

OST

Ostschweizer
Fachhochschule

Integration von Photonik in industrielle Fertigungsprozesse – Neue Ansätze und Entwicklungen

Fachkonferenz: Photonik und optische Technologien in St. Gallen
Handelskammer Deutschland-Schweiz

Prof. Dr. Tobias Lamprecht

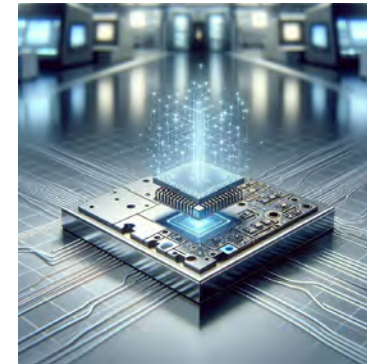
IMP Institut für Mikrotechnologie und Photonik
Department Technik

Photonik in der Fertigung

Präzision



Miniaturisierung

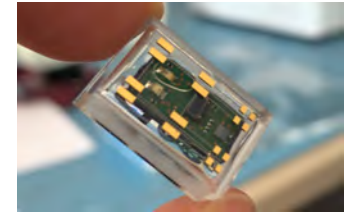


Inhalt

Herstellung

One Piece Flow

Photonik erzeugt Miniaturisierte Optik



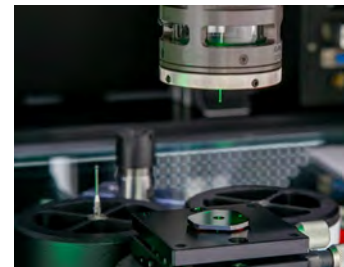
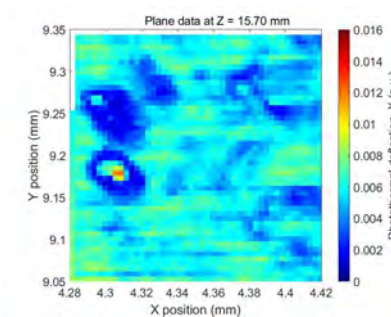
Transparent und hermetisch

Realisierung von funktionalen Minigehäusen

Charakterisierung

Zerstörungsfreie Inspektion

Optik für Hochleistungs-Laser



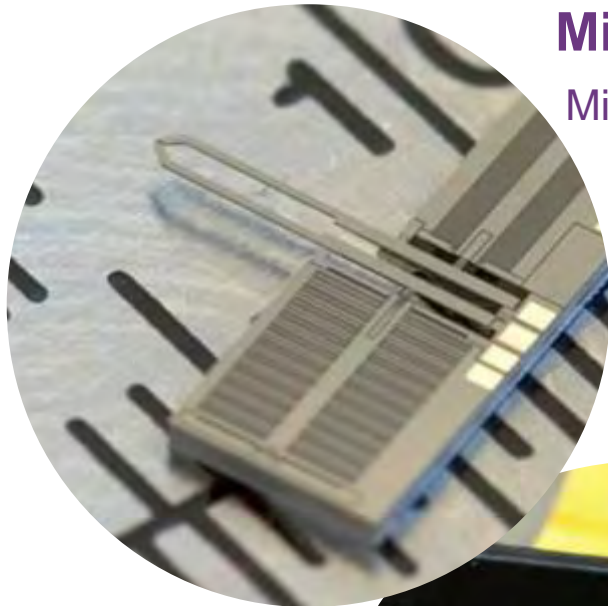
Optische Messtechnik

hochpräzise Kalibrierung für Photonendetektion

Institute of Microtechnology and Photonics (IMP)

Microtechnology (MEMS, MOEMS)

Miniaturized systems, ...



Production Metrology

Dimensions in highest accuracy



Fab

Wafer based processing
R&D
Pilot line



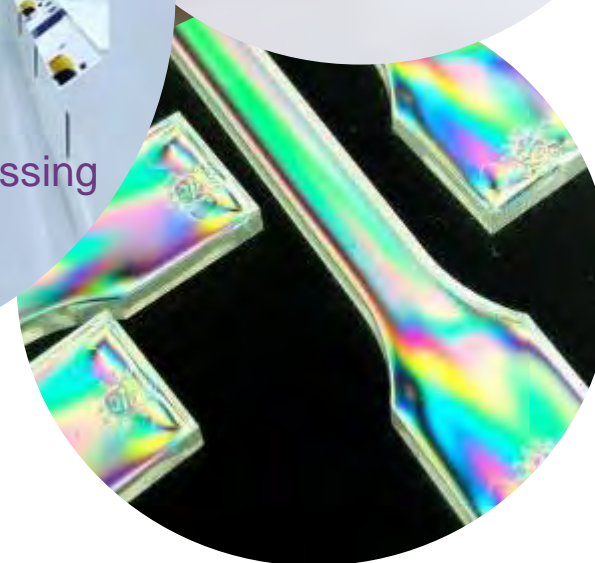
Photonic & Optics

...from development to production



Materials

Characterization and formulation of materials



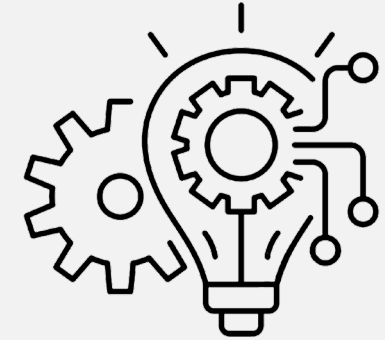


Grundlagen
Forschung



■ sensor innovation hub. ■

- Innovation
- Techtransfer
- Netzwerk



Tech-Industrie

- One Stop Shop für angewandte Sensor Forschung
- Hightech Technologietransfer für KMU
- Etablierte Start-up Angebote (Startfeld)
- Sensor-Entwicklungskette :: Expertise vom Sensorelemente bis zur Datennutzung



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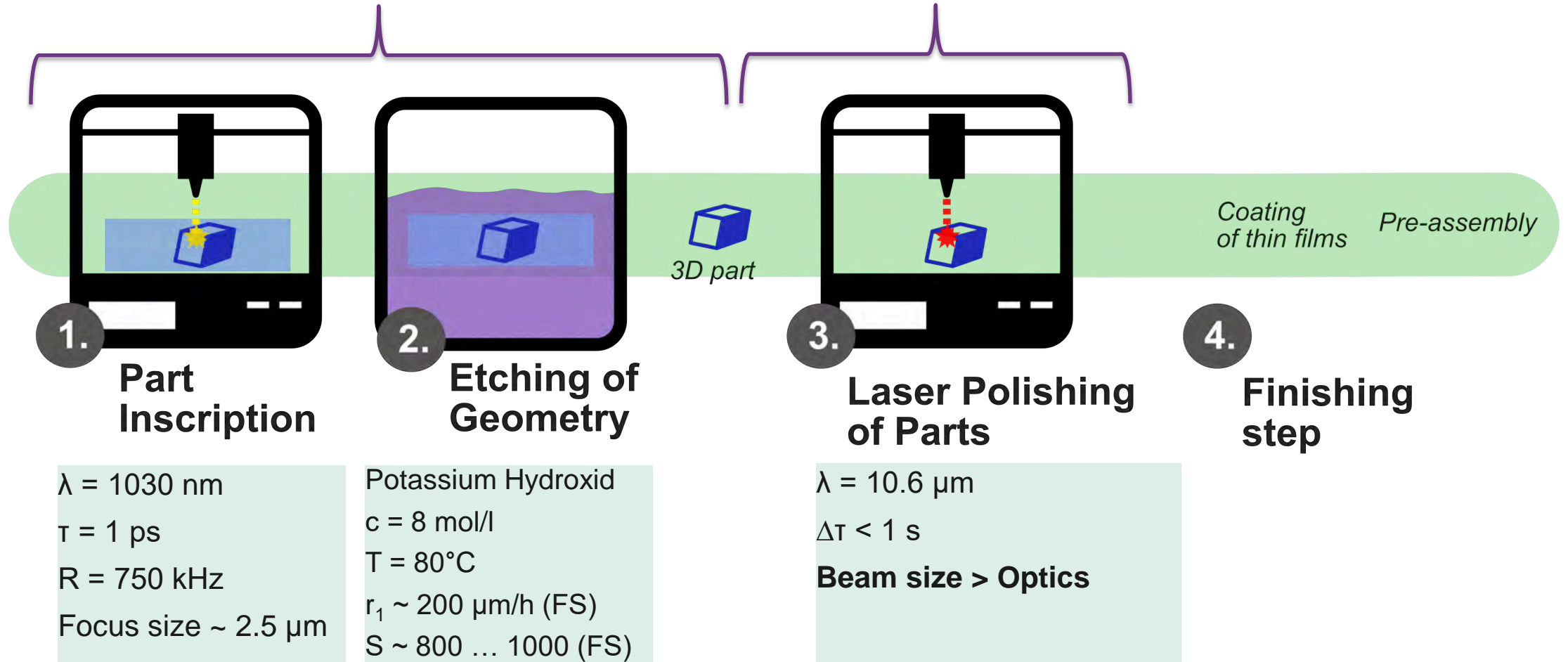
Miniaturlinsen

Selektives Ätzen und Laser-Polieren

Laser-based manufacturing chain

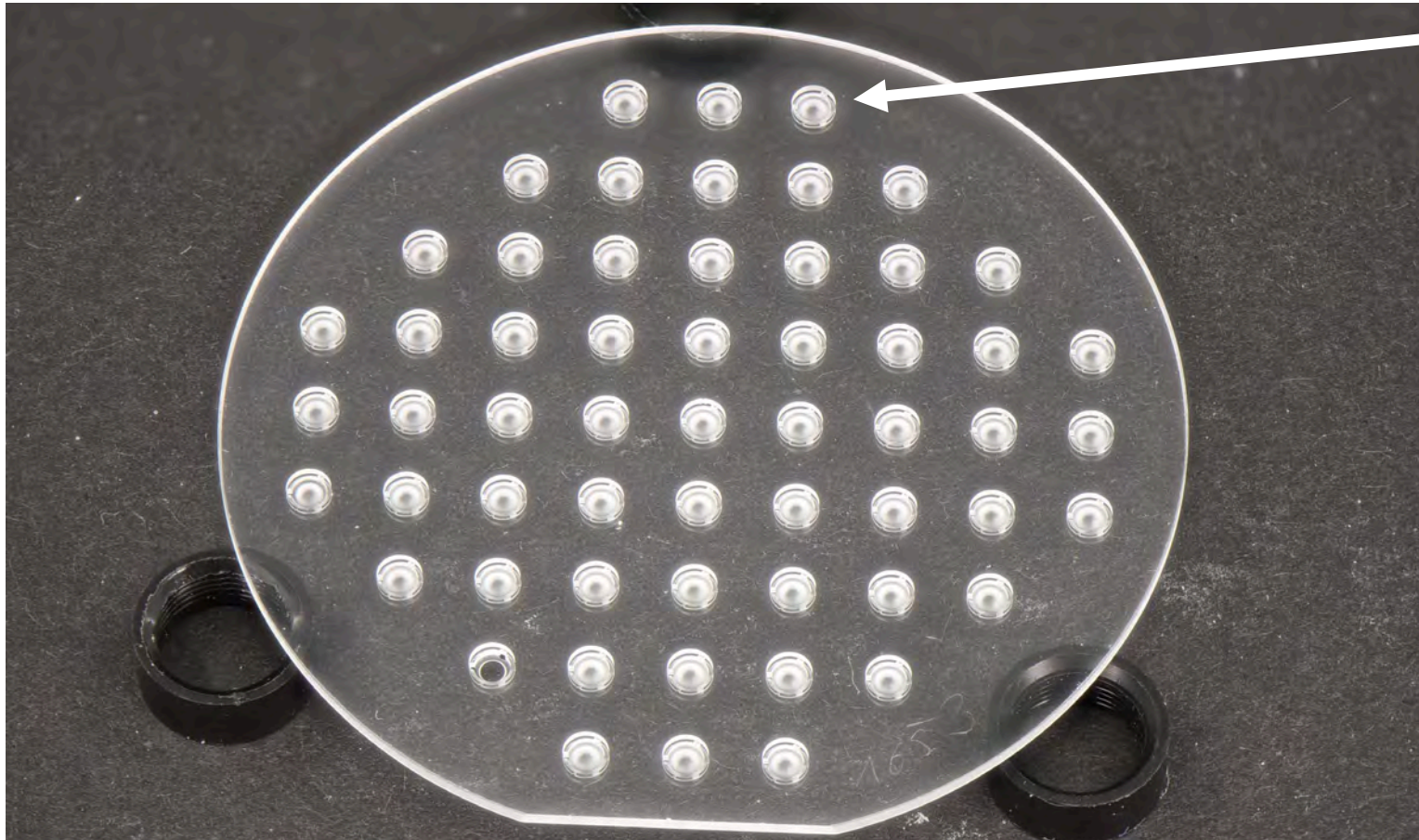
Selective Laser Etching (SLE)

«One»-shot laser polishing (LP)



Complex mini-optics

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



Lens element

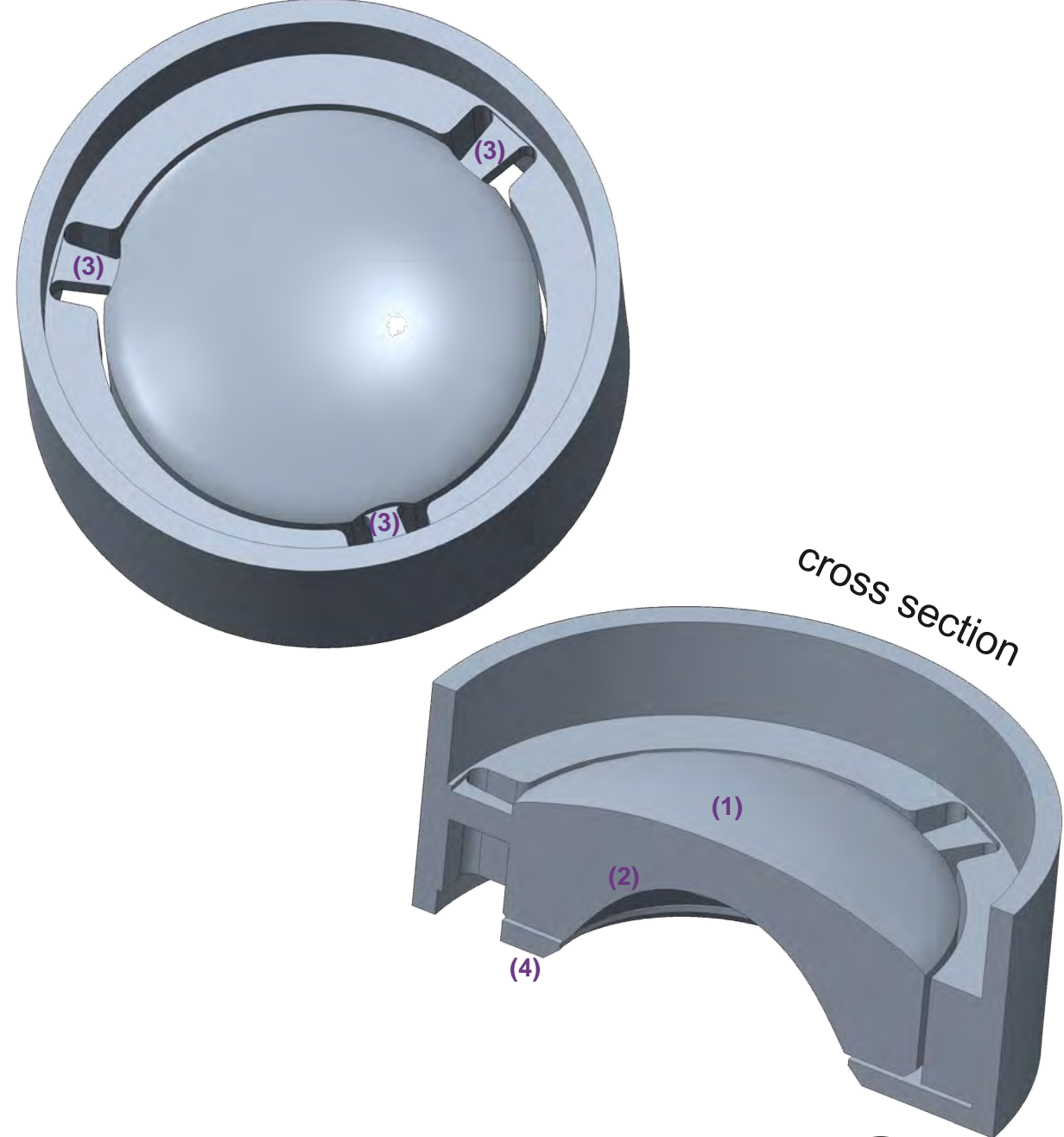
- D = 1.8 mm
- Laser marking duration of lens
 - 6 min
- Roughness after SLE
 - 200 ... 500 nm RMS
 - that is why polishing is needed

Design

Complex mini-optics

Features

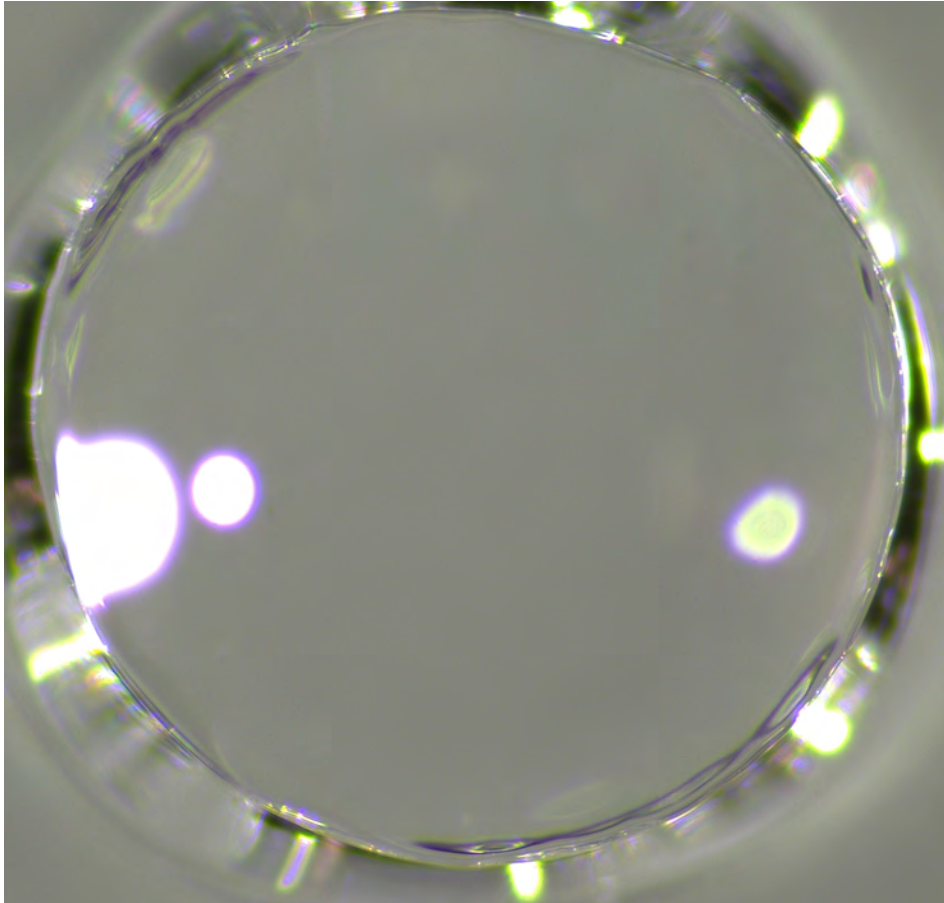
- (1) CC surface
- (2) CX surface
- (3) Connected to the wafer by three small beams
 - thermal isolation
 - singulation structures
- (4) Small integrated aperture
 - Connected to small beams for singulation
 - Mask: laserpolishing, coating process



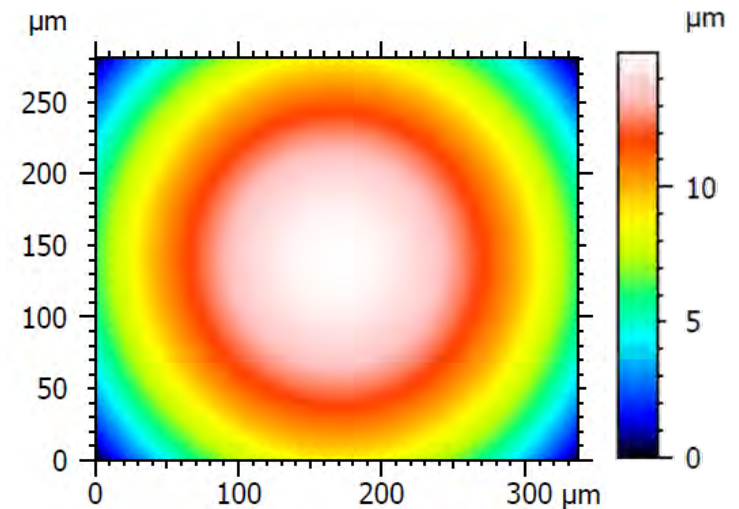
Process

«One»-Shot Laser Polishing

CX surface



Topography (Sensofar sNeox ePSI mode)



ISO 25178 - Rauheit (S-L)

S-Filter (λ_s): Gauß, 2.5 µm, 1/2 Cut-off

F: Form entfernt (TLSSP, R=1624.85...

L-Filter (λ_L): Gauß, 0.05 mm, 1/2 Cut...

Höhen-Parameter

Sq 5.07e-04 µm

Conclusion

Highlights

- Combination of
 - SLE (Selective Laser Etching)
 - «one»-shot laser polishing
- Novel lens design :: wafer-level fabrication
- Precise center position
- SLE roughness can be reduced down to nm.

Outlook

- Improving process control



Funktionale Miniatur- Glasgehäuse

Transparente & hermetische
Präzisionsgehäuse aus Glas



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Subsurface Damage

Zerstörungsfreie Prüfung

Motivation

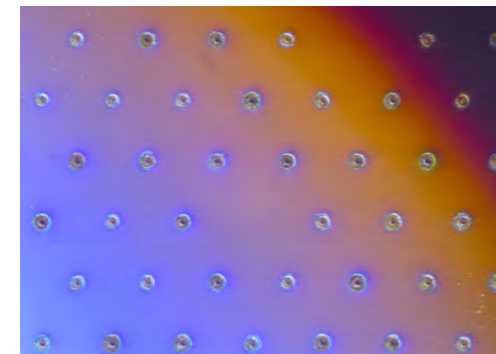
Subsurface Damage as Damage Precursors

- **Origin** of **SSD** in optical materials:
 - Manufacturing steps, surface pretreatment,
 - Coating process, handling, ...
- SSDs: **Local variations** in material **properties**
 - Cracks, material inhomogeneities, contaminations
 - Sub-stoichiometry coatings
- **Consequences** of SSD:
 - Local changes in absorption and scattering
 - **Initiators** for laser-induced **damage**
 - Premature degradation, reduced damage resistance



Residual cracks in optical materials

J. Wang et al., J. Eur. Opt. Soc. – Rapid Pub., Vol. 6, 11001, 2011.

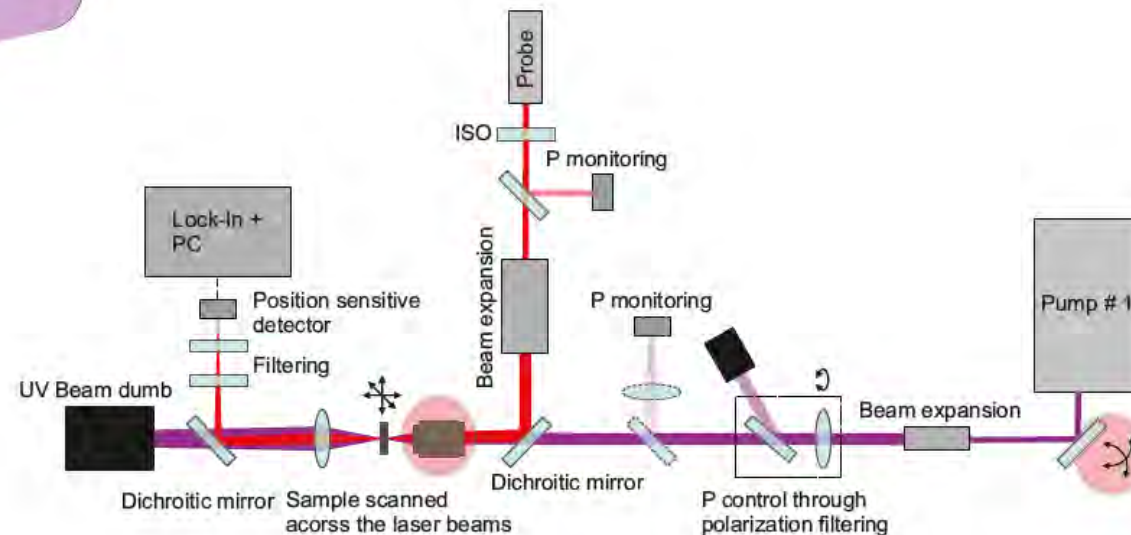
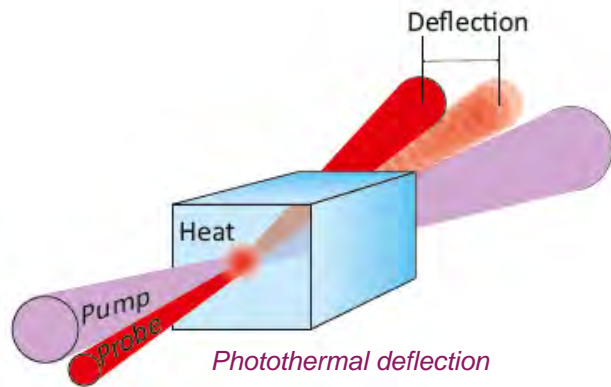


Microscope image of a sample after LIDT

Experiment

Photothermal deflection (PTD) method

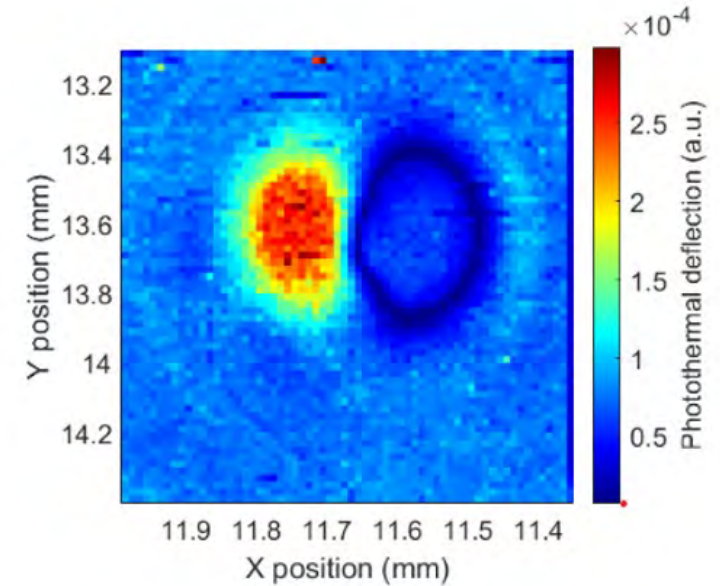
- Measurement principle:
 - Pump-probe experiment
 - local heating → refractive index gradient
 - Probe beam deflection
 - Detection scheme: transmission
- PTD setup features:
 - Transparent optical substrates
 - Sample scanning with sub-micron resolution
 - Pump: 70 mW diode laser (CW) at 375 nm
 - Probe: stabilized HeNe laser
 - Non-destructive measurement method (!)



Results

Photothermal deflection (PTD) method

- Surface dislocation and material densification:
- Coated Fused Silica substrate
- Surface dislocation: previous high-power laser treatment (LIDT)
- Small signal increase/decrease due to surface dislocation

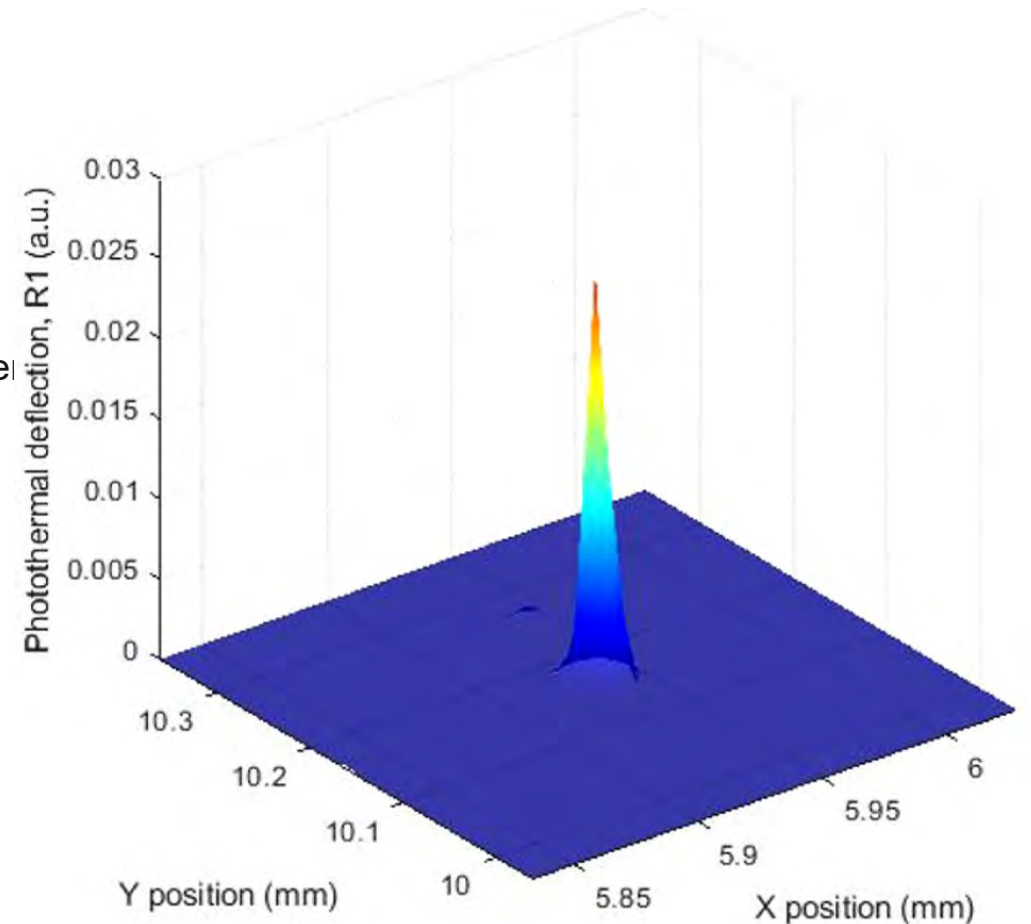


Surface dislocation in a coated sample

2 Examples of SSD detection

Photothermal deflection (PTD) method

- Damage precursor on Fused Silica substrate
- Super-polished FS substrate
- Surface absorption below detection limit (super-polished surface)
- Small contamination of metallic origin on the surface
- Signal diminishes when the measurement volume is shifted inside the material





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Kalibrierung von Blenden

Produktionsmesstechnik auf ein
neues Niveau heben

Strahlungsmessungen im Weltall

- Klimaüberwachung
- 1971: PMOD in **Davos** → WRC das **Weltstrahlungszentrum**
- **Referenzgeräten des WRC**
- **Präzisionsblenden** für Referenzgeräte erforderlich

IMP | Institute for Microtechnology
and Photonics

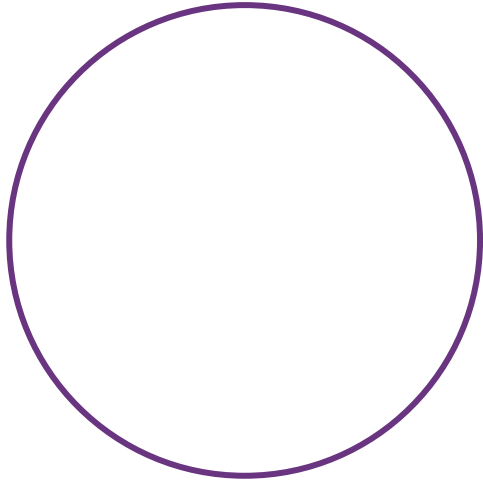
 **RhySearch**
Das Forschungs- und
Innovationszentrum Rheintal



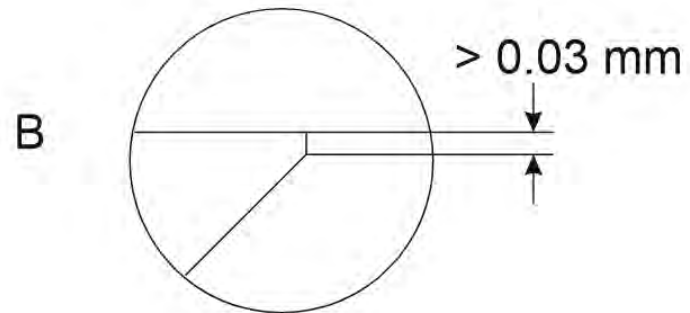
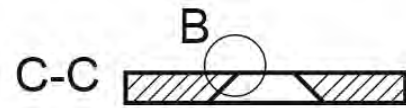
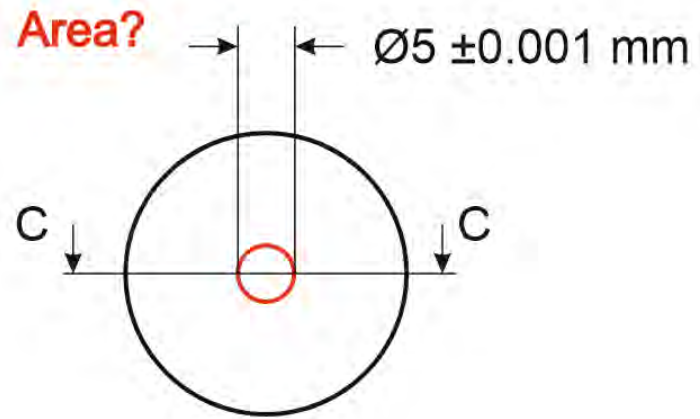
Bild: Strahlungsmessung für Sonnenstrahlung PMOD/WRC

(PMOD: Physikalisch-Meteorologischen Observatorium Davos)

Prinzip



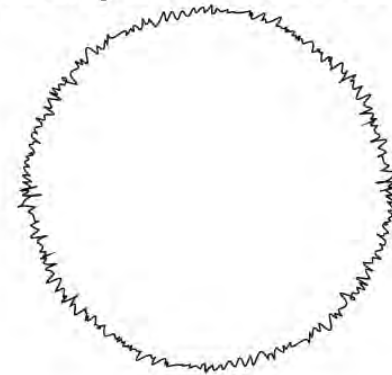
Spezifikation



Ideal

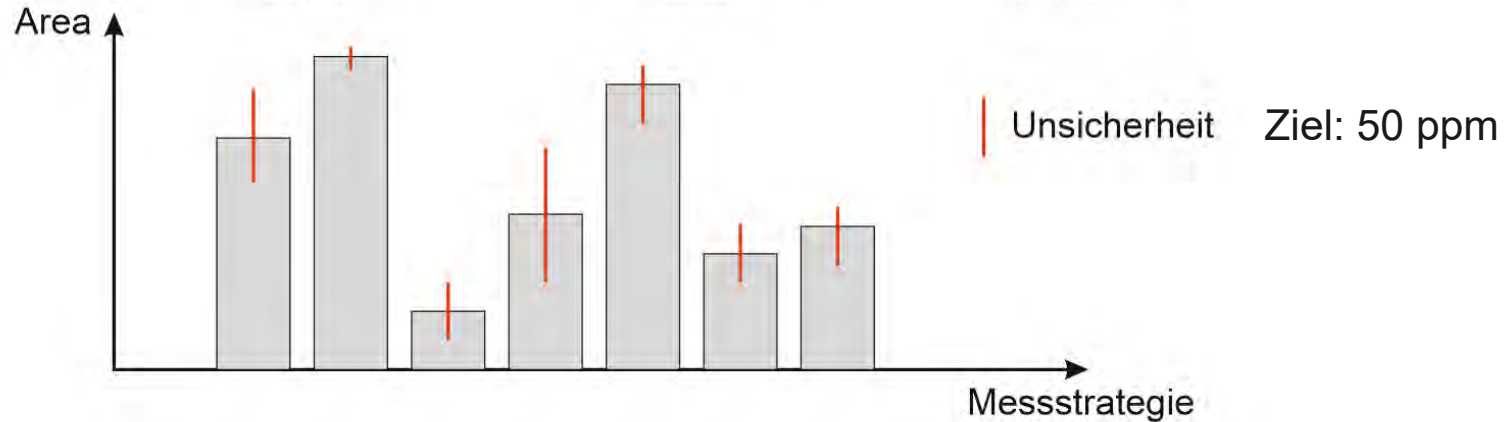
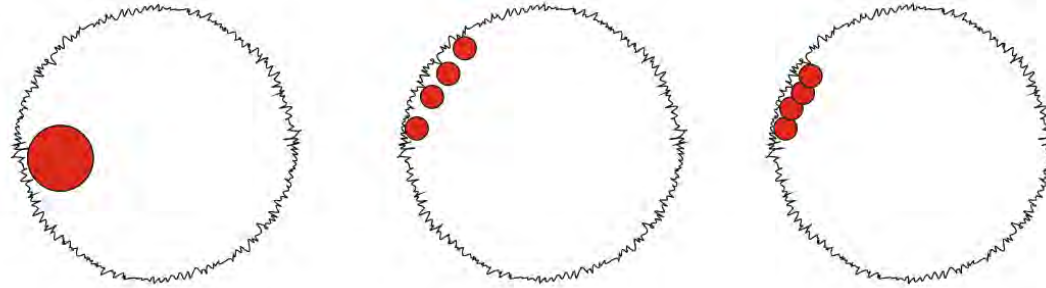


Real (deviations exceeded)

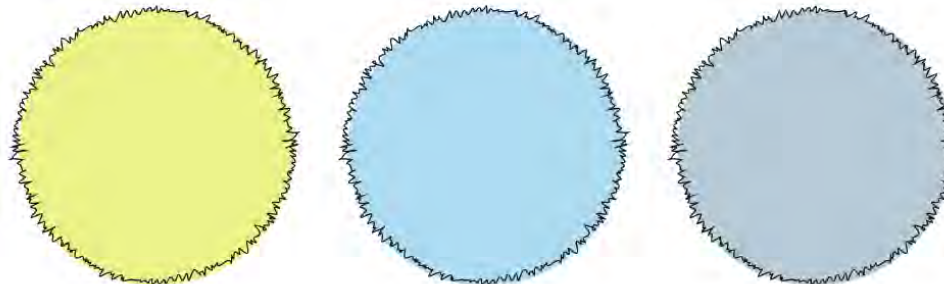


Messstrategie und Auswerteverfahren

Taktil



Optisch

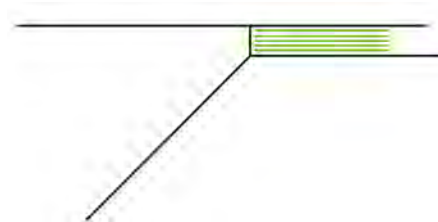


Messung der Blende taktill



- Optischer Fasertaster
- Tastelement Durchmesser 0.2 mm
- Messzeit für 10 Höhen à 1200 Punkte 4 h

Kante ideal



Kante real (Abweichungen stark übertrieben)



- Temperaturdrift < 0.05 K

Messmöglichkeiten in einzelnen Institutionen

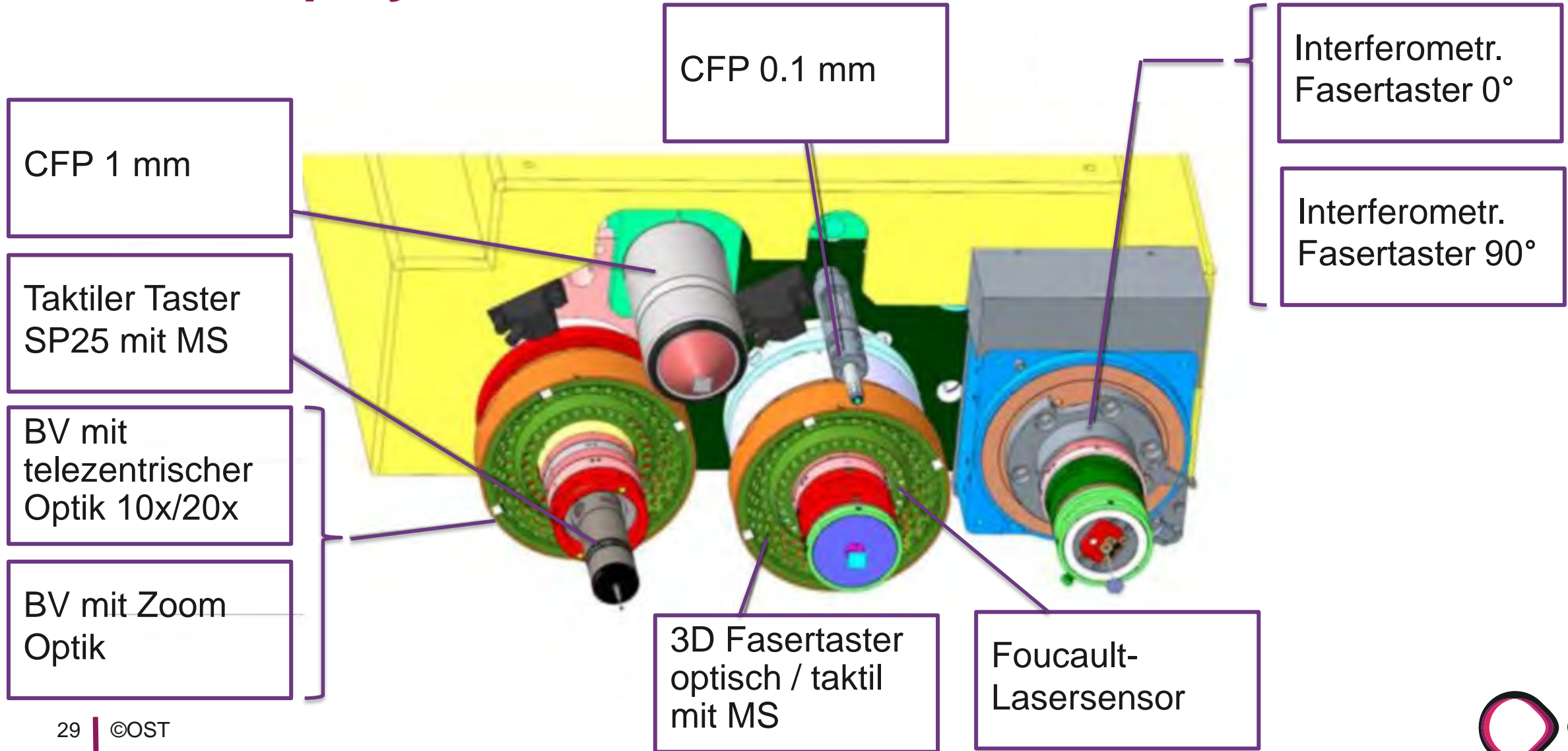
| | NMI 1 | NMI 2 | OST PMT (OST PMT |
|------------------------|-------|-------|------------------|
| Taktil | x | x | X |
| Taktil Mikrotaster | x | | Fasertaster |
| Optisch Telezentrisch | | x | X |
| Optische Endozentrisch | | | X |
| Rasterscan optisch | | | X |
| Messen bei 20°C | x | X | X |
| Messen bei 0°C | | | Neuentwicklung |

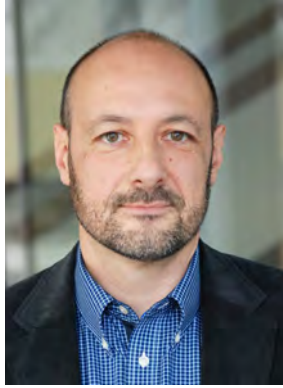
Ultragenaues Multisensor Koordinatenmessgerät



- **Weltweit genauestes Multisensor-Koordinatenmessgerät**
 - Max. Anzeigeabweichung für Längenmessungen
 $E_{0,MPE} = (0,15 + L / 2000) \mu\text{m}$
- **Messvolumen**
 - 400 mm x 400 mm x 250 mm, Drehachse zur Werkstückorientierung
- **Optimierungen**
 - Thermisch entkoppelte Wärmequellen
 - Kühlung der Antriebsstränge
 - Thermisch optimaler Materialien (Keramik, Invar)
- **Umgebung**
 - Mittlere Temperatur: $20^{\circ}\text{C} \pm 0.25 \text{ K}$
 - Temperaturgradienten: 0.1 K/h; 0.25K/m

Messkopfsysteme Werth Video Check UA





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