# Scalable fabrication of optical interconnects
## enabled by two-photon grayscale lithography (2GL®)

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MEMBER OF | LAB14

# LAB14

## Processing & Additive Electronics

osiris

NOTION SYSTEMS

amcoss components & systems

## Surface Analysis & Metrology

SPECSGROUP

nanosurf

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## Advanced Structuring

HEIDELBERG INSTRUMENTS

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4D-3D

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- Technology Aligned two-photon grayscale lithography (2GL®)
- Application Optical interconnects
- Success story PIC-based neuromorphic computing
- Our offering What can we do for you?


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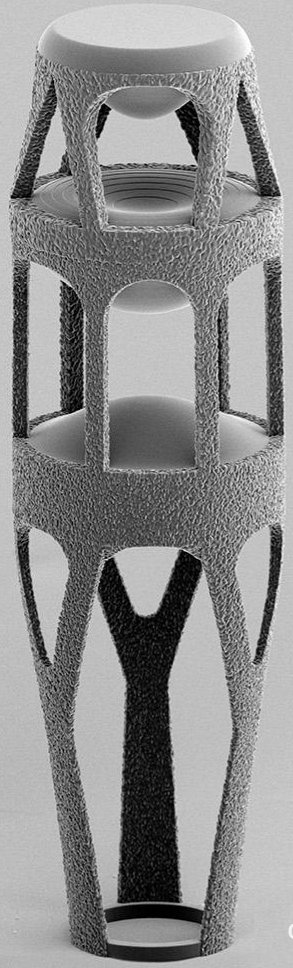
# Two-Photon Grayscale Lithography (2GL®)
## for micro-optics and photonics

- Up to **10x faster** at highest optical-grade quality
- Equally effective for texturized surfaces with finest submicron features

- Surface roughness $R_a$ down to ≤ 5 nm
- Shape accuracy $S_a$ down to ≤ 200 nm



200 µm

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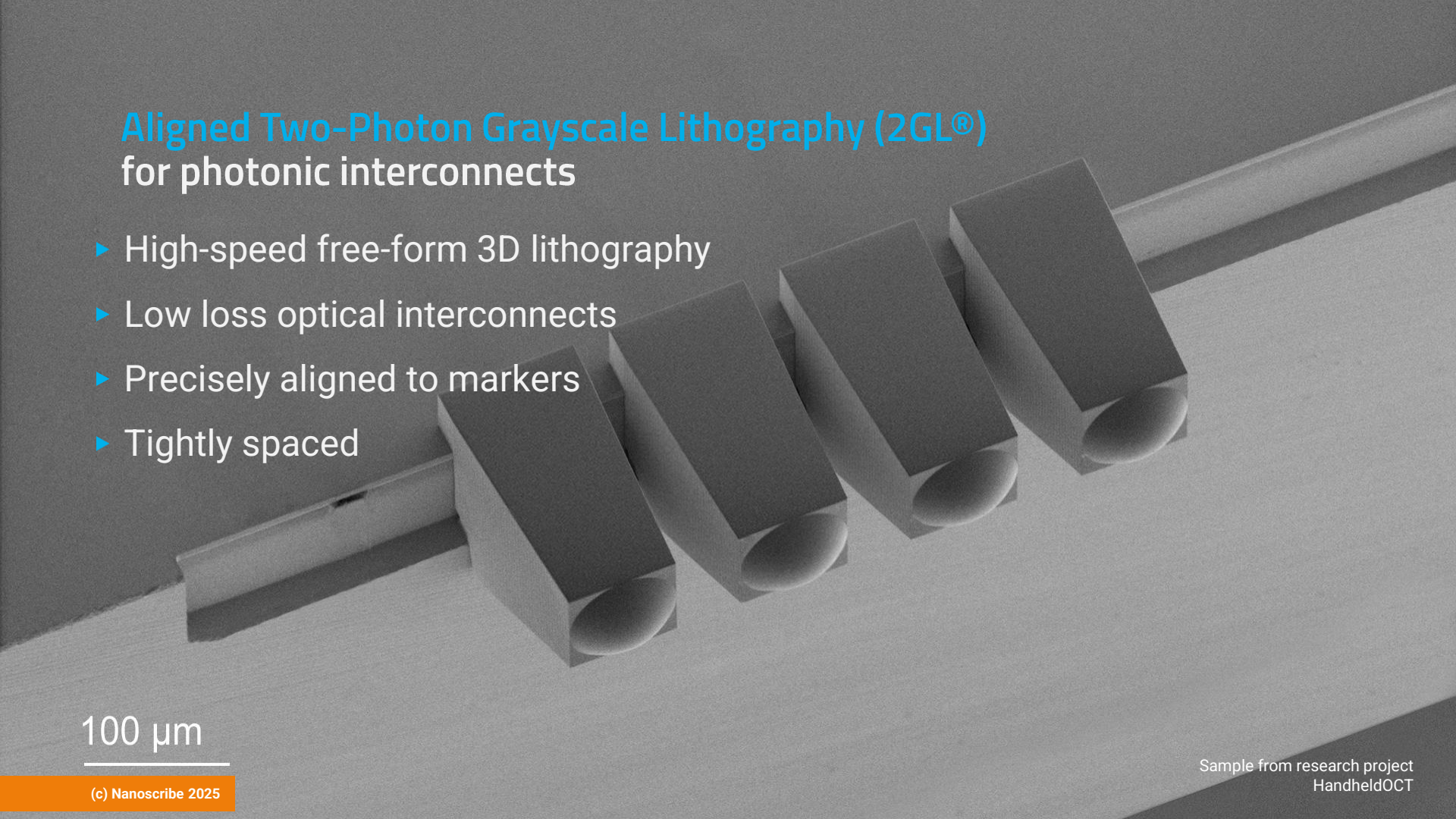
# Aligned Two-Photon Grayscale Lithography (2GL®)
## for photonic interconnects

- High-speed free-form 3D lithography
- Low loss optical interconnects
- Precisely aligned to markers
- Tightly spaced




Sample from research project
HandheldOCT

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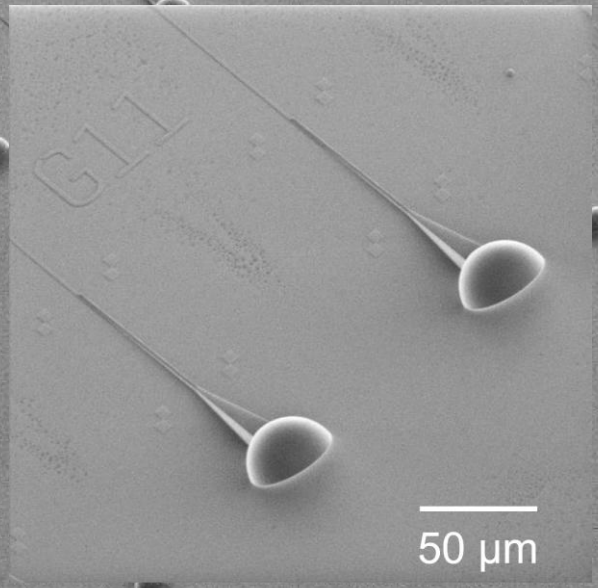


100 µm

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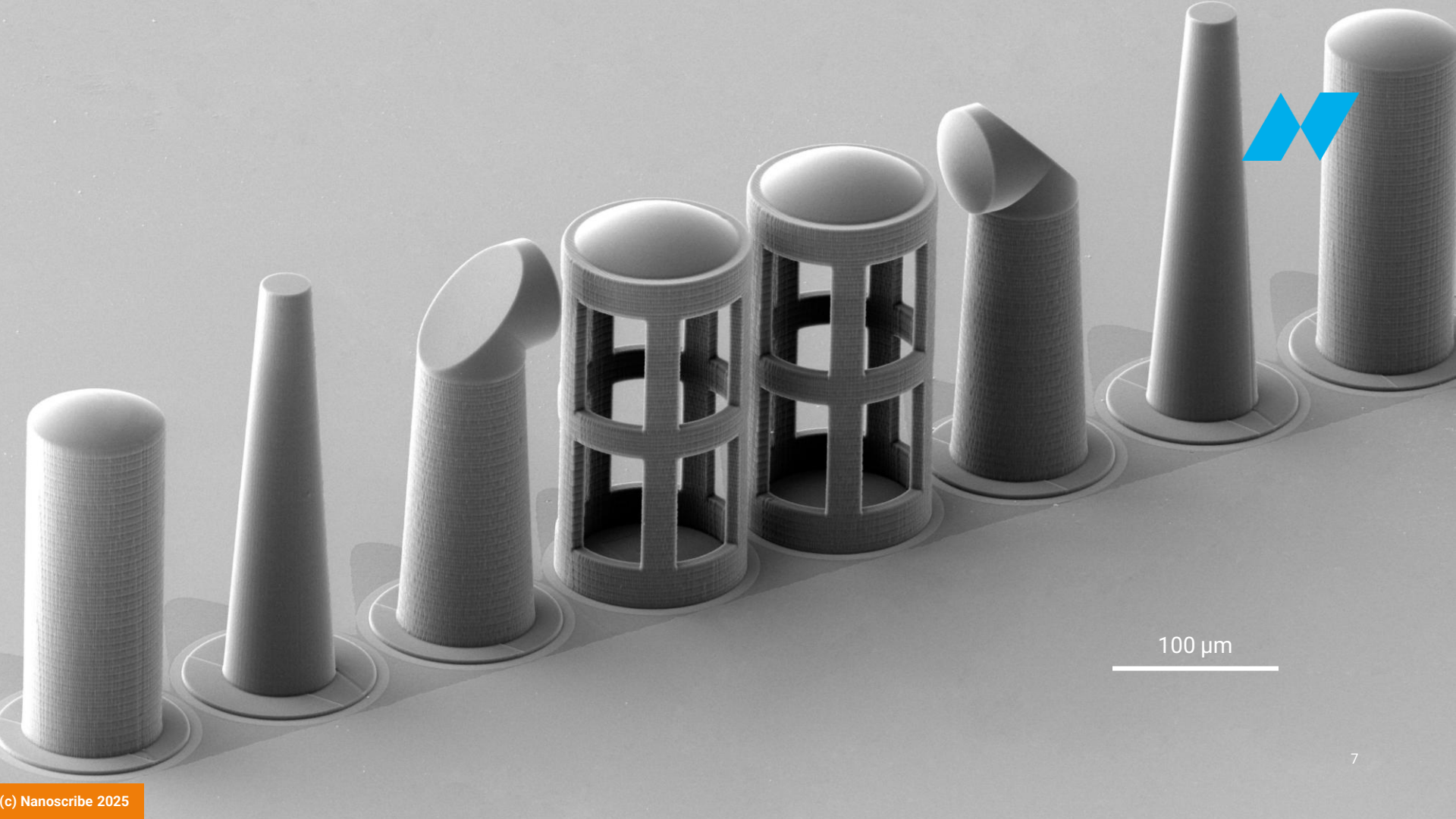
Sample from research project Phoenics



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# Polymeric optical coupling structures

Reliability, performance, and scaling

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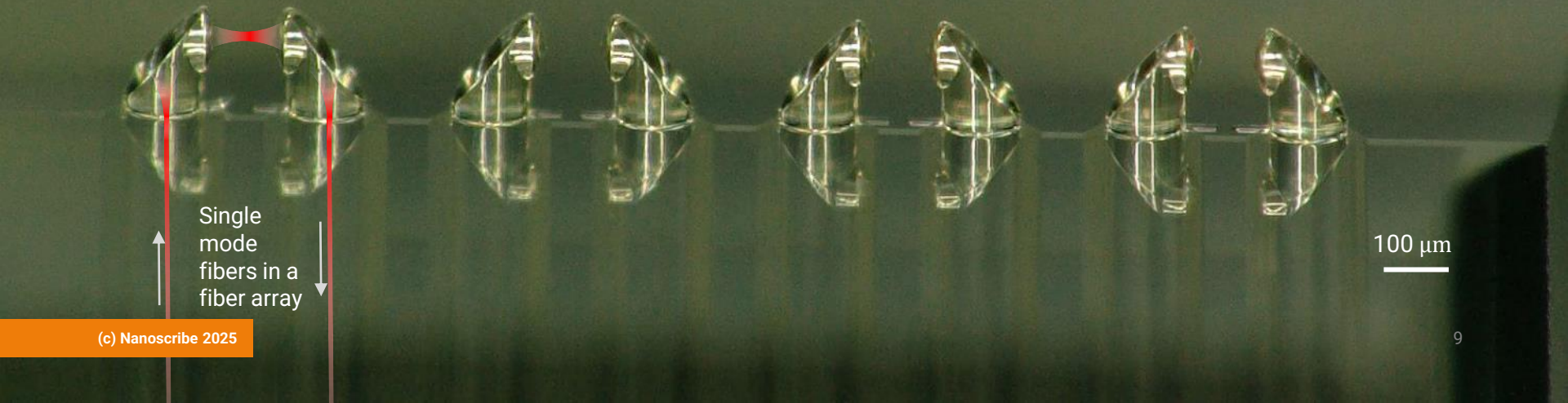
# Reliability & performance
## Humidity test passed

6 µm MFD focusing lens for 1550 nm with a polynomial TIR mirror

- down to **0.3 dB loss** per coupling interface
  for coupling two channels to each other
- 13 min print time/array
- Excess loss < 0.3 dB after **1000 h 85 % humidity 85 °C** (**Telcordia** GR-1221)

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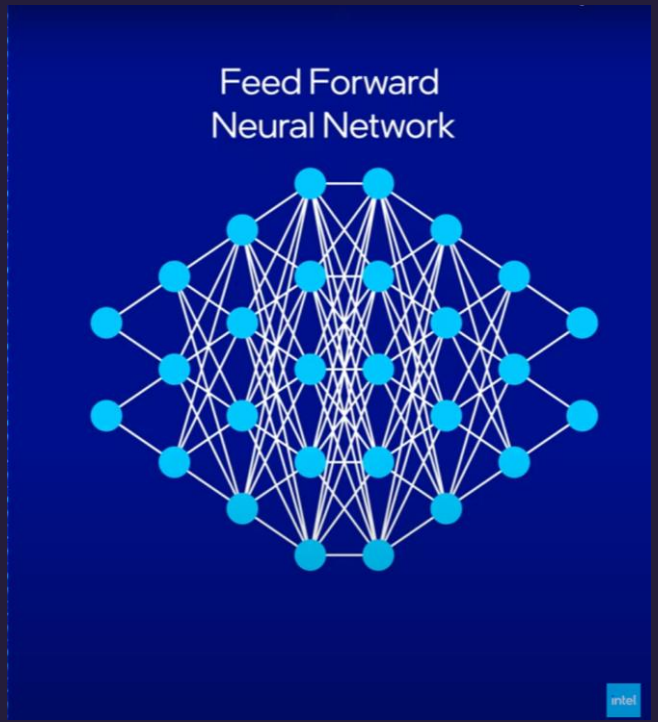
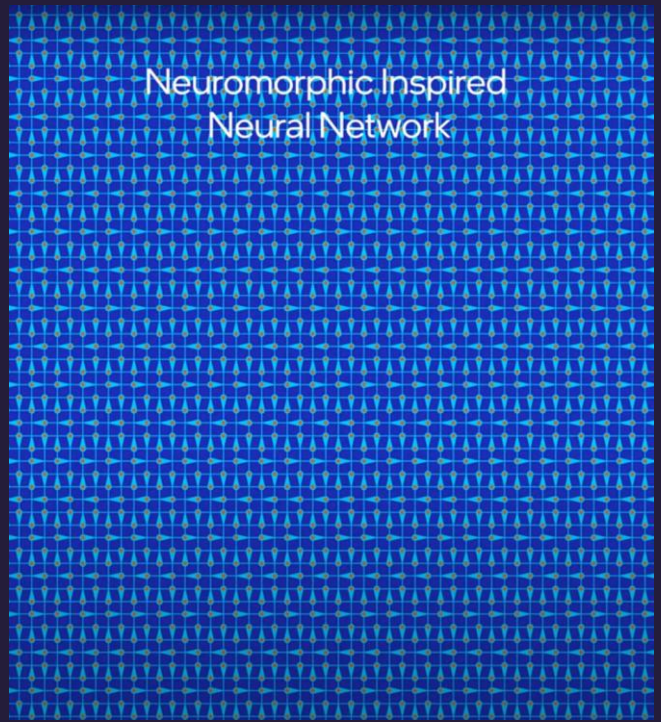
# Application example
## Photonic computing platform




Mike Davies, Intel

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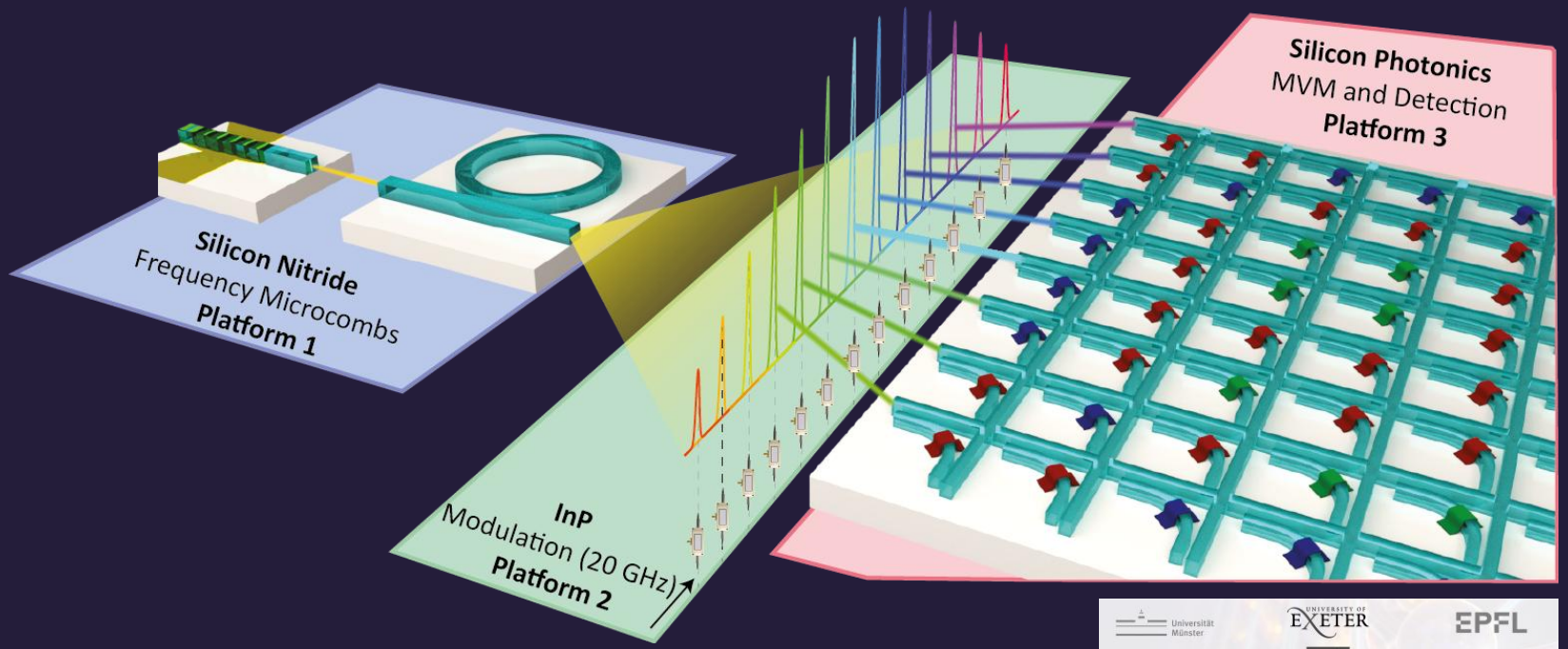
# Application example
## PIC-based neuromorphic computing

PHOENICS

Horizon 2020: Grant #101017237

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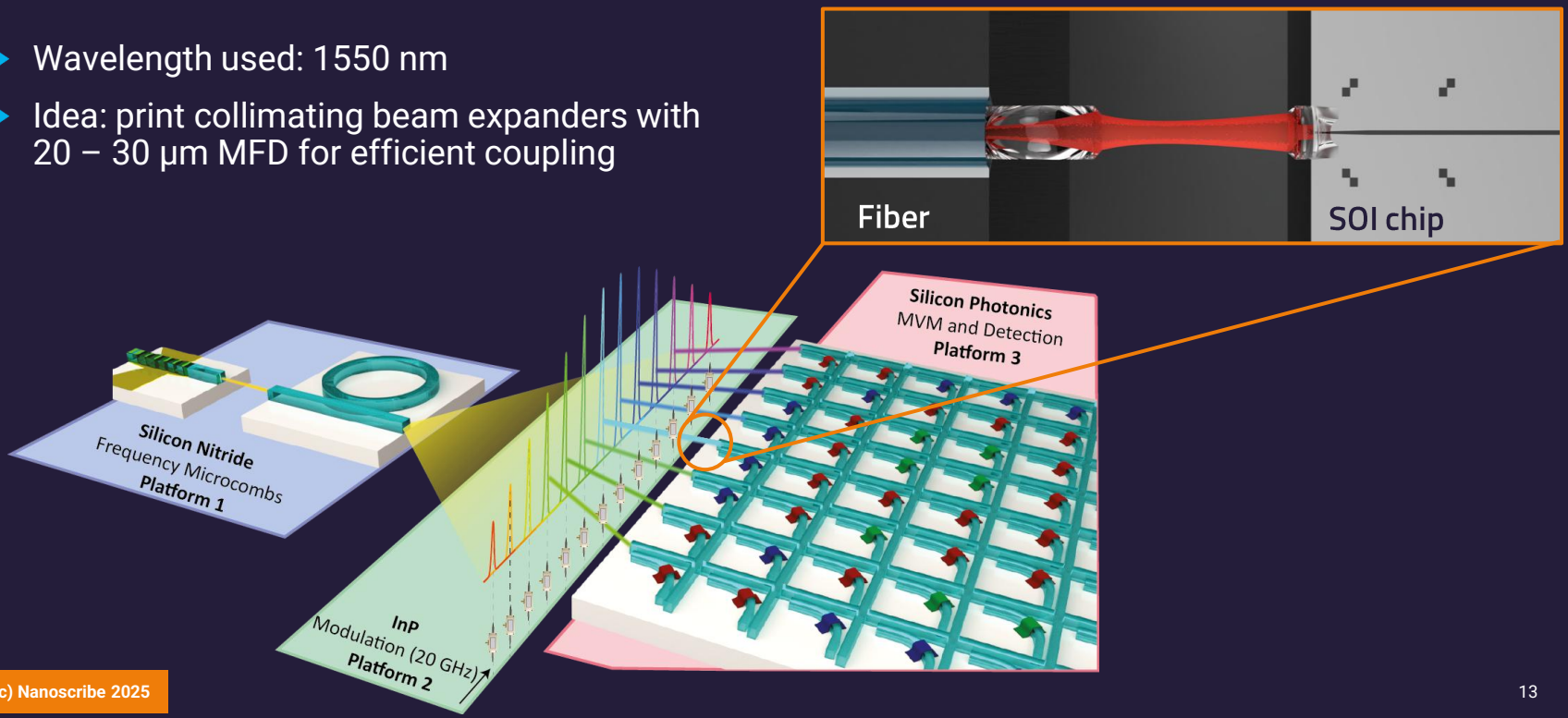
# Challenge
## Coupling between different optical platforms

PHOENICS

Horizon 2020: Grant #101017237

- Wavelength used: 1550 nm
- Idea: print collimating beam expanders with 20 – 30 µm MFD for efficient coupling

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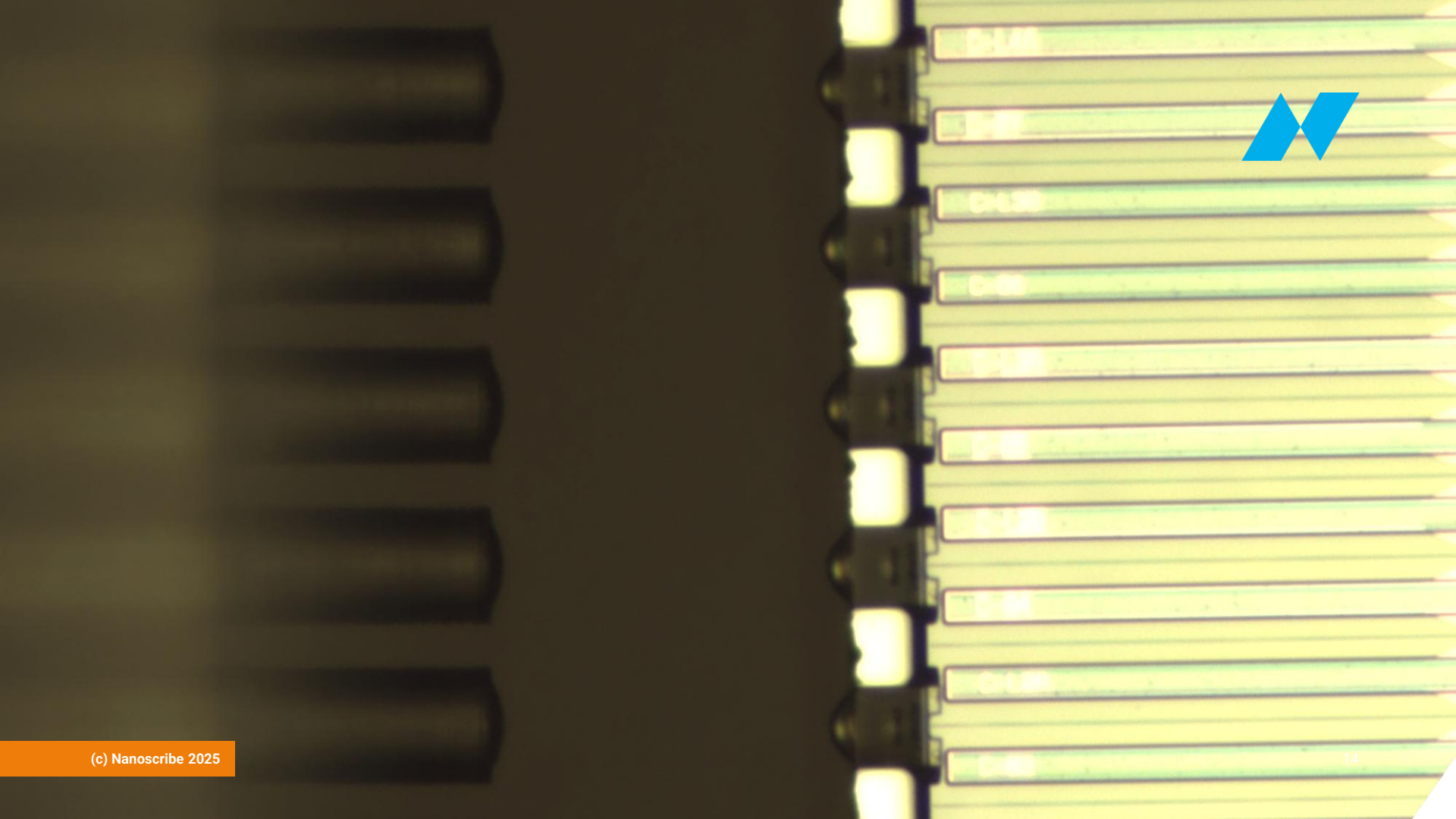

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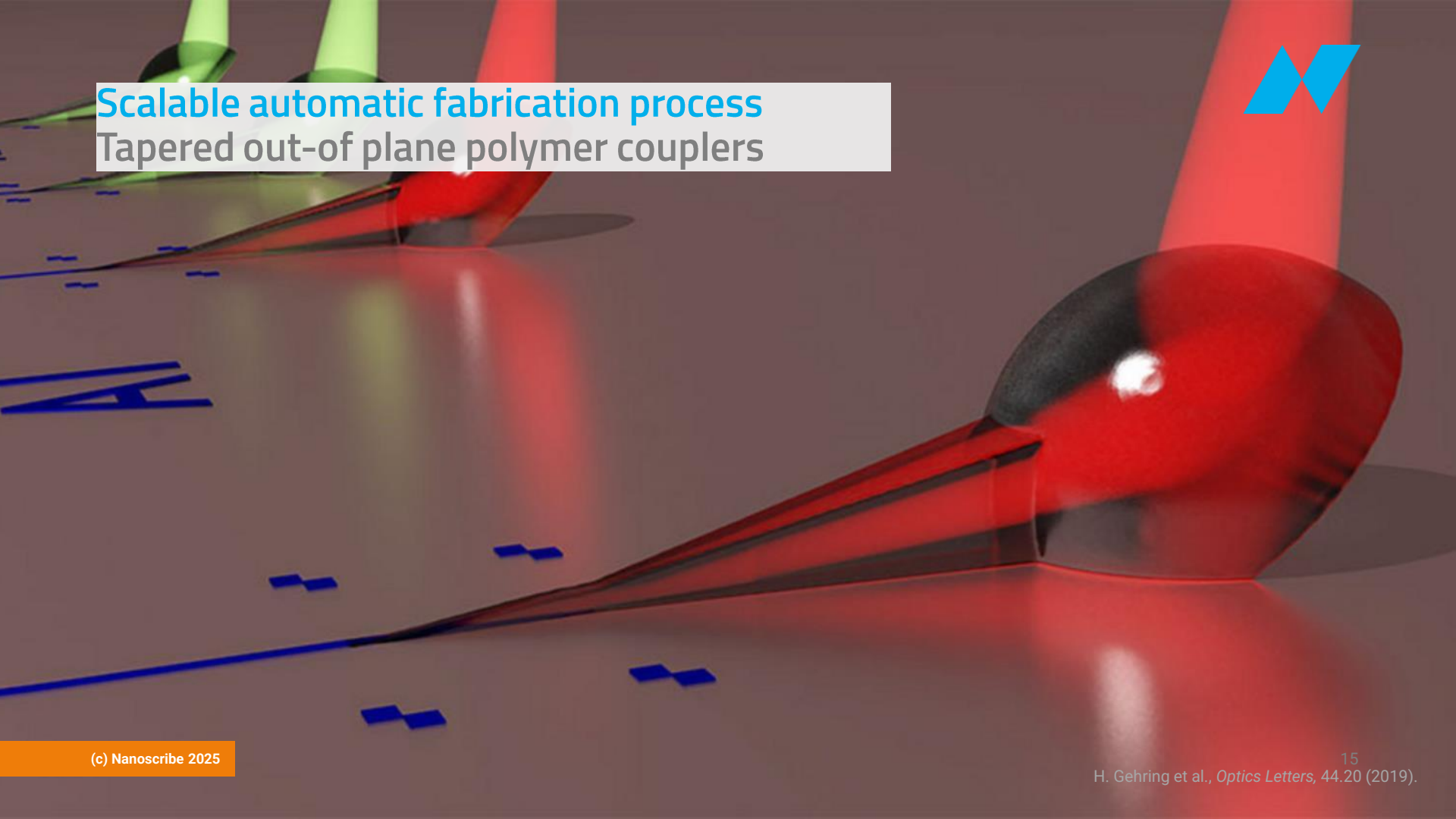
# Scalable automatic fabrication process
## Tapered out-of plane polymer couplers



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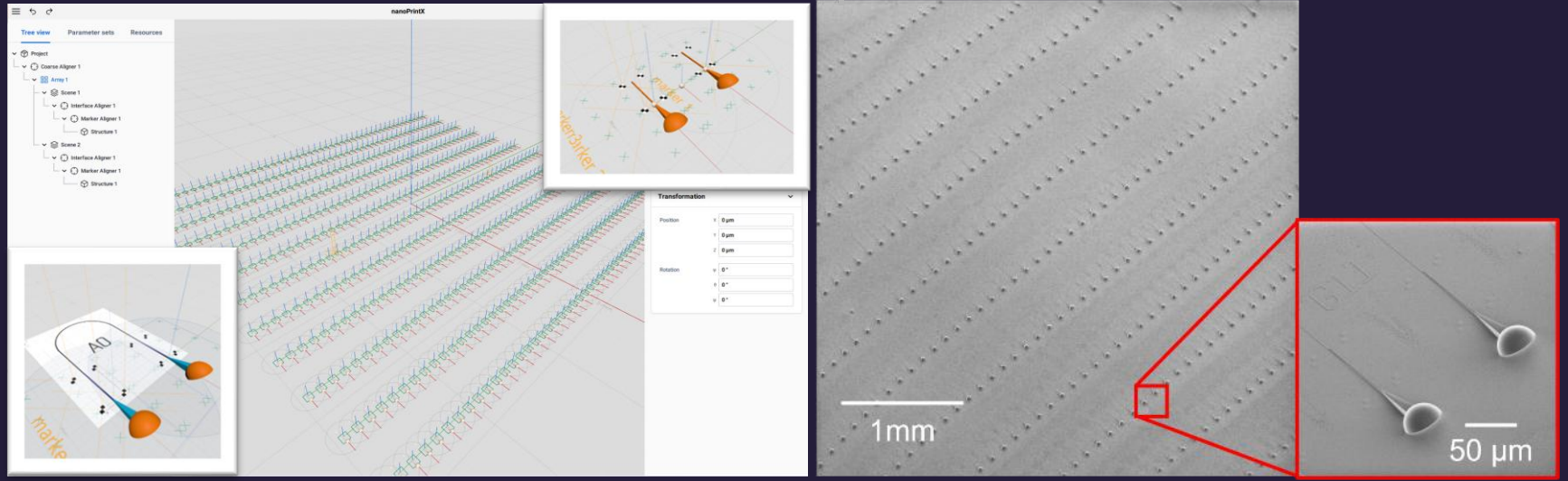
H. Gehring et al., *Optics Letters*, 44.20 (2019).

# Scalable automatic fabrication process
## Tapered out-of plane polymer couplers

PHOENICS

Sample from research project PHOENICS




- Define interconnect in nanoPrintX
- Align to fiducials (<100 nm) via pattern matching
- Select process parameters, print & develop

- Automatic print of 480 out-of-plane couplers

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# We are Nanoscribe

We offer two-photon grayscale (2GL®) systems

# higher print quality / lower losses
# faster production / scalable
# large choice of print materials
# most versatile software solutions