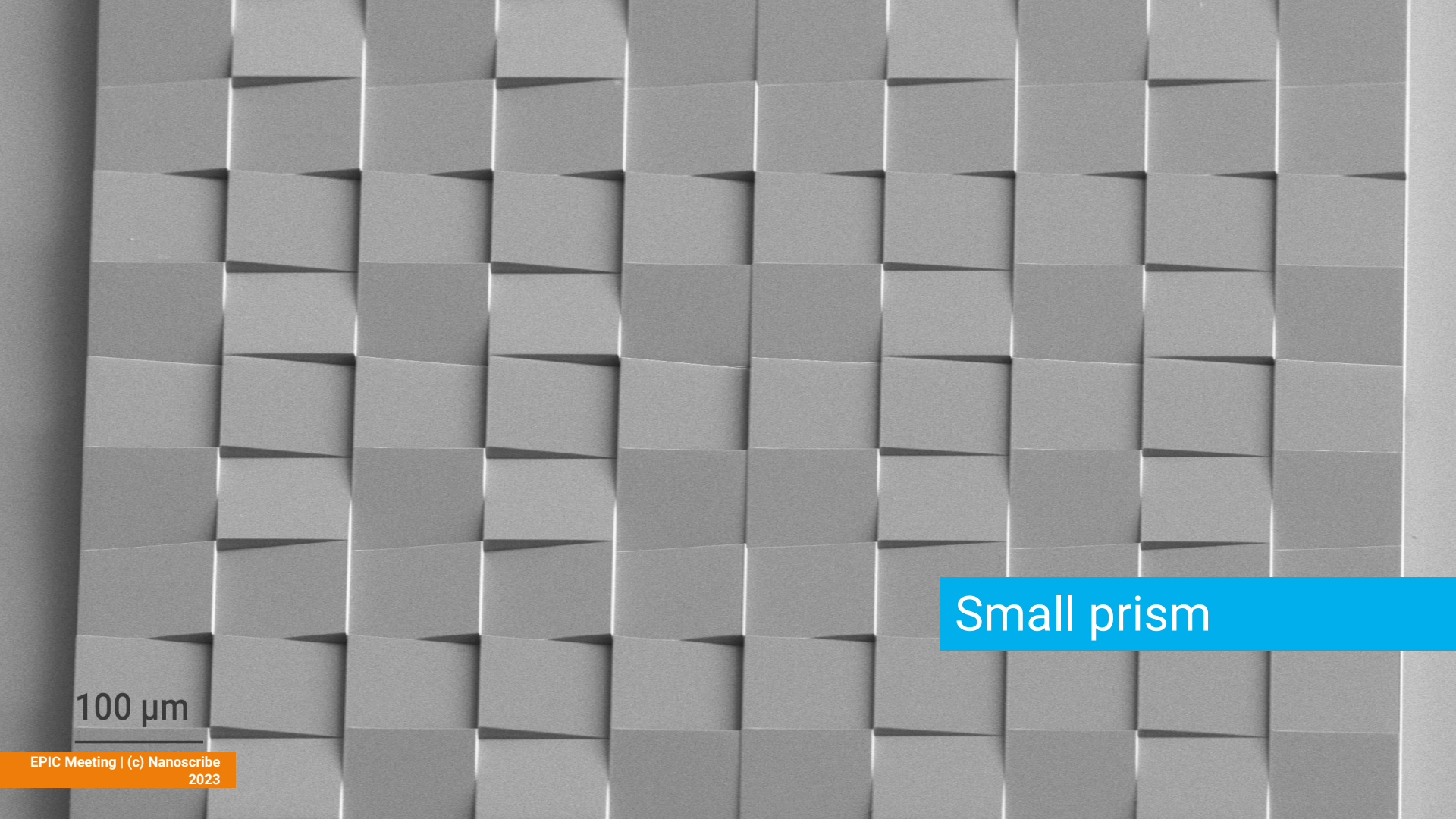
Random MLA



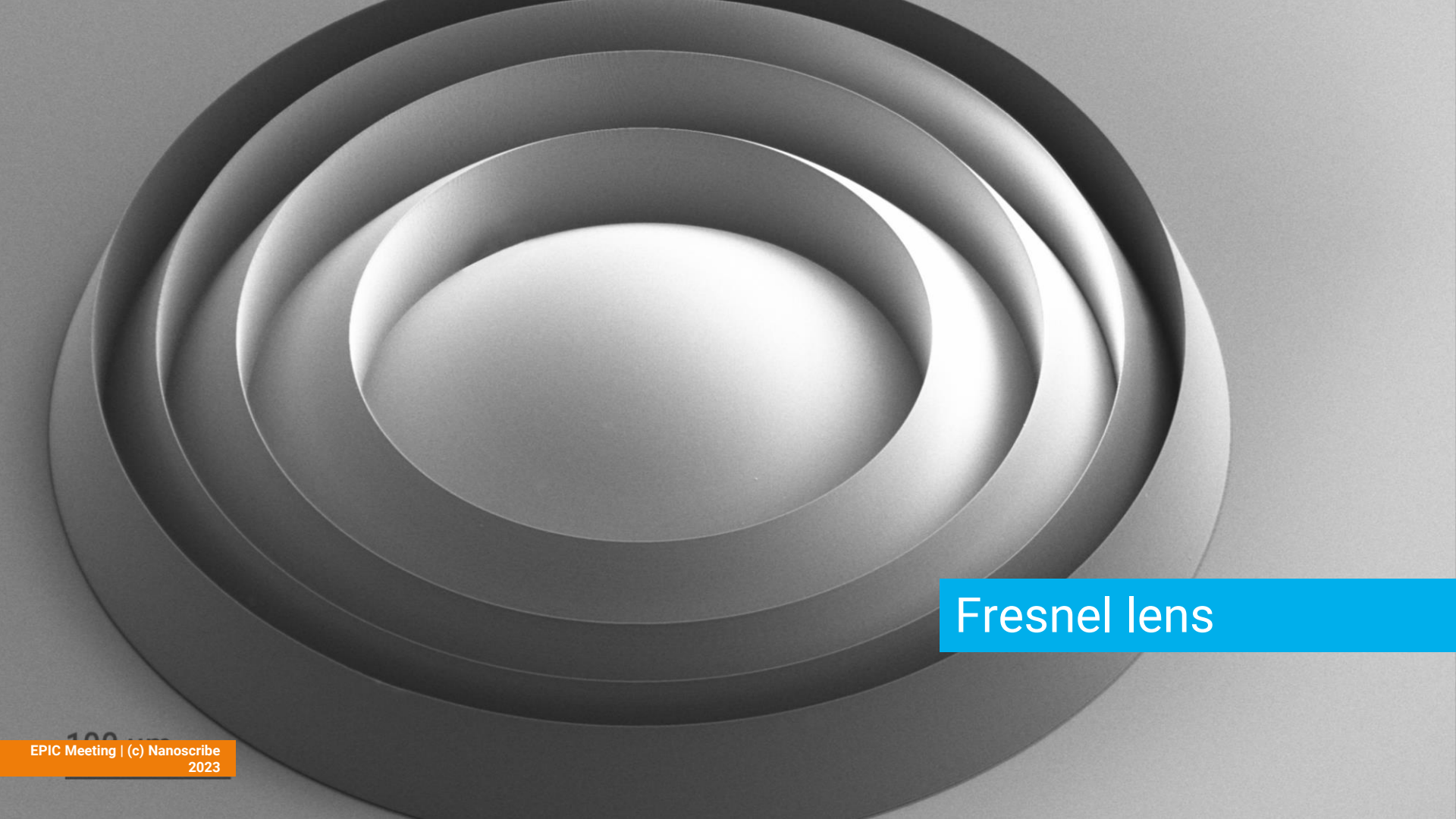
Large prisms

200 µm

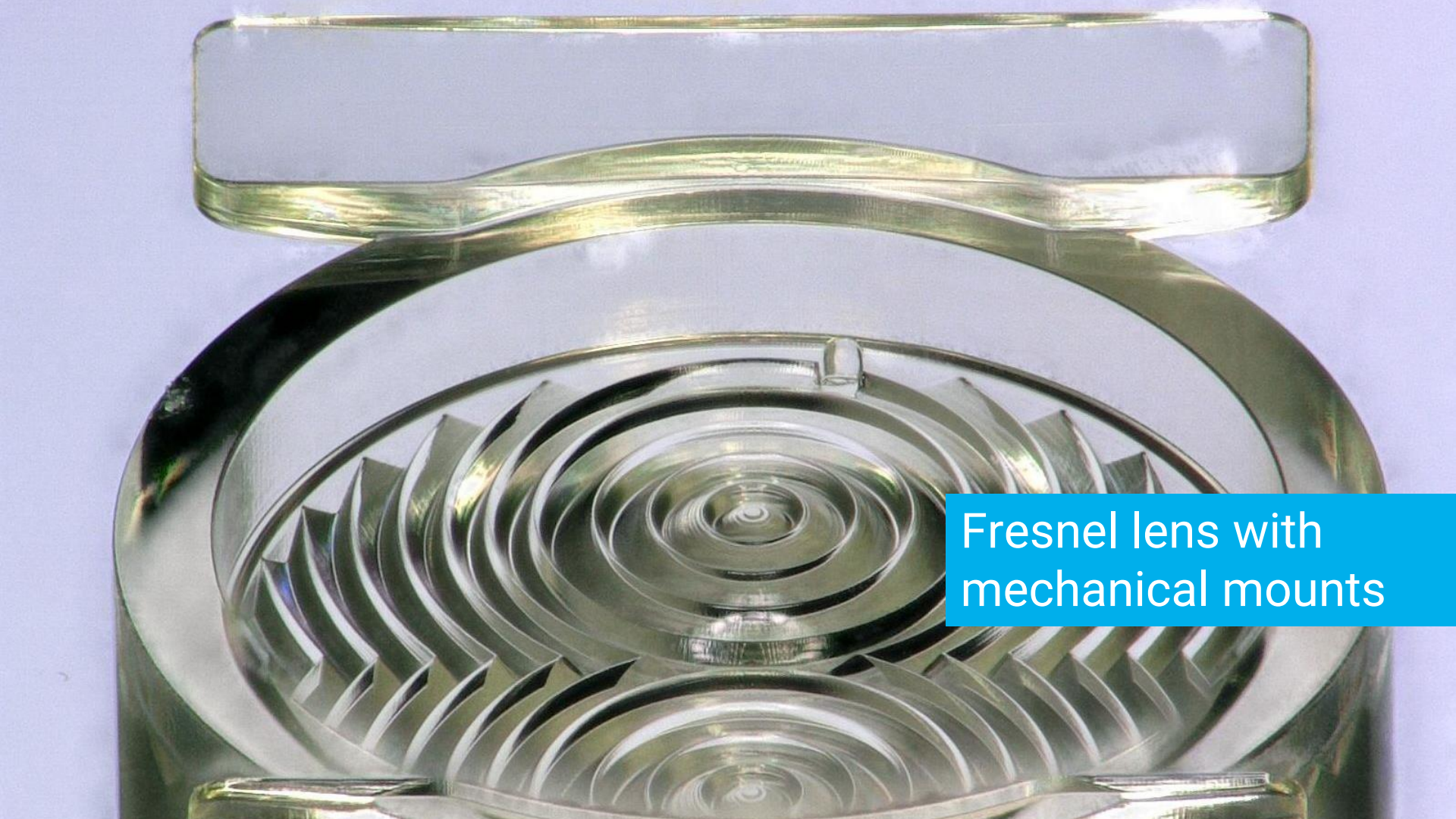

Free form lenses
EPIC Meeting | (c) Nanoscribe 2023
100 µm

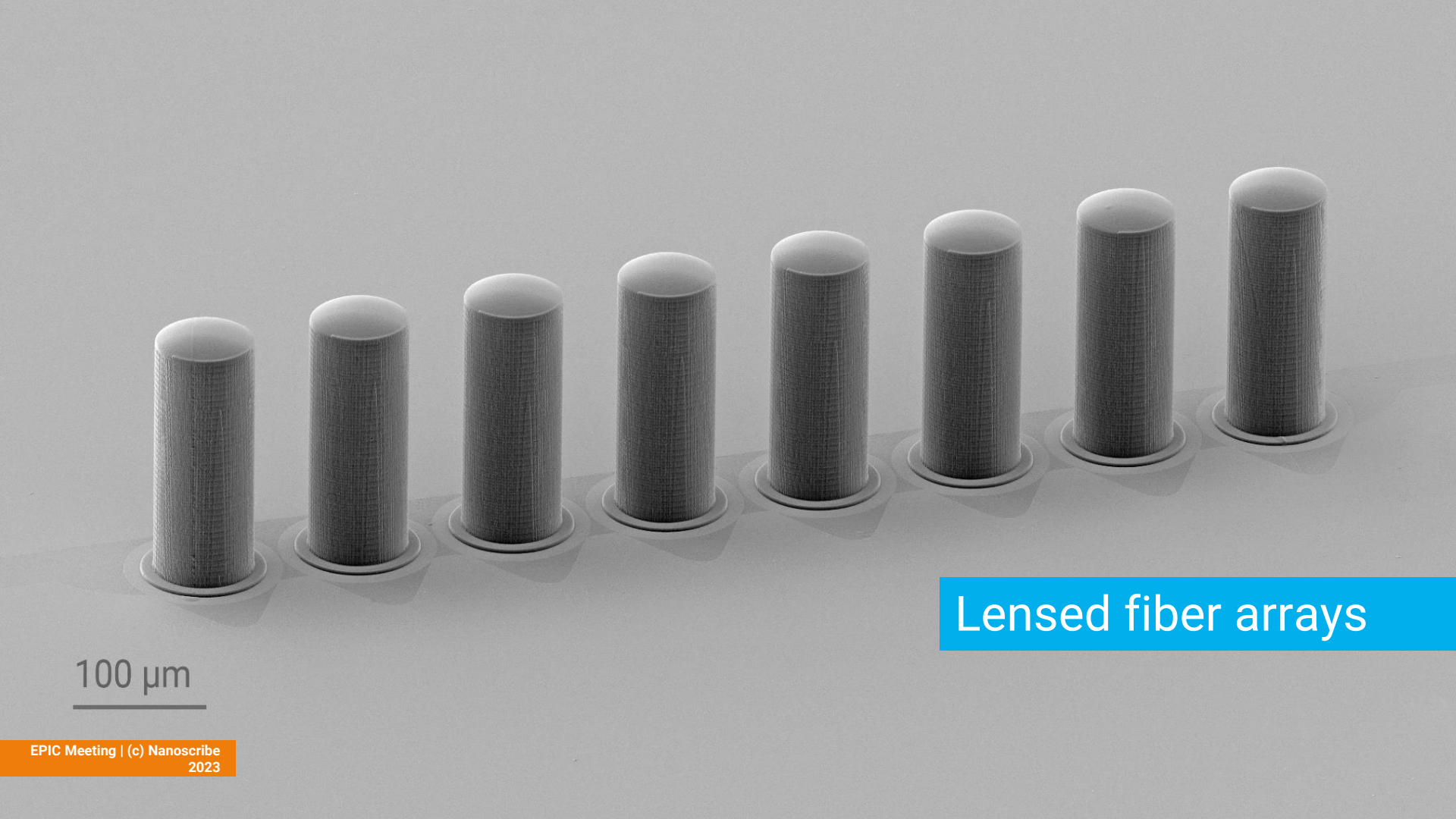


Small prism

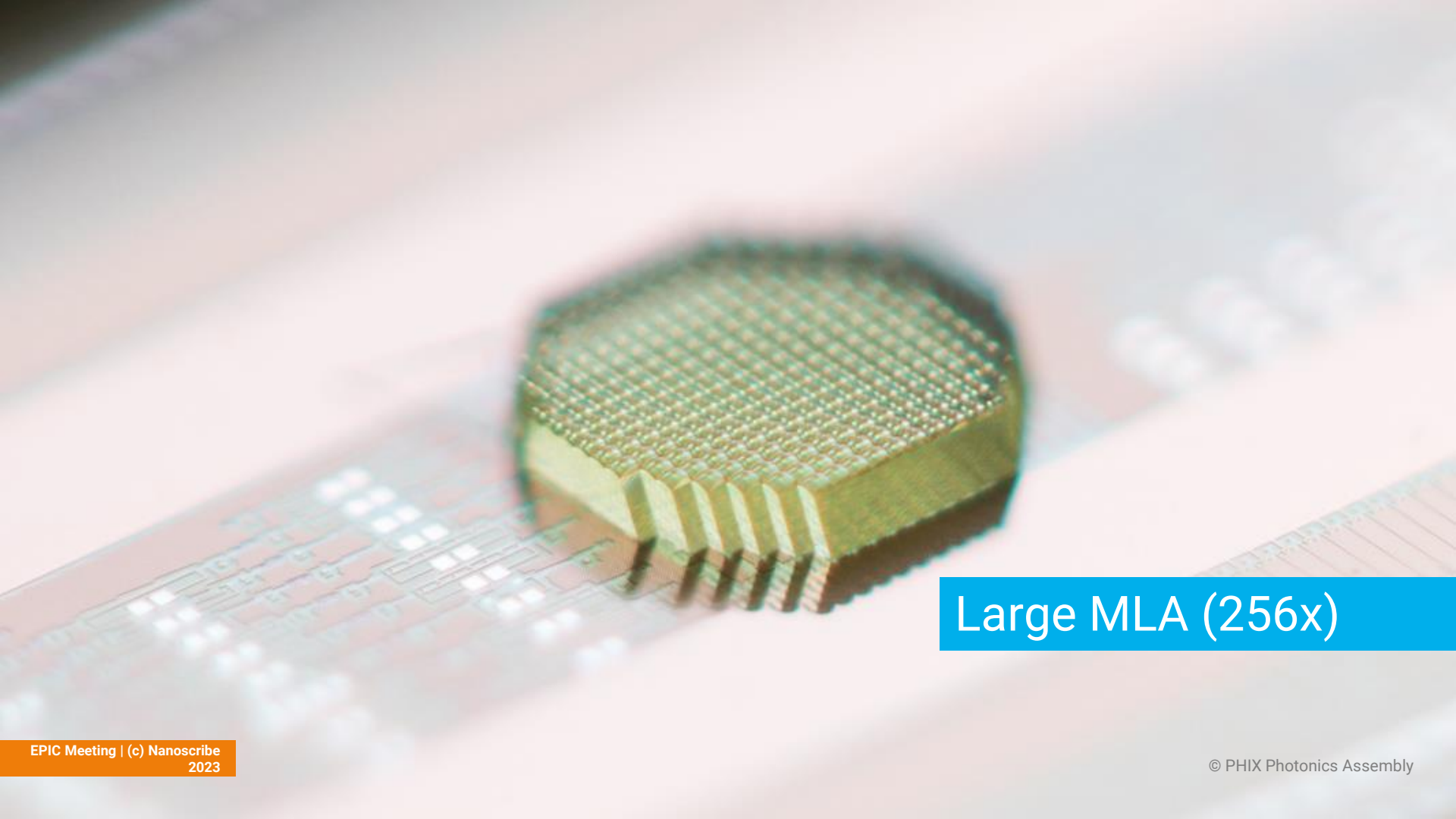


Fresnel lens

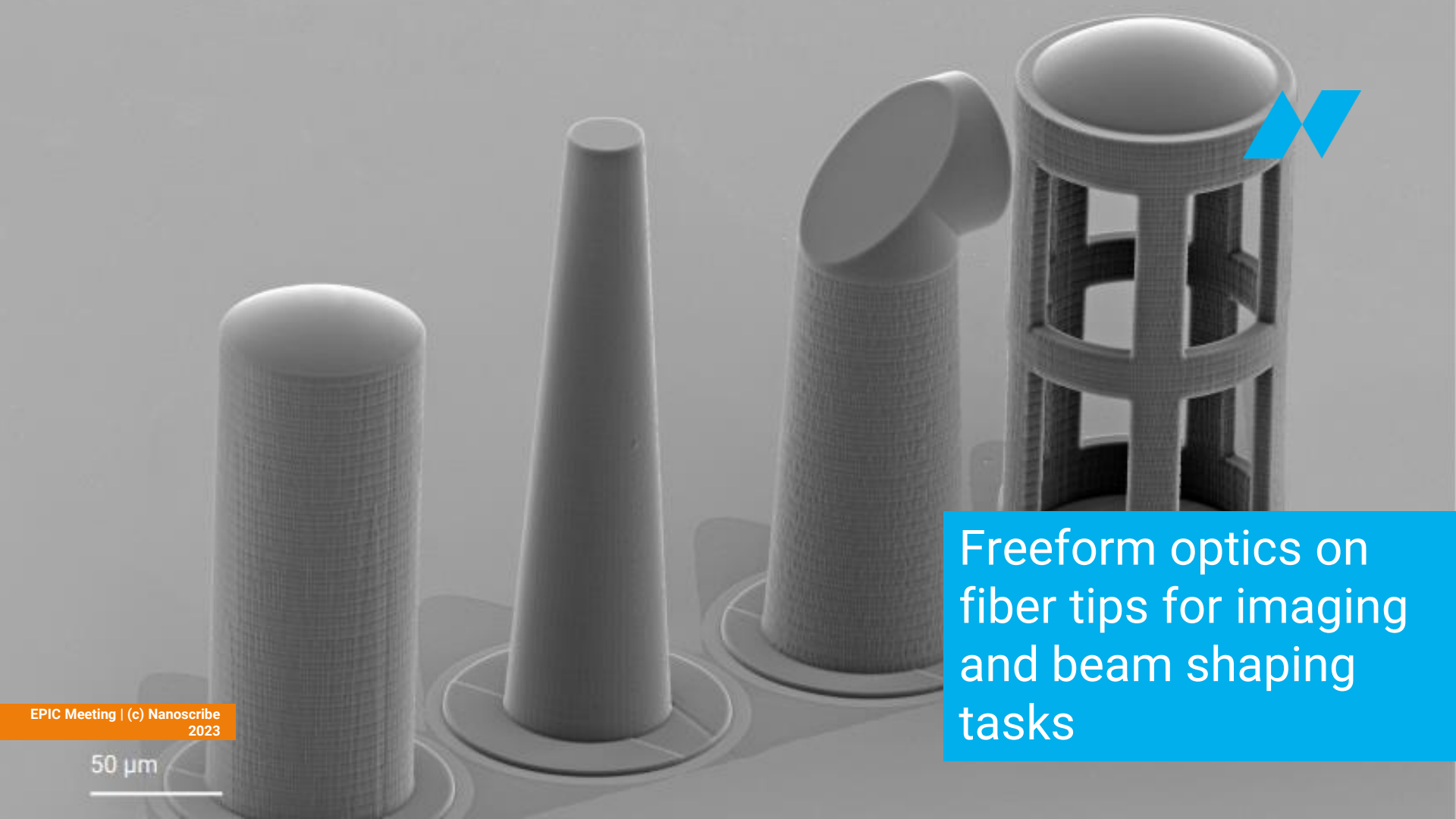

Fresnel lens with
mechanical mounts



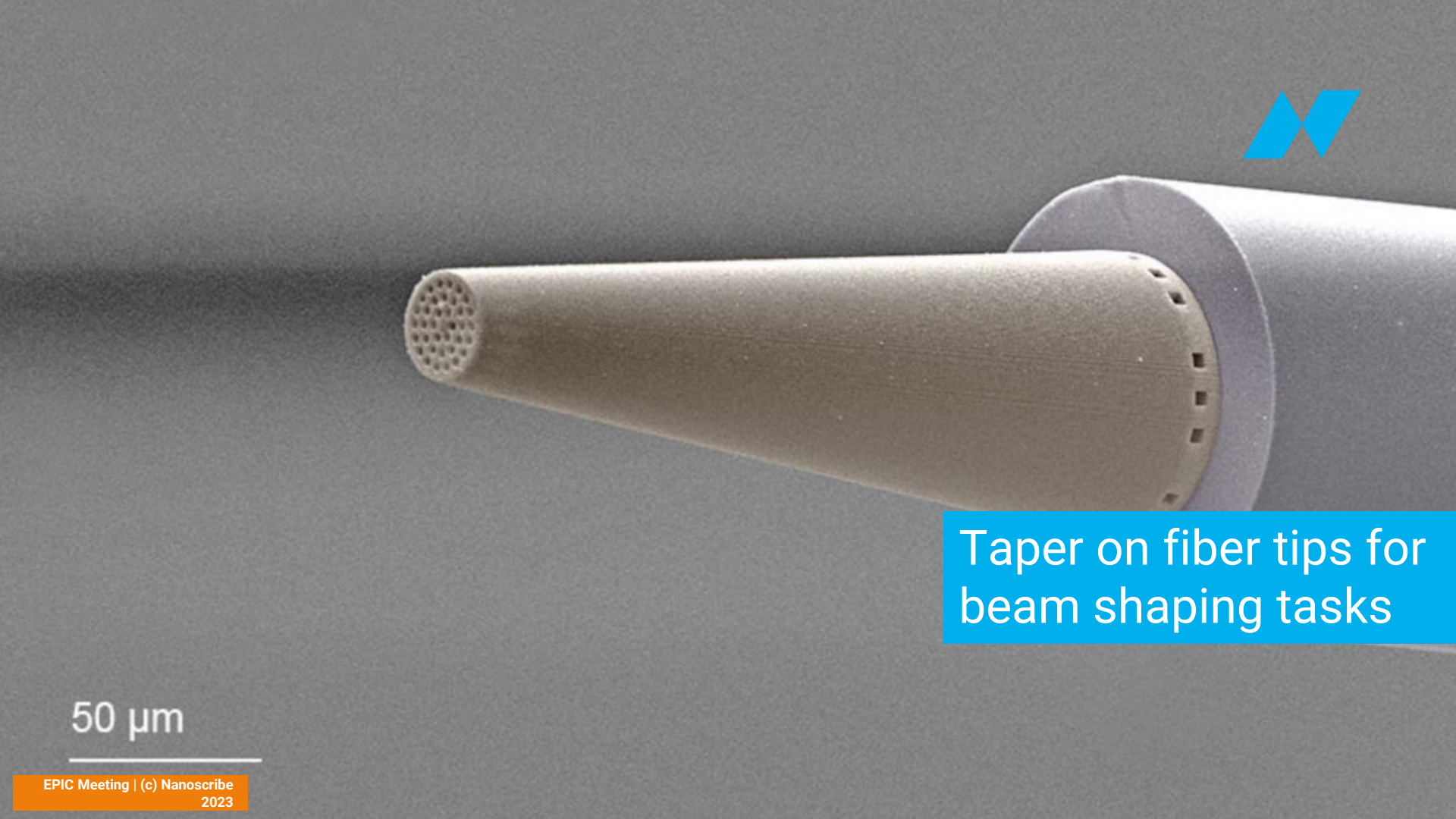
Lensed fiber arrays



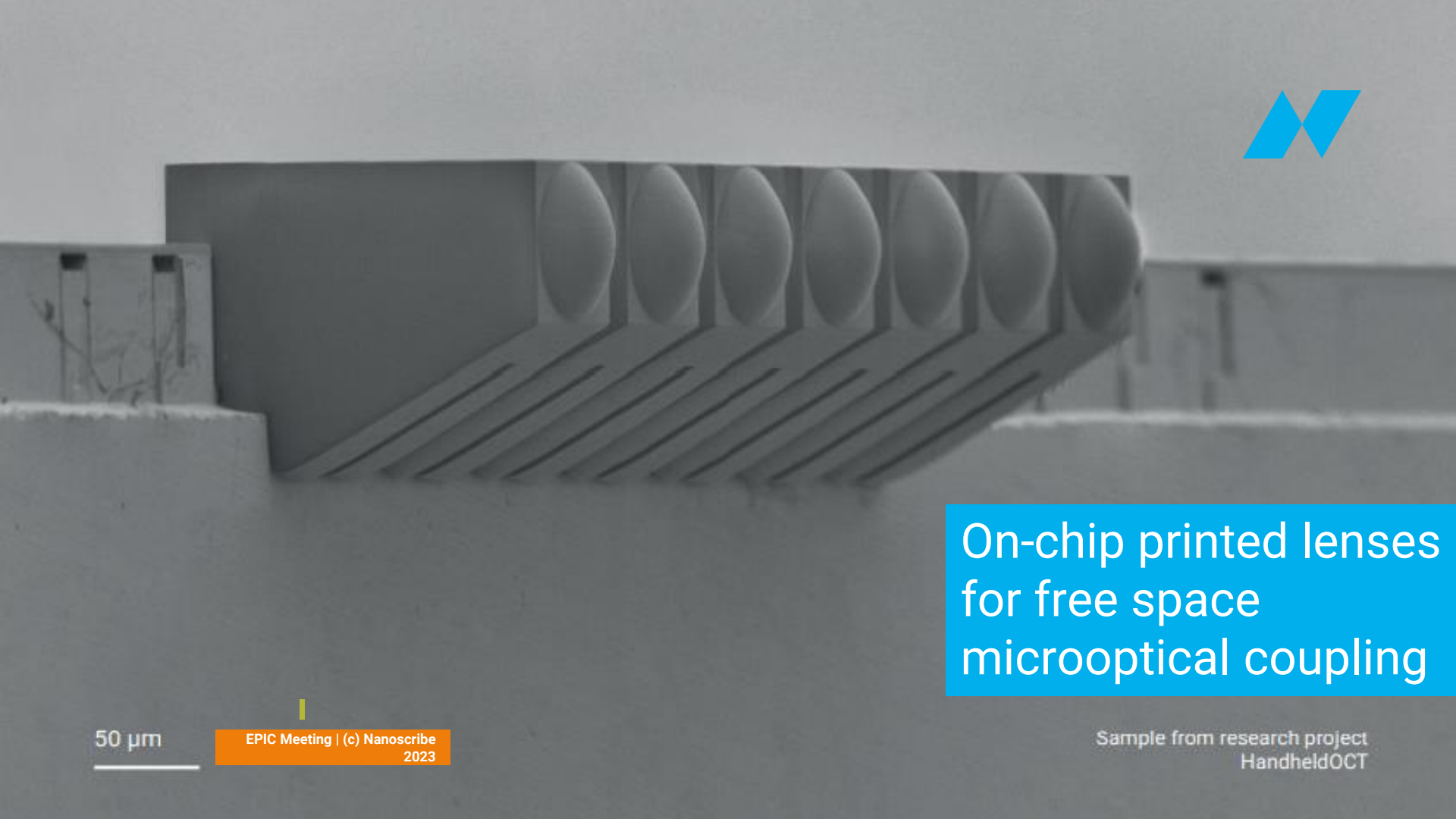
Large MLA (256x)



Freeform optics on fiber tips for imaging and beam shaping tasks



Taper on fiber tips for beam shaping tasks



On-chip printed lenses for free space microoptical coupling

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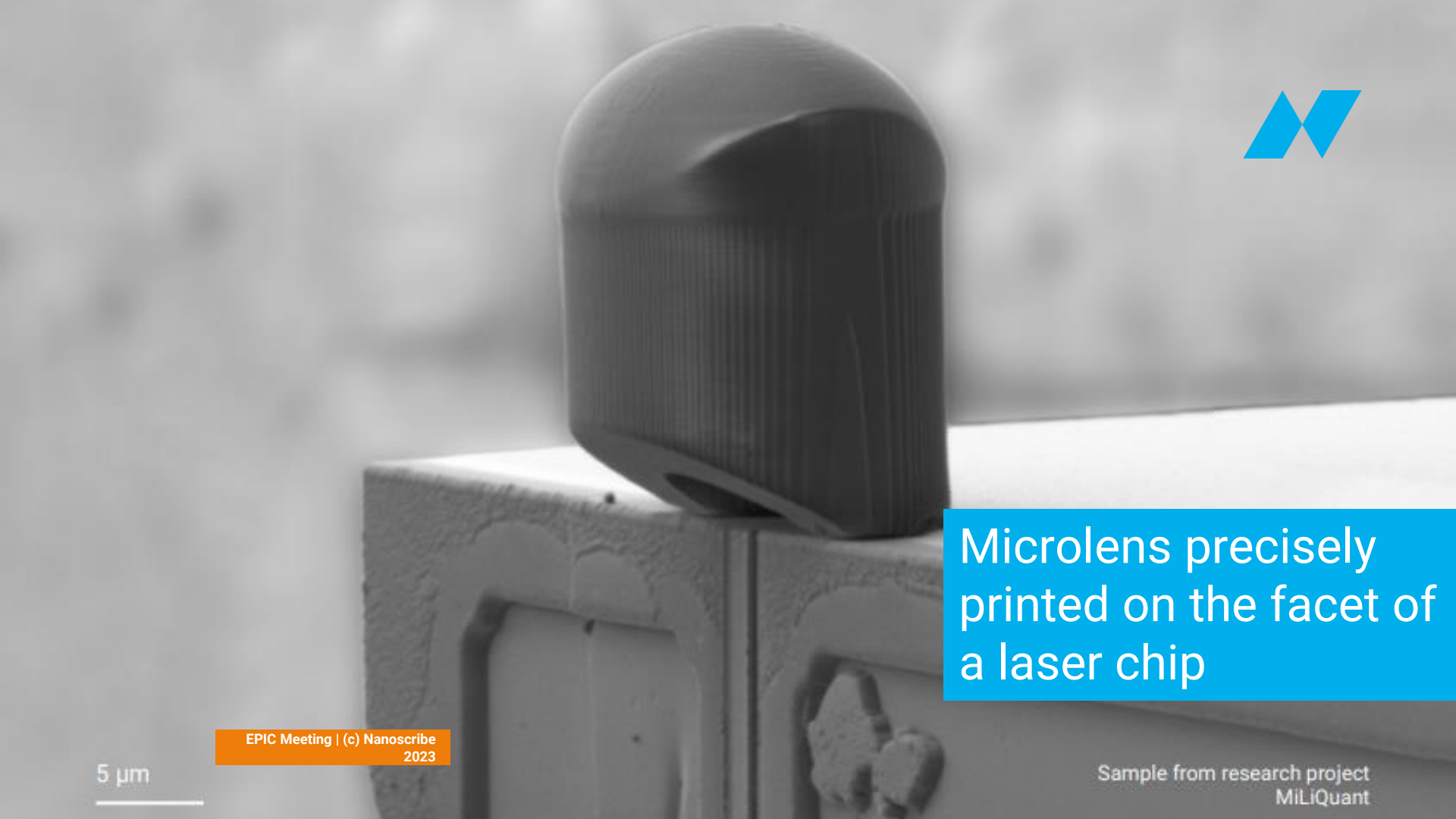
Sample from research project HandheldOCT


Microlens precisely printed on the facet of a laser chip
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5 µm
Sample from research project MiLiQuant


Hybrid lens 3D-printed on an optical fiber with diffractive elements
100 µm
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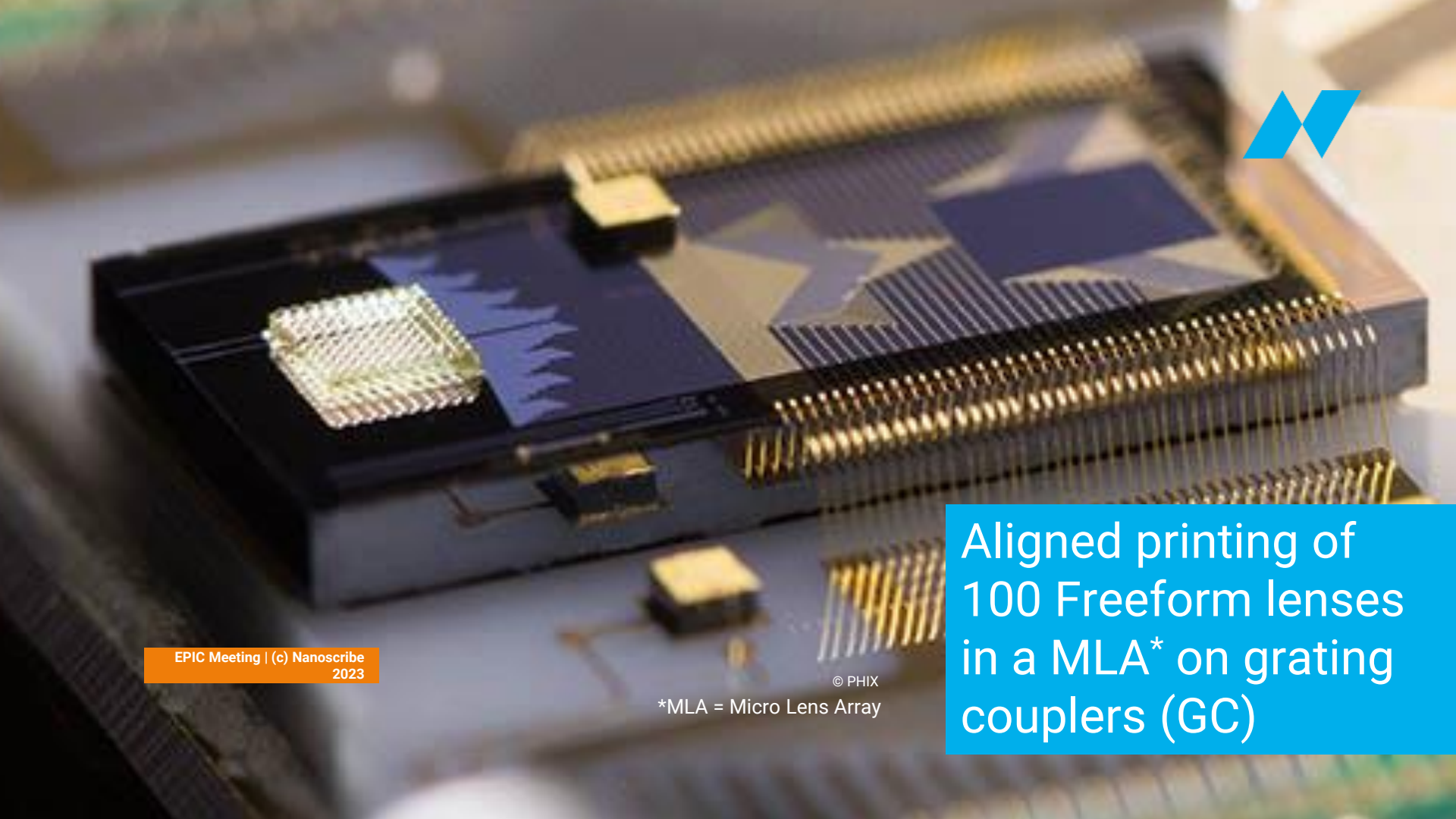
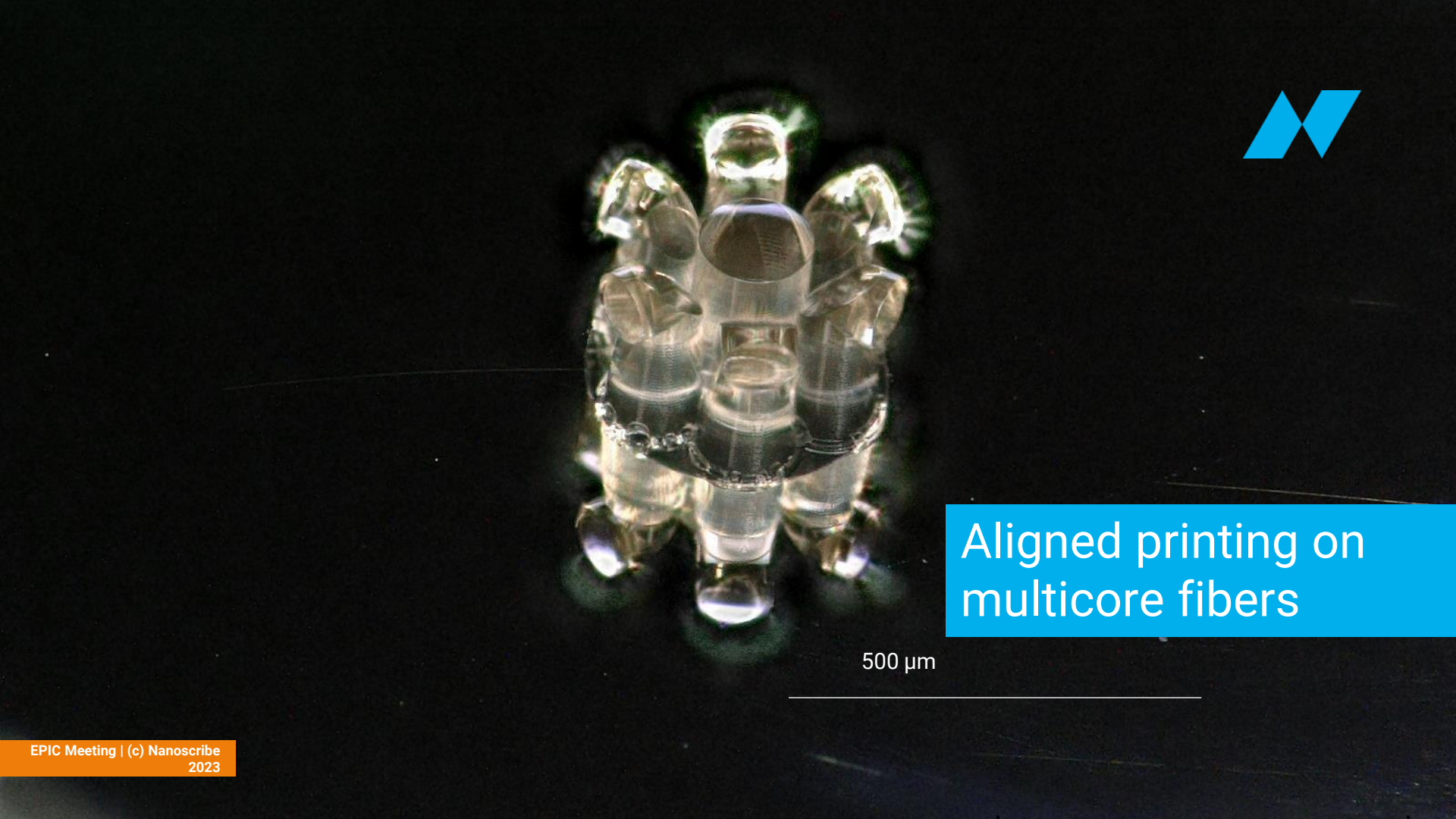
Sample from research project PRINTOPTICS

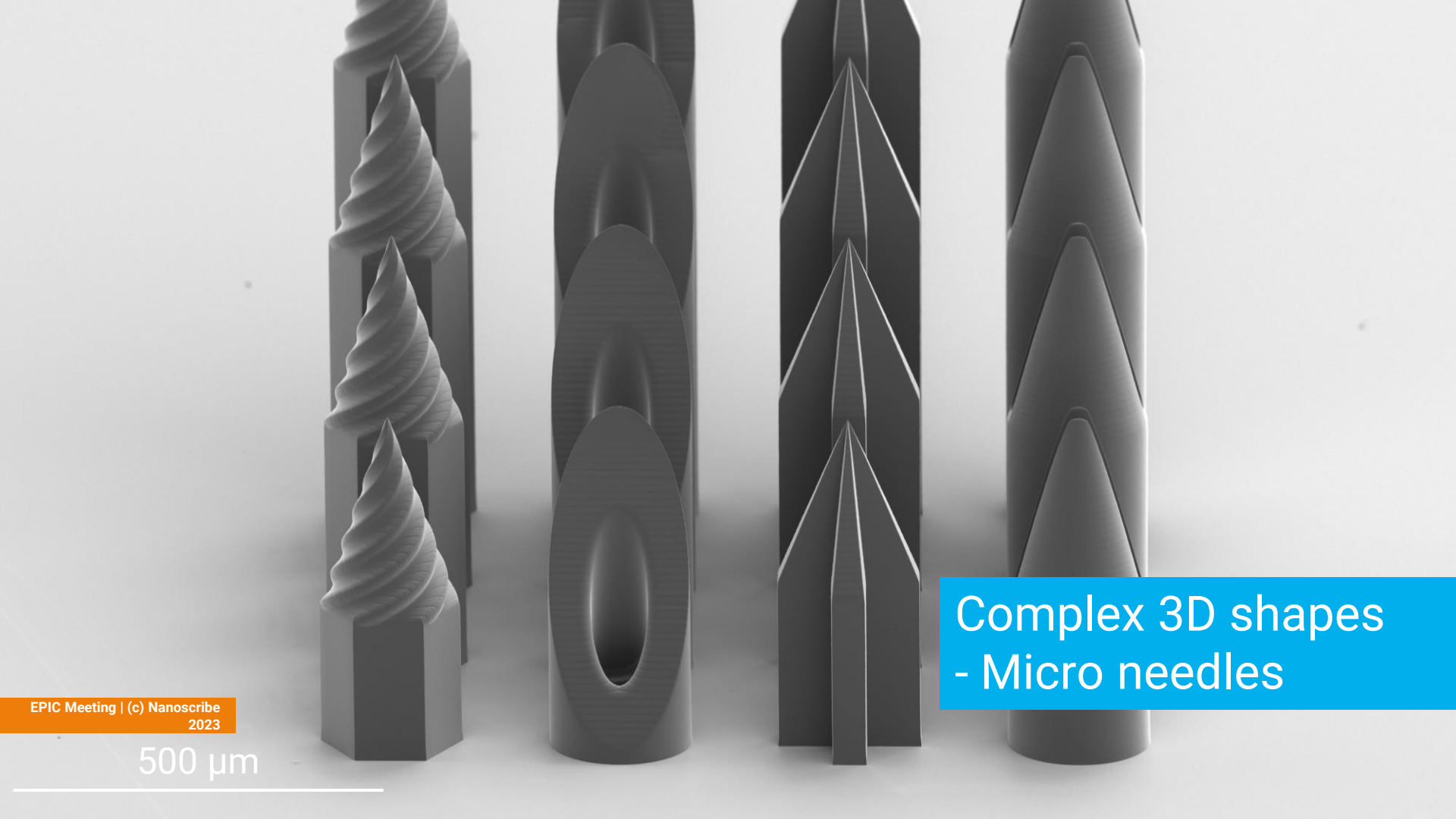


Aligned printing of 100 Freeform lenses in a MLA* on grating couplers (GC)

*MLA = Micro Lens Array



Aligned printing on multicore fibers


Complex 3D shapes
- Micro needles
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500 µm

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Thank you for your attention!

Jörg Smolenski

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