OST
Eastern Switzerland
University of Applied Sciences

Novel laser-based manufacturing chain for wafer-level mini-optics

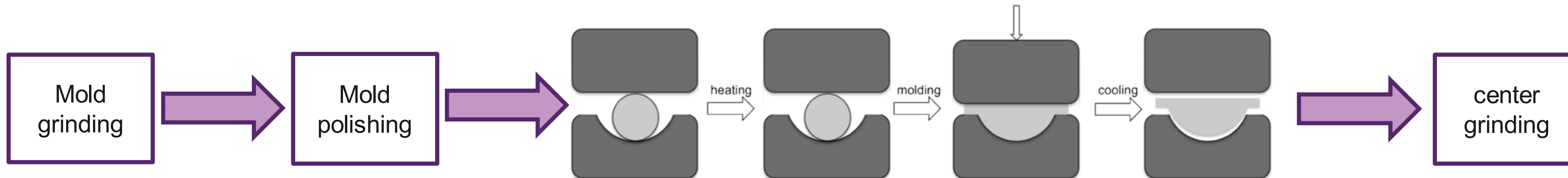
David Bischof[1,*], Sven Lämmler[1], Hansruedi Moser[2], Martin Forrer[2], Oliver Faehnle[1]

17 June 2024

[1] OST-Ostschweizer Fachhochschule, Werdenbergstrasse 4, 9471 Buchs (SG)
[2] FISBA AG, Rorschacherstrasse 268, 9016 St. Gallen

PGM vs. laser-based manufacturing chain

State of Art - Precision glass molding



State of Art - Precision glass molding

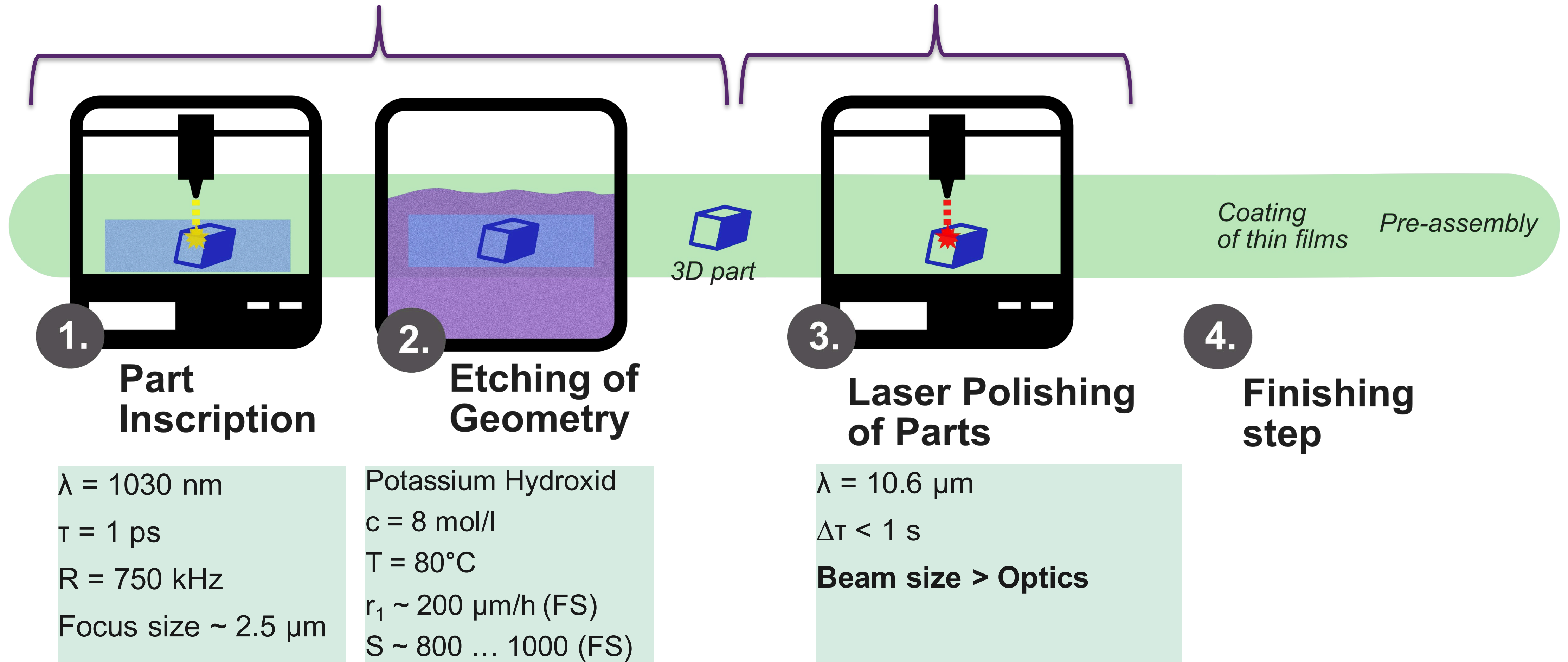
- RMS > 5 nm
- Centring accuracy 4/> 10 µm
- 40 degree surface inclination not possible
- Mould costs > 15’000 CHF
- No flexibility regarding prototyping

Status Quo @Ost – laser based manufacturing chain

- RMS < 2 nm
- Centring accuracy 4/> 0.5 µm
- 40 degree surface inclination can be produced
- No tooling costs
- High flexibility prototyping

 david.bischof@ost.ch, sven.laemmler@ost.ch

Laser-based manufacturing chain

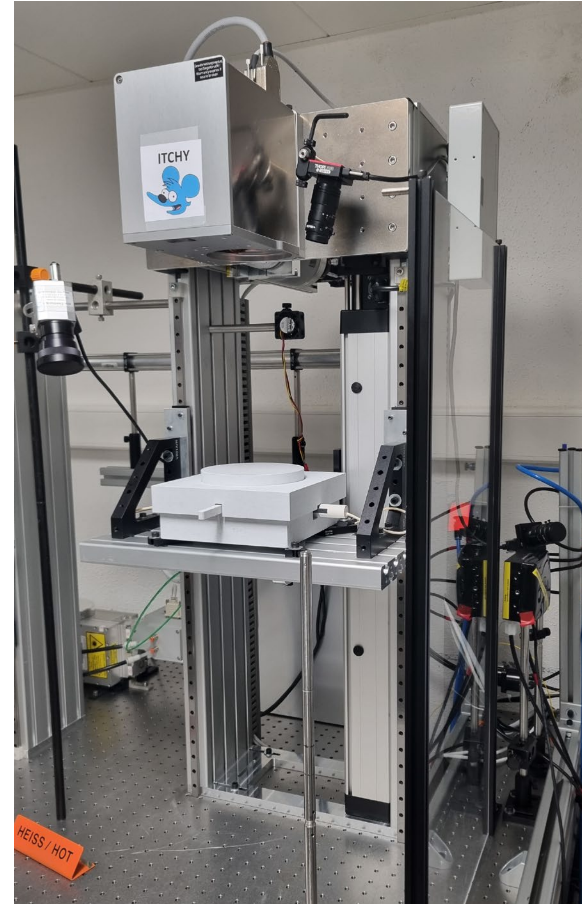


david.bischof@ost.ch, sven.laemmler@ost.ch

Laser-based manufacturing chain - Laser systems

- SLE

- LP



Design

Complex mini-optics

Features

(1) CC surface

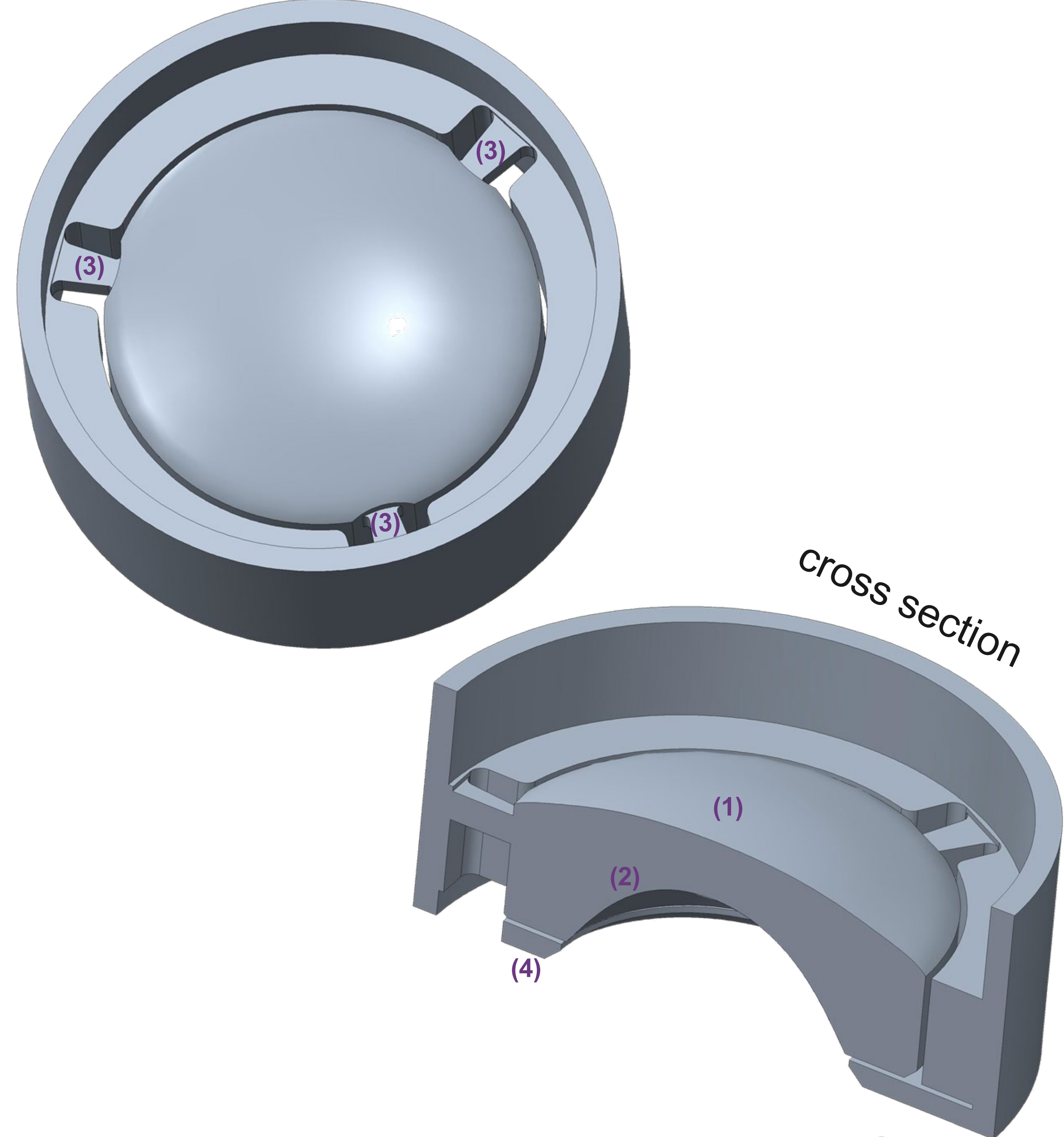
(2) CX surface

(3) Connected to the wafer by three small beams

- thermal isolation
- singulation / break-out structure

(4) Small integrated aperture

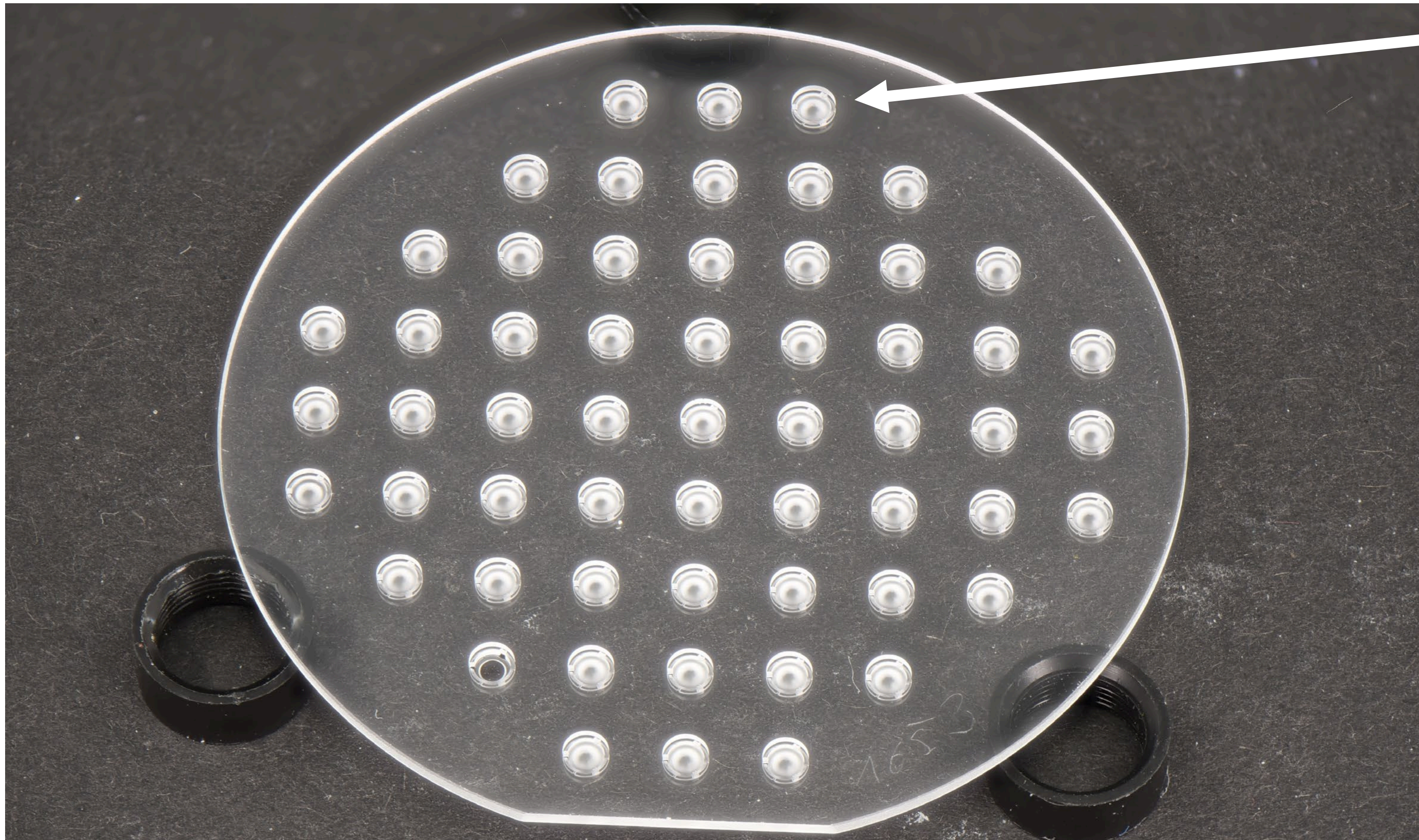
- Connected to small beams for singulation
  - Laser polishing mask
  - Shadow mask for the coating process



david.bischof@ost.ch, sven.laemmler@ost.ch

Complex mini-optics

Array in Fused Silica (D = 50 mm, t = 1 mm)



Lens element

- D = 1.8 mm
- Laser marking duration of lens
  - 6 min
- Roughness after SLE
  - 200 … 500 nm RMS
    - that is why polishing is needed

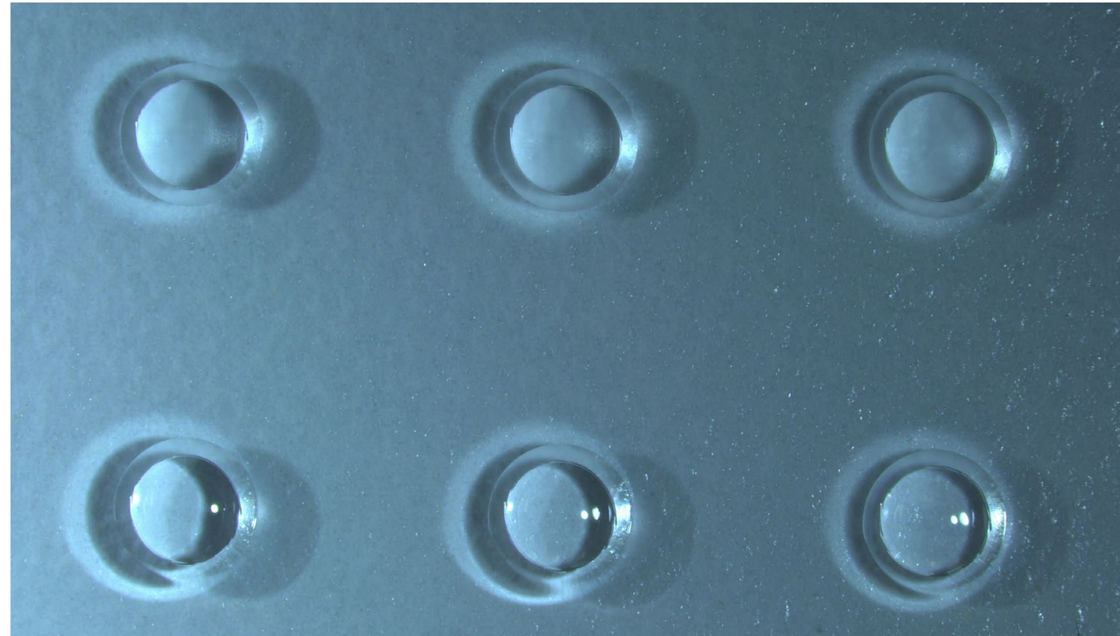
Selective Laser Etching (SLE)

Specifications after the SLE process

- Shape: PV ca. 1 µm
- Roughness: Sq ca. 0.2-0.5 µm

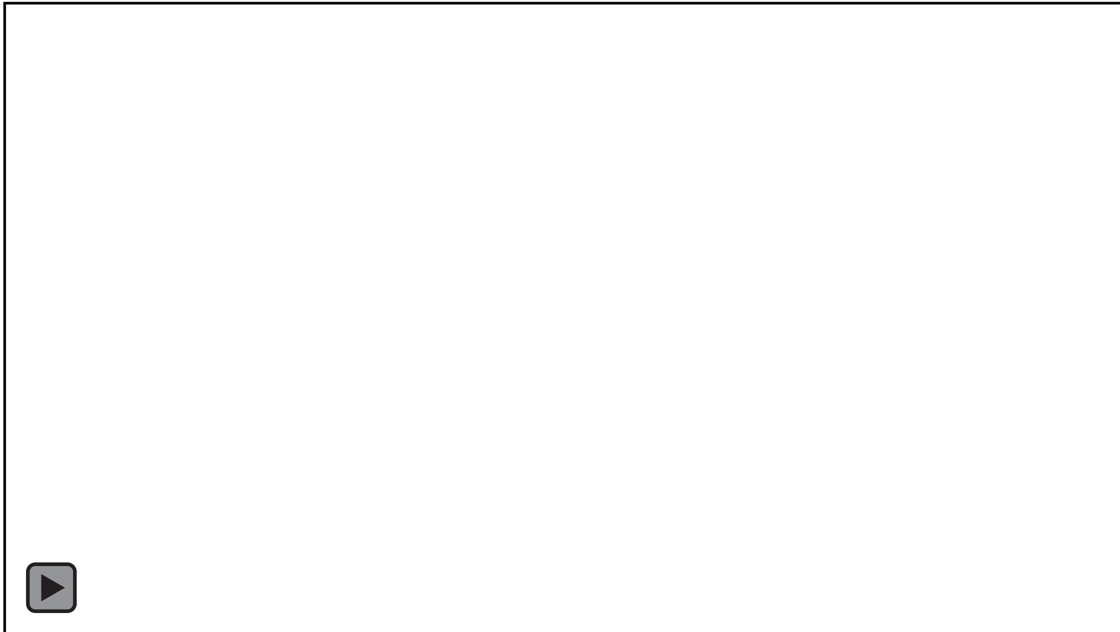
After SLE:

After LP:



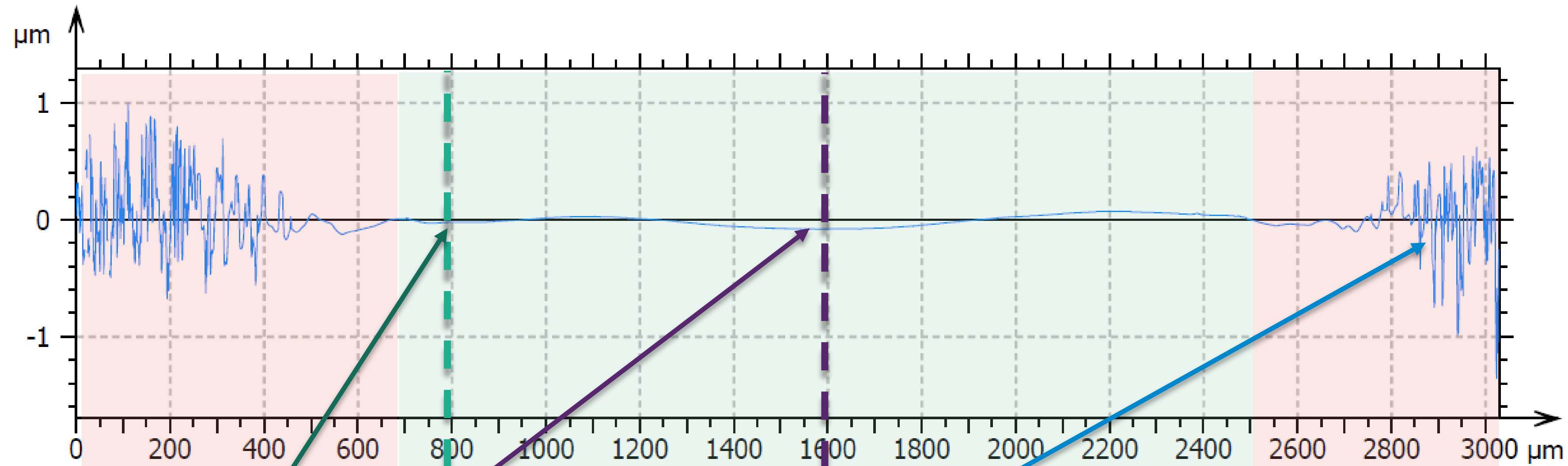
«One»-Shot Laser Polishing

Illumination of lens aperture with a laser beam larger than the lens



«One»-Shot Laser Polishing

Topography of a polished flat surface



Roughness

(S-filter: 2.5 µm; L-Filter: 0.03 mm, Field size 150 µm x 150 µm)

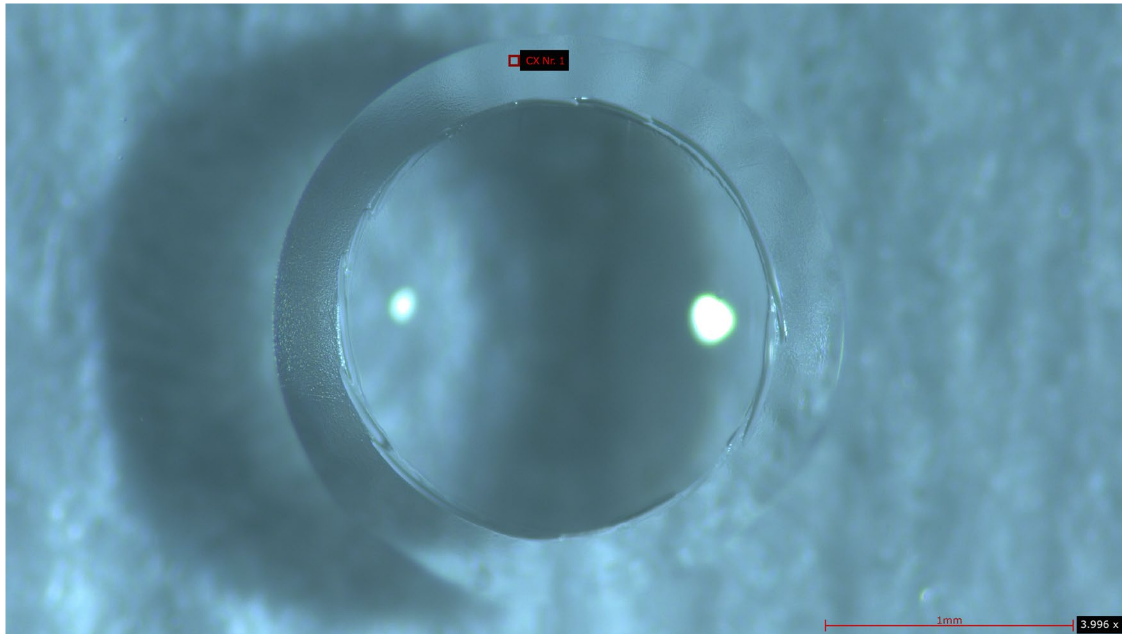
- Edge 0.7 nm
- Center 0.2 nm
- Unpolished 500 nm

david.bischof@ost.ch, sven.laemmler@ost.ch

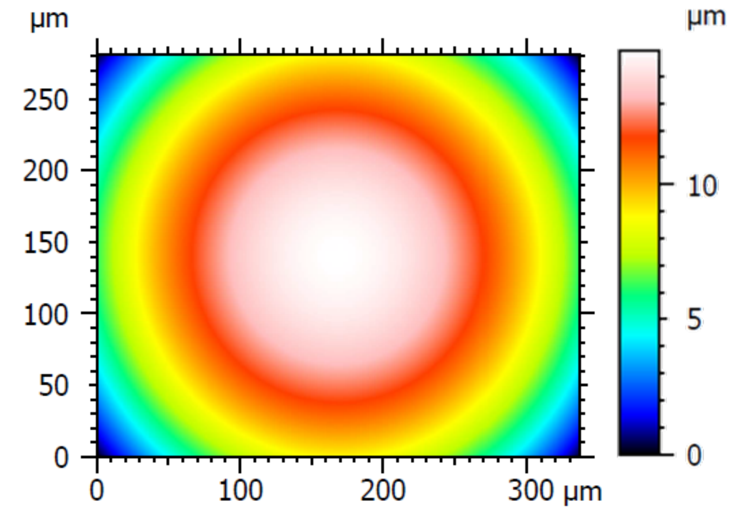
Process

«One»-Shot Laser Polishing

CX surface



Topography (Sensofar sNeox ePSI mode)



ISO 25178 - Rauheit (S-L)		
S-Filter (λs): Gauß, 2.5 µm, 1/2 Cut-off		
F: Form entfernt (TLSSP, R=1624.85...		
L-Filter (λc): Gauß, 0.05 mm, 1/2 Cut..		
Höhen-Parameter		
Sq	5.07e-04	µm

david.bischof@ost.ch, sven.laemmler@ost.ch

Outlook

- Improving laser polishing setup and process control
- Variouse Materials under investigation

OST