

Fotonica Pilotlijnen – toelichting VUB infrastructuur

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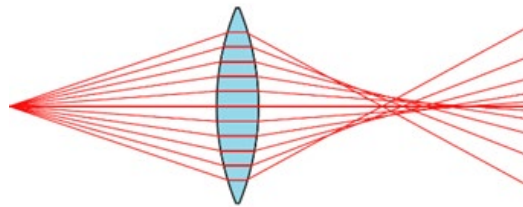
Inauguratie Fotonica Pilotlijnen

Woensdag 23 november 2022

Freeform optics: a revolution in photonics!

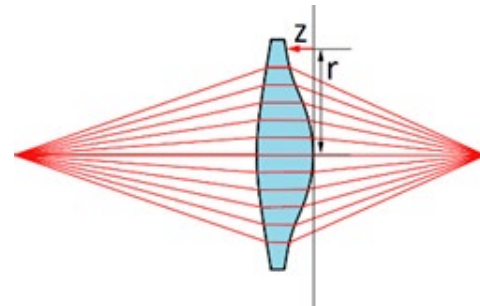
Rotationally
Symmetric

Spherical lenses



Spherical aberration
+ other distortions

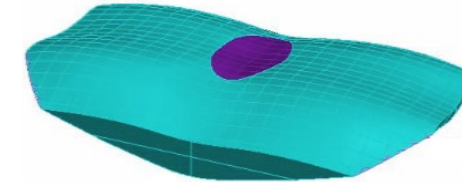
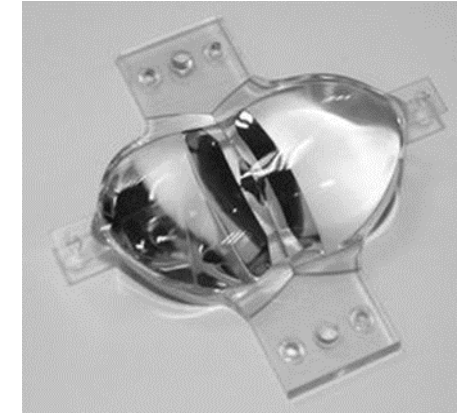
Aspherical lenses



No spherical aberration
+ other distortions

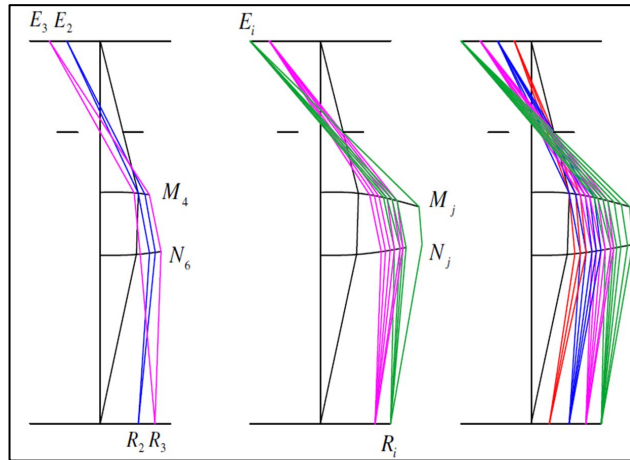
Non-Rotationally
Symmetric

Freeform optics

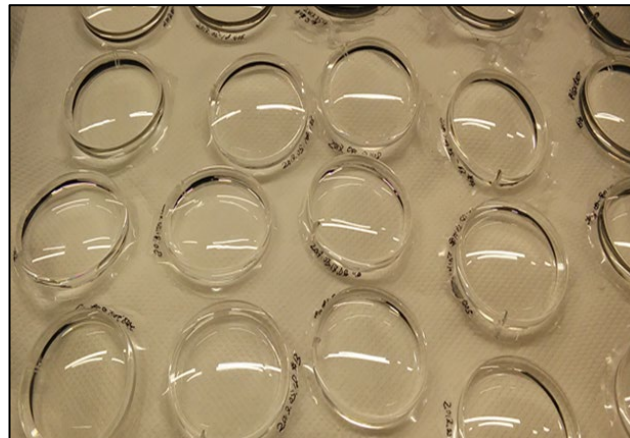


Complex monolithic
+ unprecedented
functionalities

The grand challenges of freeform optics



Direct design

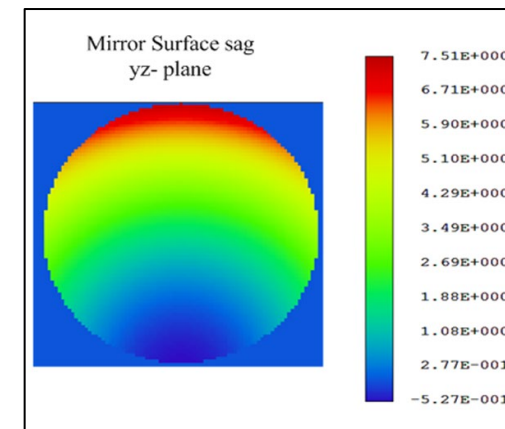


High-precision mass-manufacturing @ low-cost

CONCURRENT
DEVELOPMENT

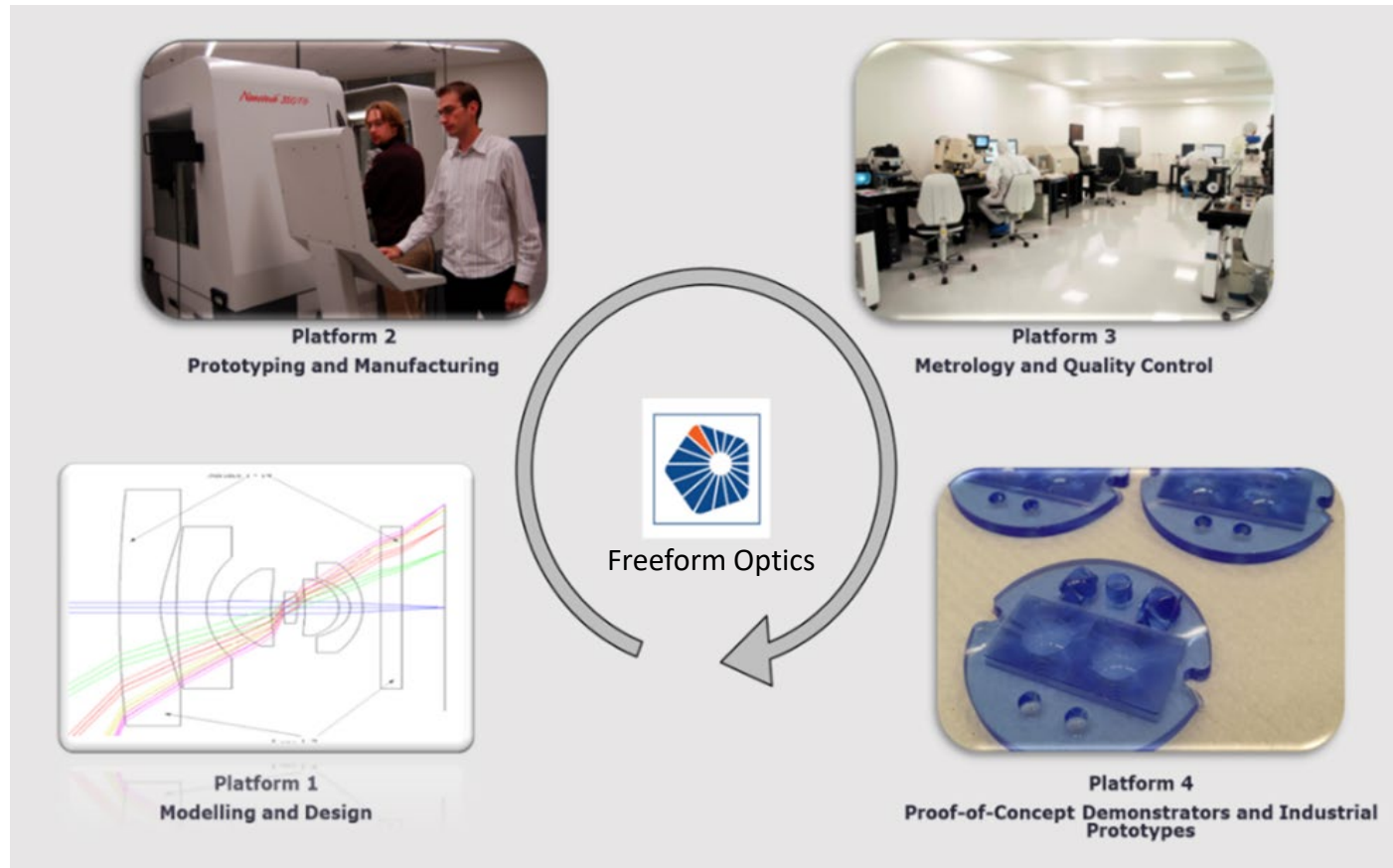


Extreme manufacturing

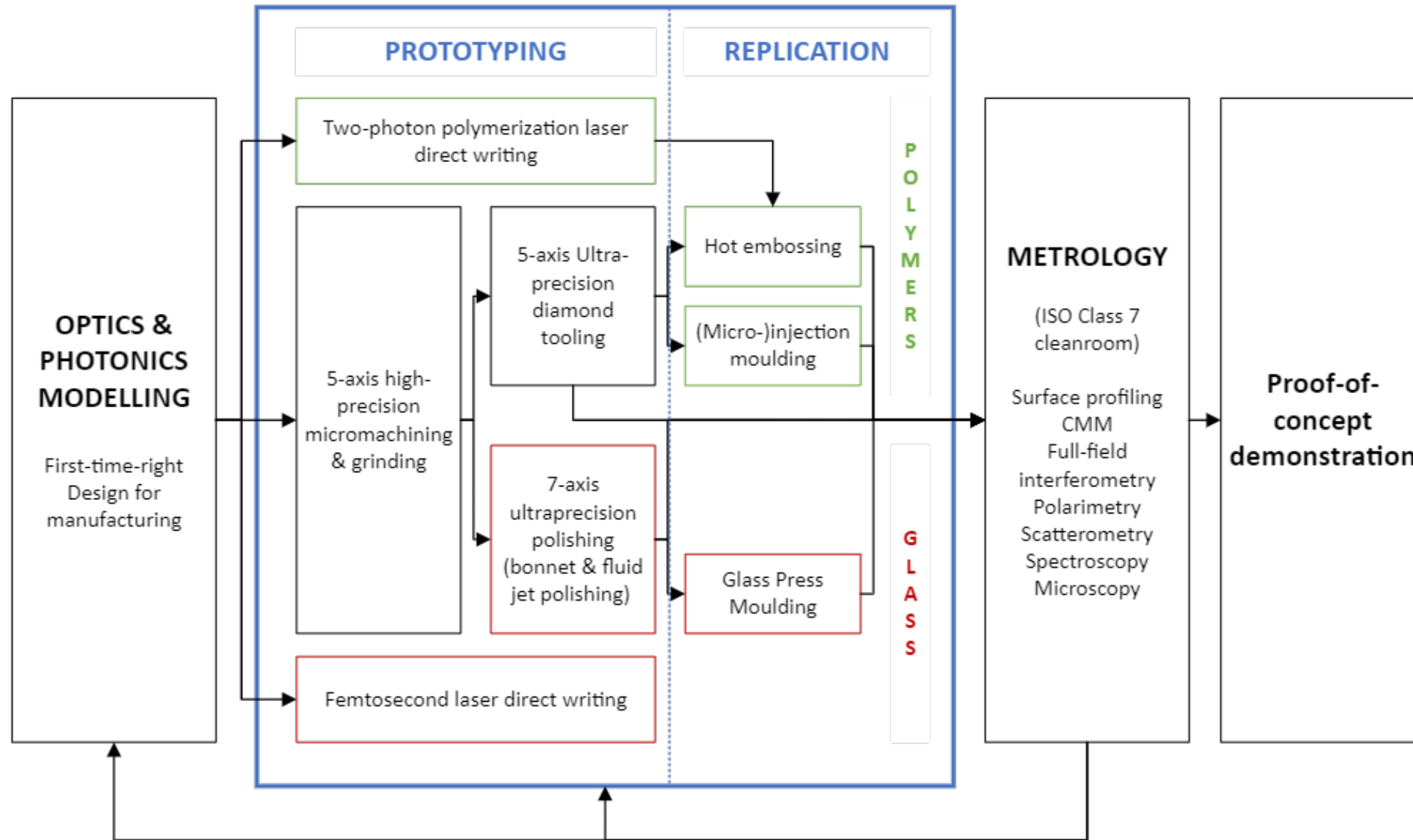


Advanced metrology and quality control

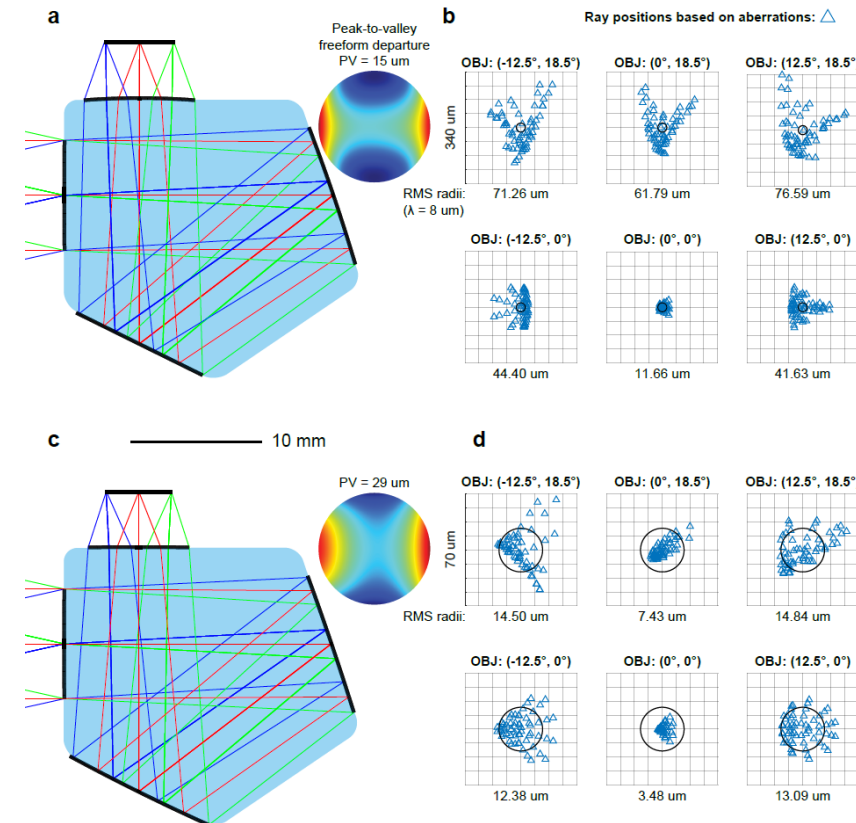
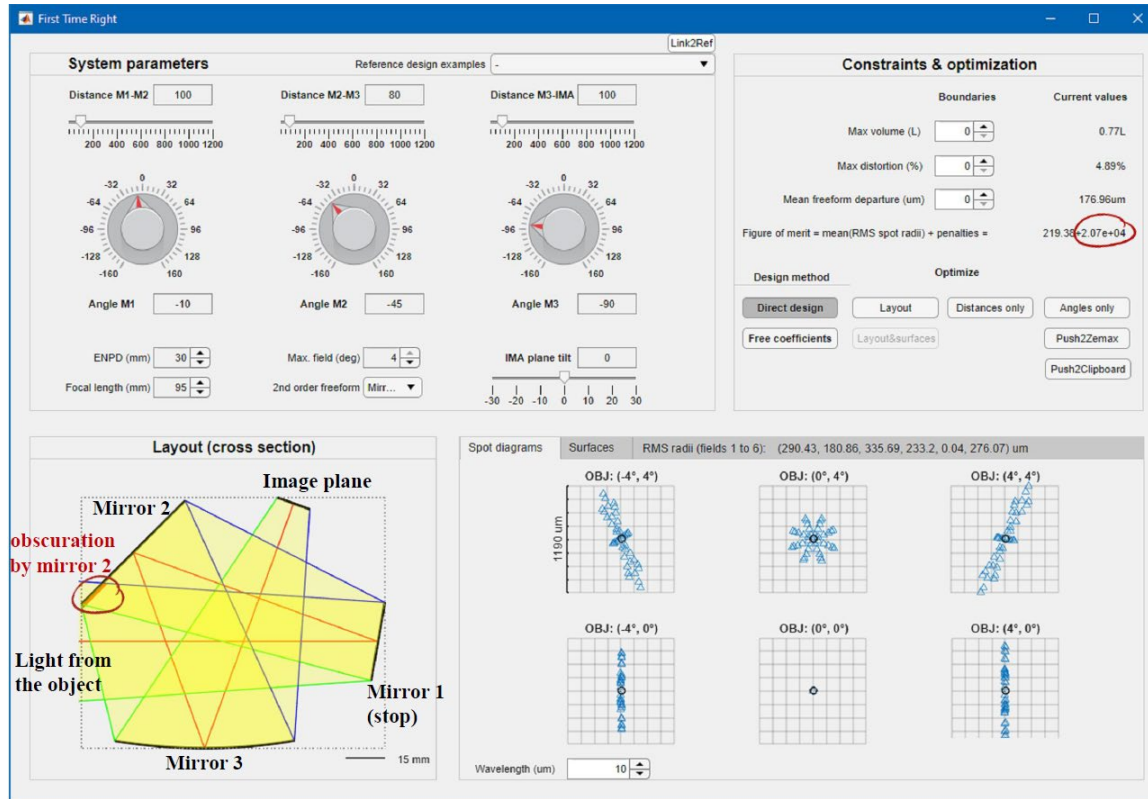
B-PHOT's Research and Innovation Teams are supported by a Supply-Chain of Cutting-Edge Technology Platforms TRLs 3-6



Pilot Line for polymer and glass freeform optics



FTR catadioptric design using aspheres and freeform



Initial 'first time right' design

Optimized result

WO2019129872
PCT/EP2018/097117

Optical Design Methods for Imaging Systems and Optical Systems Designed Therewith

- ✓ Fast development cycles
- ✓ Superior performance
- ✓ Low freeform departure

Freeform Optics: Pilot Line Manufacturing Room 1

Fluid jet polishing robot

Ultraprecision bonnet polishing

Precision micro-machining for mould manufacturing



Micro-electron discharge machining for mould manufacturing

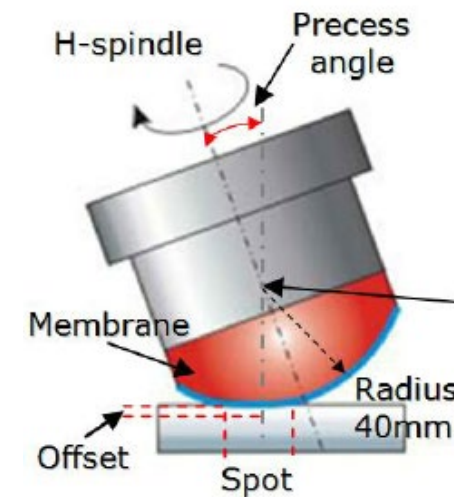
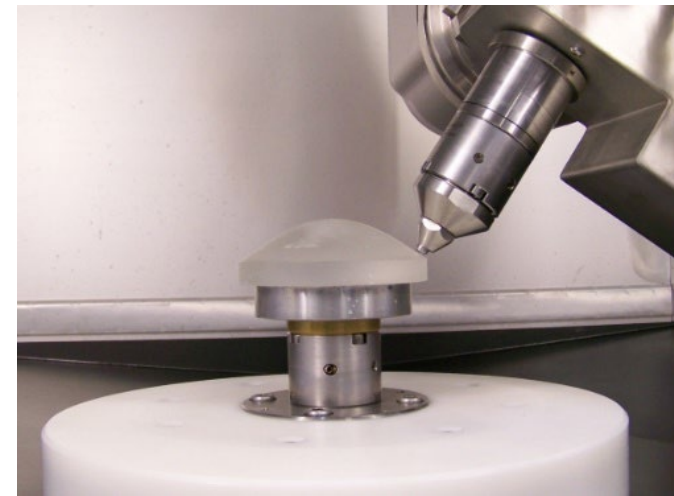
5-axis high-precision micro-machining & grinding

- grinding of freeform glass optics,
- preshaping of moulds for subsequent finishing with ultraprecision diamond tooling for polymer replication,
- preshaping of moulds for subsequent finishing with polishing for glass replication



7-axis bonnet and fluid jet polishing

- unique combination of bonnet and fluid jet polishing capabilities for finishing the surface quality of the ground glass freeform optics,
- finishing the surface quality of the moulds for use in a subsequent glass press moulding replication step



Freeform Optics: Pilot Line Manufacturing Room 2

Injection moulding replication of plastic optics

Ultraprecision diamond tooling

Hot embossing replication of plastic optics

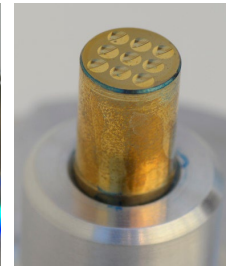
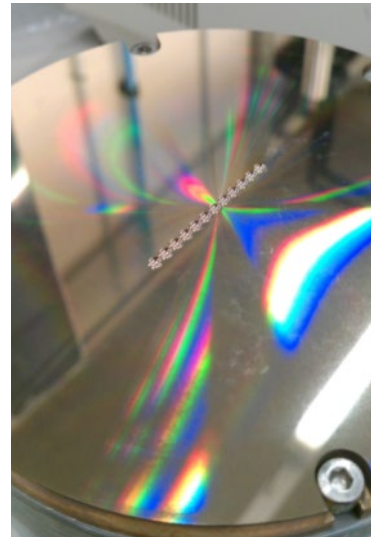
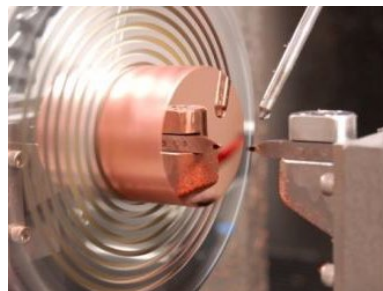
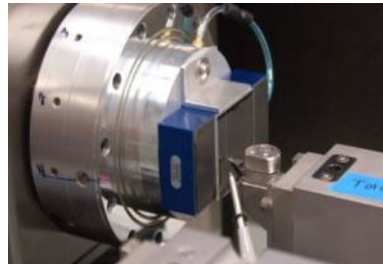
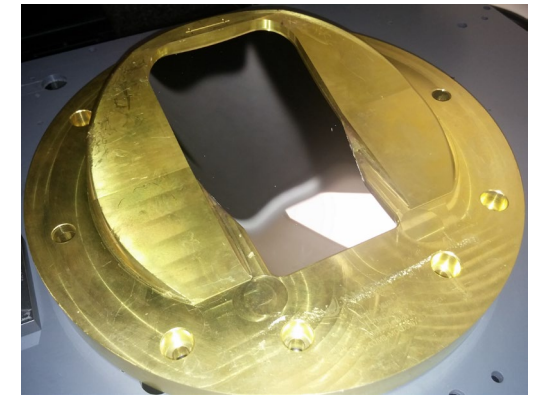
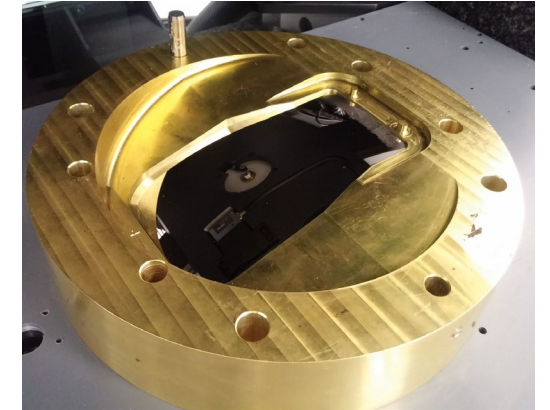


Glass press moulding replication of glass optics

Micro-injection moulding replication of plastic optics

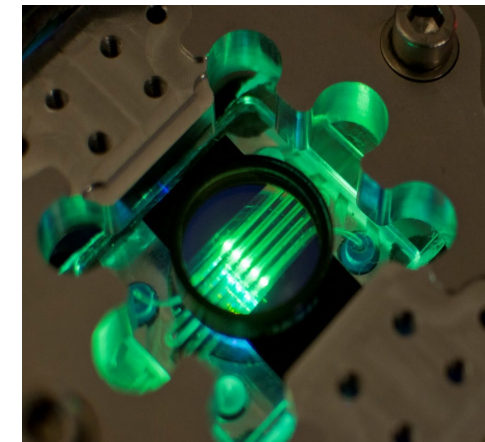
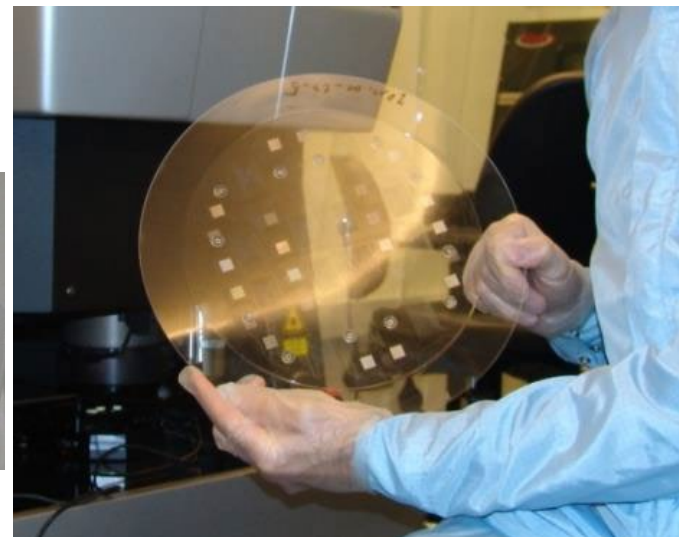
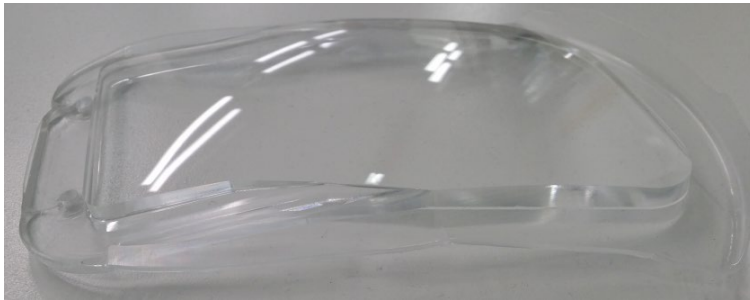
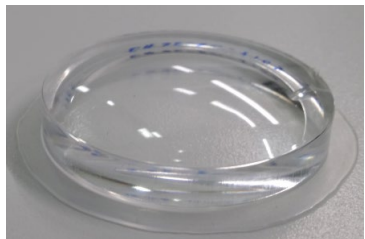
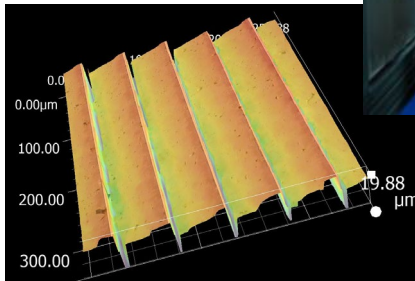
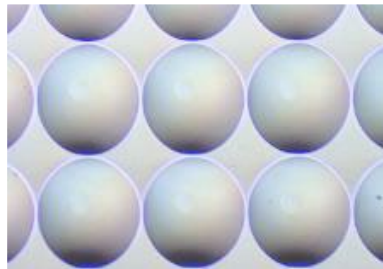
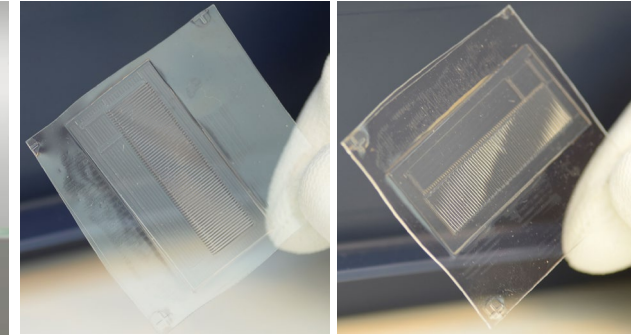
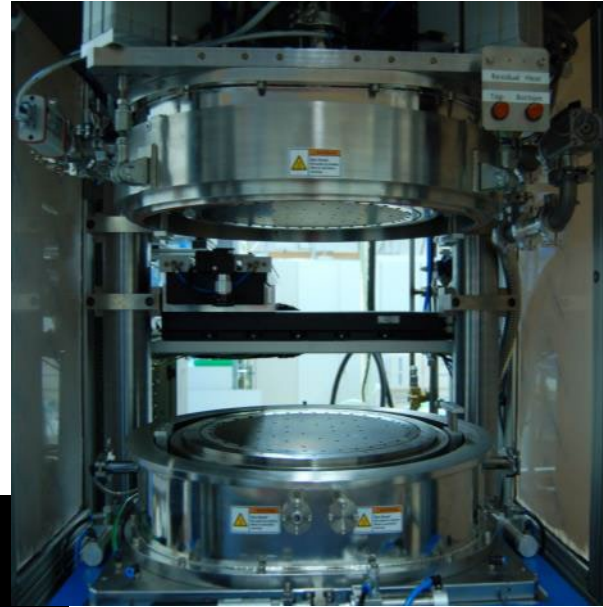
Mastering & Prototyping: Ultraprecision diamond tooling

- Ultraprecision machining: <140 nm PV and $Ra < 5$ nm
- Materials
 - Non-ferrous metals for mould formation
 - Polymers or IR glasses for direct prototyping
- Applications
 - Freeform one step optics
 - Micro-optics on non-flat substrates in diverse materials
 - Mould fabrication



We test mass-manufacturability and fabricate low-volume series

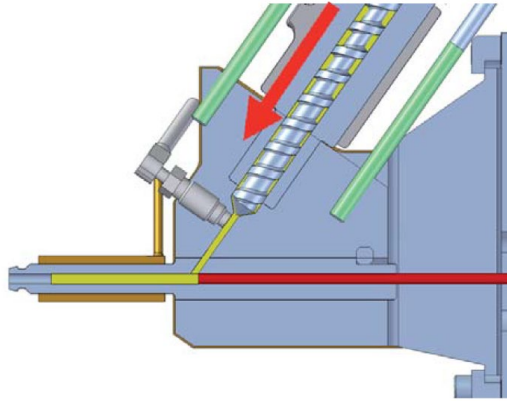
- 300 mm wafer capacity
- Double-sided embossing (Mould alignment $<2\ \mu\text{m}$)
- Typical cycle times: 5 minutes
- Maximum temp.: $(350\pm 2)^\circ\text{C}$
- Maximum force: 450 kN
- Low-temperature UV embossing (nano-imprinting) possible



We test mass-manufacturability and fabricate medium-volume series with (micro-)injection moulding

Battenfeld Micropower 15 / 3

- Cycle time down to a few seconds
- Injection volume up to 1.1cm³
- Variotherm process to counter the effects of rapid surface solidification
- Automated part ejection and vision evaluation
- Automatic sprue removal



Battenfeld EcoPower 90



We test mass-manufacturability and fabricate small-volume series in glass with glass press moulding

- Small-series **replication** of the freeform optics in a variety of high-end glasses
- Processing temperatures up to 800°C, which allows the use of a wide range of **UV-VIS glasses** and **specialty IR materials**.



Metrology and testing in ISO Class 7 cleanroom

Atomic force microscopy

Multisensor coordinate measurement machine

Polarimetry for assessing birefringence in replicated optics

Scatterometry



White light interferometry for surface roughness

Stylus profilometry

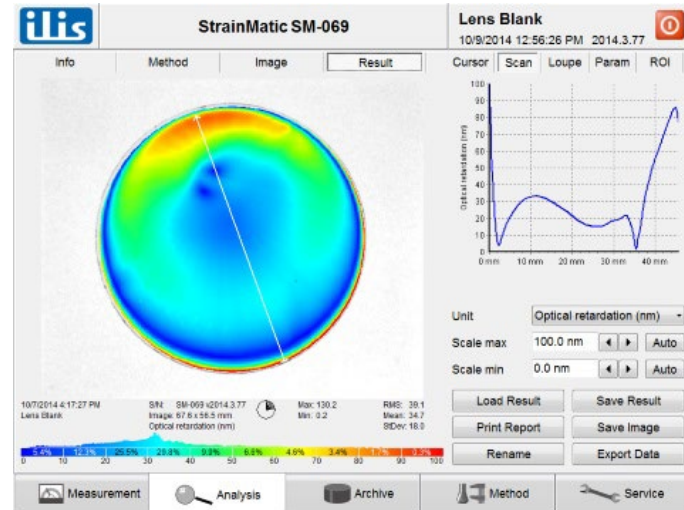
Scanning electron microscopy

Full-field interferometry for freeform surfaces

Metrology and testing in ISO Class 7 cleanroom

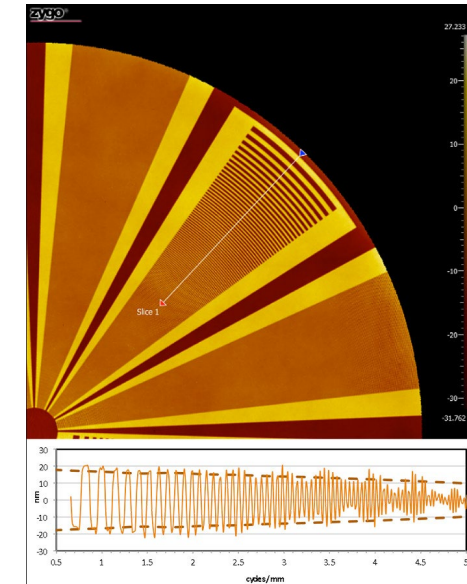
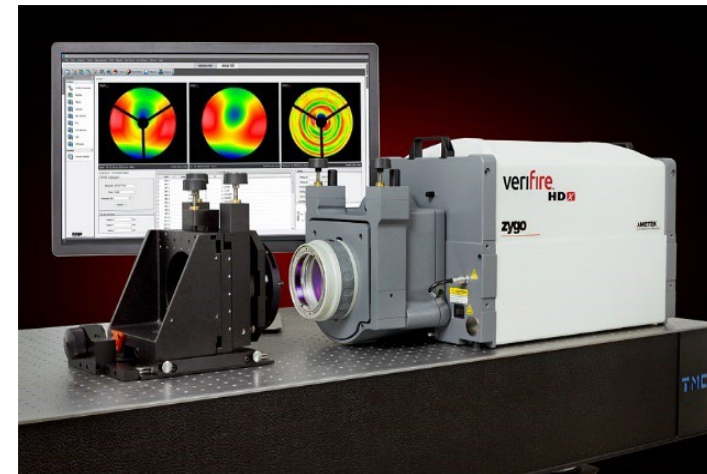
Imaging polarimeter:

- Residual stress measurements in glass or polymer replica
- Invaluable tool for glass/polymer replication process optimization.



Ultrahigh resolution full-field laser interferometer:

- Mid-spatial frequency (MSF) content characterization (e.g. diamond cutting marks)
- High-precision full-field surface form error measurement of (near-)spherical optics
- Serves as input for deterministic optical polishing process optimization



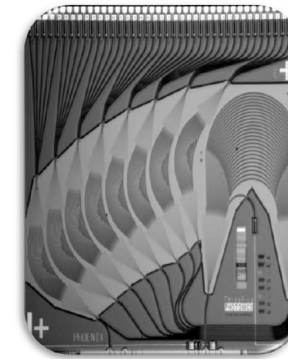
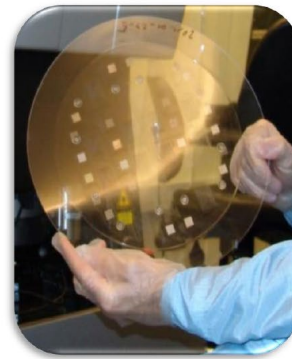
Demonstration Labs



This Interreg call has been the ideal opportunity to team up and jointly tackle the challenges



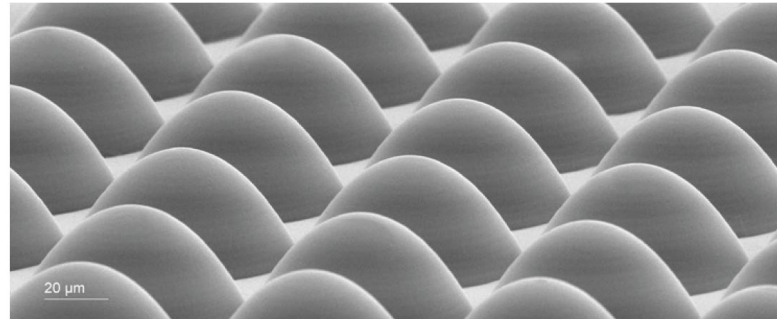
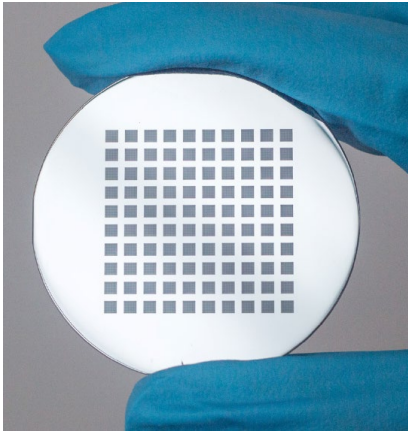
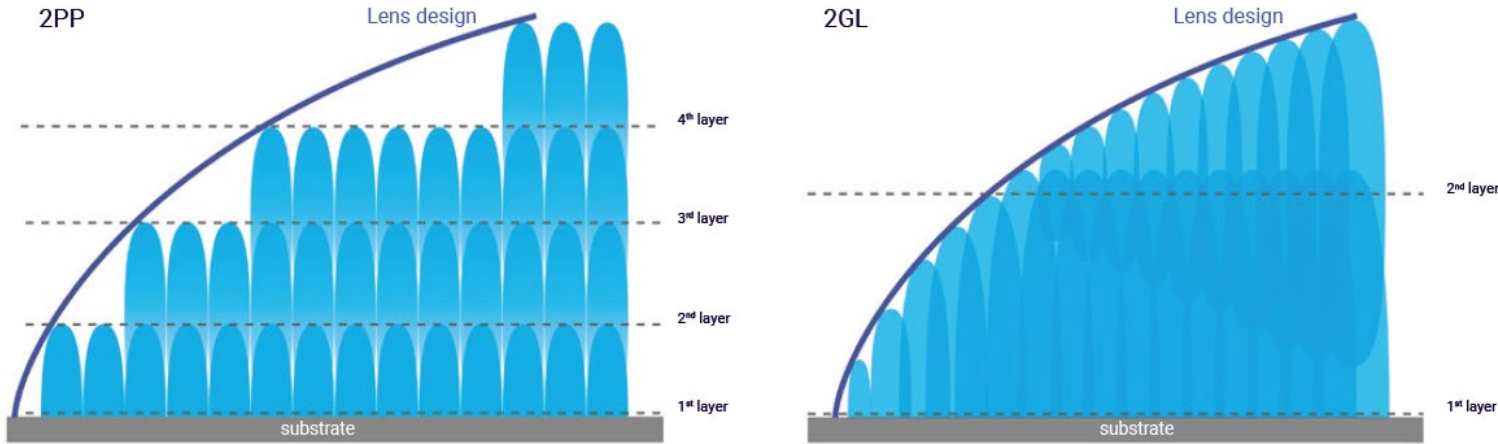
Freeform Optics



Photonic Integrated Circuits

Increased capabilities with Nanoscribe Quantum X

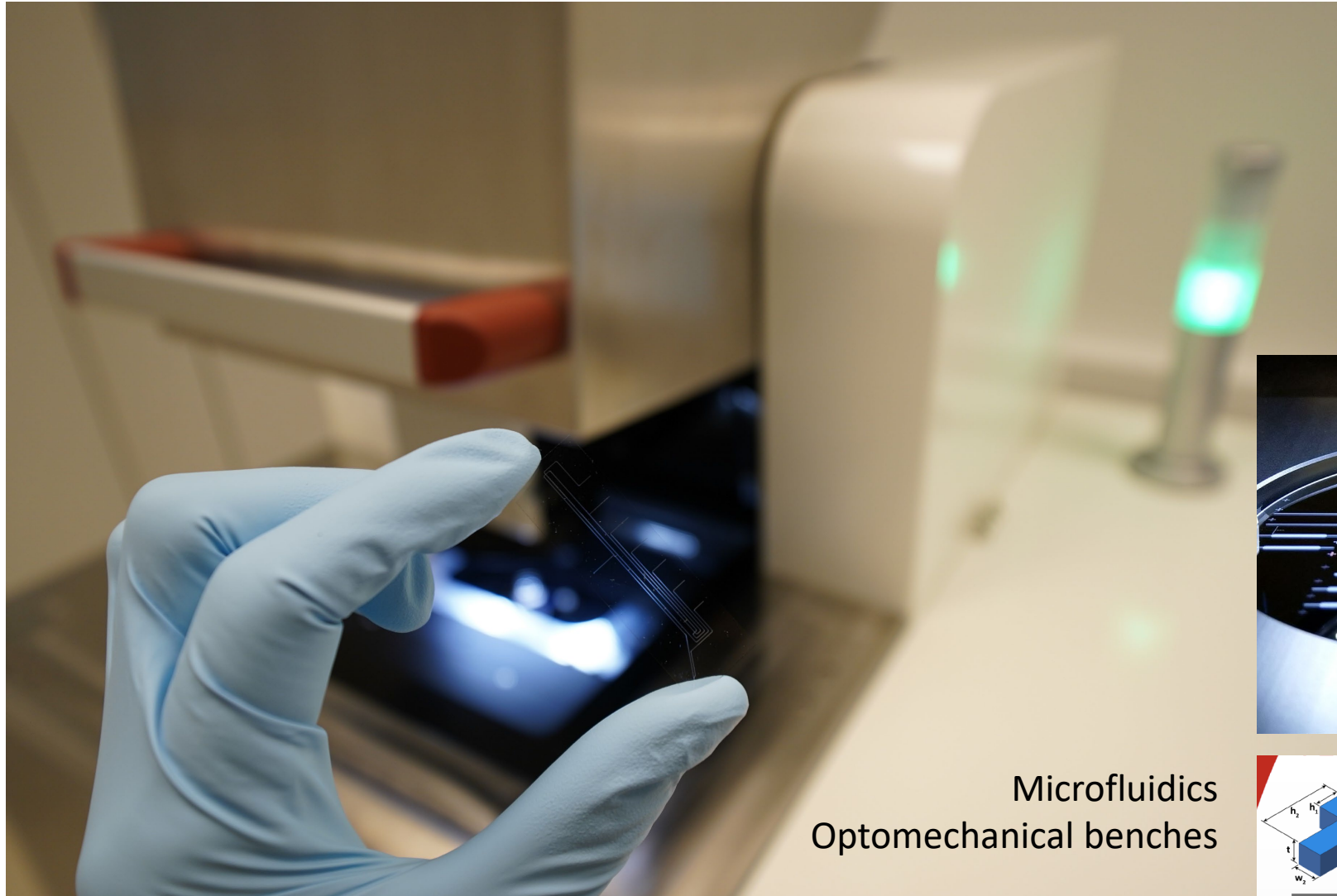
Two-photon greyscale lithography



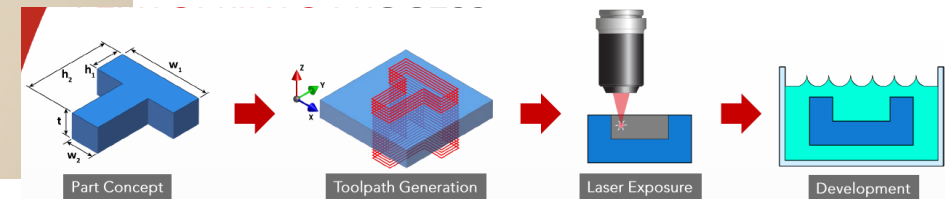
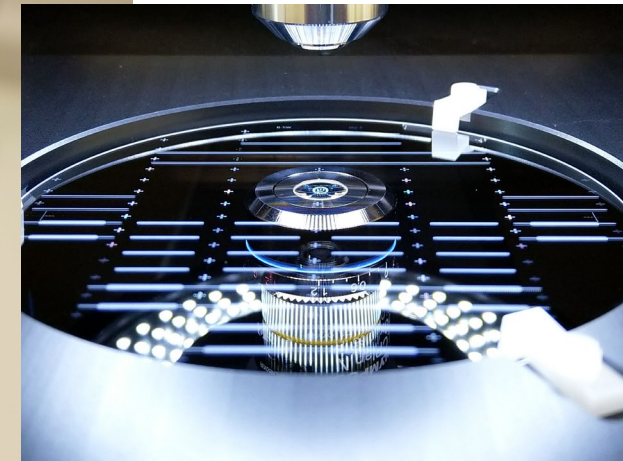
Diffraction-limited micro-optics!



Laser micromachining in glass



Microfluidics
Optomechanical benches



Thank you!

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