

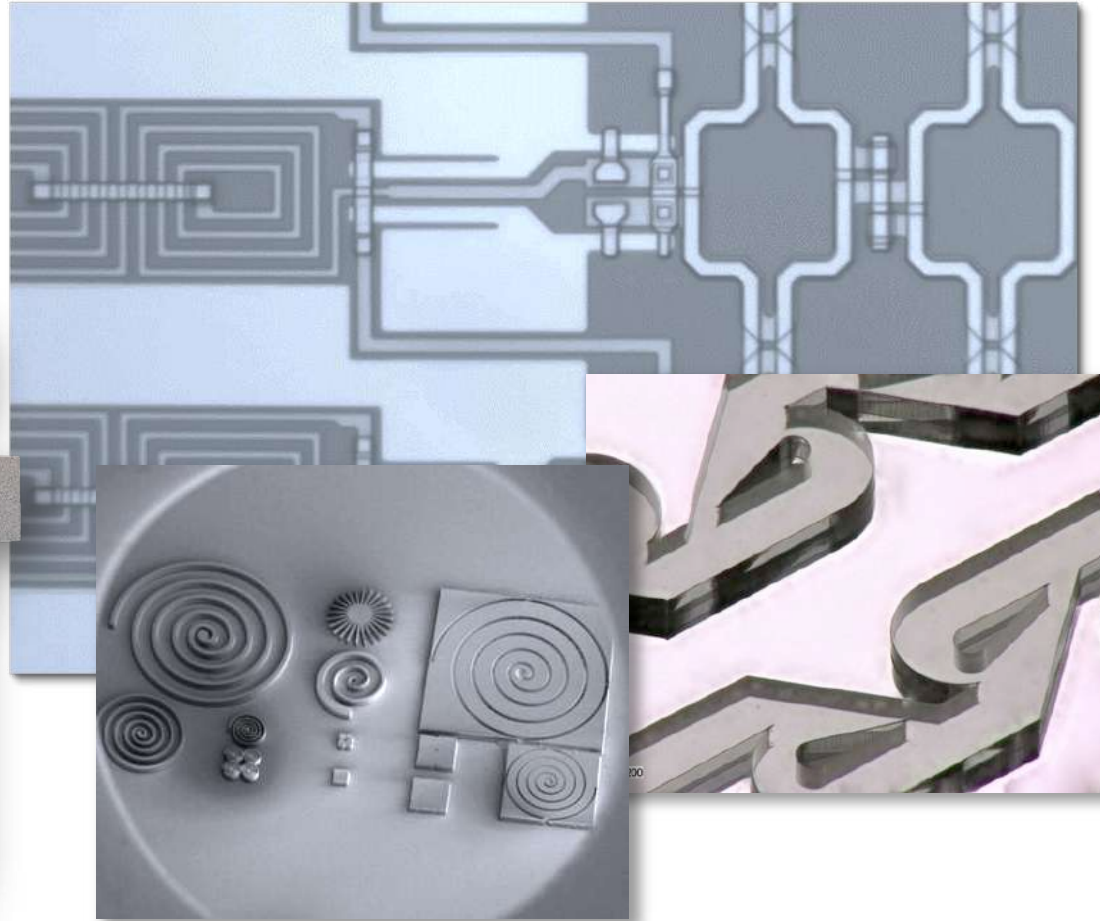
**HEIDELBERG INSTRUMENTS**  
The Power of Direct-Write Lithography

# Heidelberg Instruments Product Portfolio





# $\mu$ MLA – The Tabletop Maskless Aligner



## $\mu$ MLA Key Characteristics

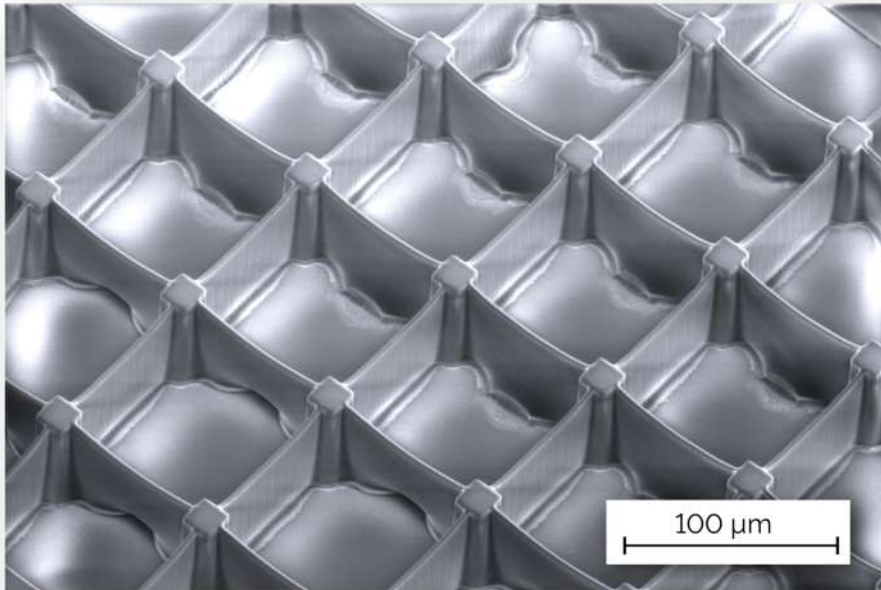
- Versatile
- User-friendly
- Precise
- Economical

## Features and Specifications:

- Raster scan and/or vector mode
- Variable resolution
- Minimum substrate size < 5 mm
- Front side alignment: local 500nm ; global 1000nm
- Minimum feature size 600 nm

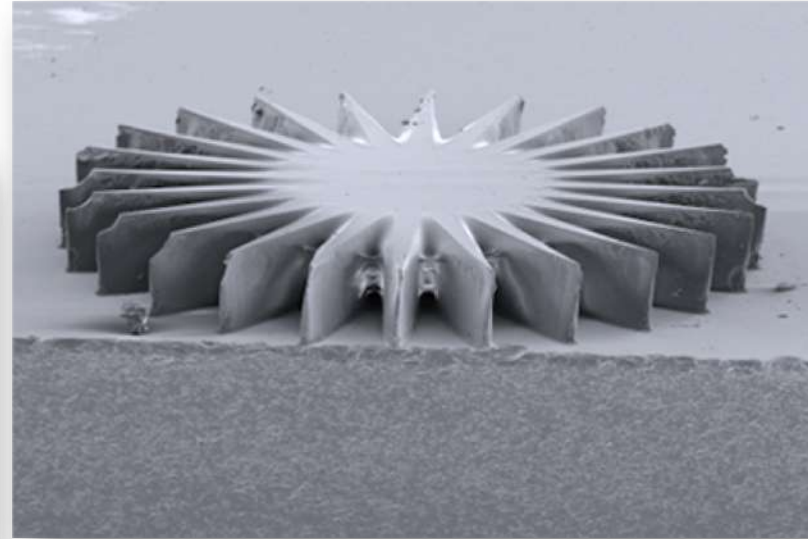


# $\mu$ MLA – Applications



Cage structures (used in biological applications to trap and grow cells)

Courtesy of the University of Hamburg



High-aspect ratio MEMS

Courtesy of P. Pittet and N. Terrier (INL) - Université Lyon 1

Customers:  
Research  
institutions  
worldwide

Research Fields:

- Material research
- Microfluidics
- Lifescience
- Electronics
- Physics



# MLA150 – Advanced High-Speed Maskless Aligner

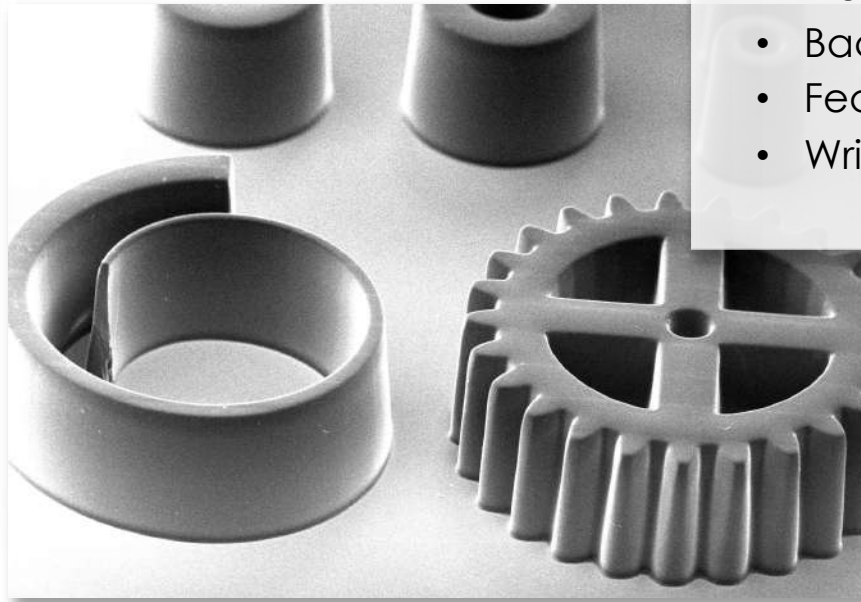


## MLA150 key characteristics

- Fast
- Easy to operate
- Precise
- Versatile

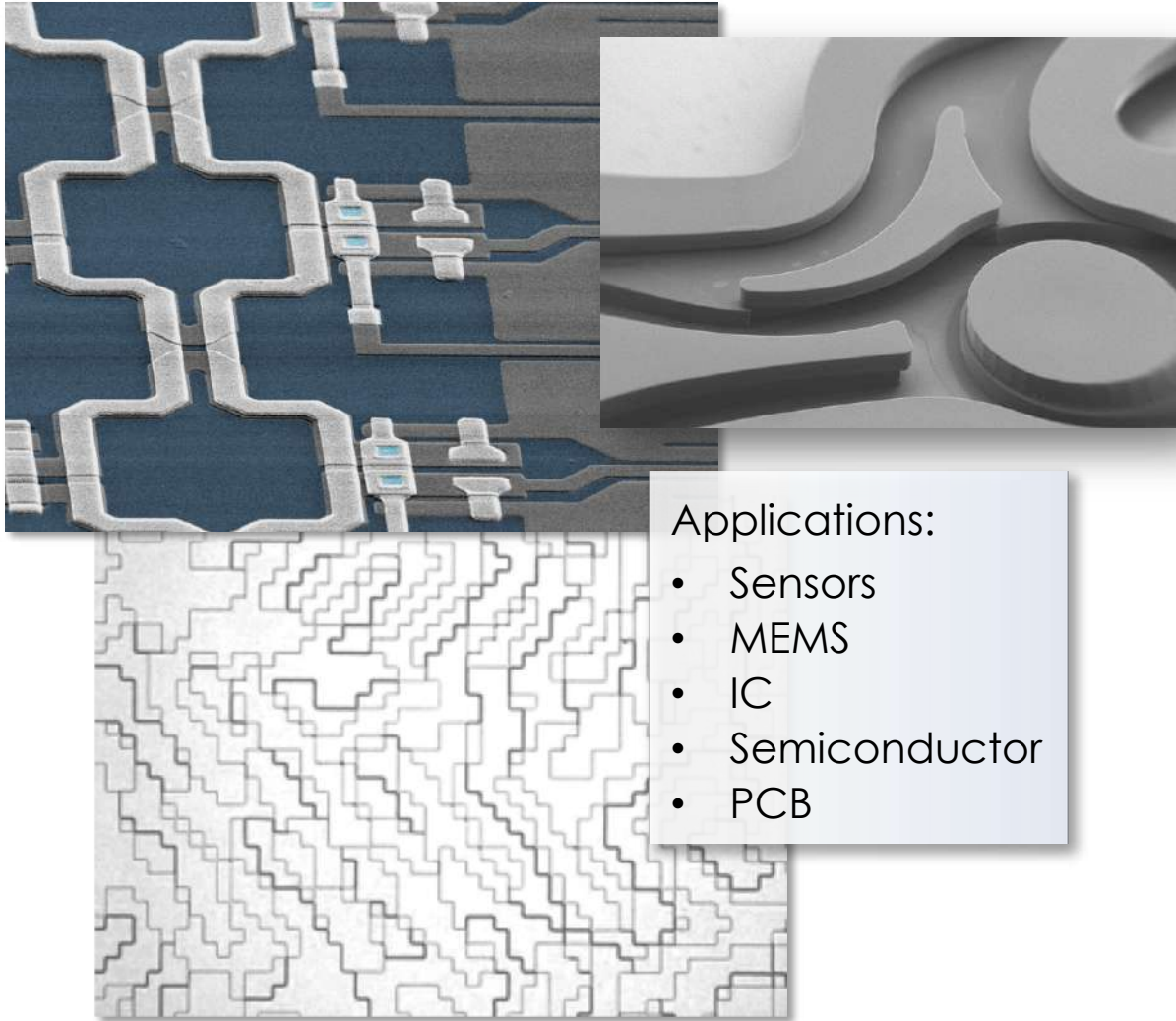
## Features and specifications:

- Multiple high-power diode laser (405 nm / 375 nm)
- Environmental chamber
- Control software with wizard and quick instructions
- Front side alignment  $< 0.5 \mu\text{m}$
- Backside alignment  $< 1 \mu\text{m}$
- Feature size down to  $0.6 \mu\text{m}$
- Write speed up to  $1600 \text{ mm}^2 / \text{min}$





# MLA150 – Applications

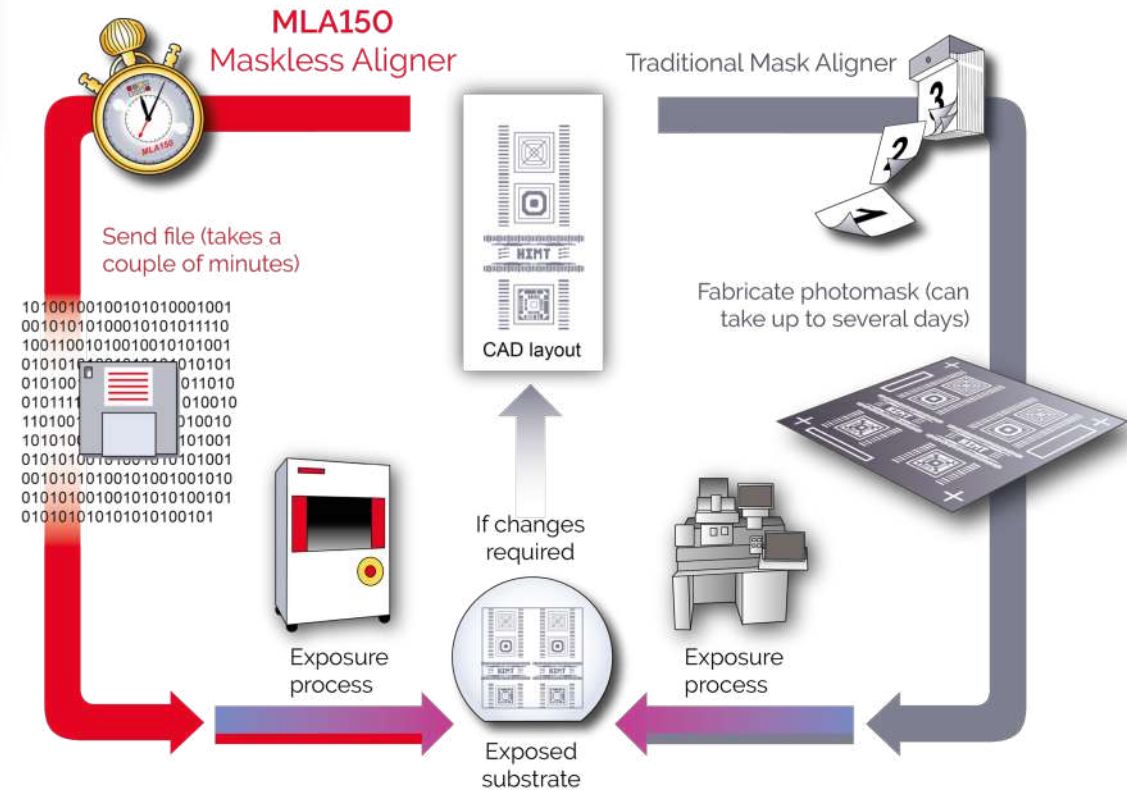


## Applications:

- Sensors
- MEMS
- IC
- Semiconductor
- PCB

## Customers:

Research institutions and mid volume production facilities worldwide



# DWL 66<sup>+</sup> – The Ultimate Lithography Research Tool

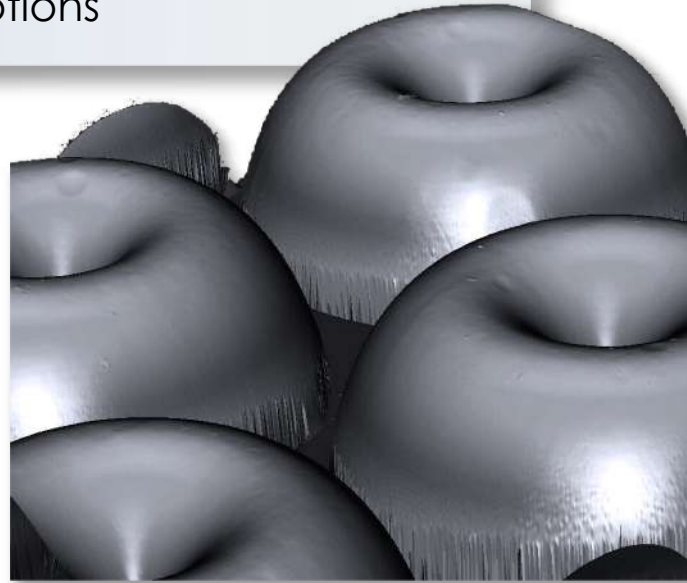


## Characteristics:

- High Resolution
- Grayscale Lithography
- Freeform Capabilities
- Maximum versatility: From basic system to professional advanced options

## Features and specifications:

- Minimum structure size 0.3  $\mu\text{m}$
- Exchangeable write modes
- Front and backside alignment
- Customer specific laser source
- Advanced gray scale exposure mode
- Write speed up to 2000  $\text{mm}^2 / \text{min}$  (WM V)

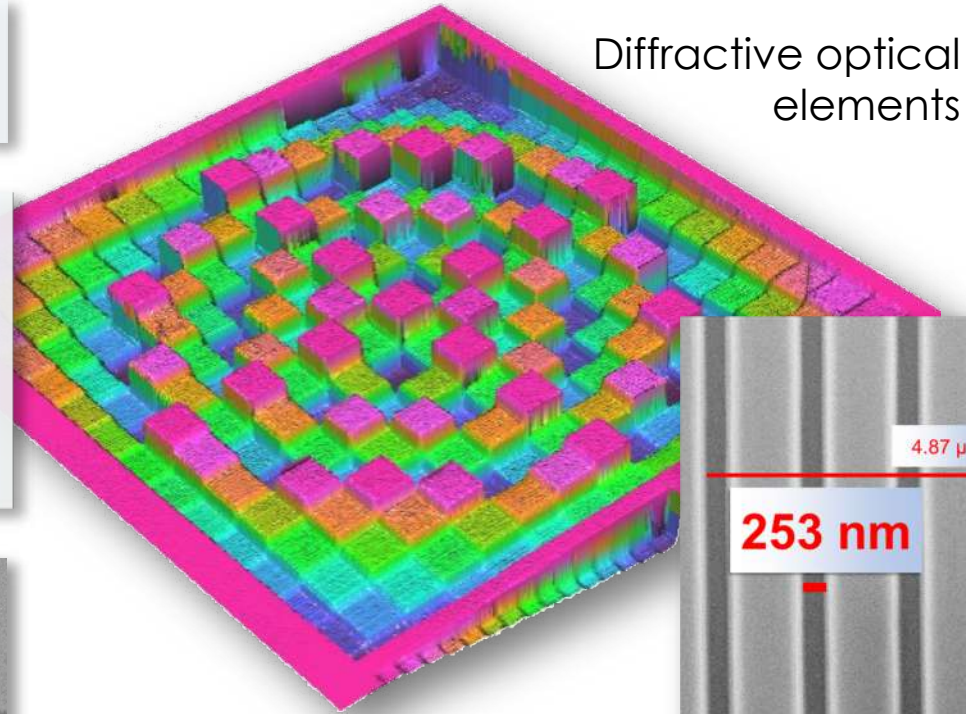


# DWL 66<sup>+</sup> – Applications

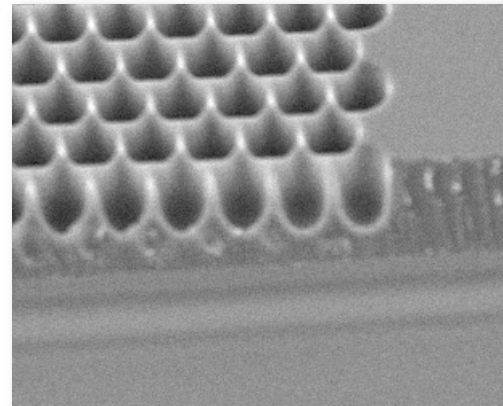


Customers: Research institutions worldwide

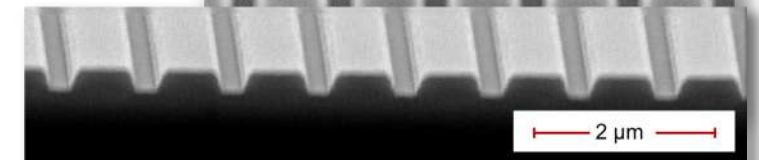
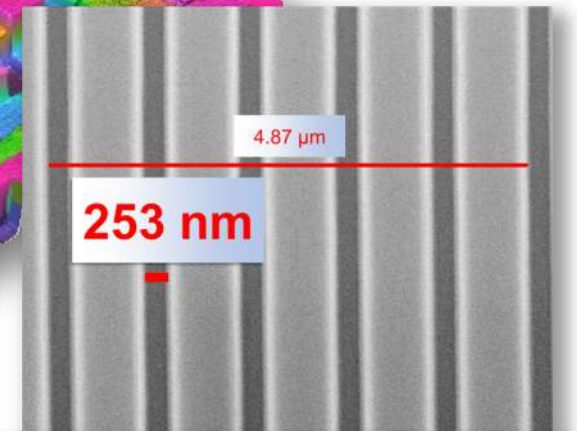
Applications:  
MEMS, BioMEMS,  
micro optics, ASICs,  
micro fluidics, sensors,  
CGHs



Diffractive optical elements



Microlens arrays



High resolution





# DWL 2000GS / 4000GS – The Grayscale Production Experts



## Key characteristics:

- Fast and flexible high resolution pattern generator: From direct writing of 2D and 3D micro structures to mask-making
- The “go to” system for advanced grayscale

## The High Resolution Pattern Generators for Grayscale Lithography

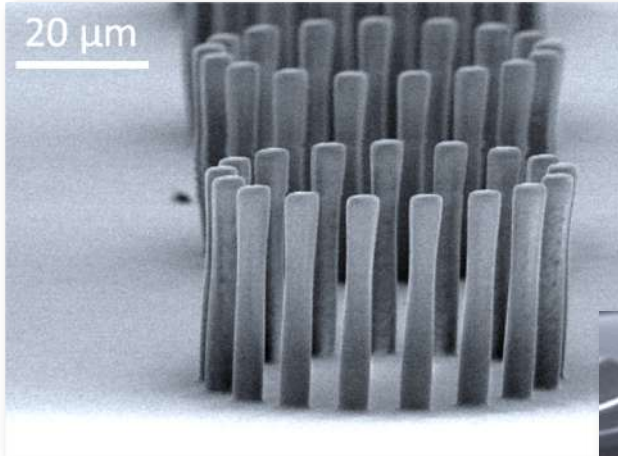
### Features and specifications:

- Professional grayscale exposure mode
- Advanced climate chamber
- Automatic substrate loading system
- Exchangeable write modes
- Maximum write speed: 370 mm<sup>2</sup> / min
- Minimum structure size 0.5 μm



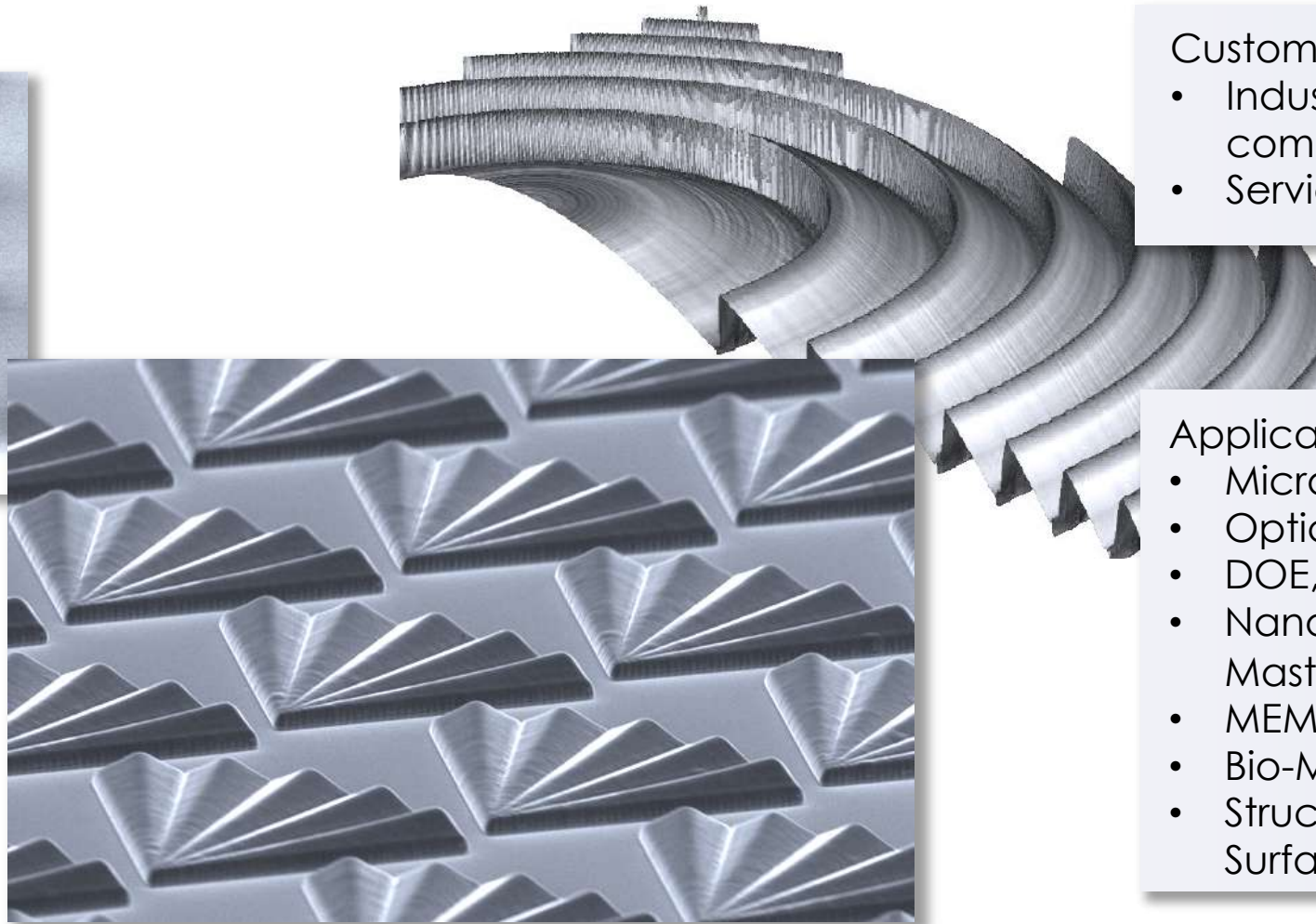
# DWL 2000GS / 4000GS – Applications

High aspect ratio



Courtesy of Dr. Victor Cadarso and Prof. Jürgen Bruckner, EPFL (V.J. Cadarso, et al., J. Micromech. Microeng. 2011)

Grayscale:  
MEMS /  
MOEMS



Grayscale images courtesy of Kuraray

Customers:

- Industrial companies
- Service provider

Applications:

- Micro-Optics
- Optical Films
- DOE, CGH
- Nano-Imprint Master
- MEMS
- Bio-Medicine
- Structured Surfaces



# VPG<sup>+</sup> -Volume Pattern Generator

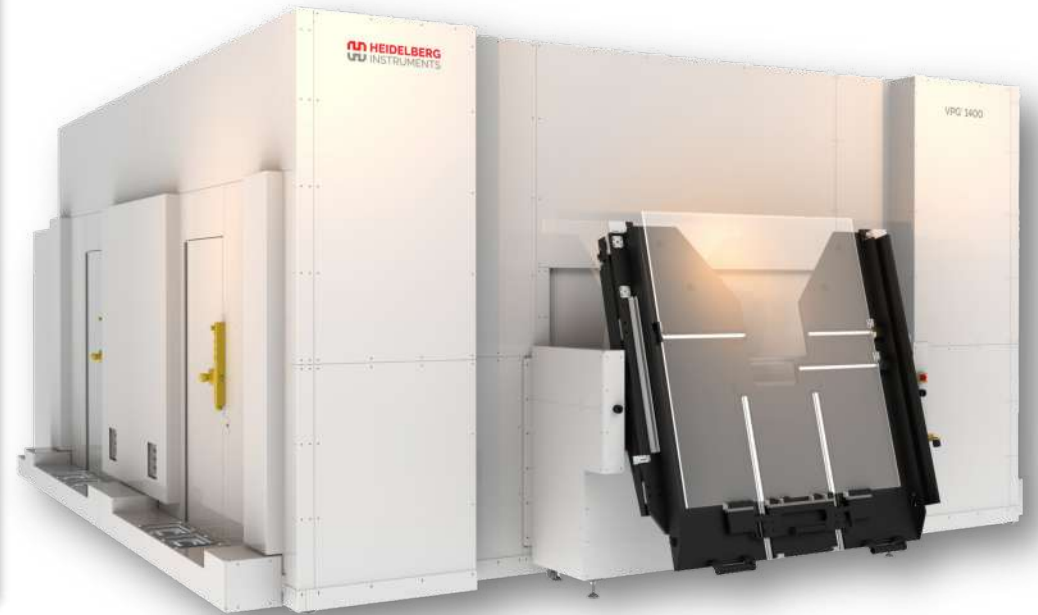


## Features and specifications:

- Ultra-high-speed exposure engine
- Full automization
- High-power i-line pulsed laser
- Powerful data path
- Metrology and alignment capabilities
- Minimum structure size: 0.75  $\mu\text{m}$
- Maximum write speed: 13,500  $\text{mm}^2 / \text{min}$  (WM IV)

## Characteristics:

- The next generation Volume Pattern Generators
- Fastest photomask production tool in the Market

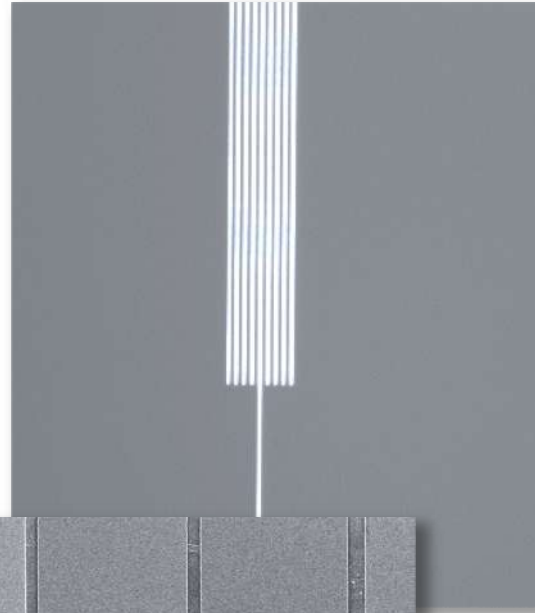




# VPG<sup>+</sup> Small Area – Applications

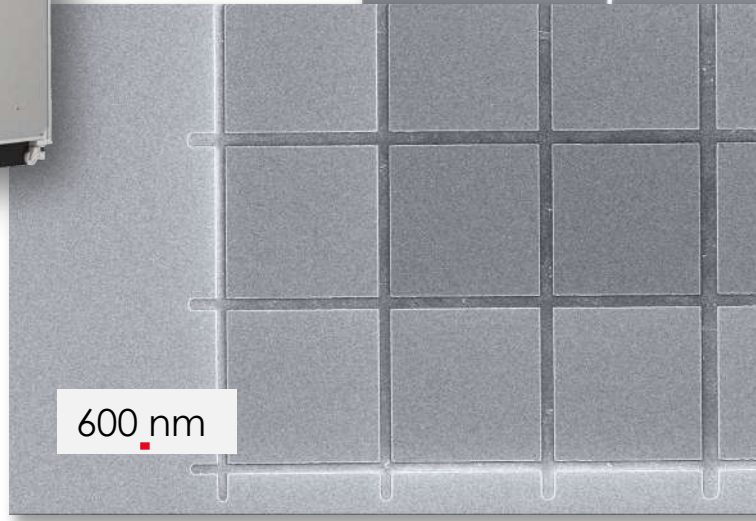


500 nm  
lines  
and  
spaces



Chrome  
mask

600 nm



## Applications:

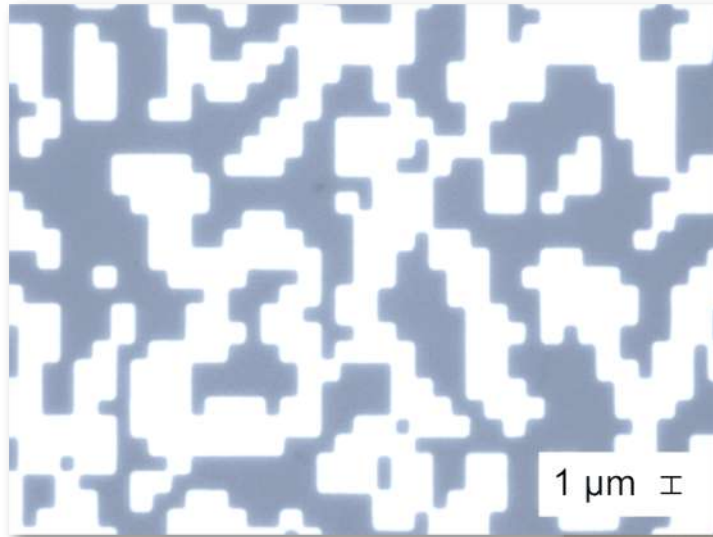
- Photomask Production
- Prototyping
- i-line stepper replacement

## Customers:

- Photomask shops
- High-end research Institutes
- Institutes

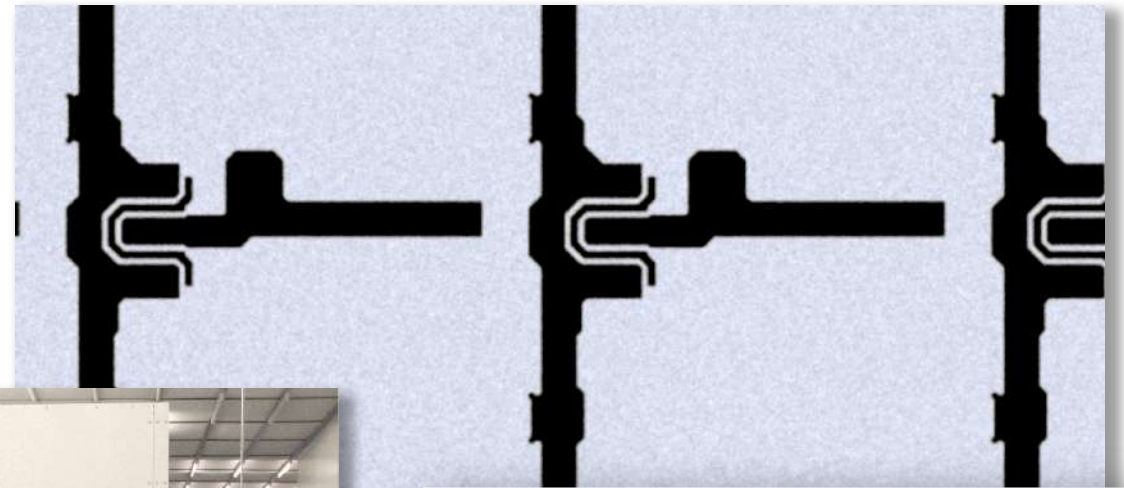


# VPG<sup>+</sup> Large Area – Applications



Computer  
Generated Hologram

GTM  
structures



Photomask  
production



## Applications:

- Industrial photomask fabrication
- large area chrome and emulsion photomasks for Advanced Packaging (3dIC), MEMS, LED
- VPG 1400: Touchscreens, flat panel displays, AMOLED



# ULTRA – The Semiconductor Maskwriter



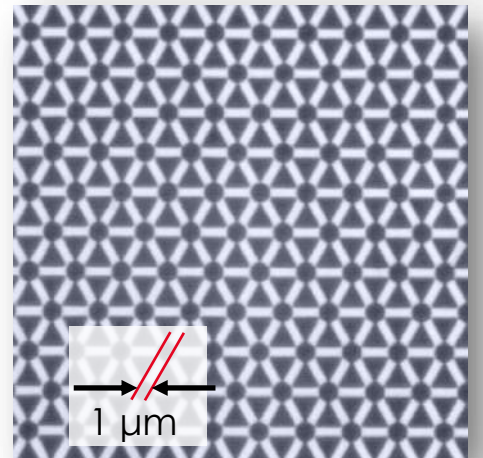
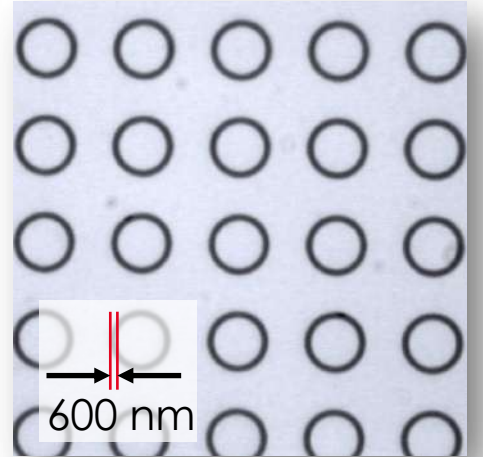
## Characteristics:

### Semiconductor Laser Mask Writer

- High speed
- Low cost of ownership
- Precision
- Stability

## Specifications:

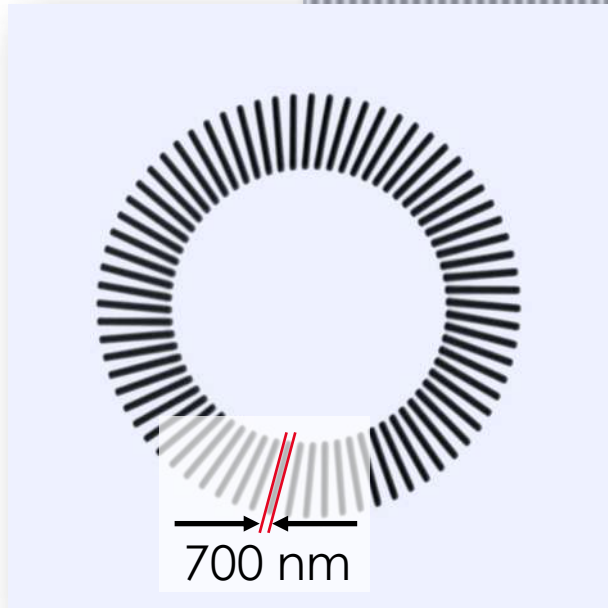
- Minimum feature size:  $0.5\ \mu\text{m}$
- Write speed  $325\ \text{mm}^2 / \text{min}$





# ULTRA – Performance

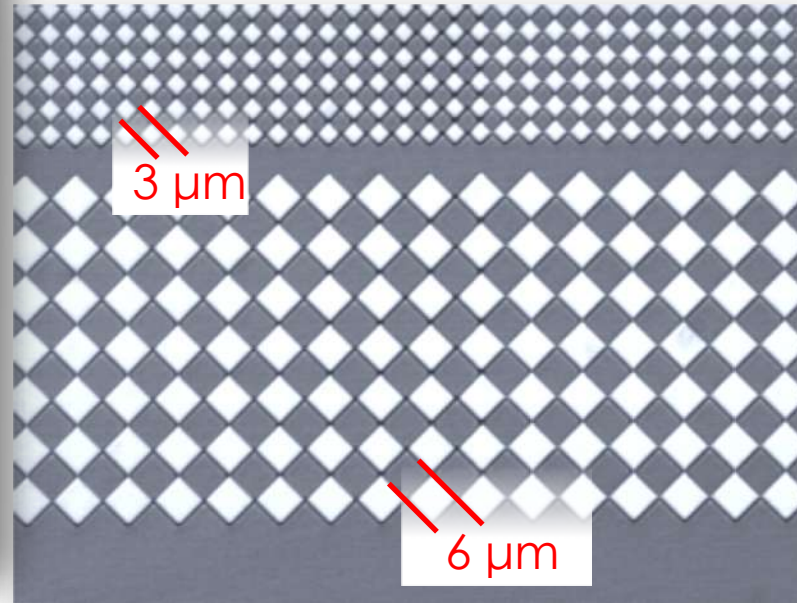
500 nm lines and spaces



	QX mode	FX mode
Address grid [nm]	5	10
Line edge roughness [ $3\sigma$ , nm]	20	40
Position accuracy [ $3\sigma$ , nm]	40	100
Overlay [ $3\sigma$ , nm]	30	60
2nd layer alignment [ $3\sigma$ , nm]	100	100
CD uniformity [ $3\sigma$ , nm]	30	60
Minimum feature size [nm]	500	700
Write speed [ $\text{mm}^2 / \text{min}$ ]	325	580
Write time for 6" x 6" [min]	75	45



# MLA300 – The Maskless Aligner for Volume Production



## Characteristics:

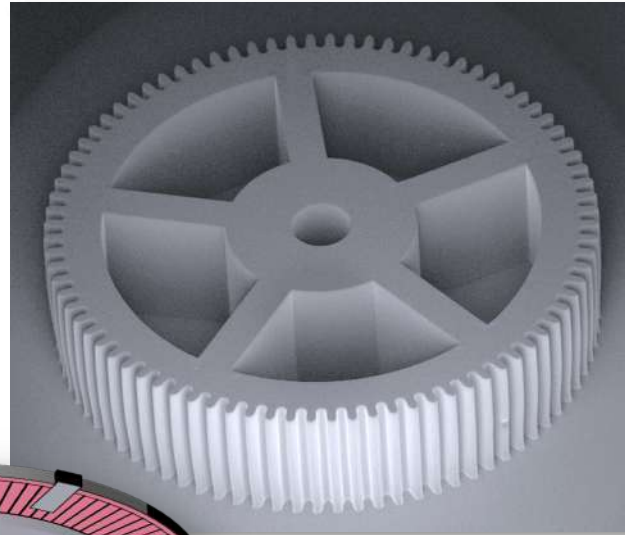
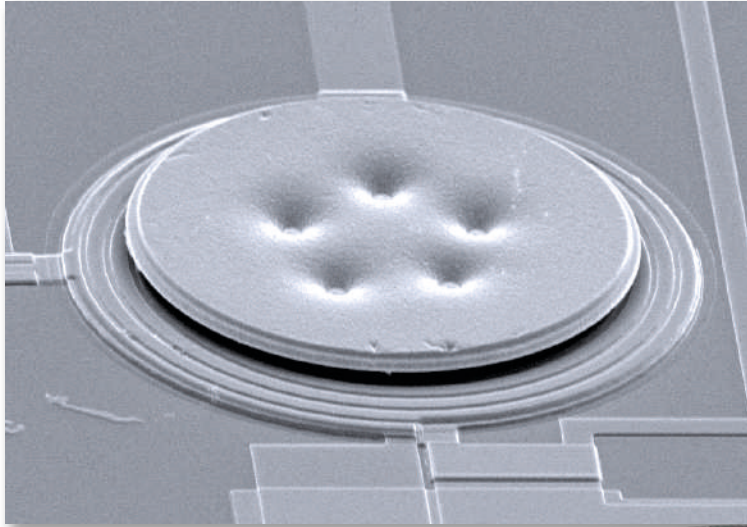
- Maskless Lithography for Volume Production
- Warped substrate handling
- High precision and overlay accuracy
- Dynamic distortion correction
- Low cost of ownership

## Features and specifications:

- Wafer robot with multiple loadports
- Advanced alignment
- Laser wavelength: 375 nm and 405 nm
- High power diode laser with long life-time
- Alignment accuracy [ $3\sigma$ ]: 500 nm
- Pattern placement [ $3\sigma$ ]: < 500 nm
- Minimum feature size: 2 μm



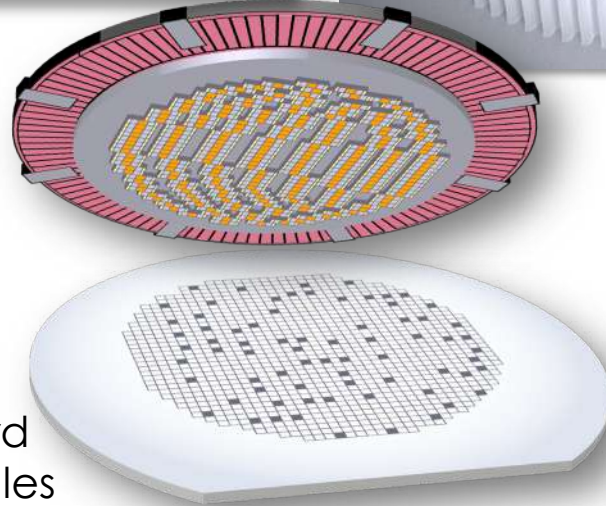
# MLA300 – Applications



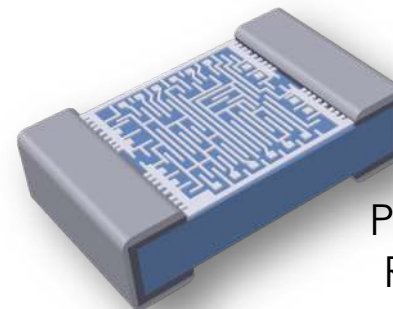
Micro-mechanical components: Gearwheel

## Sensors

Image courtesy of Kirchhoff-Institute for Physics, Heidelberg



Probe card with needles



High-Precision Resistors

## Applications

- Advanced semiconductor packaging (3DIC)
- IR-Sensors
- Photovoltaic
- Electronic probes
- High precision analog electronic components
- ... and many more





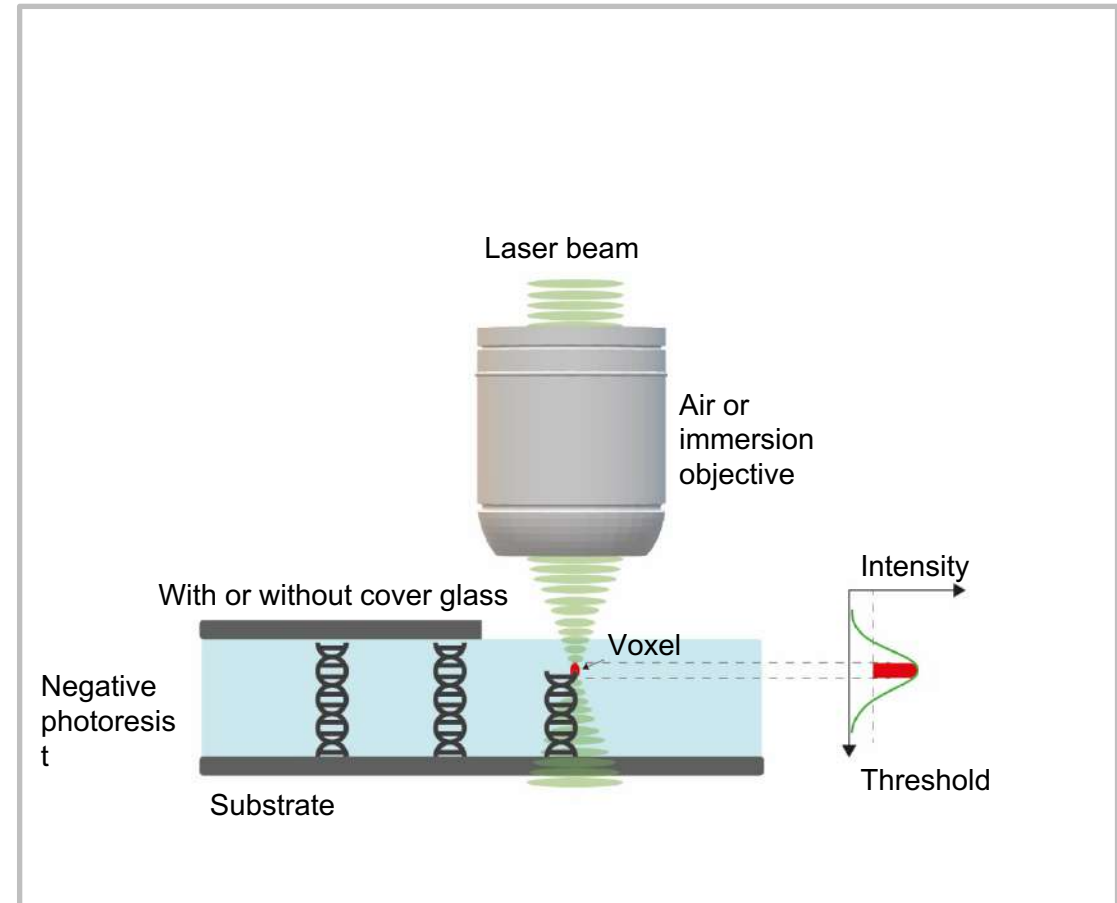
# MPO100

Two Photon Polymertization





- Two-Photon Polymerization (TPP) is a **Direct Laser Writing (DLW)** technology. With TPP, the light-matter interaction only takes place within the volume of a **focused laser spot**.
- The simultaneous **absorption of two photons** in the focused spot triggers the **locally confined polymerization** of an exposed photoresist.
- The laser focus can be moved through the volume of the photoresist along all three spatial dimensions. **Complex 3D structures are written along the laser's trajectory**, using light like a brush.
- Thanks to its versatility, TPP fabrication has applications in many fields, including **micro-optics, photonics, micro-mechanics and biomedicine**.



*Simplified illustration of the Two-Photon Polymerization (TPP) process.*

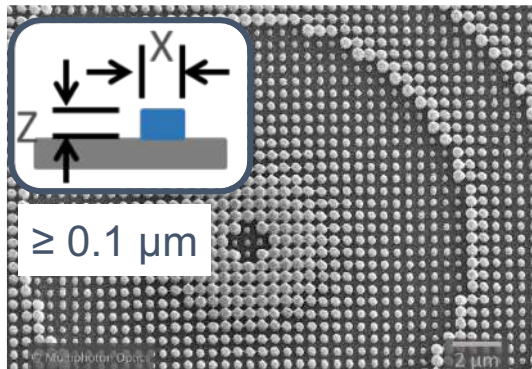
# MPO TPP Fabrication Process | Unparalleled design freedom



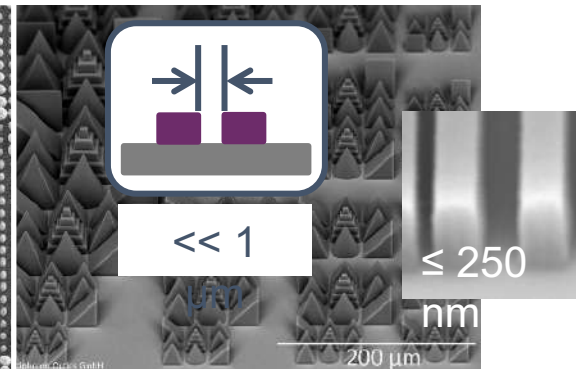
## Nano – Micro – Meso – Macro

Multiphoton Optics' technology removes limitations in design and enables the creation of free-form 3D structures on virtually any substrate including active devices.

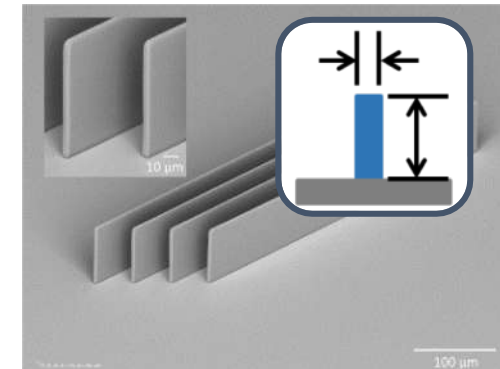
**Features sizes can be as tiny as  $0.1\ \mu\text{m}$**



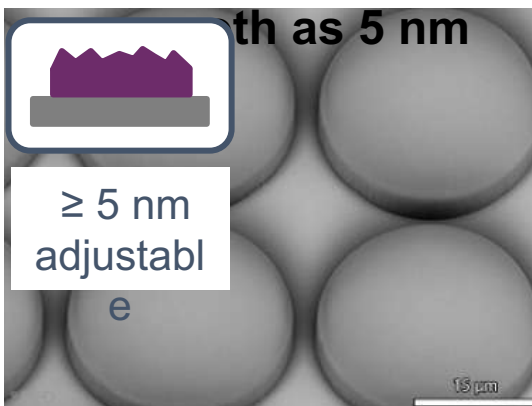
**Objects can be much closer than 1**



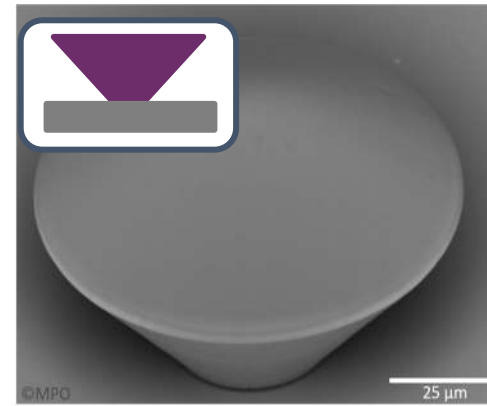
**Extreme aspect ratios of 16:1 and**



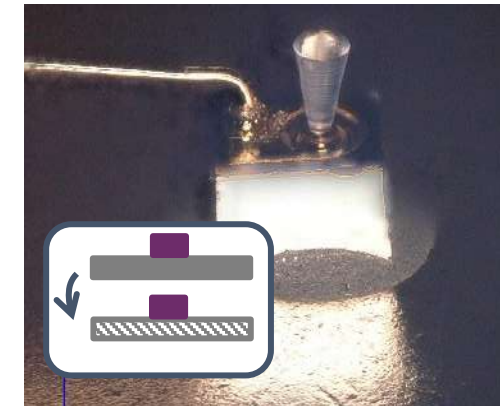
**Achievable roughness can be adjusted as**



**Overhangs do not require supporting**



**Substrate can be chosen**





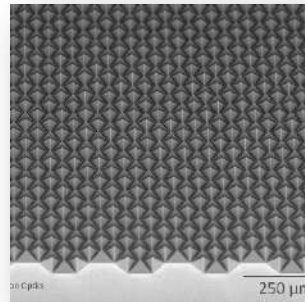


MPO has developed and optimized processes to produce **basic functional structures** that can be integrated in a variety of components.

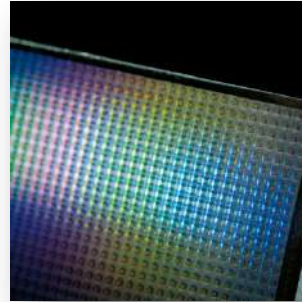
**Microlenses/  
microlens  
arrays**



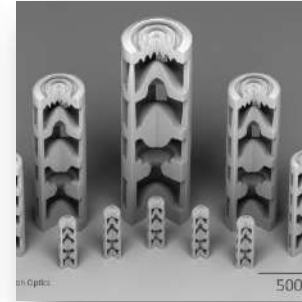
**Prisms (2.5D)**



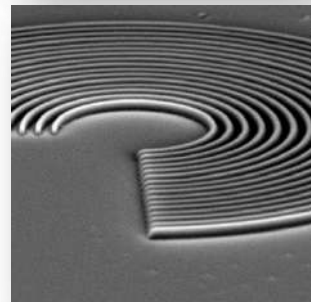
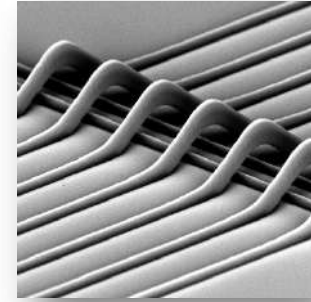
**DOEs/  
diffusers**



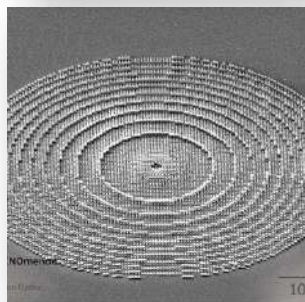
**Free-form lens  
stacks**



**Waveguides**



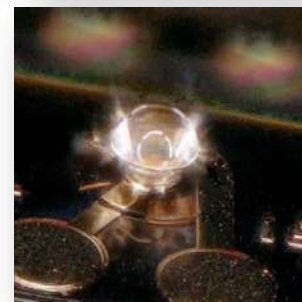
**Gratings**



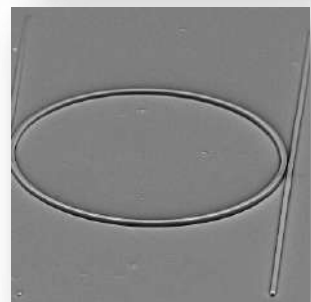
**Meta  
structures**



**Filters/scaffold  
s**



**Microlens on  
active device**



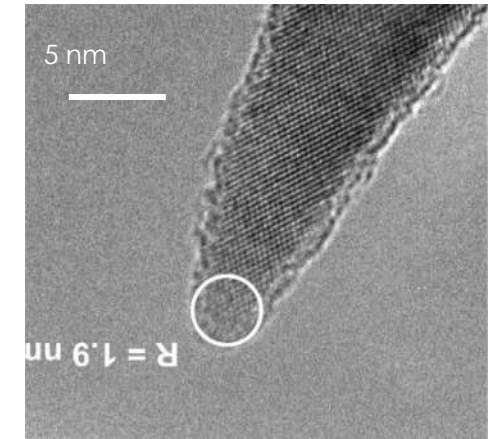
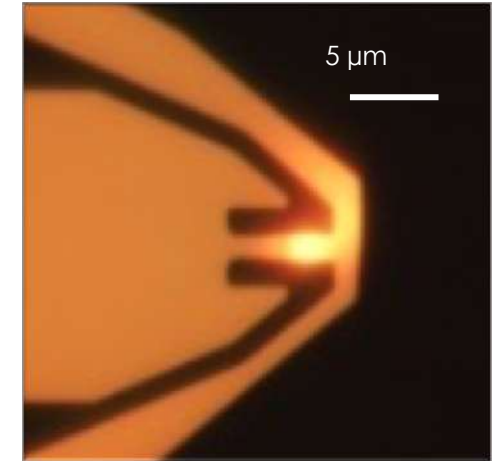
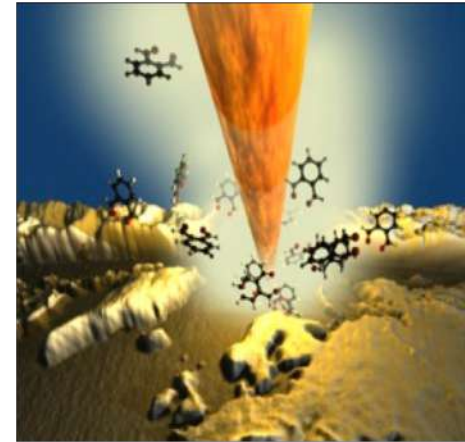
**Resonators**

# Heidelberg Instruments Nano (SwissLitho AG)

## Thermal Scanning Probe Lithography

### Core Technology

- » NanoFrazor Cantilever: Ultra-sharp Silicon tip with Integrated heater
- » Direct removal of resist by local heat
- **Closed-Loop Lithography**  
In-situ inspection and metrology while writing
- **3D (grayscale) lithography**  
Unprecedented resolution and accuracy below 1 nm
- **No damage during lithography**  
Crucial for new 2D and quantum materials and devices
- **Ultra-high resolution**  
Below 10 nm (half-pitch) demonstrated



# Heidelberg Instruments Nano (SwissLitho AG)

## Products



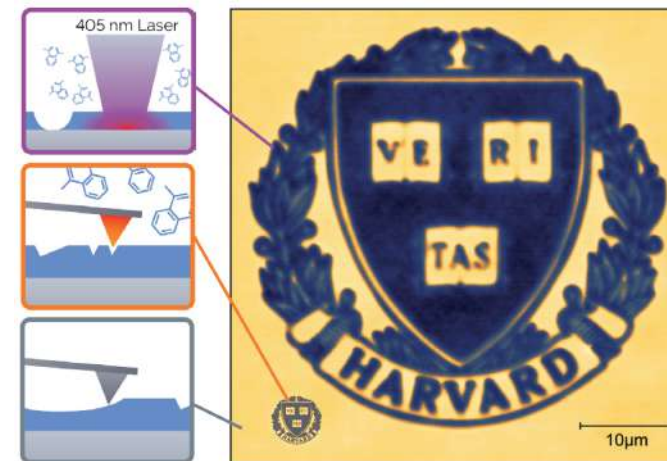
NanoFrazor Explore



NanoFrazor Scholar

### Hybrid NanoFrazor with integrated laser writer

- » Laser writing for micro, tip-writing for nano
- » High speed AFM for inspection
- Ideal combination for rapid-prototyping



Nano and Micro  
"Harvard Logos"  
written and imaged  
by NanoFrazor



# NanoFrazor Applications

Extension and/or alternative to electron beam lithography:

## Rapid-prototyping of nanostructures and devices

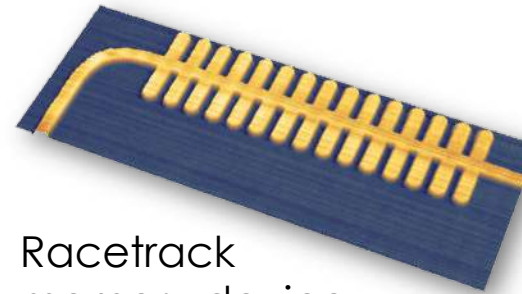
Mix & match lithography with other techniques

## Master fabrication

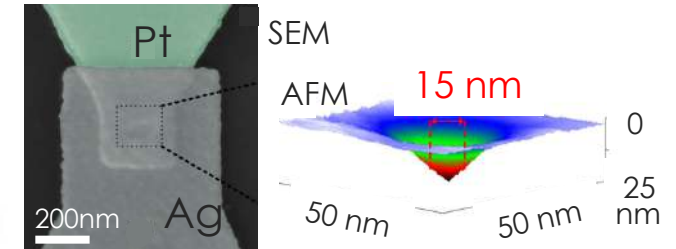
Nanoimprint stamps

## Small area manufacturing

E.g. critical part of a sensor

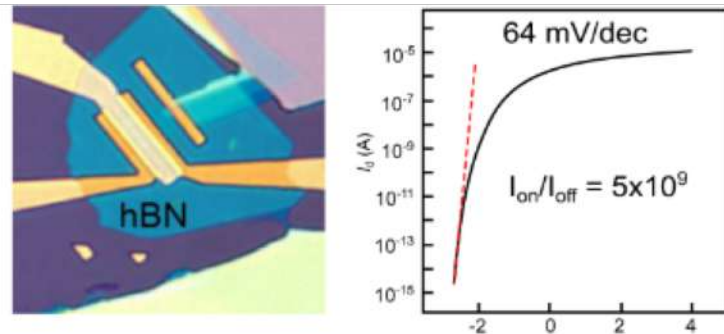


Racetrack memory device



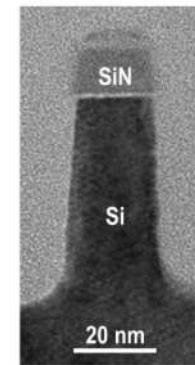
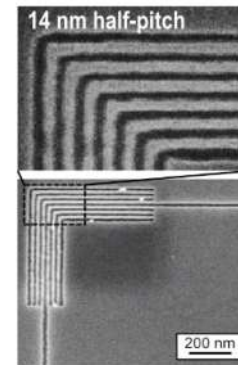
Atomistic Memristors

ETH Zurich., Nature Comm. Phys, 2019



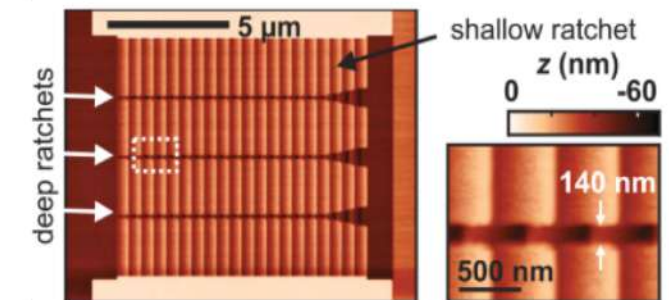
Record MoS<sub>2</sub> transistors

NYU, Nature Electronics, 2019



Silicon nanostructures

imec, ACS Nano, 2018



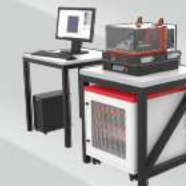
Nanofluidic Brownian Motors

IBM, Science, 2018

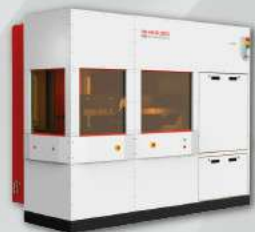




VPG+ 1400



SCHOLAR



ULTRA



EXPLORE



DWL 2000 GS



MLA 150



DWL 66+



MPO 100



MLA 300



µMLA



