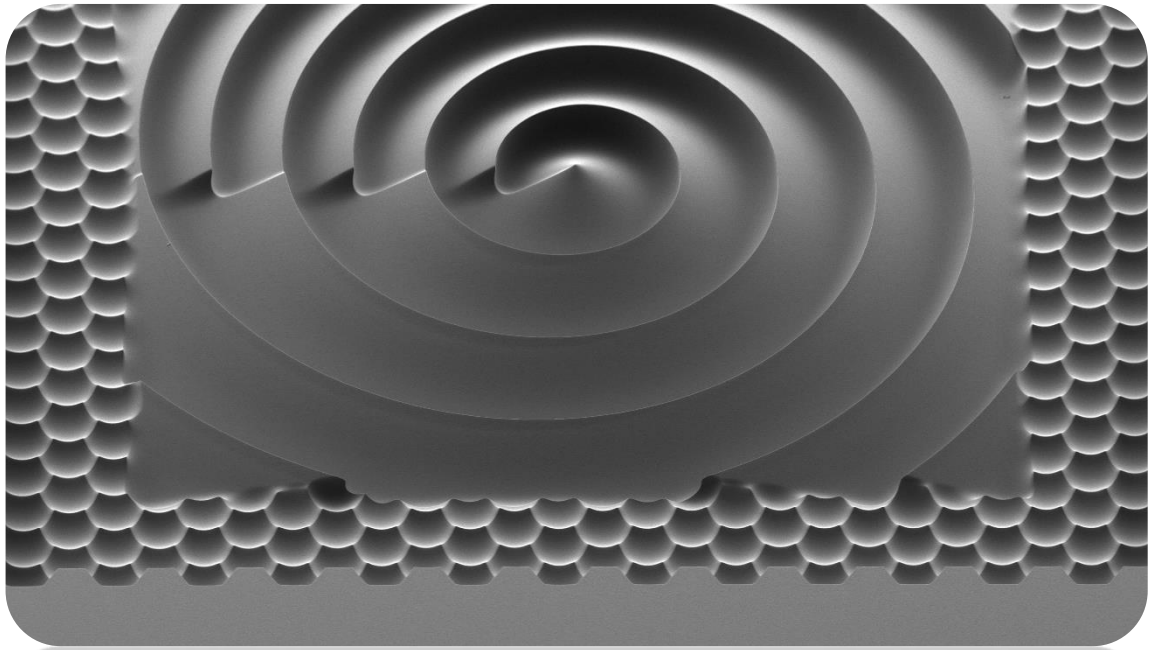
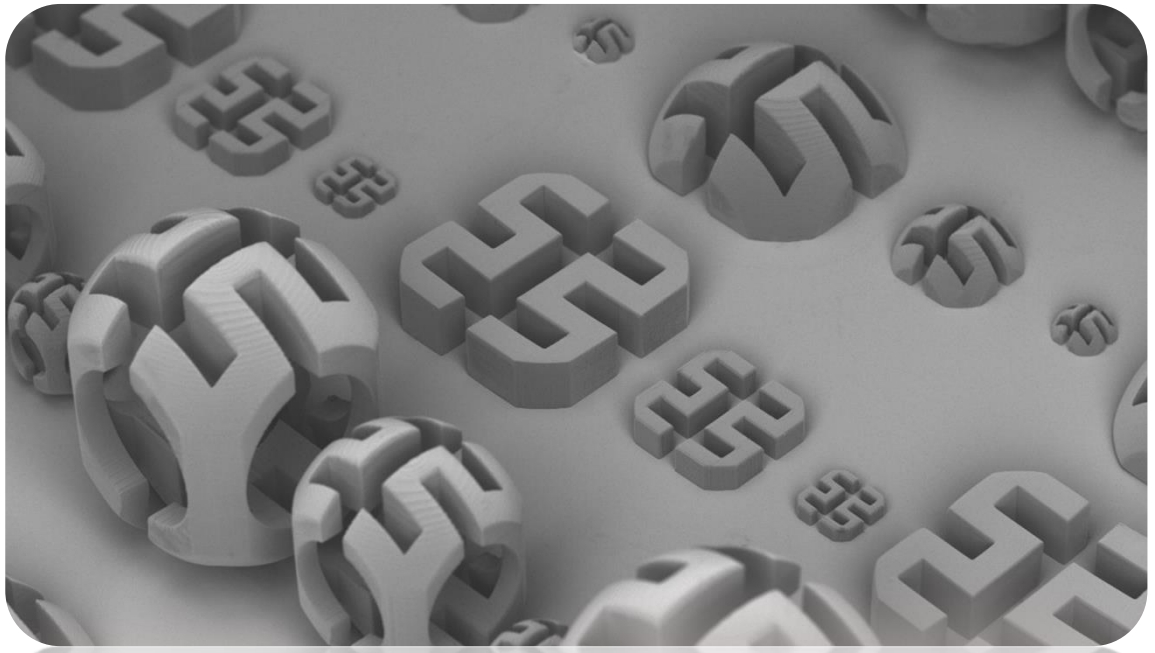
HEIDELBERG INSTRUMENTS





2.5D & 3D micro-structures with Maskless Laser Lithography

Grayscale lithography & two-photon polymerization applied to micro-optic

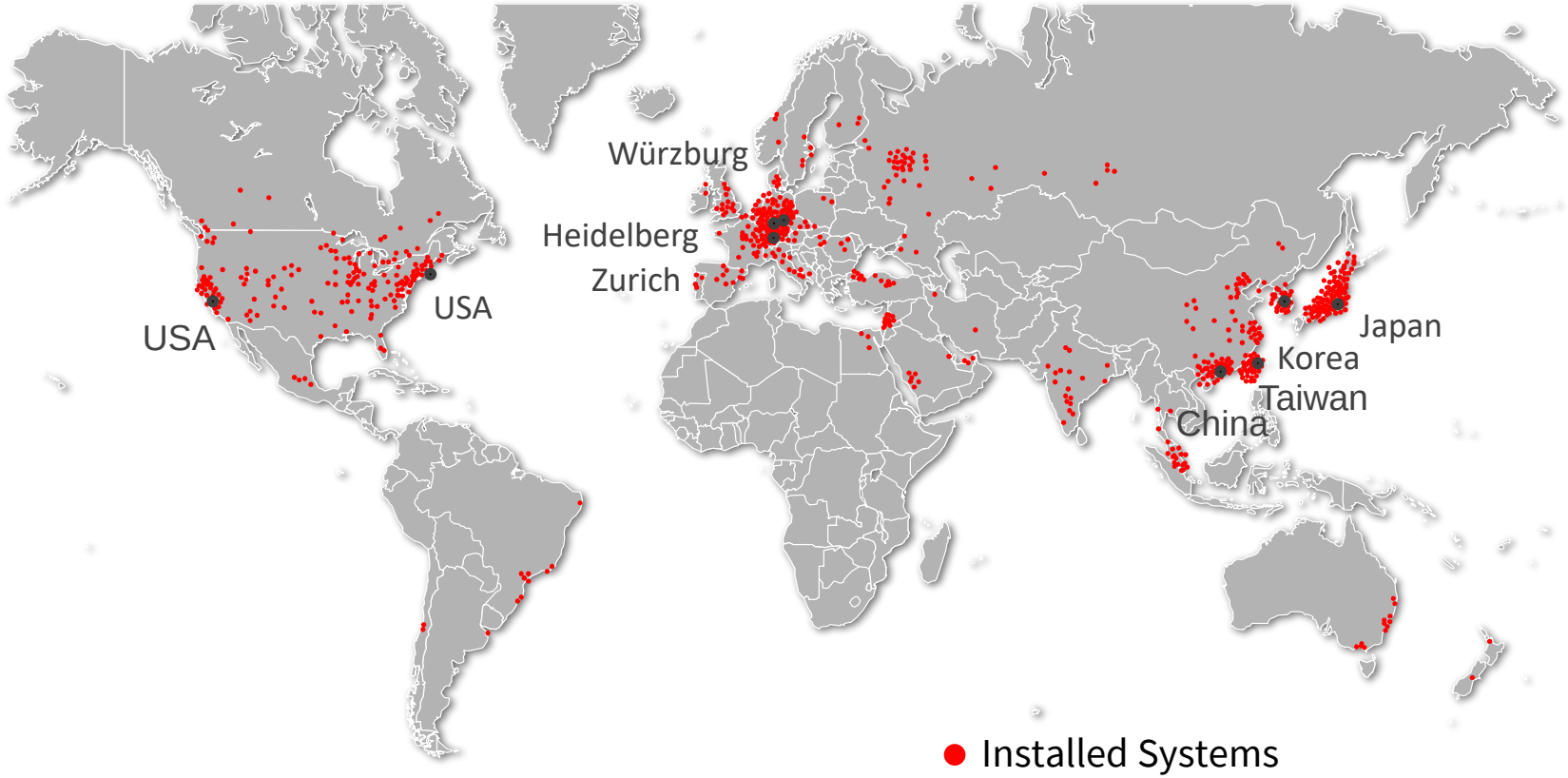
EPIC Meeting on Advanced Microoptics 11 & 12 MAY 2022

Dominique Collé

HEIDELBERG INSTRUMENTS

The power of direct writing

- More than 1200 systems in more than 50 countries
- World leader in the development and production of high-precision micro- and nano-lithography systems
- Extensive know-how in developing customized lithography solutions
- More than 300 employees worldwide
- 50 million Euros turnover in 2020
- Founded in 1984

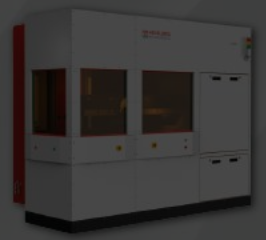


ISO 9001
Certified
Quality Management System
www.tuvsud.com/ms-cert

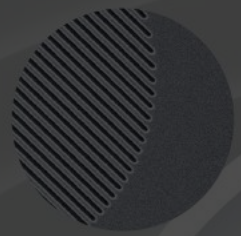
2.5D & 3D micro-structures with Maskless Laser Lithography

HEIDELBERG INSTRUMENTS
The power of direct writing

VPG+ 1400



ULTRA

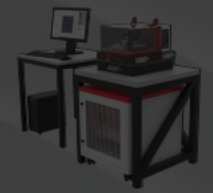


Photomask Production

Advanced Packaging, Displays, Semiconductors, 3D IC

Nanofabrication

Nanoelectronics, Nanofluidics, Nanoimprint Templates



SCHOLAR

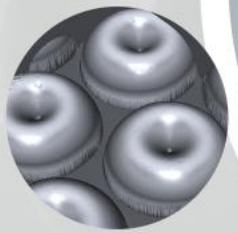
EXPLORE

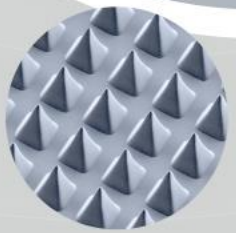
Today's focus

DWL 2000 GS

DWL 66+

MPO 100





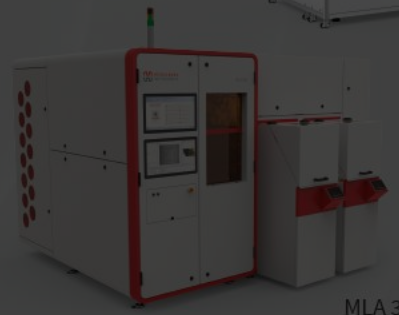
2.5D and 3D Lithography

Micro-Optics, Lenses, Reflectors, Surface Textures

Microfabrication

Electronic Components, Sensors, MEMS, Microfluidics

MLA 150



MLA 300

µMLA

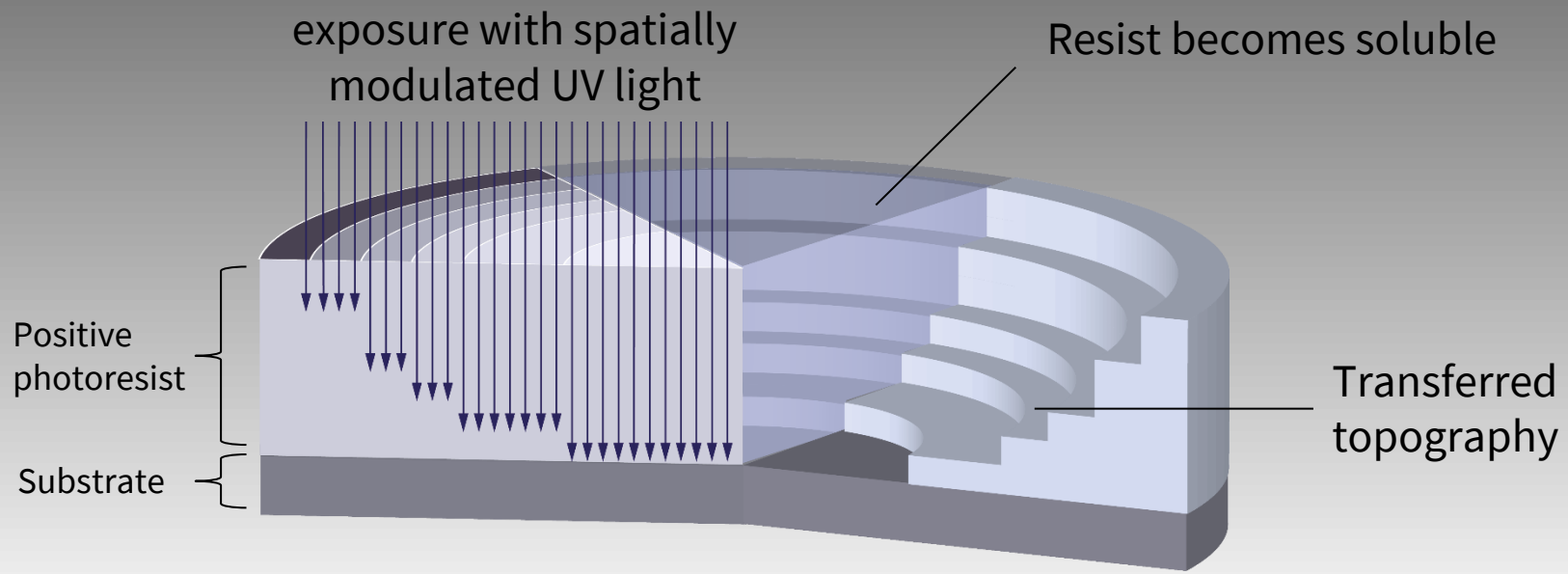
DWL 2000GS

DWL 66+

Grayscale lithography with the DWL Series

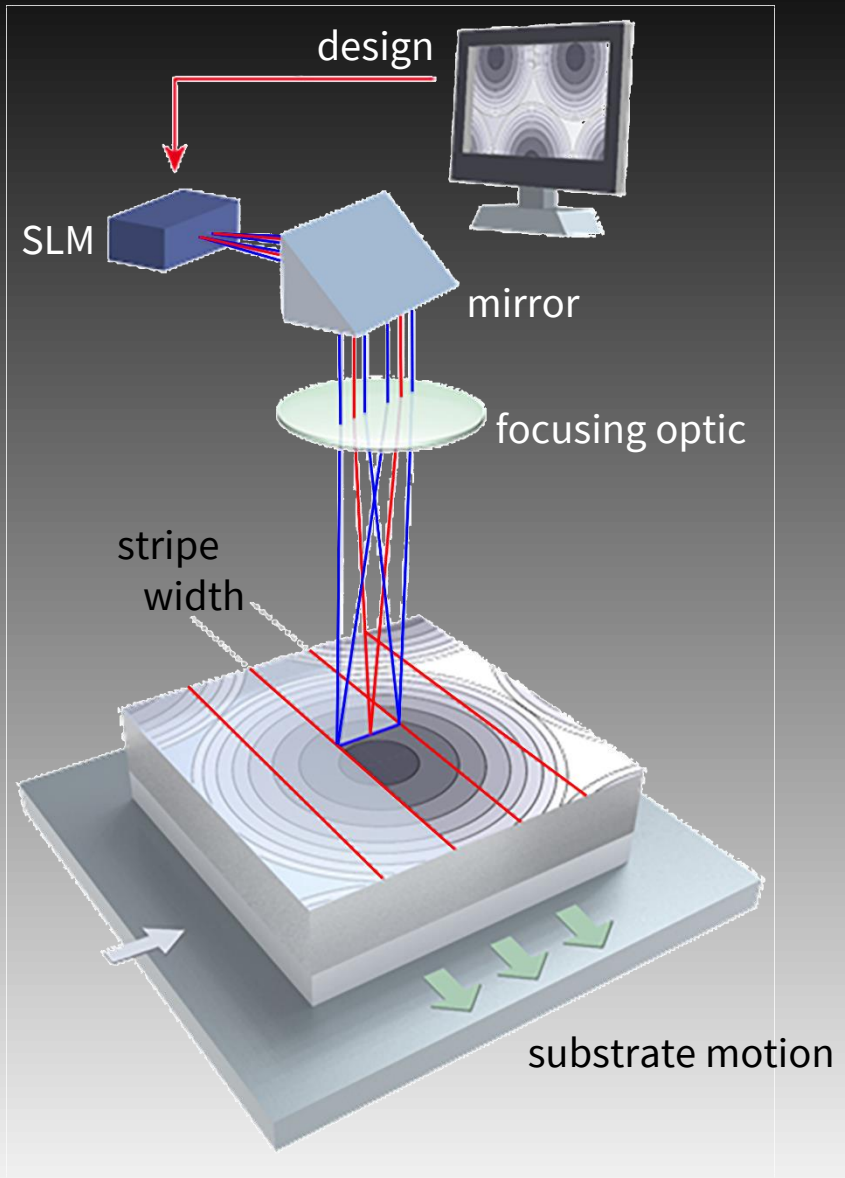
- Maskless: Fast & flexible
- Professional Grayscale
- Pixel grid down to 50nm
- 1024 intensity levels

Principle of grayscale lithography



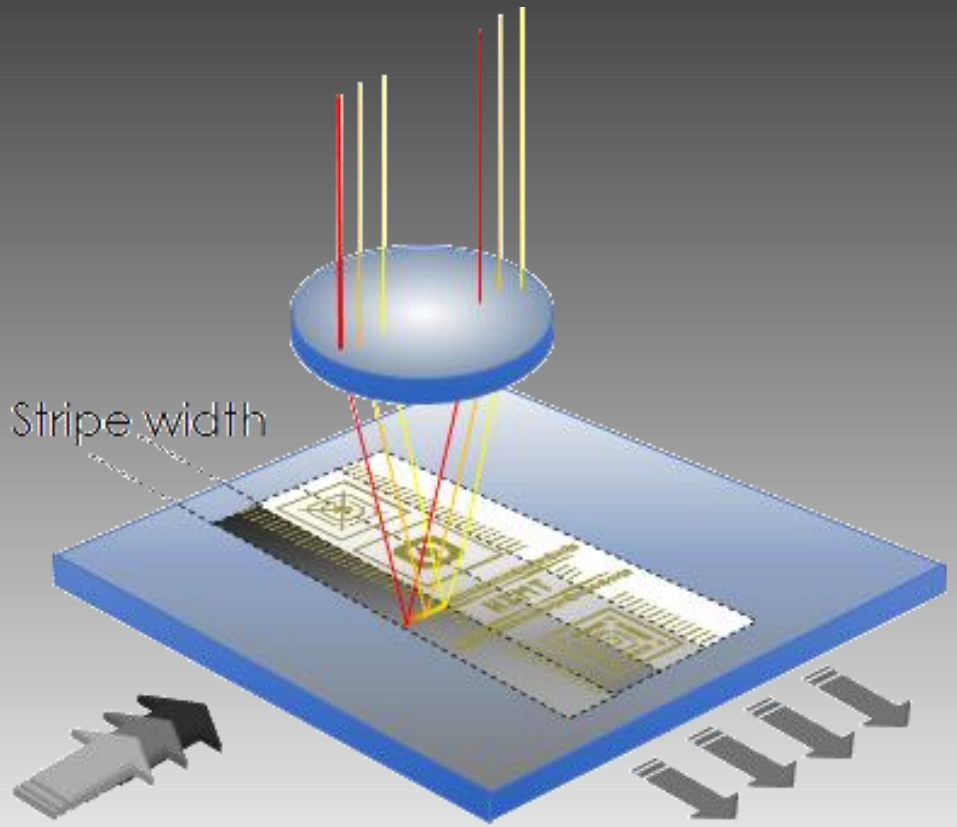
DWL: Raster Scan exposure

- Spatial Light Modulator (SLM) : dynamic mask
- Ultra fast light modulation between each pixel.
- SLM combined with focusing optic and XY stage motion enables fast writing of high resolution over large areas.
- The design is exposed stripe after stripe.

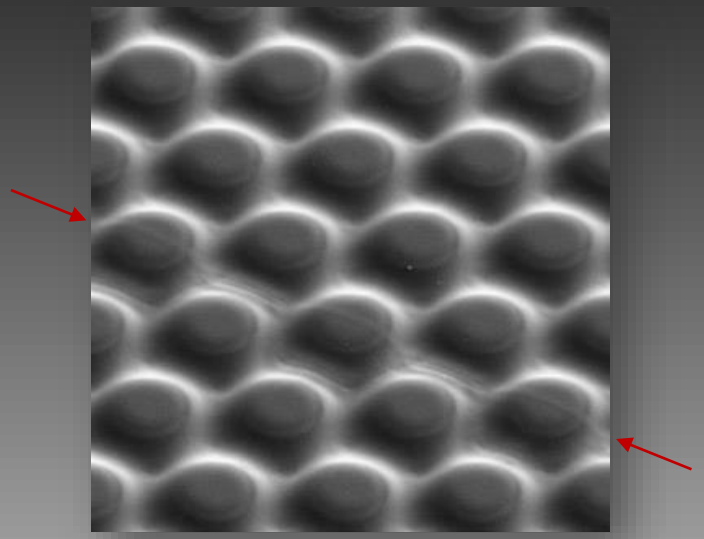


DWL: Stripes stitching

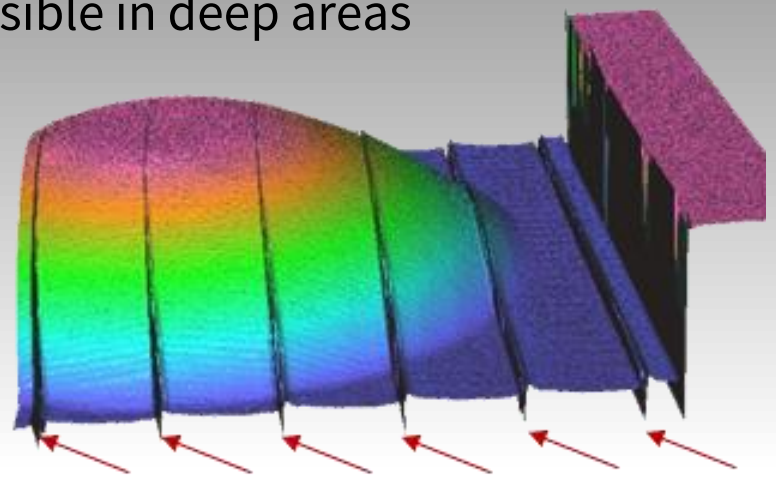
Invisible in binary exposures



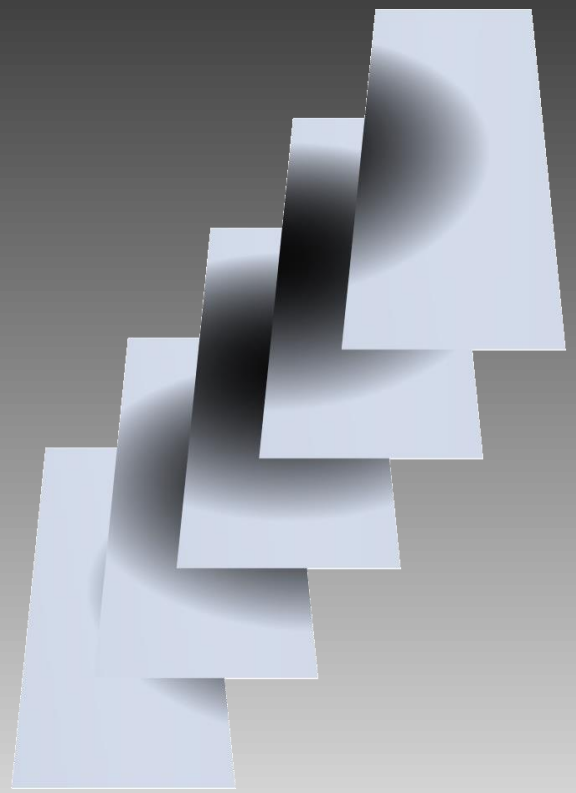
- Small artefacts at the border between stripes in thick photo resist.



- More visible in deep areas

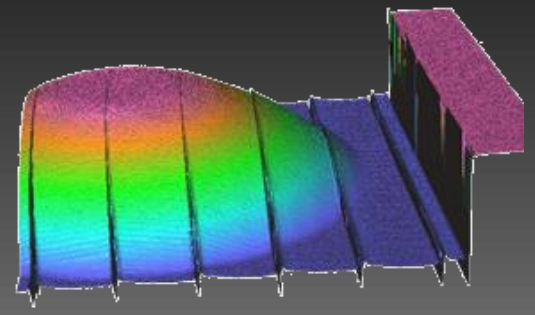


DWL: Stitching optimization

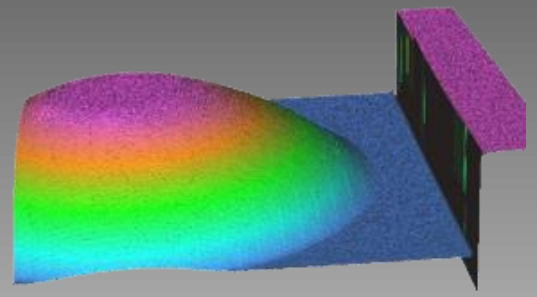


CI-Over : Optimized overlaping strategy

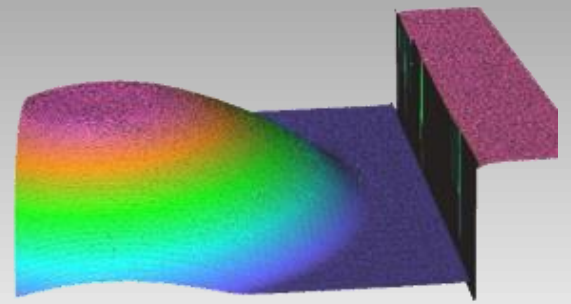
- Number of overlaps is reduced by a factor 5 compared to simple overlaping strategy.
- Each pixel is exposed N times.



- Without overlaping



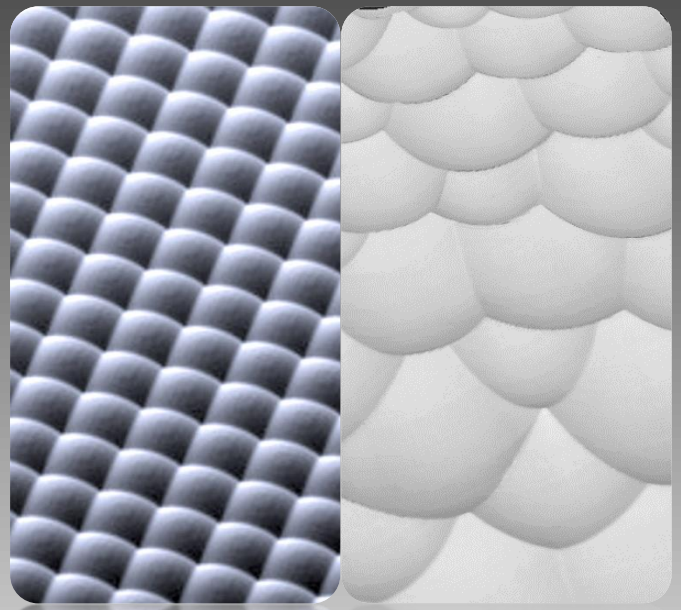
- With 4 overlapping CI-Over 4



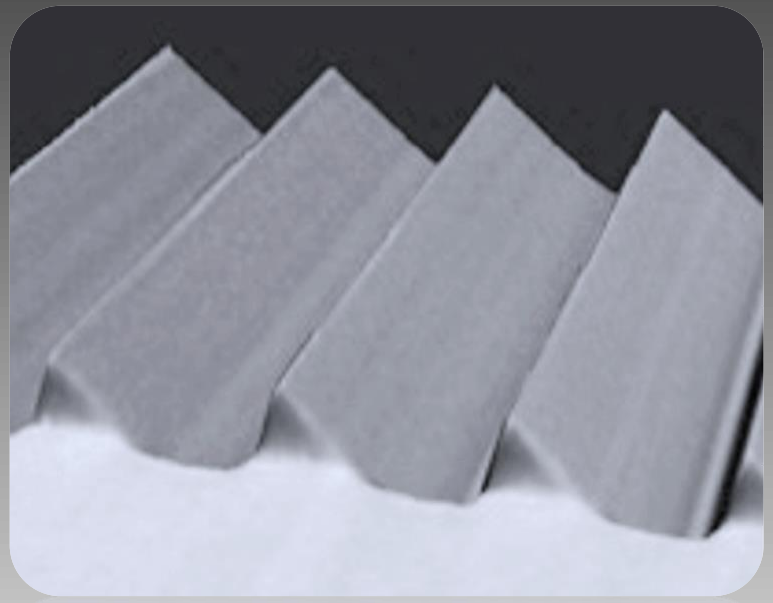
- With 10 overlapping CI-Over 10

Grayscale: Micro-optic applications

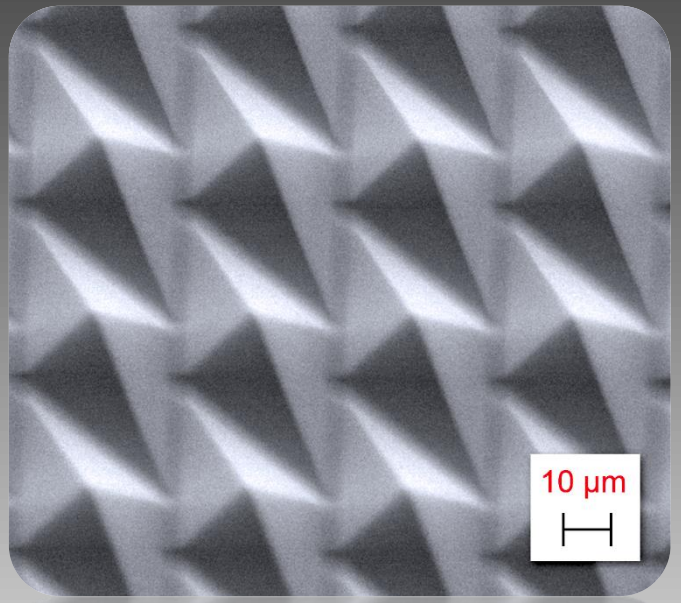
Micro Lens Arrays



Blazed gratings

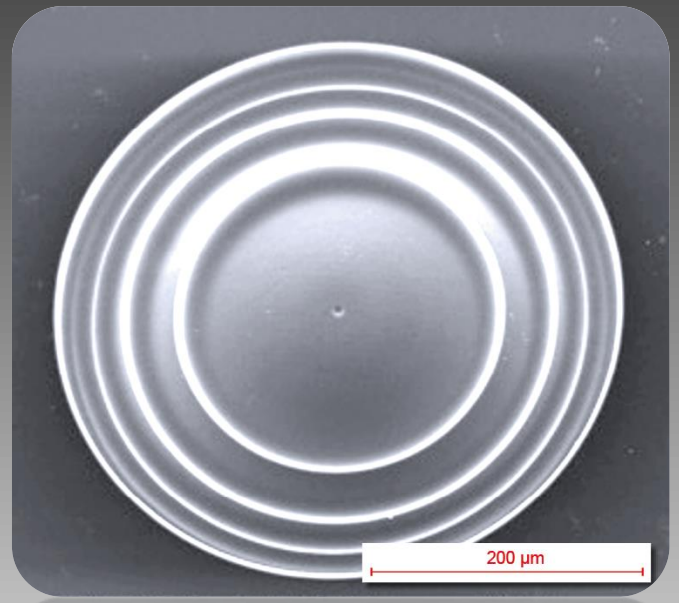


Diffusers & reflectors

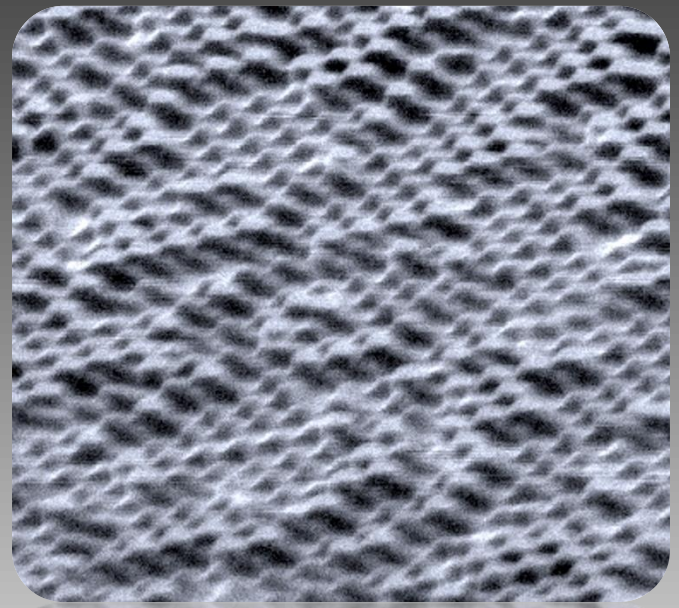


Grayscale: Micro-optic applications

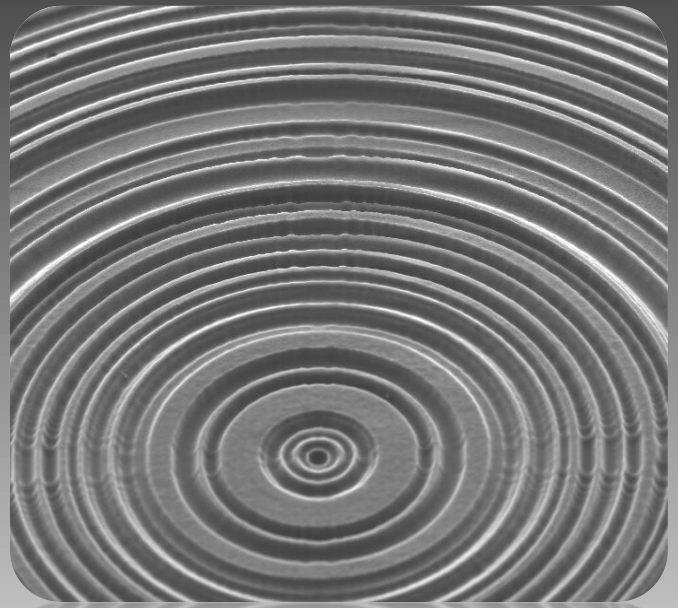
Fresnel lenses



DOE

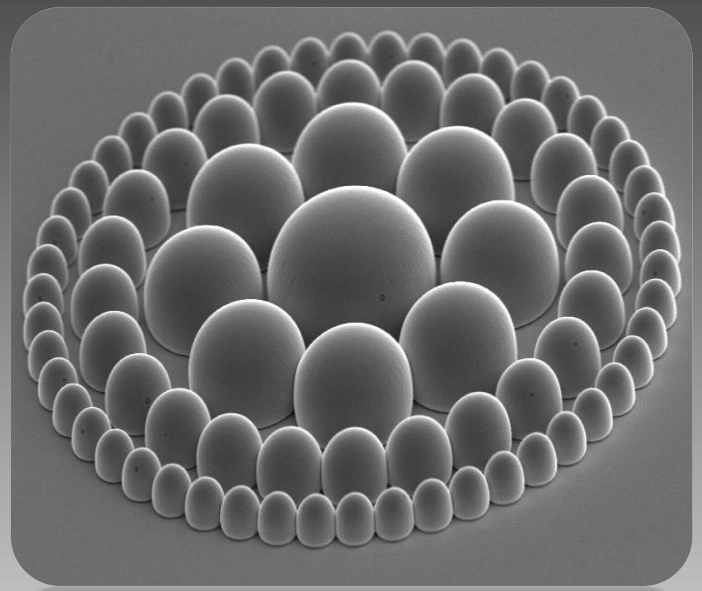


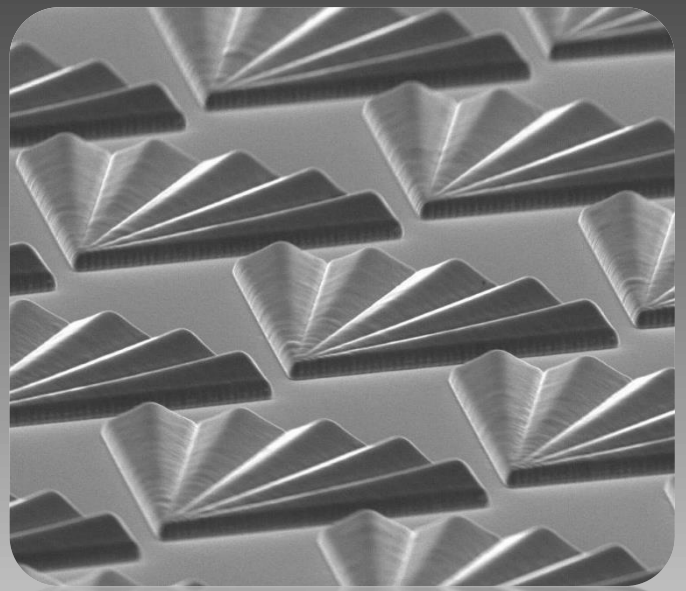
Multi Level Diffractive Flat Lens



*Paper reference - **DOI: 10.1063/5.0012759***

Grayscale: Micro-optic applications



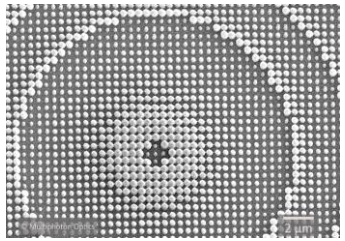
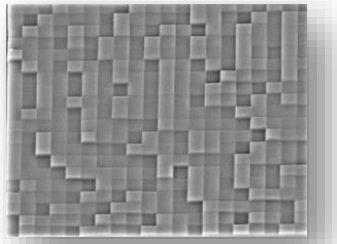
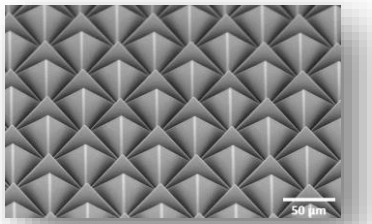
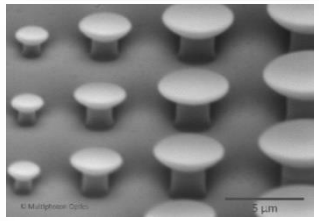


SEM images courtesy of Kuraray & IGI

MPO 100

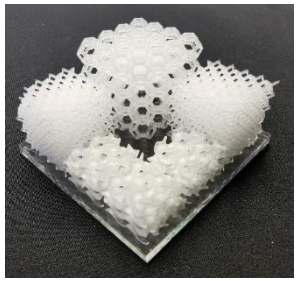
3D Lithography

Applications:
Photonics, Microoptics, ...

3D Microprinting

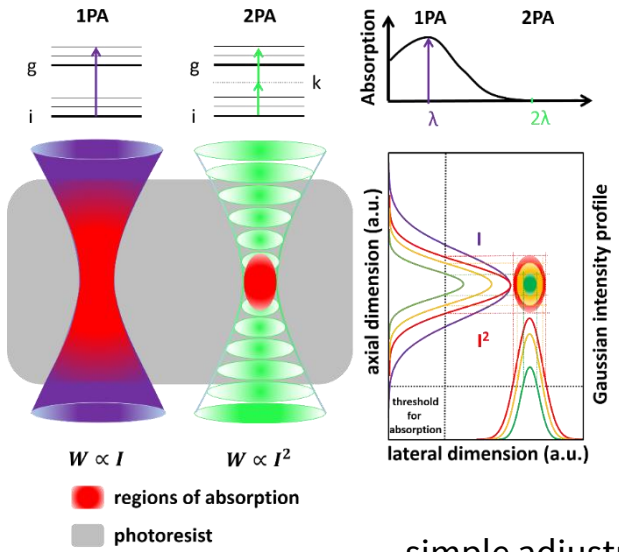
Applications:
µ-fluidics, µ-mechanics, Biomedical, …

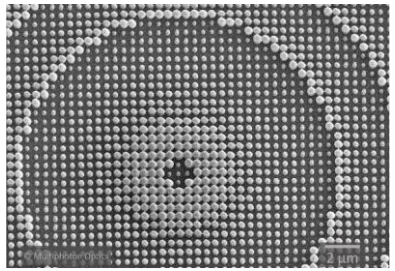




MPO 100 enables…
… 3D Lithography with feature sizes of 100 nm and optical surface quality below Ra = 10 nm
… 3D Microprinting of structures with a height of over 1 cm and maximum scan speeds ≥ 1000 mm/s

Principle of two-photon polymerization

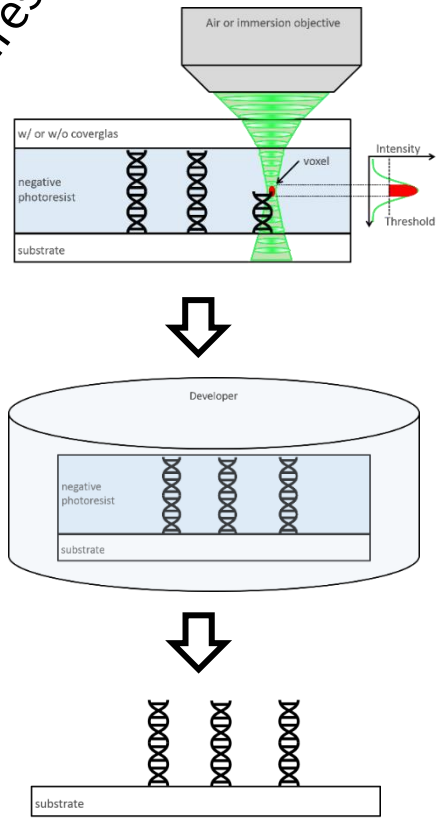
single voxel

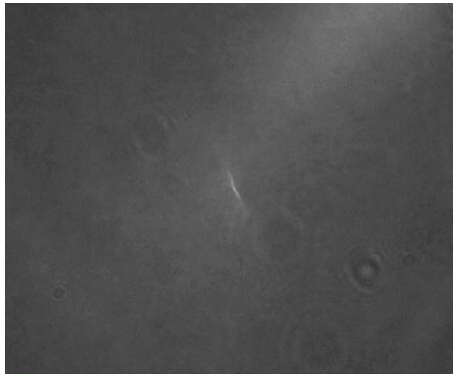


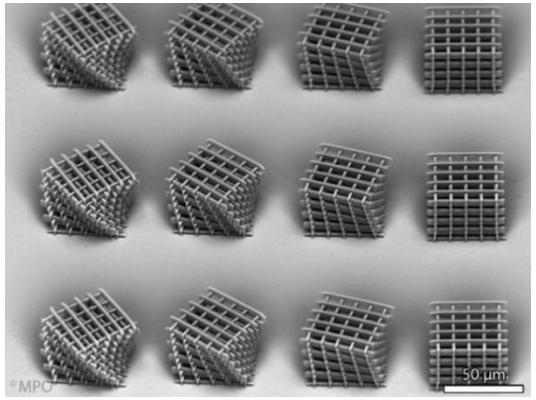


simple adjustment by
laser power & focusing objective

structures







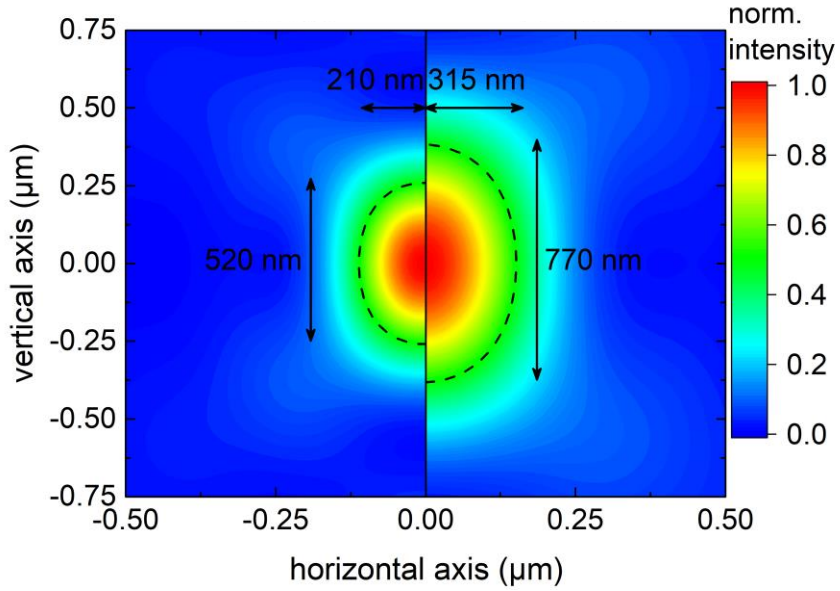
100 nm feature size

Simulation

Intensity Distribution at Focal Point

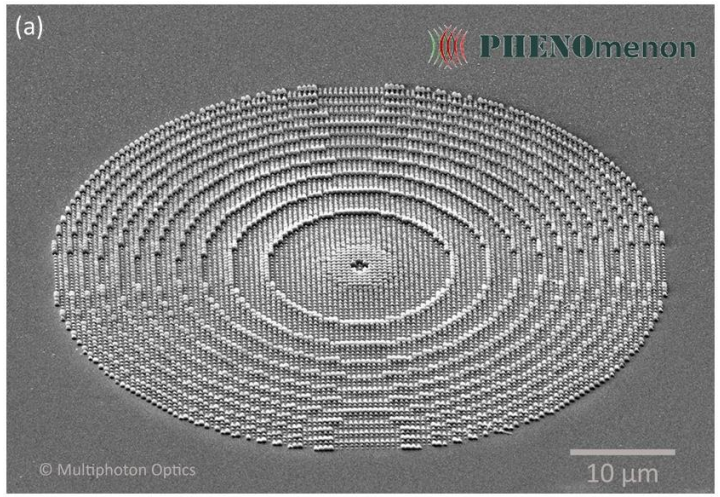
fs laser wavelength:

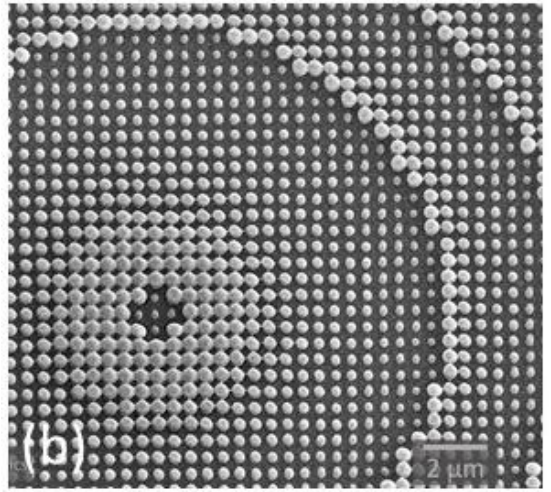
522 nm **780 nm**



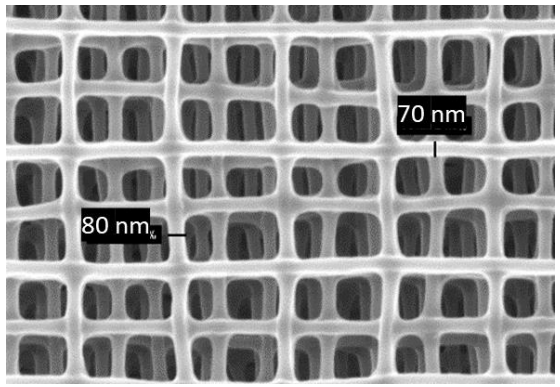
Increase of resolution as by Rayleigh criterion of about 30%

Experiment



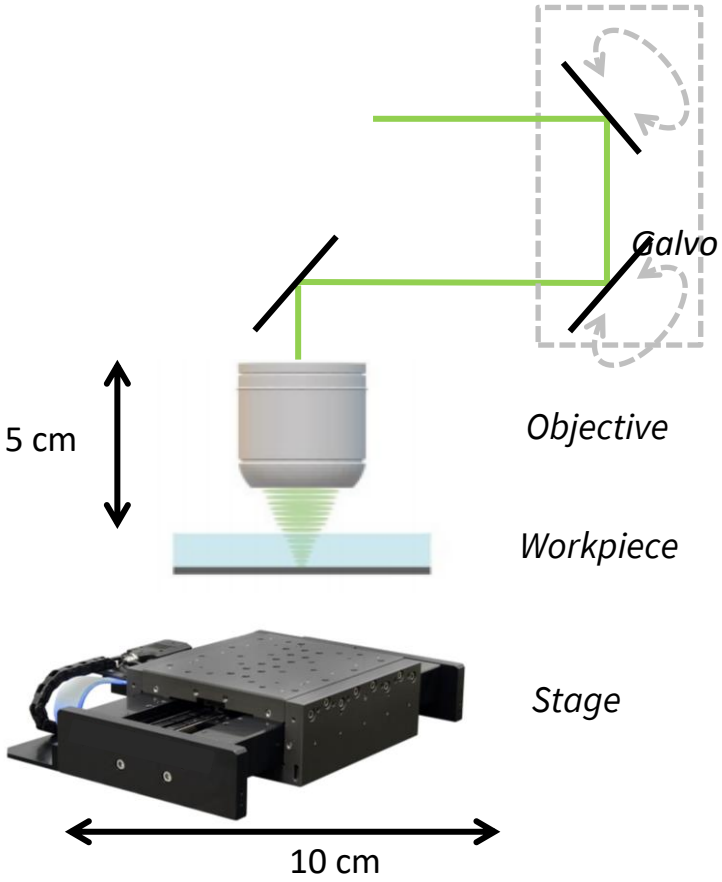


Metalens with 100nm features



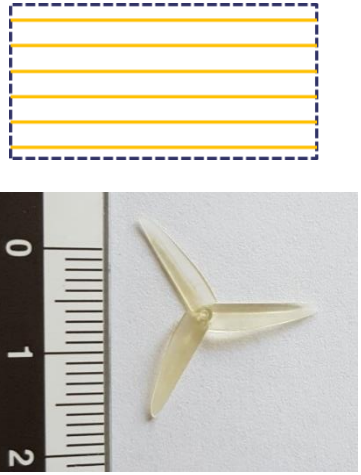
Pushed to the limit:
~75 nm lines
@ 350 nm pitch

Beam, motion & strategies



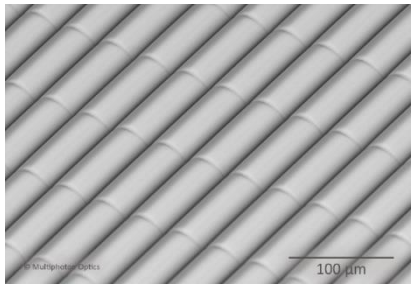
Continuous Scan

Laser focus fixed
Scanning with stage



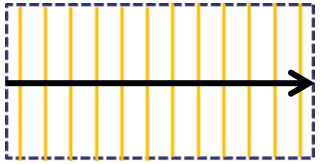
Scan-and-Step

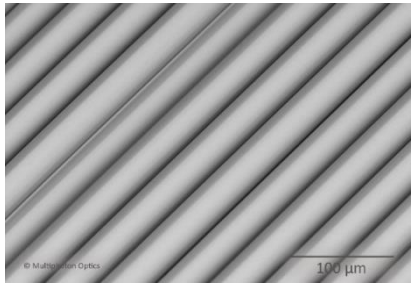
Stage moving in steps
Scanning with galvo



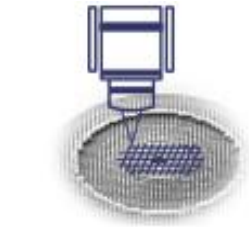
IFoV
Infinite Field-of-View

Stage continuously moving
Scanning with galvo





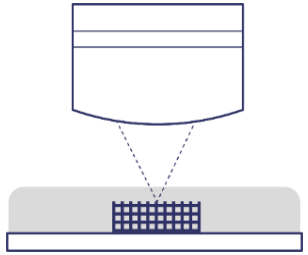
Materials

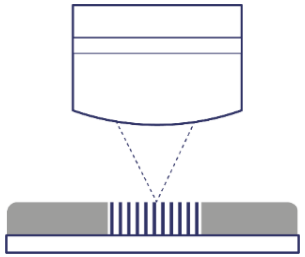


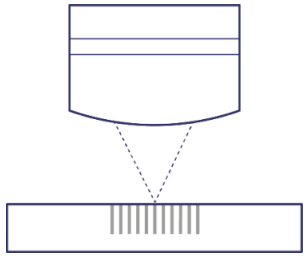
Additive

Subtractive

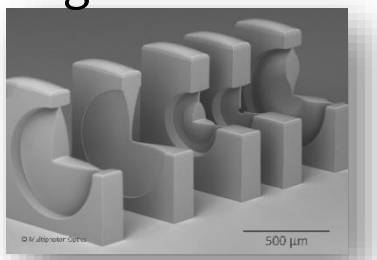
Other



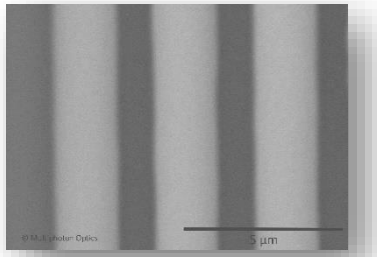




Negative resist



Positive resist

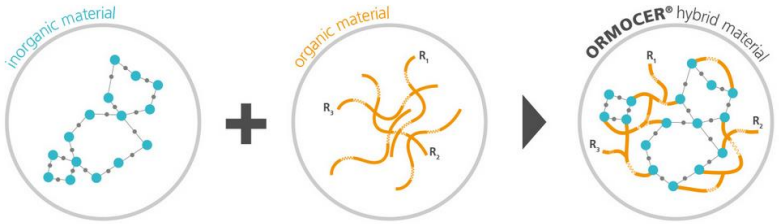


Foturan glass

Customer Use Case

ORMOCER® - ORganically MOdified CERamic

Hybrid polymer with organic and inorganic components



- High thermal and chemical stability
- Very high transmission
- Excellent mechanical properties
- Applicable as functional component
- Long term stability

OrmoComp®

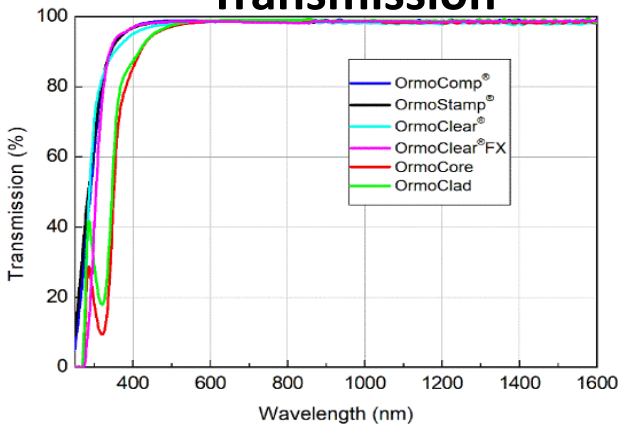
Solvent-free	Yes
Volume shrinkage [%]	5 – 7
RI @ 589 nm (25 °C, cured)	1.520
Abbe number	47
CTE (20-100 °C) [ppm/K]	60
Thermal stability [°C]	270
Oxygen sensitivity	No
Biocompatibility	Yes[1]

[1] J. Tissue Eng. Regen. Med. 2007; 1: 443-449; https://doi.org/10.1002/term.57

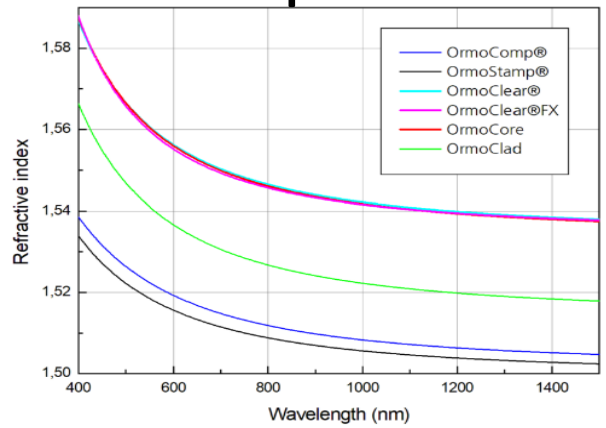
Fraunhofer

micro resist technology

Transmission



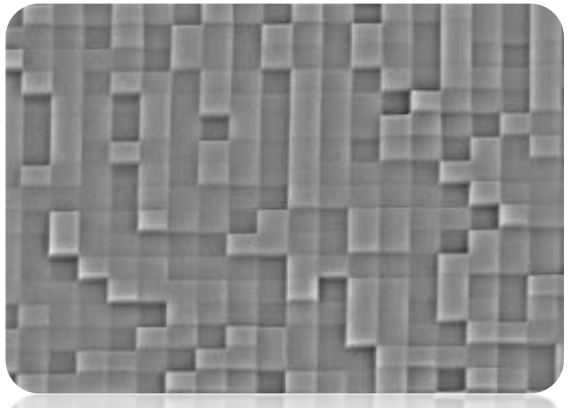
Dispersion



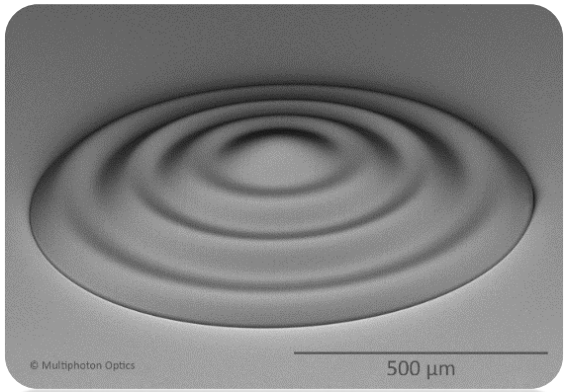
Multiphoton Optics®
a company of Heidelberg Instruments

On Substrate fabrication

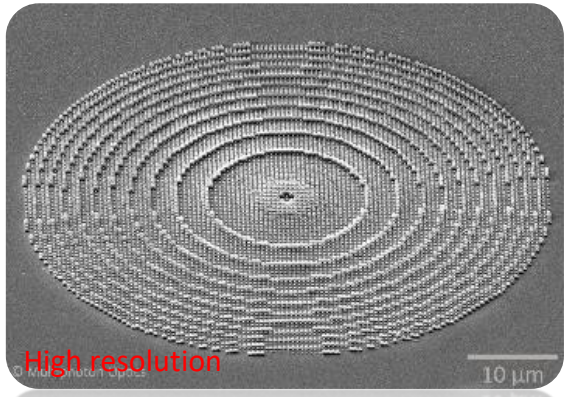
DOE



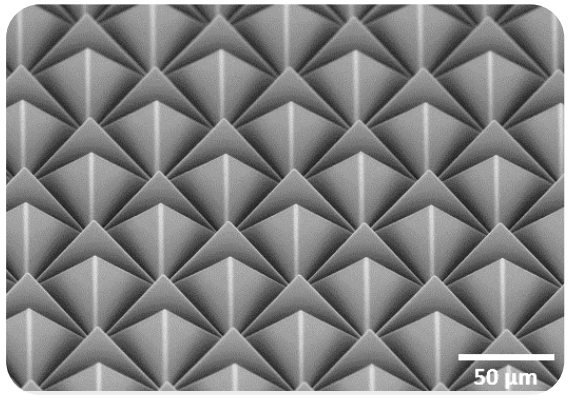
Fresnel lens

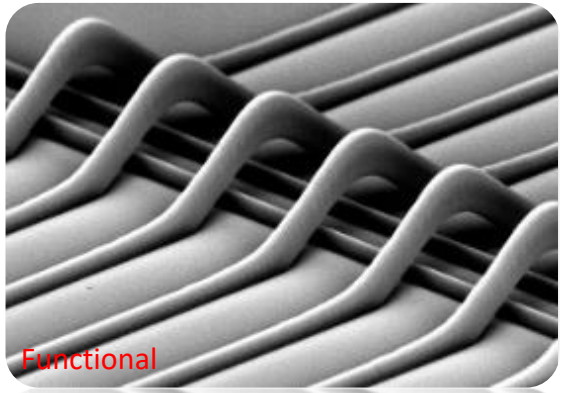


Meta lens



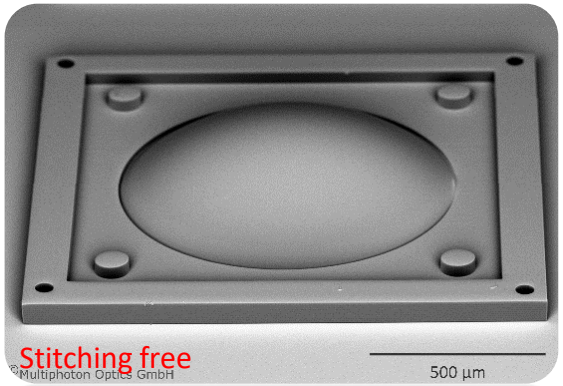
Reflector





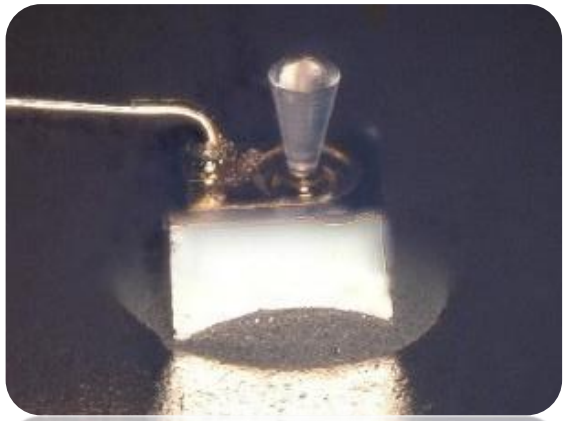
On a substrate, the components can be functional or used as a master (2.5D).

Real 3D, high resolution and stitching free objects can be fabricated.

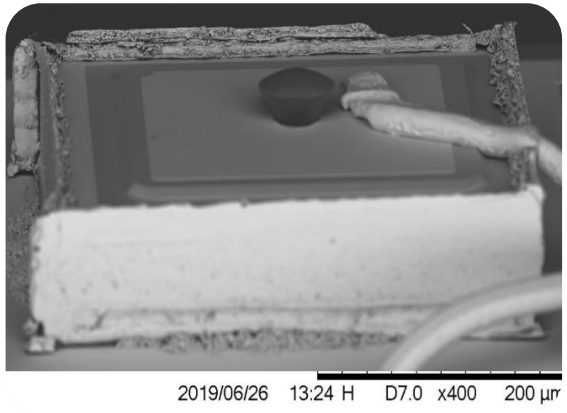


On device fabrication

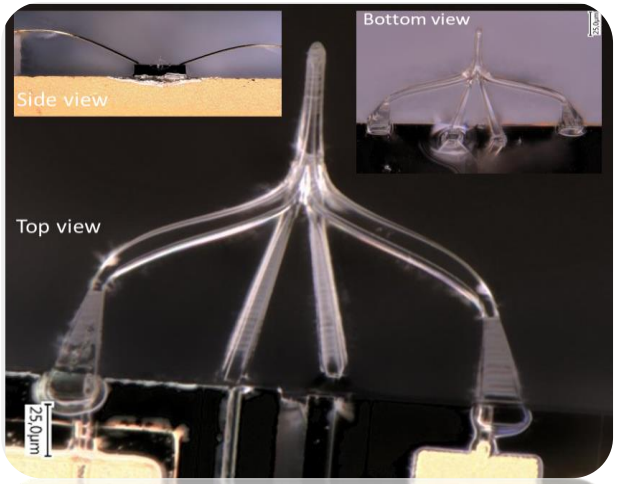
Conic lens on a LED



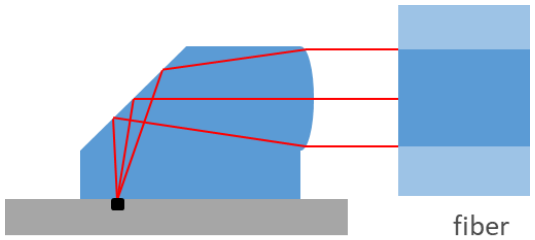
Microlens on a VCSEL

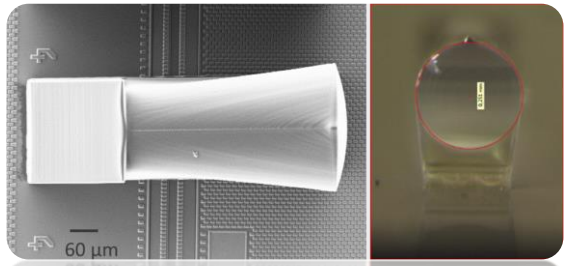


Coupling of 2 lasers with a lens on the output tip

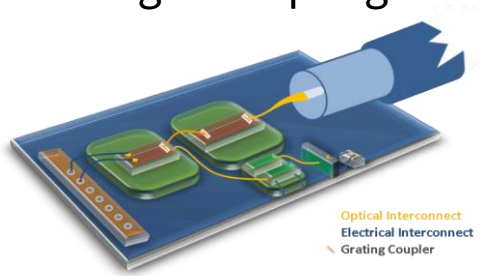


All-in-one micro-mirror & micro-collimator



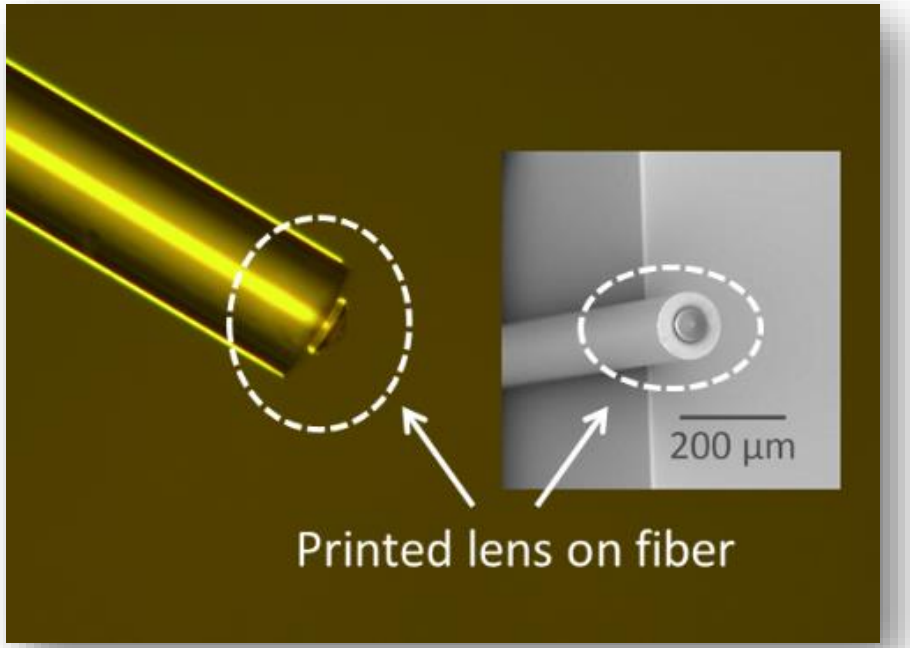


Light coupling

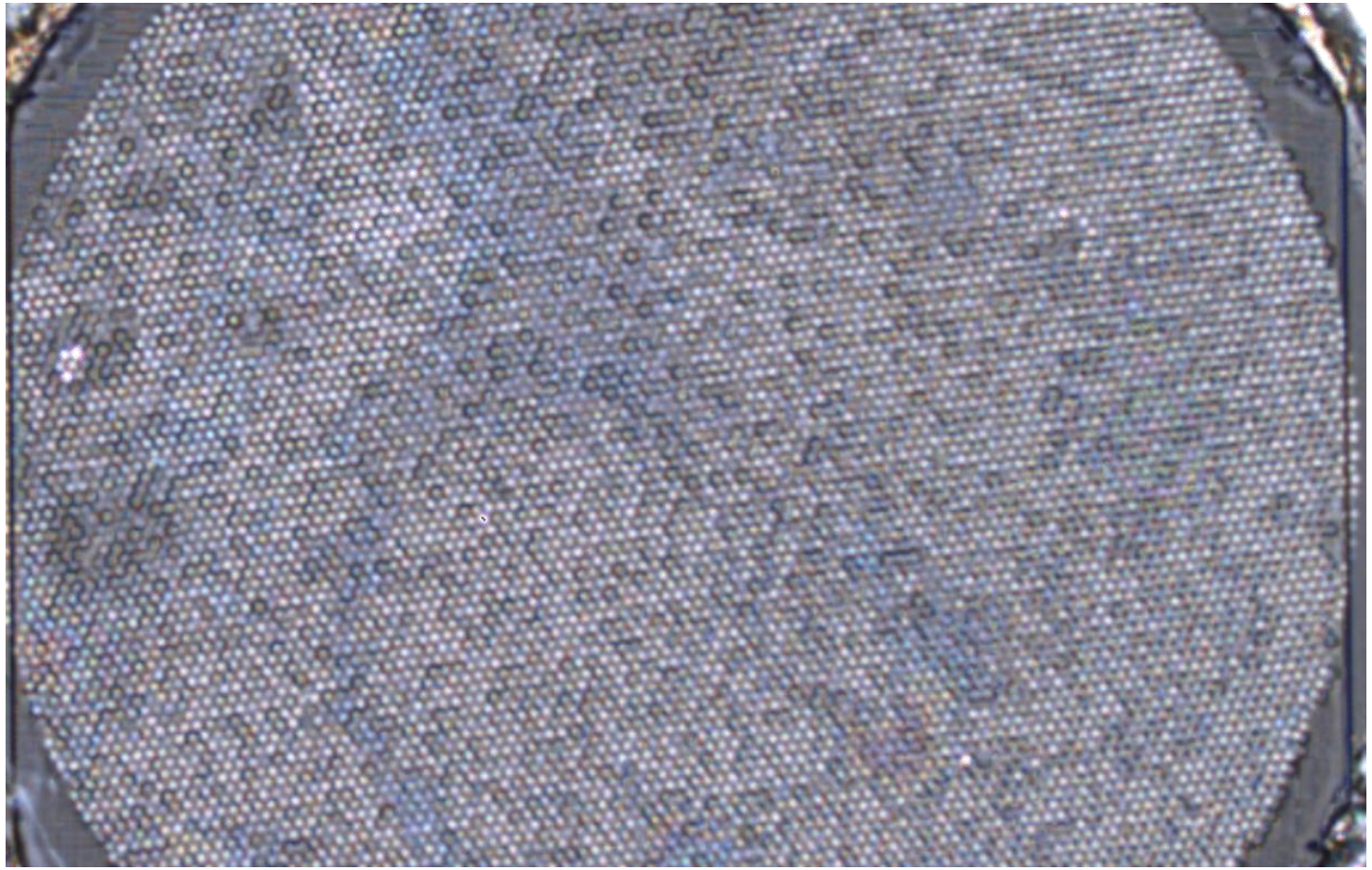


Use cases: endoscopy

Lenses printed on the fiber tip



Phase correcting optical elements on fiber with multicores



THANK YOU!

Dominique.Colle@heidelberg-instruments.de

HEIDELBERG INSTRUMENTS
MIKROTECHNIK GMBH
MITTELGEWANNWEG 27
69123 HEIDELBERG
GERMANY
PHONE +49 6221 728899-0
HEIDELBERG-INSTRUMENTS.COM