



Enabling HighPrecision Optics in Consumer Devices with 3D Microfabrication

James Schildknecht, Head of Sales

December 3rd, 2024

Micro Optics Summit

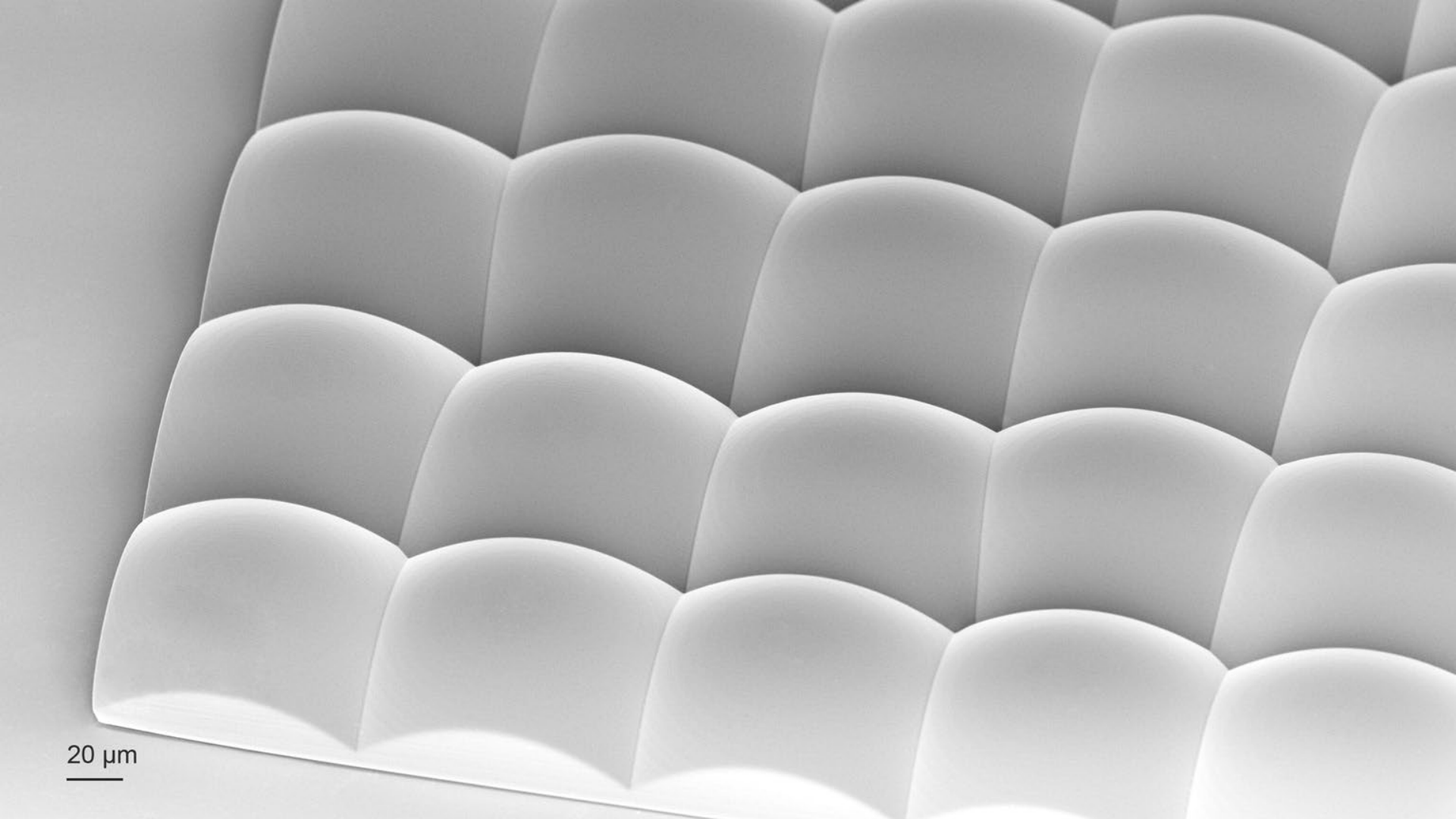
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15
YEARS Think big.
Print nano.

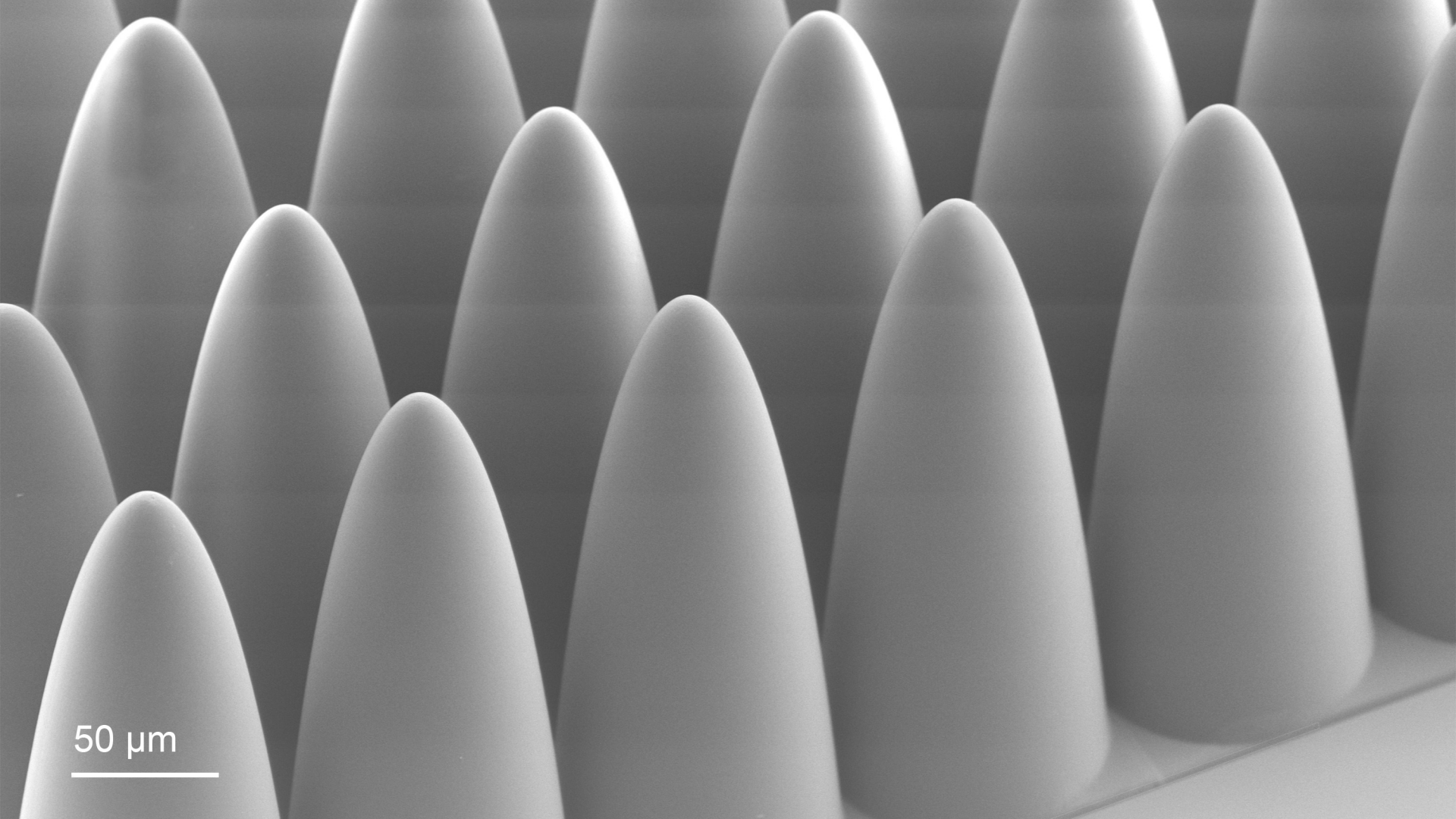


Company Facts & Figures

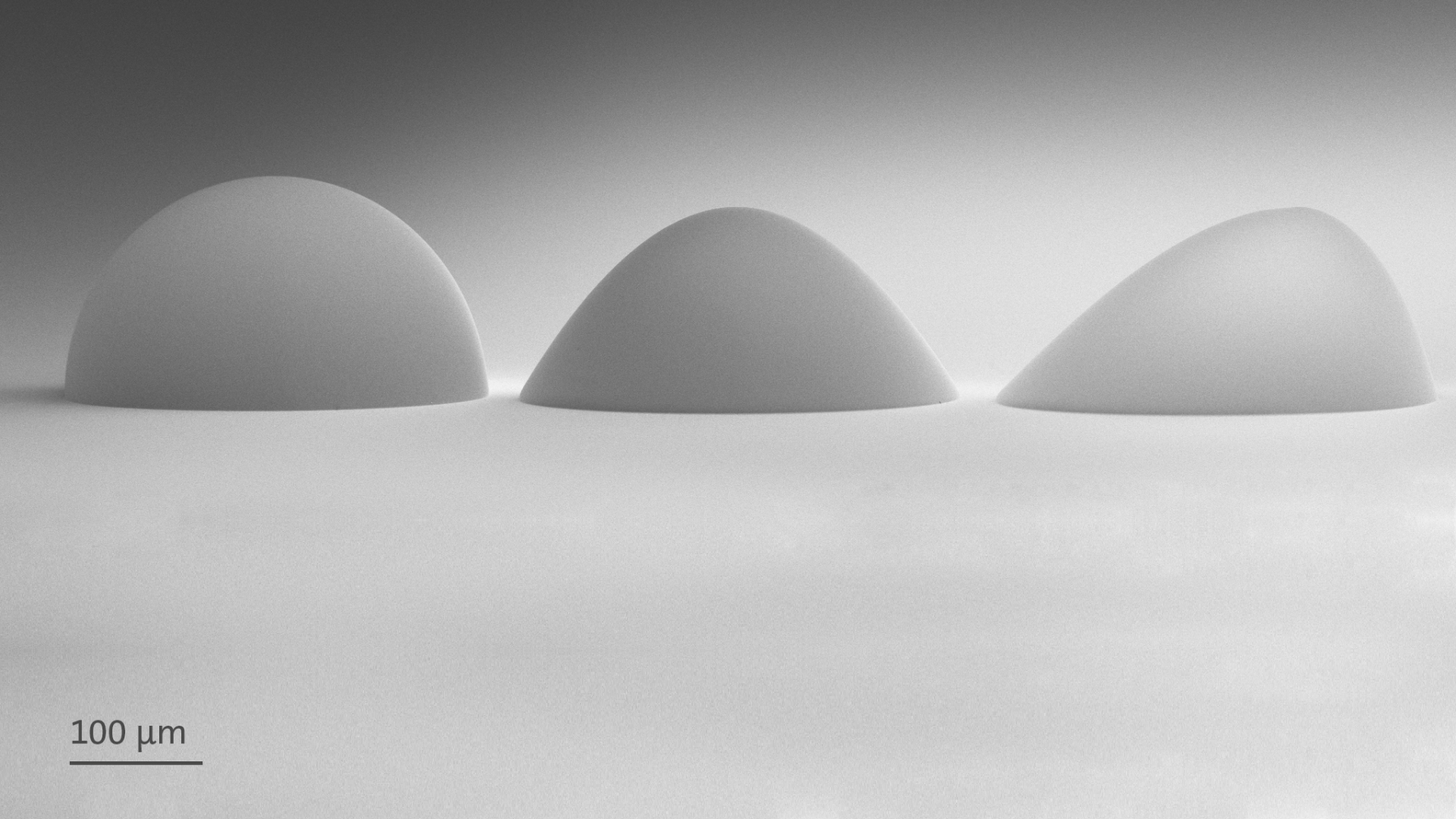
- ▶ 100+ employees
- ▶ 35% R&D intensity
- ▶ 4,000+ users
- ▶ 2,000+ publications
- ▶ HQ in Karlsruhe, Germany with >4,200 m² space
- ▶ Subsidiary Boston, US
- ▶ Subsidiary Shanghai, CN
- ▶ 17+ years of success



20 μm



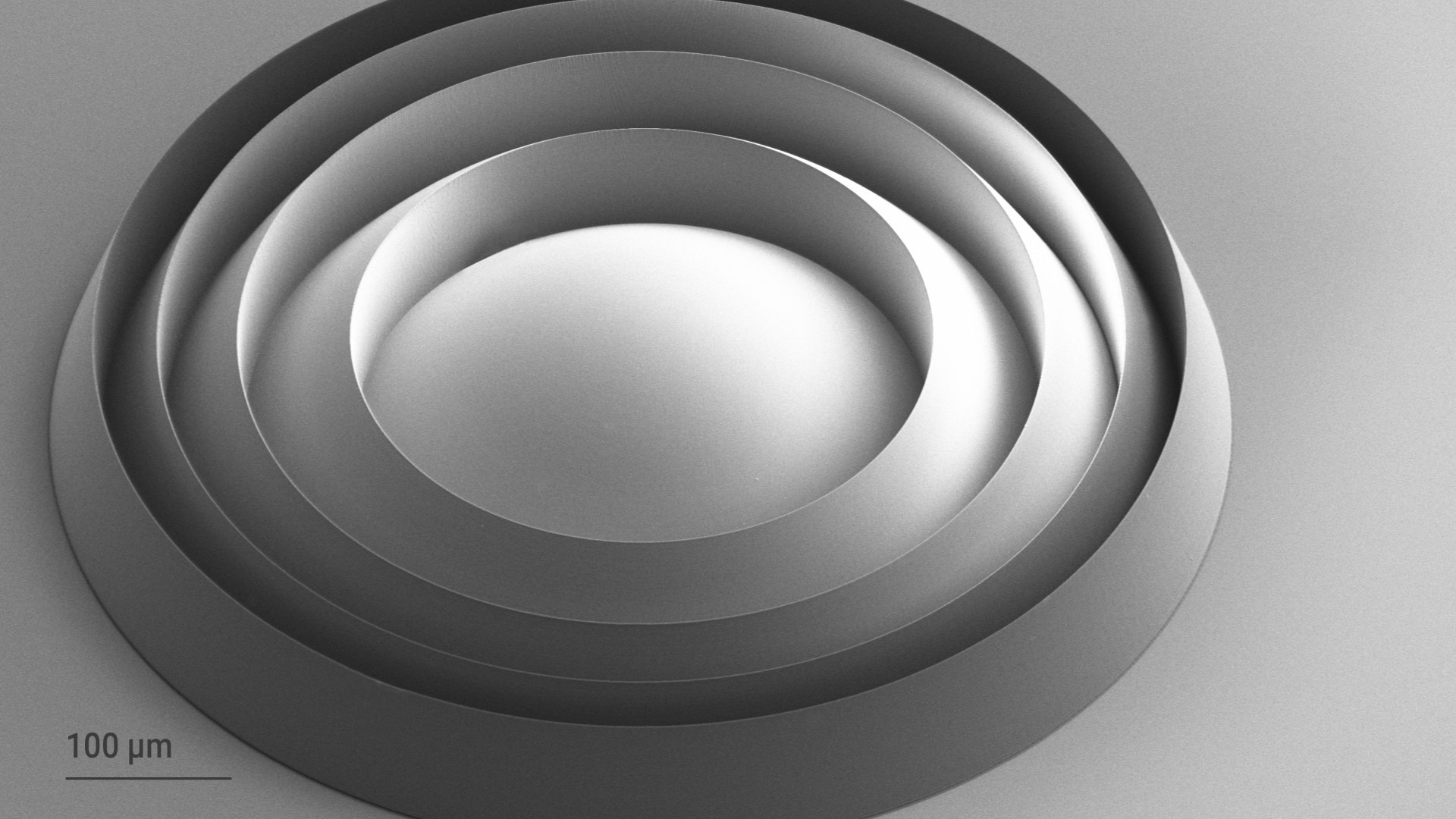
50 μm



100 μm

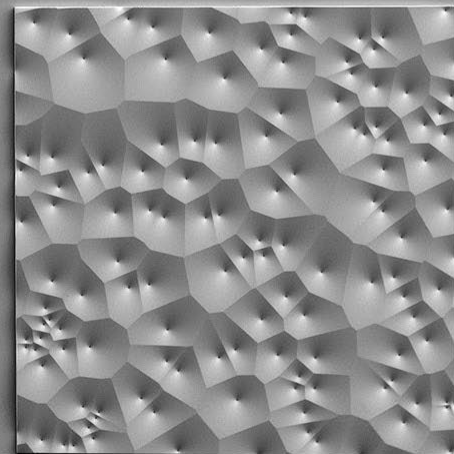
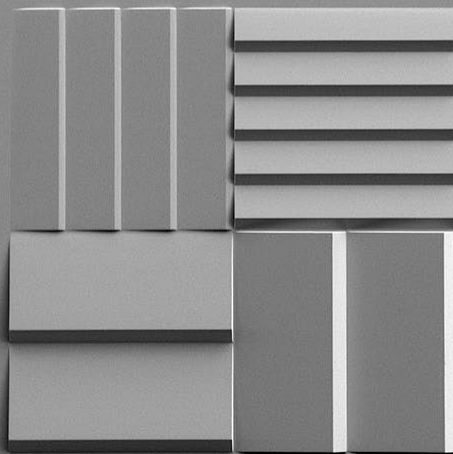
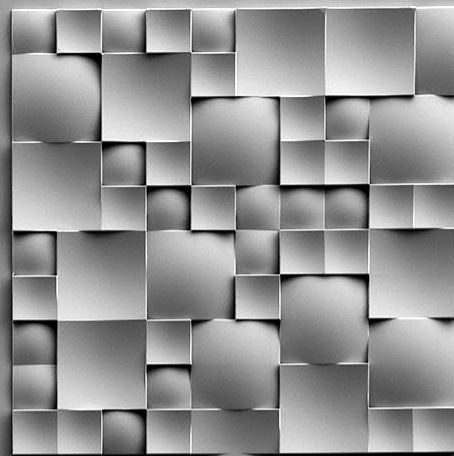
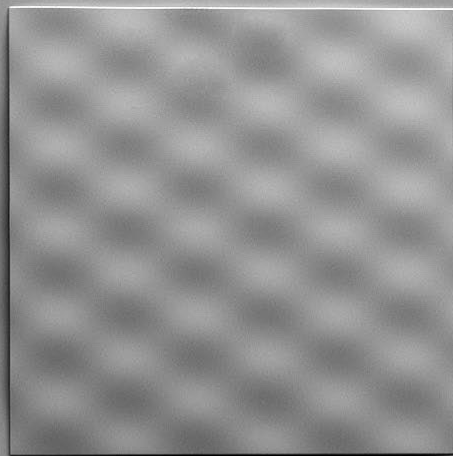


100 μm



100 μm

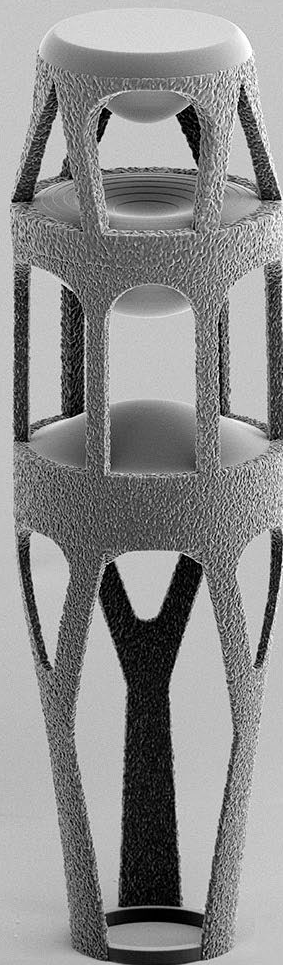




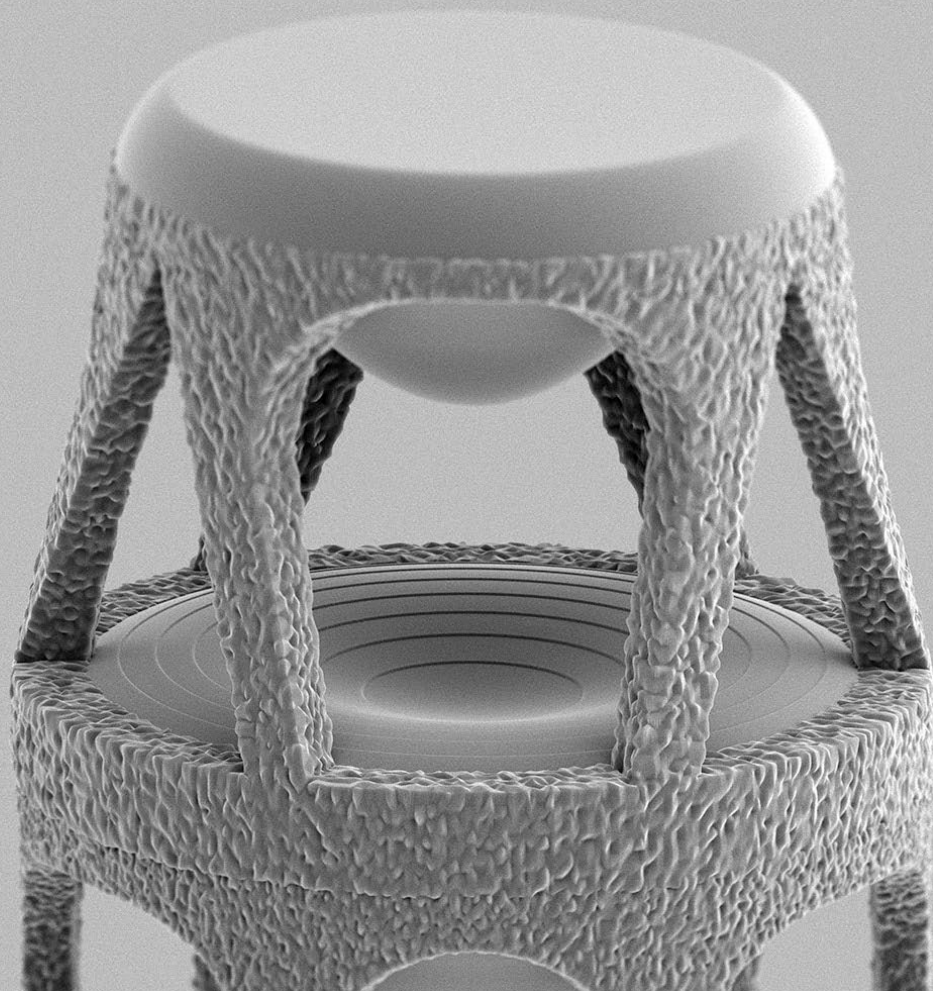
500 μm



200 μm

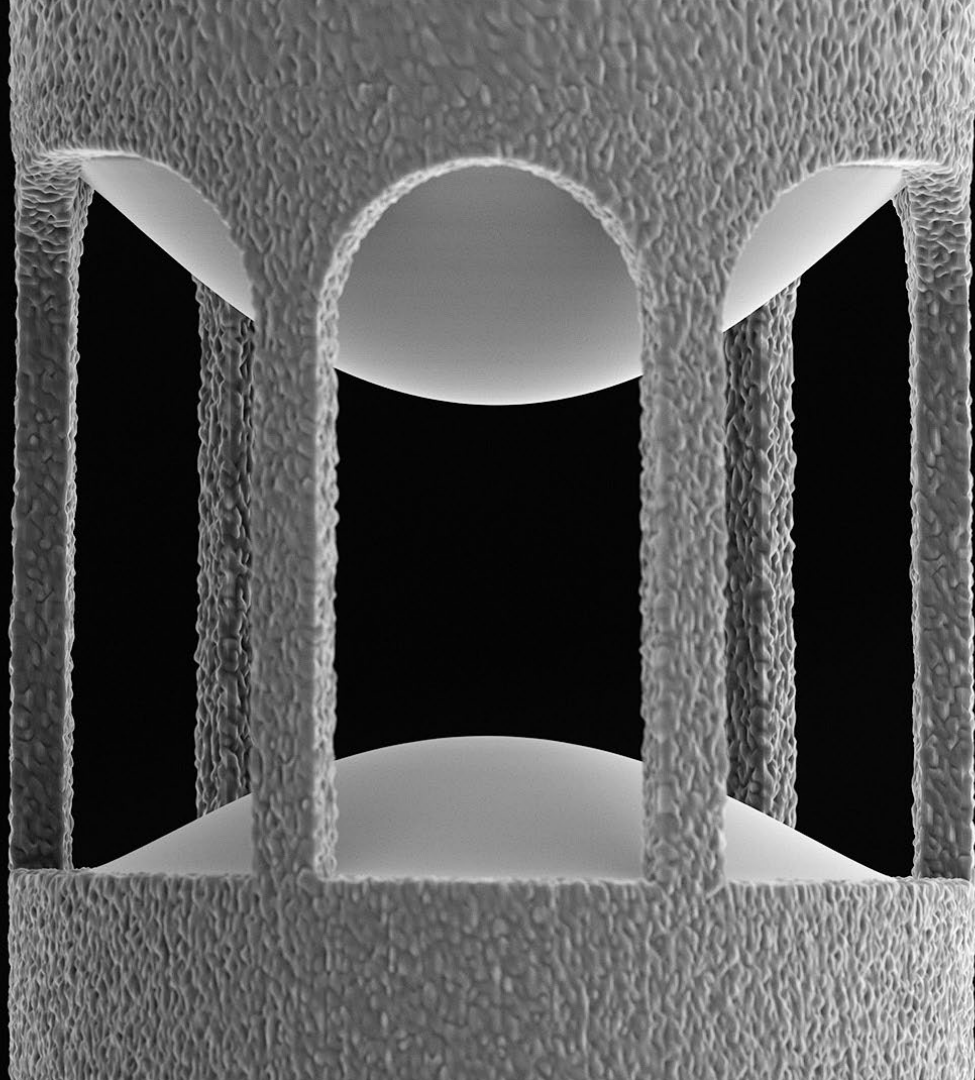


Optical design by Printoptix



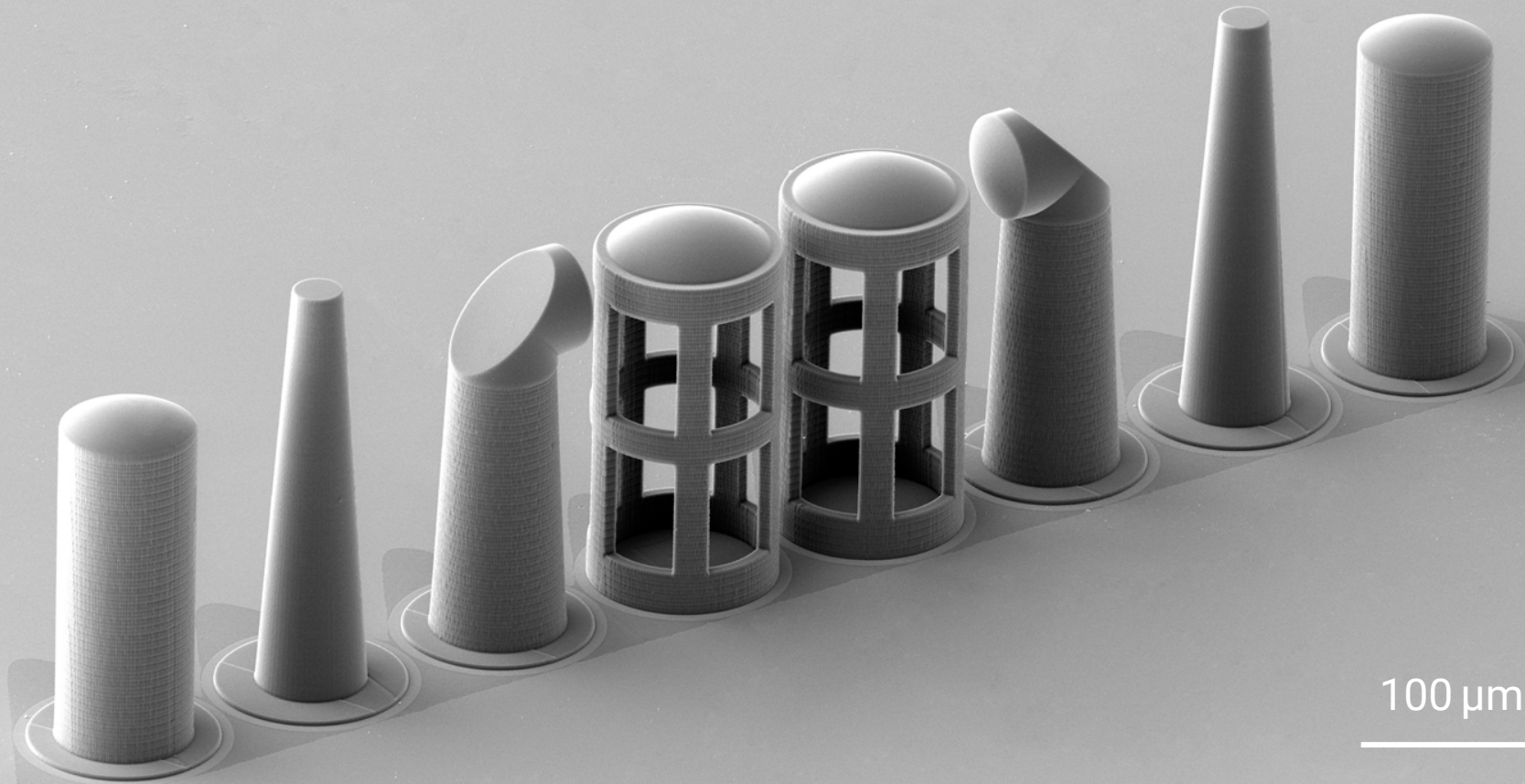
50 μm

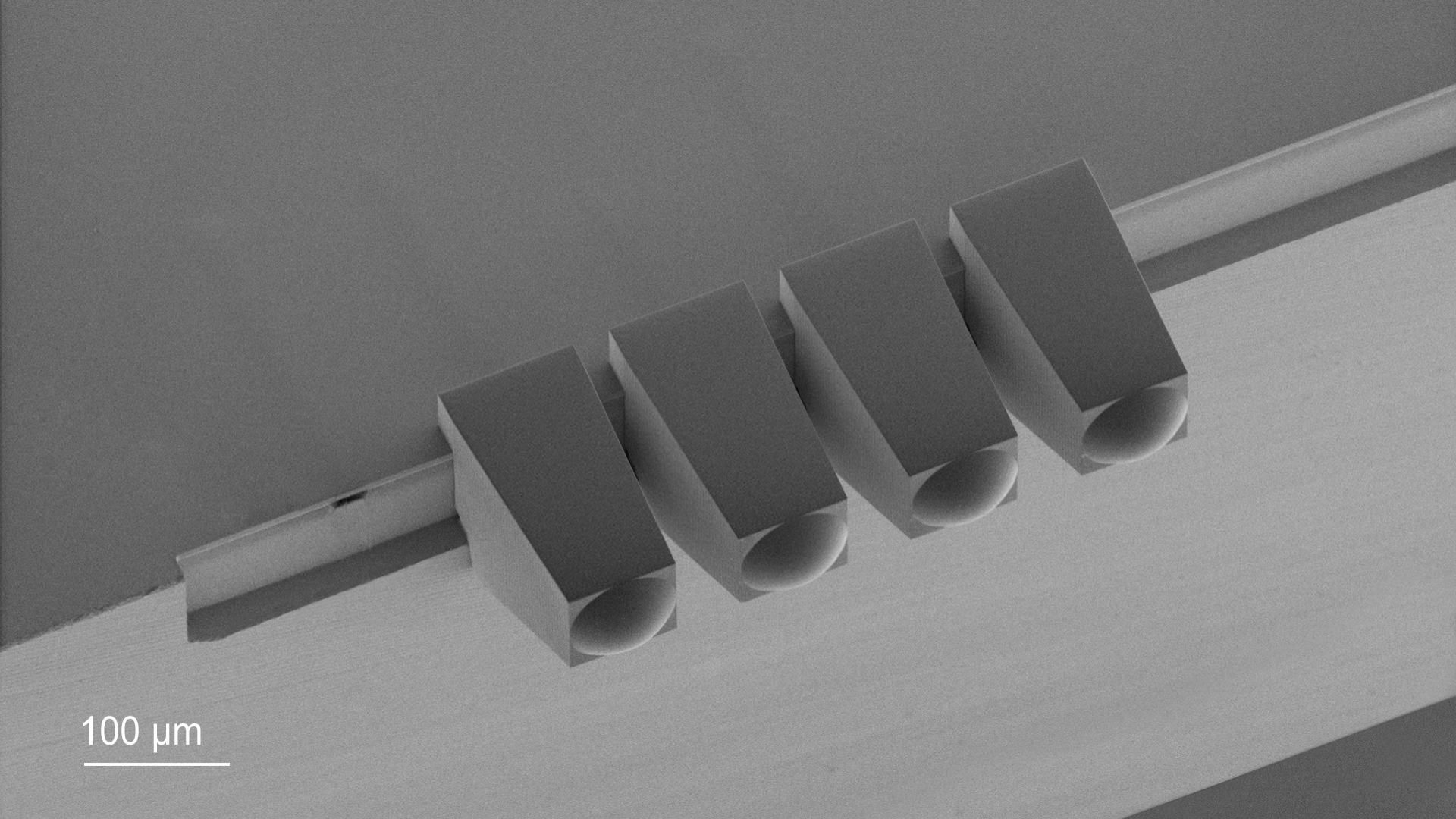
Optical design by Printoptix



50 μm

Optical design by Printoptix



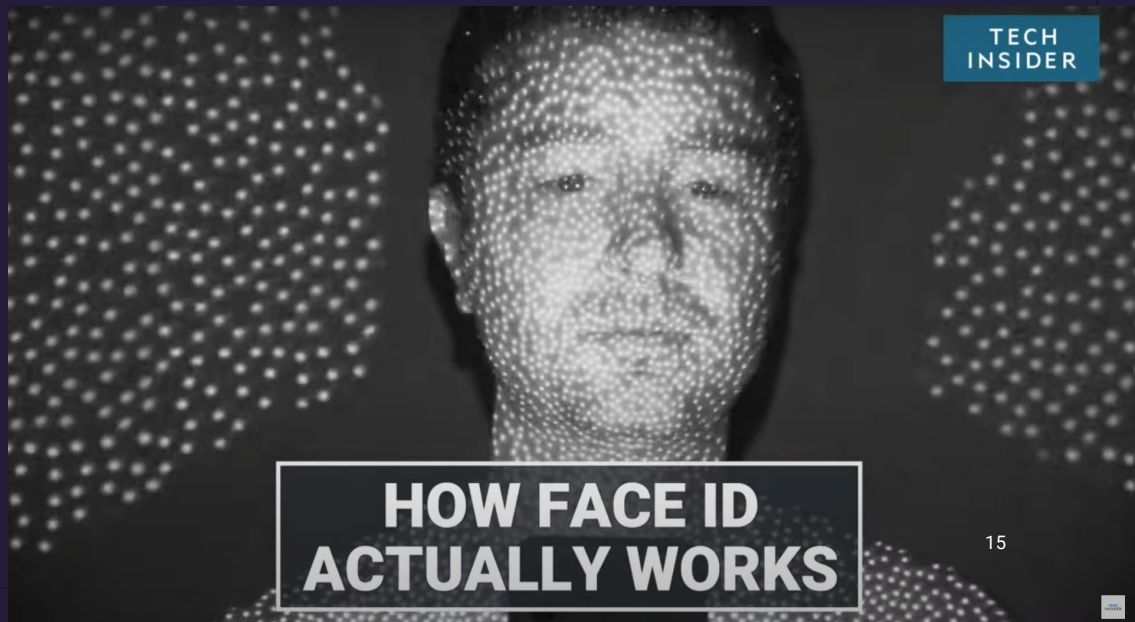


100 μm

Grid Projection



Laser spot grid projection has important applications for 3D depth sensing, lidar, and so on.



TECH
INSIDER

**HOW FACE ID
ACTUALLY WORKS**

Diffractive optical elements

- ▶ Digital design workflow for diffractive optical elements
- ▶ New design paradigm: Continuous designs without steps or squared pixels

Design by

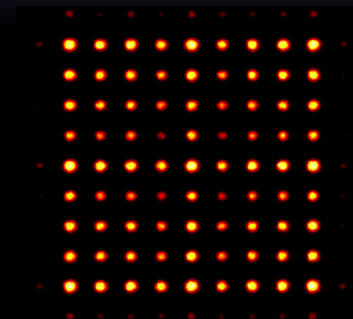
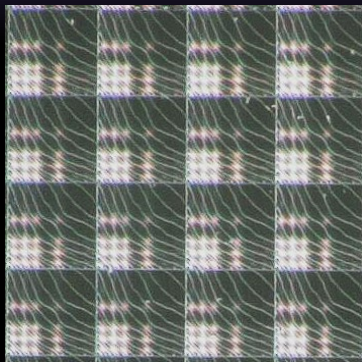


DOE for 9x9 dot grid projection

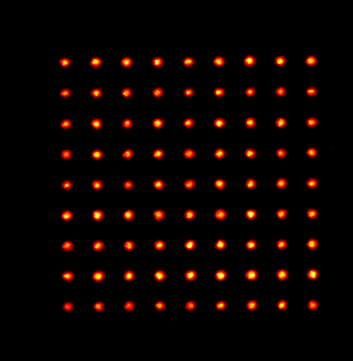
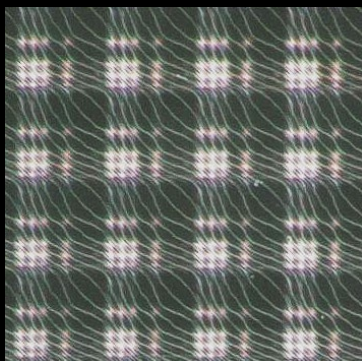


100 μ m

No tilt
compensation



Tilt
compensation





Prototyping and Mastering of a Beam Homogenizer

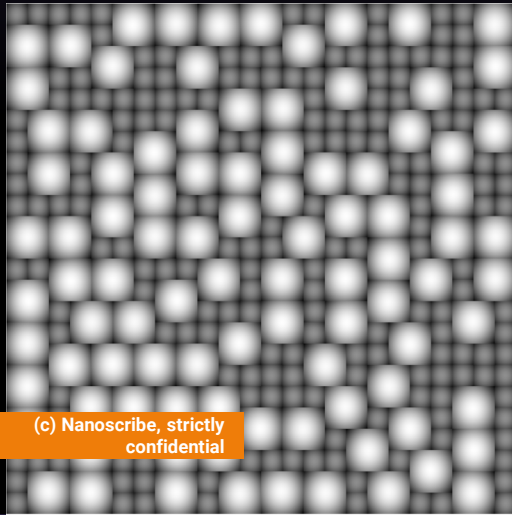
Design freedom outperforms current standards

Refractive beam diffuser based on random MLA



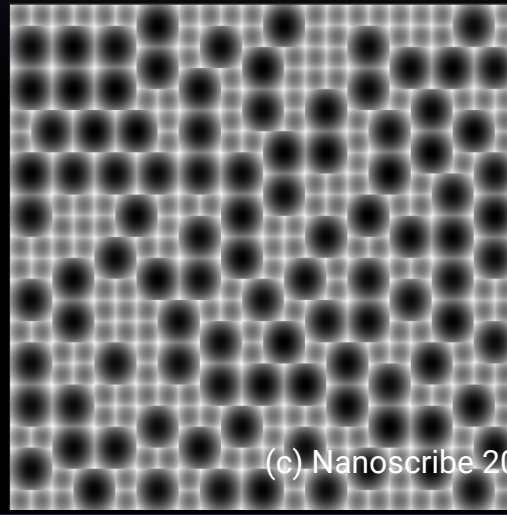
- Design files exported to grayscale 16-bit PNG images with a pixel size of 200nm
- Base unit 1.8 mm wide was repeated in a 3x3 array to create a 5.4 mm diffuser.

Convex (standard)

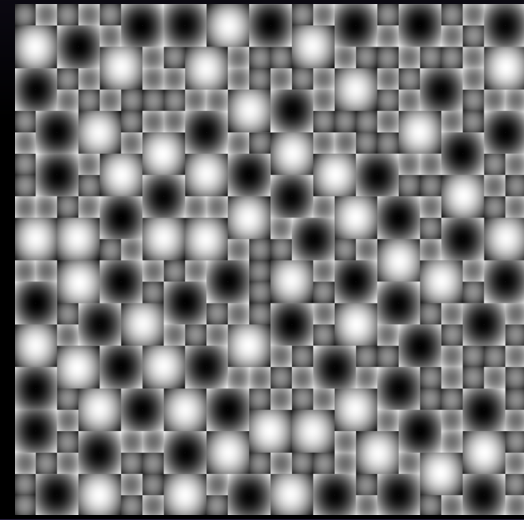


Concave

1.8 mm (base unit)



Mixed



56 μm

Height

0 μm

(c) Nanoscribe, strictly
confidential

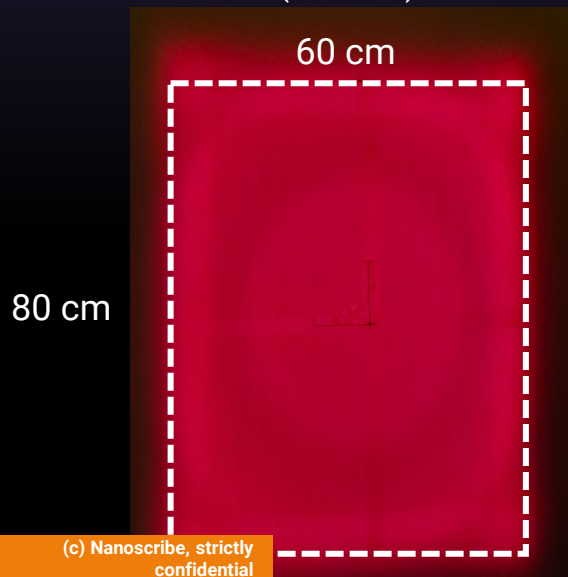
(c) Nanoscribe 2024

Refractive beam diffuser based on random MLA

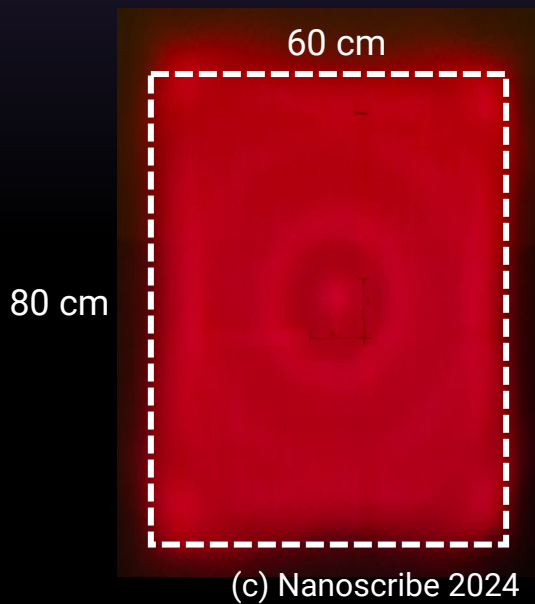


- Experimental results

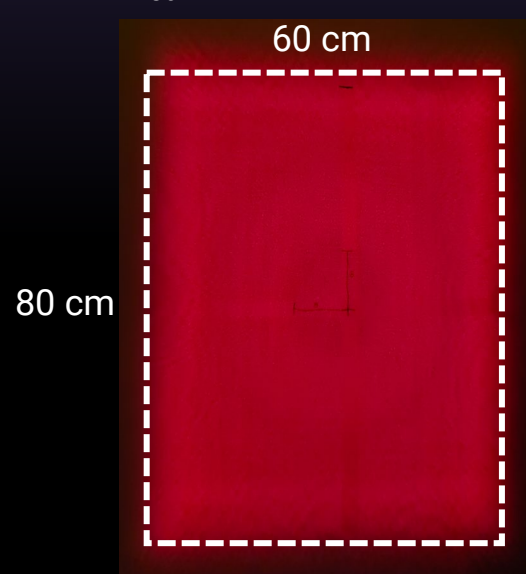
Convex (standard)



Concave



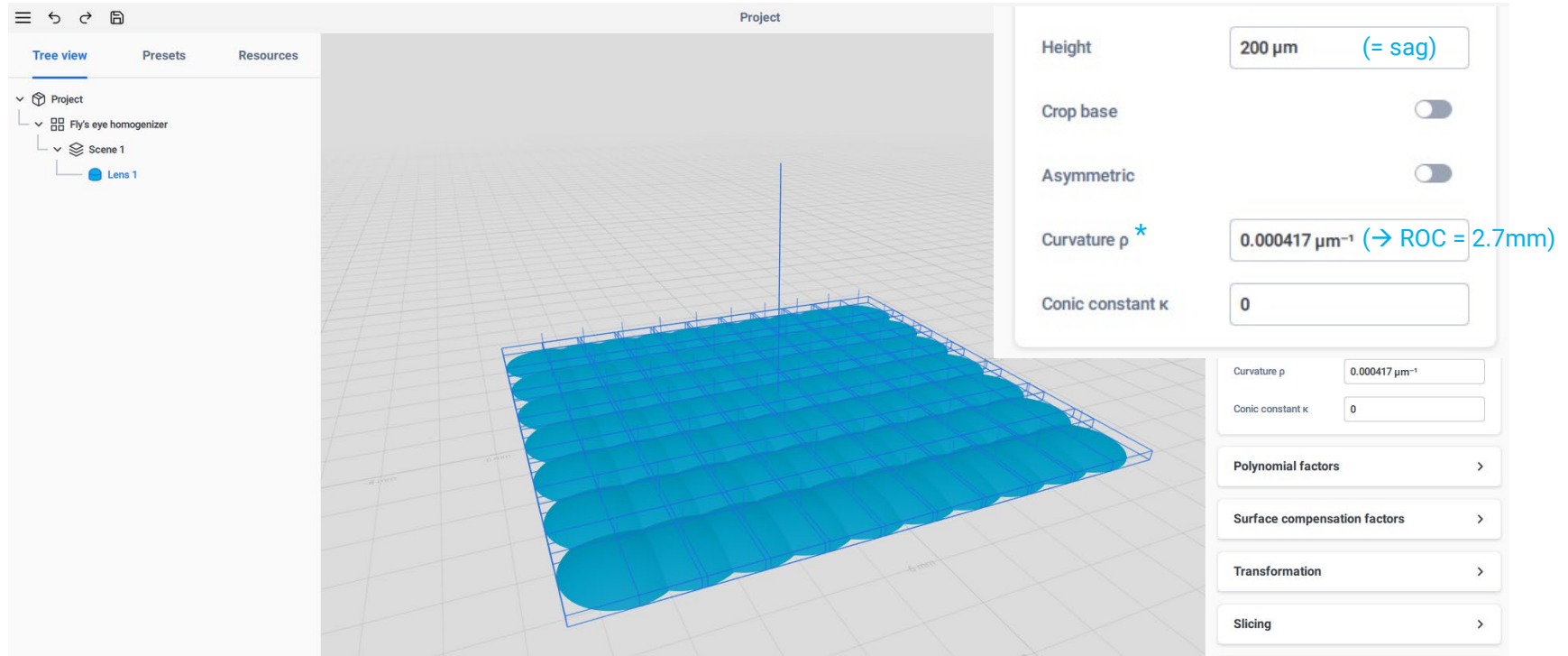
Mixed





Fly's Eye Homogenizer

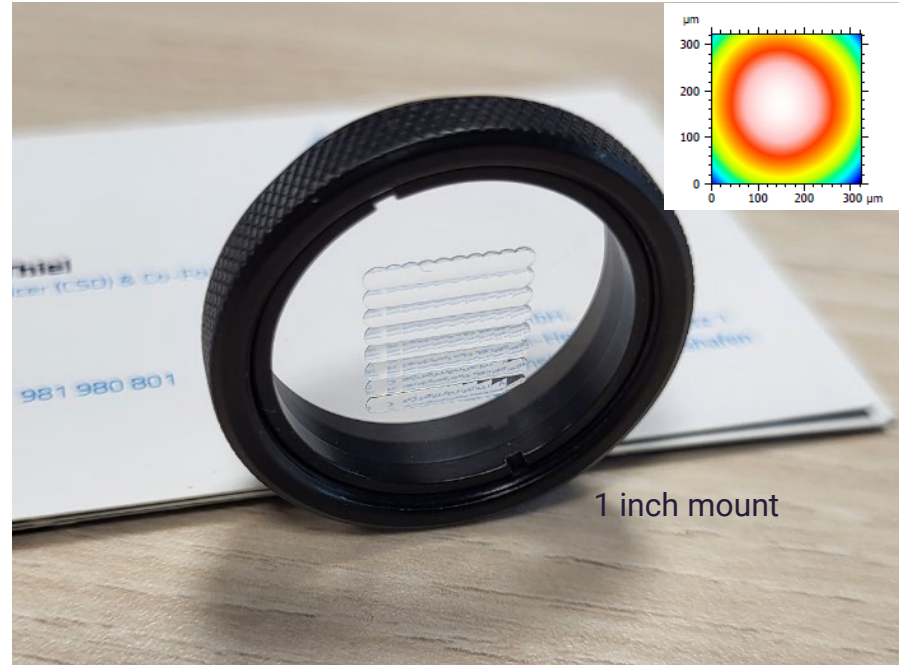
Software: Fly's eye homogenizer



Print: Fly's eye homogenizer



- ▶ Array Size: 10.0 mm x 9.8 mm x 0.37mm
- ▶ Array Type: Rectangular Grid
- ▶ Polymer: Nanoscribe
- ▶ Substrate: borosilicate glass
- ▶ Lenslet Pitch: 1.0 mm x 1.4 mm
- ▶ Lens sag: 0.2 mm
- ▶ Conic constant: 0 (RMS <150nm)
- ▶ Radius of Curvature: 2.7 mm (+3%, uncorr.)
- ▶ Surface roughness: <10 nm





Double-sided MLAs

Freeform microoptics



- ▶ Digital design workflow
- ▶ Freeform lenses with typ. diameters between 10-2000 μm
- ▶ Sag not limited
- ▶ ROC error (+/-) 1-2% (corr.)
- ▶ Very good surface quality

Double-sided

Designed with
Ansys



2GL– Quality and Speed



GrayscaleX

GrayScribeX - [unsaved]

Project 2GL calibration Help

Project Settings

Printer	c1
Objective	25x MF
Resin	IP-S
Substrate	Fused Silica
Structure Sorting	Lexical
Interface Finding	Execute
Coordinate Origin	Start Position
Dispense	<input type="checkbox"/>
Tilt Measurement	Tilt and Curvature
Measurement Strategy	Per Structure

Structures

4mm_2015.STL		
Add New	Duplicate	Delete

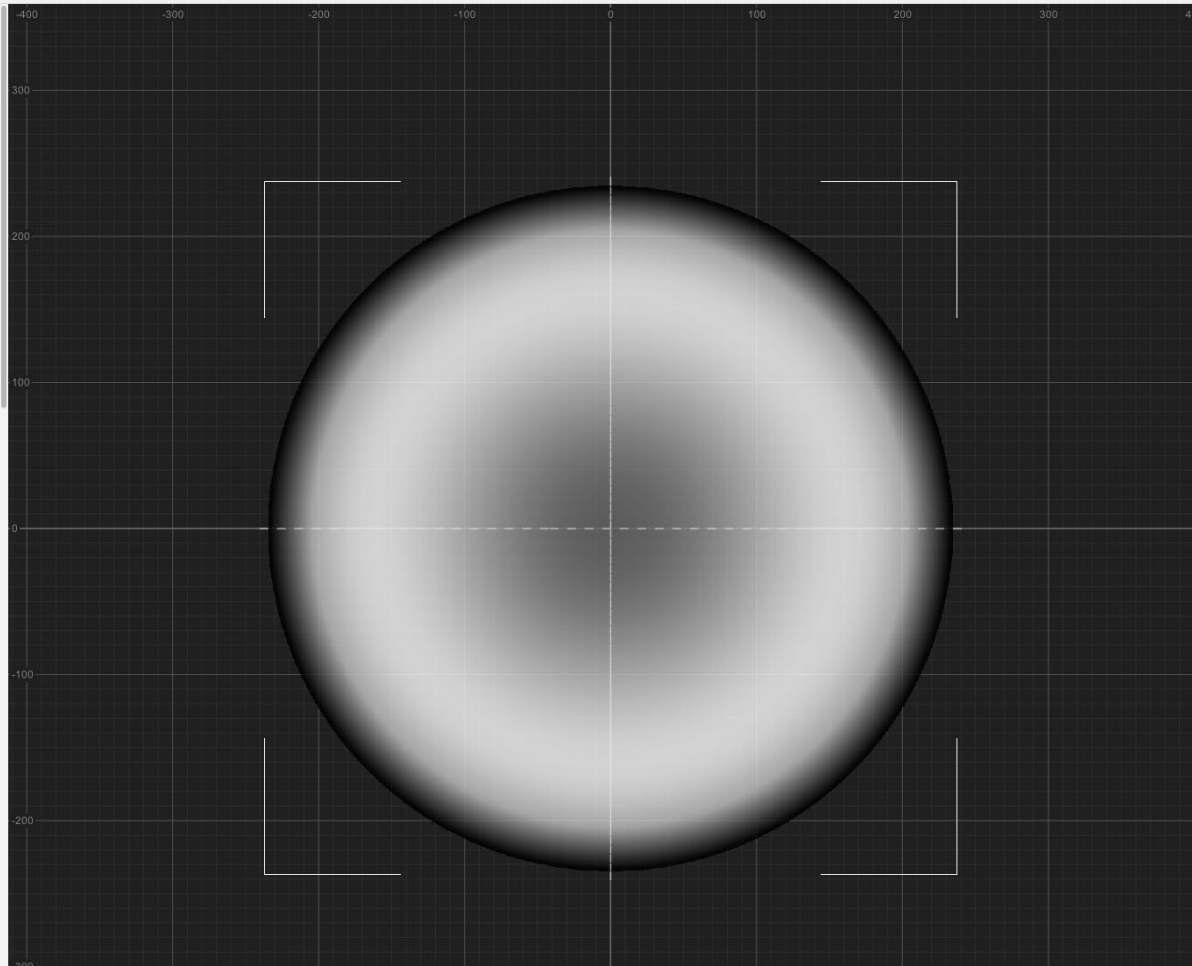
Parameters

Parameter Preset	25x MF/IP-S/FuSi/LM2
------------------	----------------------

Design Parameters

Source Path	4mm_2015.STL
Size X	469.2 μm
Size Y	469.2 μm
Size Z	35.296 μm
Center X	0 μm
Center Y	0 μm
Tiling X	1
Tiling Y	1
Interpolate	<input checked="" type="checkbox"/>
Display Color	
Preview Downsampling	1

Compensation Parameters



[https://doi.org/
10.7554/eLife.
58882](https://doi.org/10.7554/eLife.58882)

Optimized fabrication

2017

12 hours
Barely decent surface quality
(100nm Ra)

slicing (0.05 μm)
hatching (0.5 μm)
contour printing
12 shell layers.



	curr	mag	HV	WD	tilt	det	spot
	26.6 pA	350 x	5.00 kV	10.2 mm	52 °	ETD	4.5

100 μm
Quanta 3D FEG

جامعة الملك عبد الله
للعلوم والتقنية
King Abdullah University of
Science and Technology



QuantumX

25x MF set 2GL



Quiz time

- ▶ A = 6 hours (2x)
- ▶ B = 1 hour (12x)
- ▶ C = 5 minutes (144x)
- ▶ D = 2 minutes (360x)

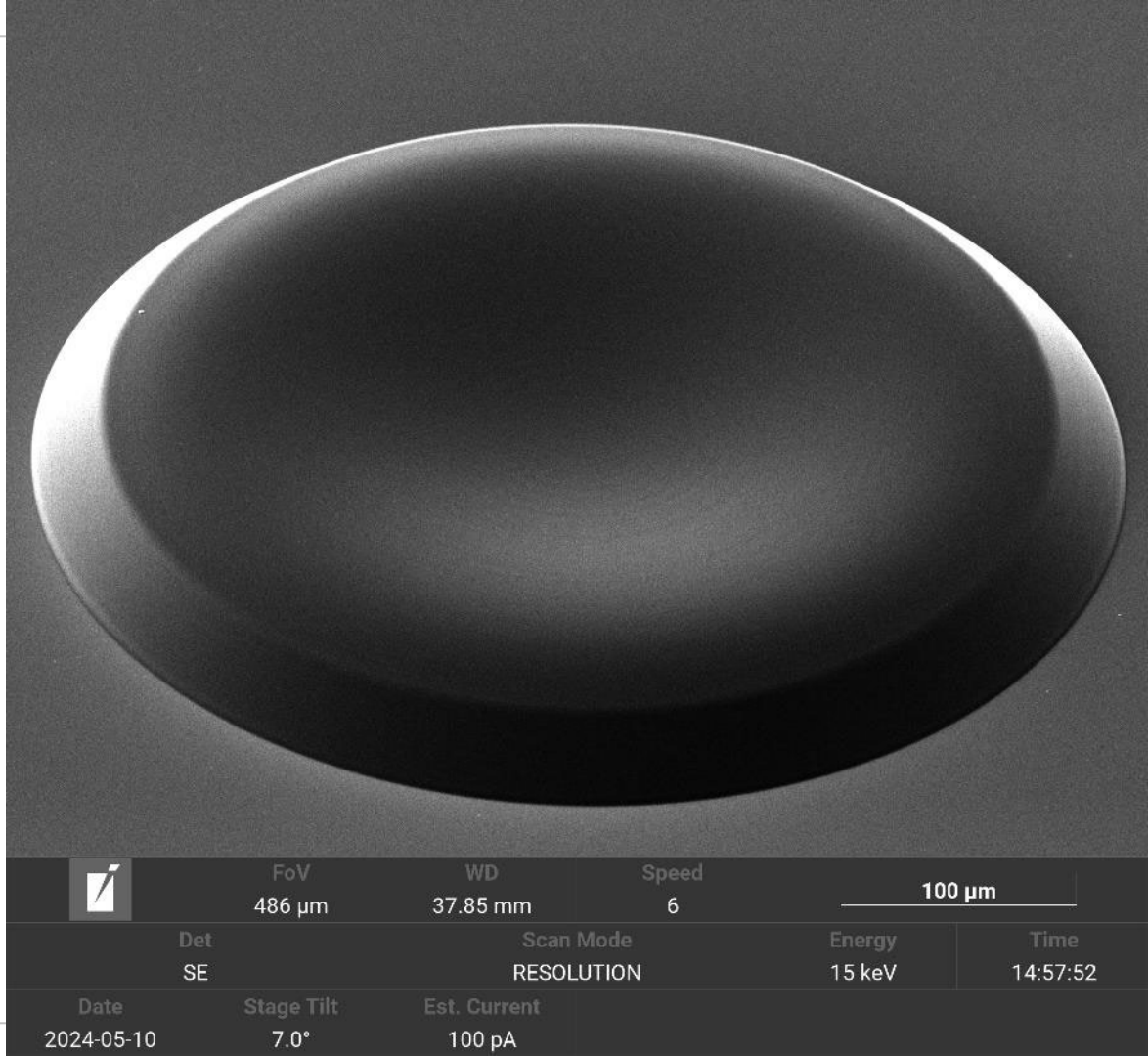


QuantumX 25x MF set 2GL

Quiz time

- ▶ ~~A = 6 hours (2x)~~
- ▶ ~~B = 1 hour (12x)~~
- ▶ C = 5 minutes (144x)
- ▶ ~~D = 2 minutes (360x)~~

Ra<10nm



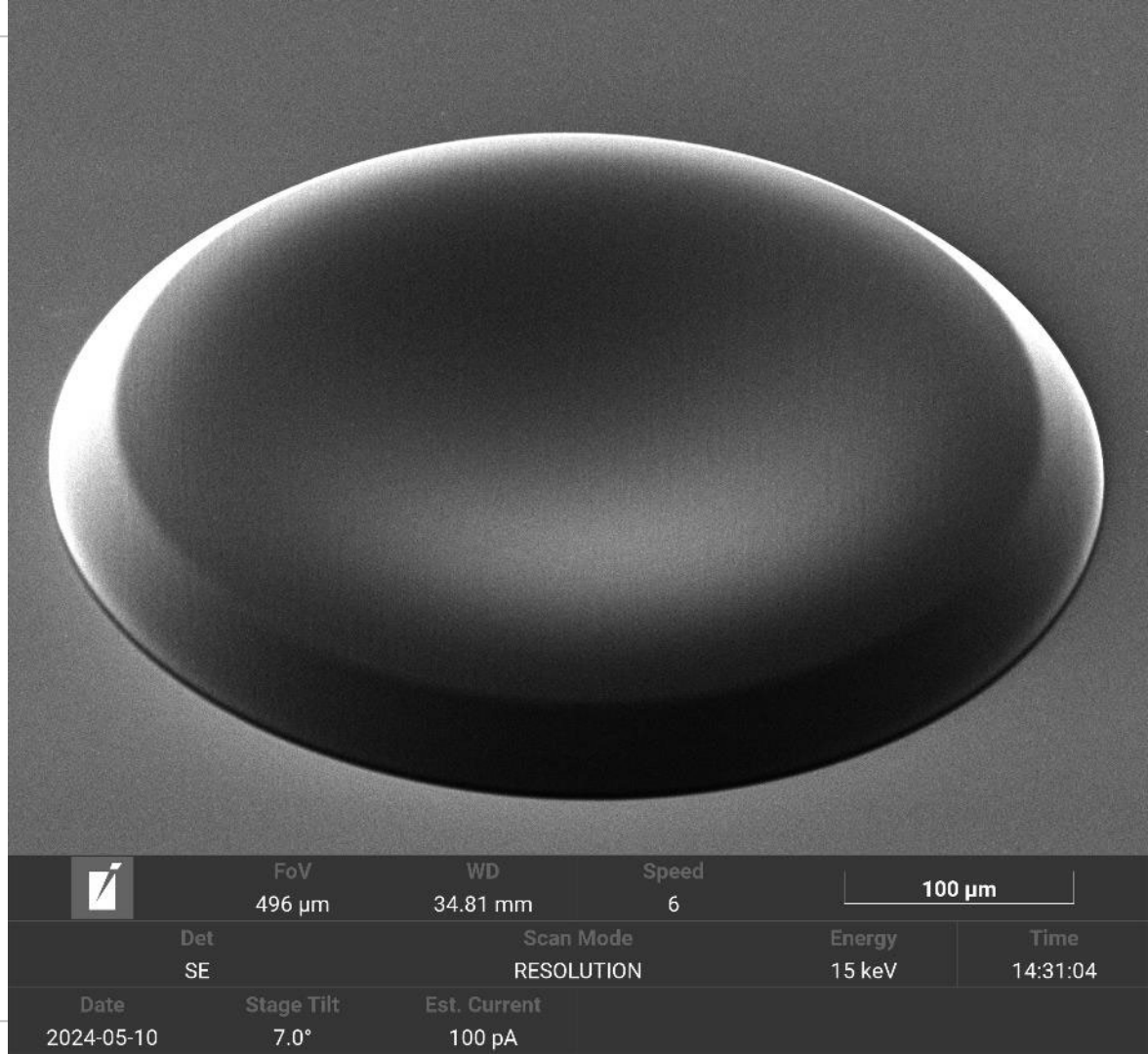
	FoV	WD	Speed	100 µm	
	486 µm	37.85 mm	6		
Det	Scan Mode		Energy	Time	
SE	RESOLUTION		15 keV	14:57:52	
Date	Stage Tilt	Est. Current			
2024-05-10	7.0°	100 pA			

QuantumX 10x LF set 2GL

Quiz time

- ▶ ~~A = 6 hours (2x)~~
- ▶ ~~B = 1 hour (12x)~~
- ▶ ~~C = 5 minutes (144x)~~
- ▶ D = 2 minutes (360x)

Ra<20nm



FoV
496 μm

WD
34.81 mm

Speed
6

100 μm

Det
SE

Scan Mode
RESOLUTION

Energy
15 keV

Time
14:31:04

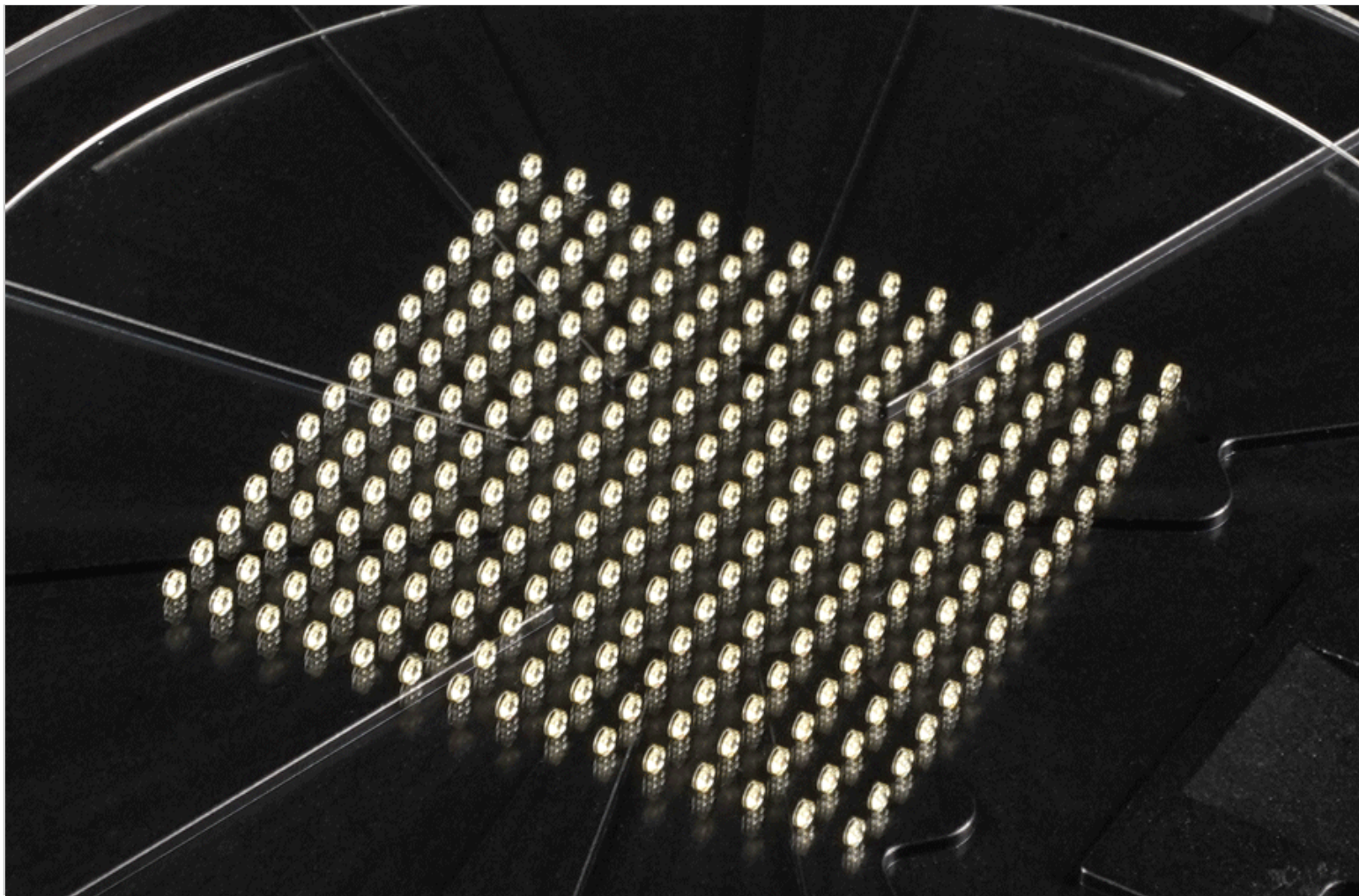
Date
2024-05-10

Stage Tilt
7.0°

Est. Current
100 pA



Production Runs





Replication of Microoptics

Mass fabrication based on 2PP printed masters:
Nano Imprint lithography (NIL) & Injection Molding (IM)

Masters and molds



- ▶ Masters for different replication techniques
- ▶ Injection molding
- ▶ Nanoimprint lithography allows for 8"-12" wafer replication

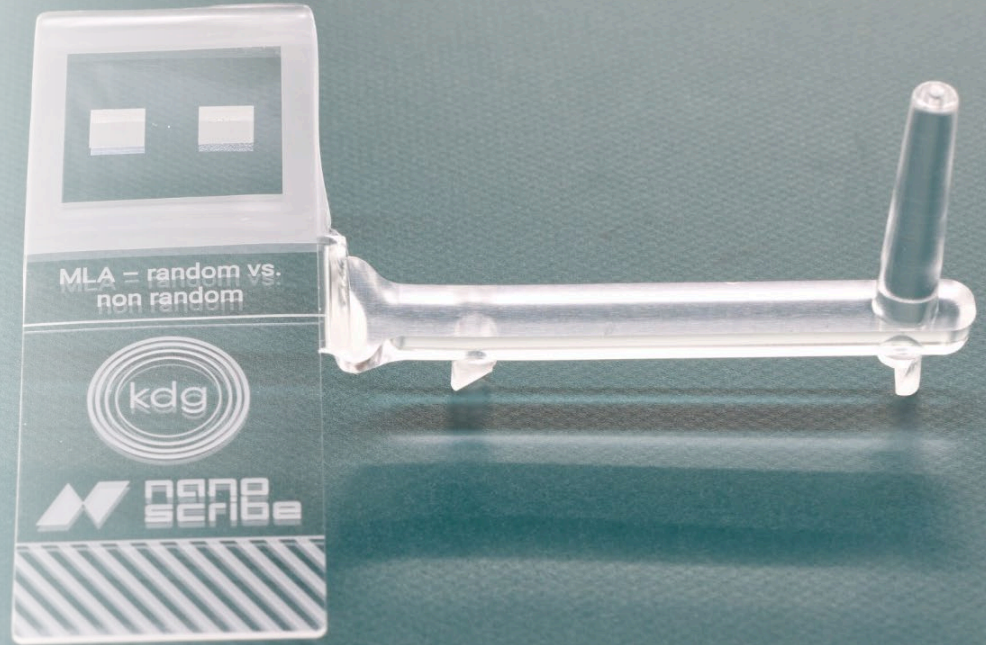
Partner:



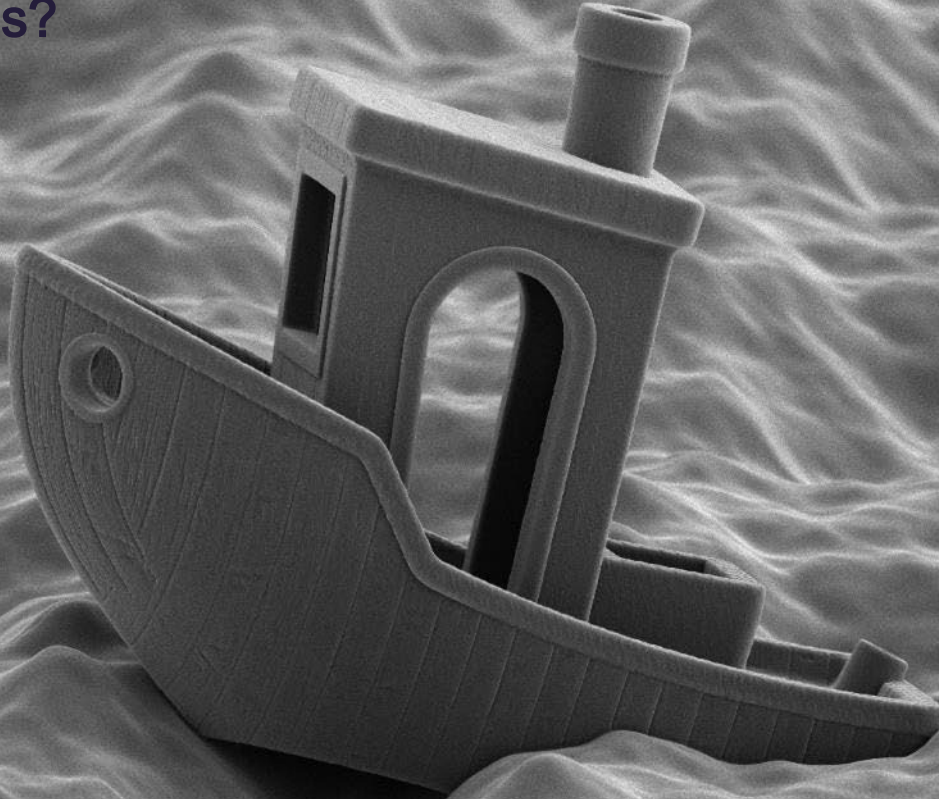
Replication processes

Injection Molding

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



Questions?



200 um



MEMBER OF
GROUP

LAB¹⁴

James Schildknecht
Head of Sales

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Web: [nanoscribe.com](https://www.nanoscribe.com)

Thankyou for your attention !

As the pioneer in 3D printing solutions for optics and photonics, we push the limits of advanced lithography.

[Lab14](#) is a group of successful high-tech companies with complementary products and services for nano- and microfabrication as well as surface analysis.

Validate our Quantum X platform

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

CERTIFIED
ISO 9001

Quality Management Systems

CERTIFIED
ISO 14001

Environmental Management Systems