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Update on the activities at RhySearch and conclusion of OCLA 2021

Symposium on Optical Coatings for Laser Applications - OCLA

31st March 2021

Roelene Botha

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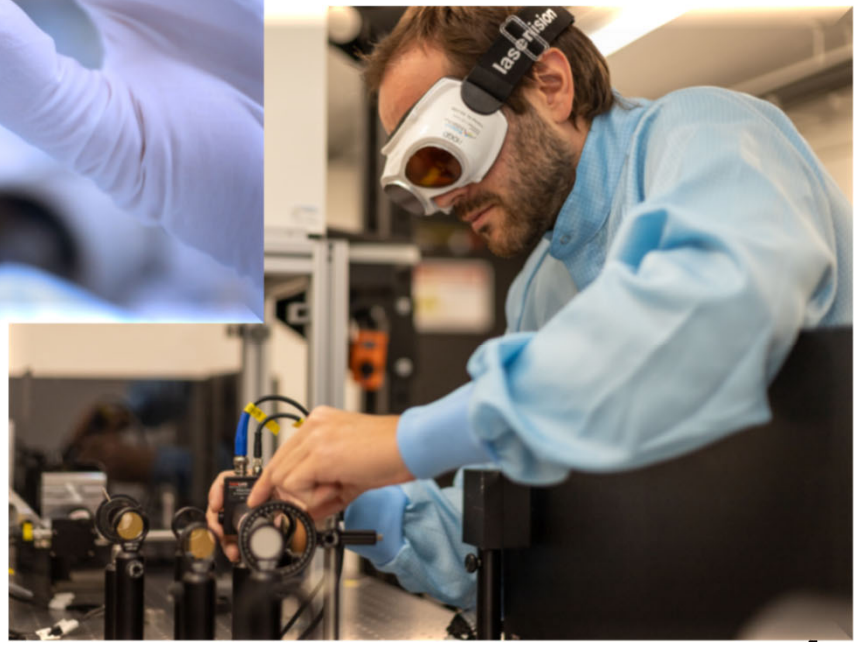
RhySearch Division Optical Coating:
The Swiss and Liechtenstein Competence Centre for Optical Coatings

- Expert knowledge and a wide range of equipment representing the entire process chain to produce and investigate optical components
- Wide range of services



Division Optical Coating: Three areas of focus

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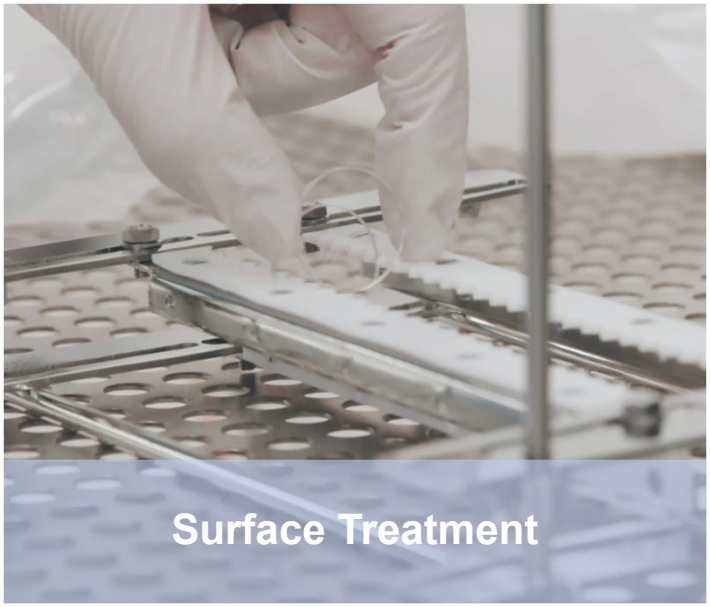
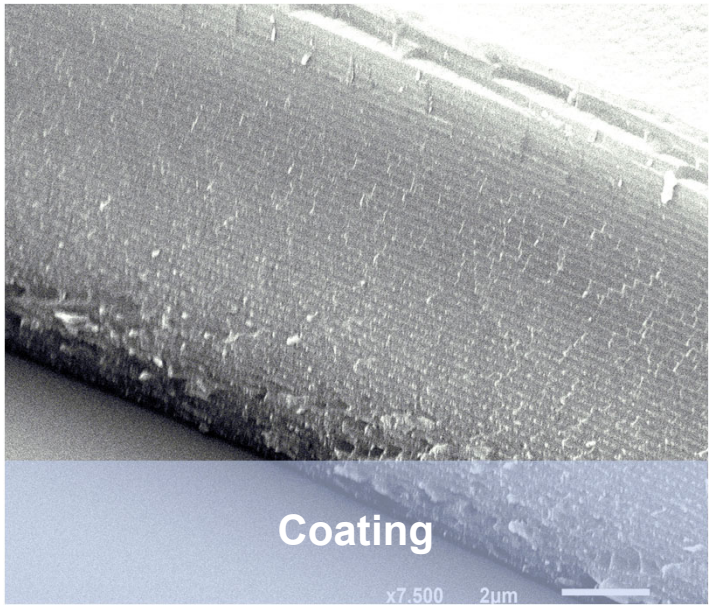


Surface Treatment

– Substrate preparation and cleaning



Coating

– Development of dielectric materials with novel optical properties
– Research on the industrialization of new coating technologies

Characterization

– Quality control using high-precision characterization methods

Division Optical Coating: Infrastructure

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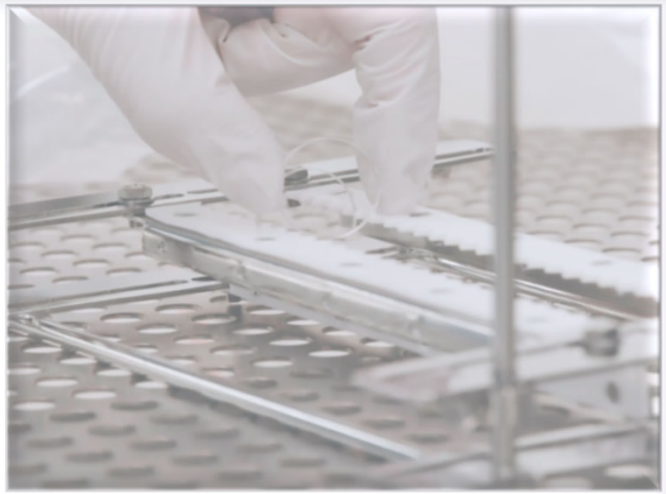


Surface treatment

Ion beam etching
- Surface polishing and cross sections

Laser pre-treatment

Cleaning processes

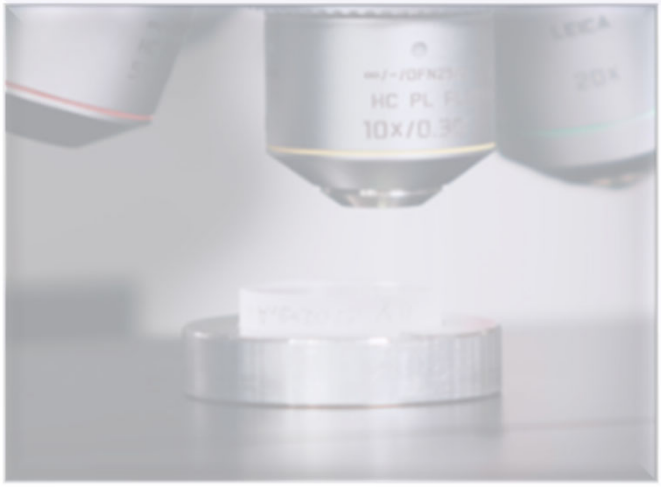
Annealing furnace

Coating technology

Dual Ion beam sputtering (DIBS)
- Broadband and single wavelength optical monitoring

Atomic layer deposition (ALD)
- Thermal and plasma processes

ForzA: Flexible research system
- Combination of IBS, pulsed laser deposition, ion beam etching, laser treatment



Characterization

Laser induced damage threshold (LIDT)
Cavity ring-down (CRD)
White light interferometer
Total scattered light measurement
Absorption measurement *(ordered)*
Nano-scratch test
Climate chamber
DIC microscope with wave front sensor

Division Precision Manufacturing: Three areas of focus

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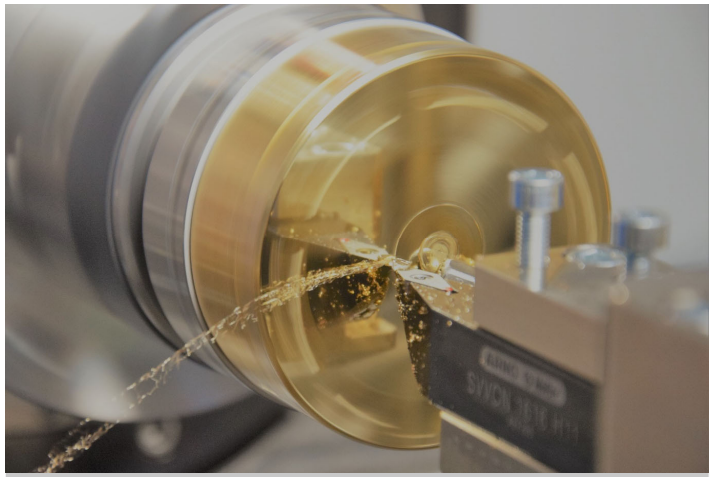
Precision machining

- Applied R&D with focus on precision, productivity, flexibility and materials
- Services, e.g. prototype and small batch machining



Optic system generation

- Applied R&D with focus on ultra-precision turning for optical and photonic applications (with OST)
- Services, e.g. prototype and small batch machining

Automation and digitalization

- Selected topics of “Industry 4.0”

Division Precision Manufacturing: Infrastructure

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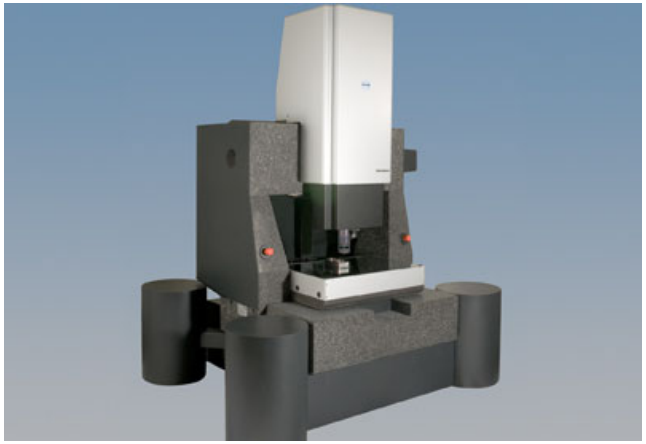
- **Machine tools with highest precision**
  - Ultra-precision turning, up to optical surfaces in non-ferrous metals as well as hardened steel
  - 5-axis milling and grinding, bridging the gap between high-speed cutting and highest precision
  - 5-axis high-precision laser machining
- **Analytics**
  - Coordinate measuring machine
  - Cutting force measurement with dynamometers



Division Optical Coating: Research Activities

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THERMODYNAMX

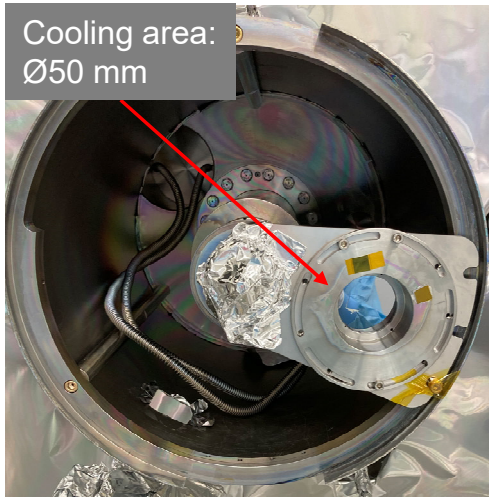
Actively cooled substrate holder:
An additional degree of freedom during IBS coating

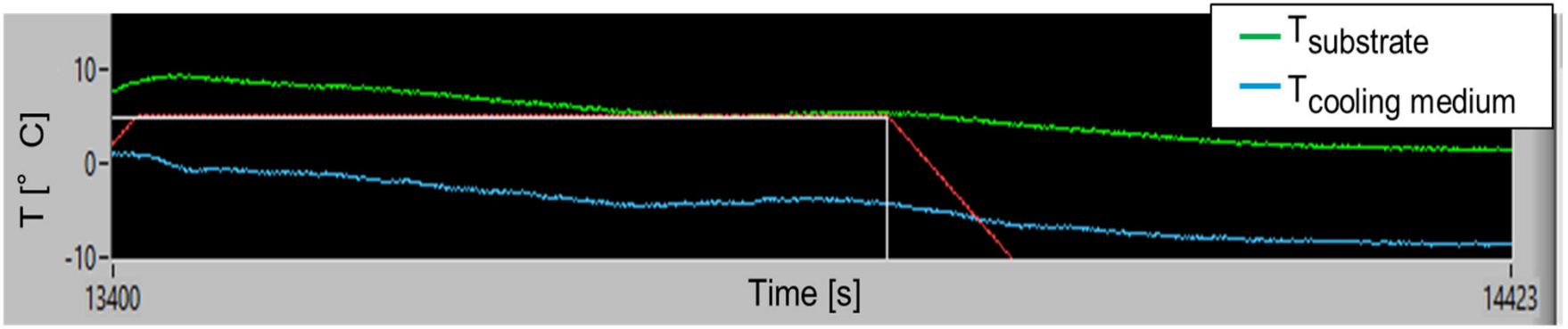
- Investigate the layer stress as a function of temperature
- Develop processes for coating temperature sensitive substrates
- Allows depositing material well below the usual saturation temperature

- Technical details:
  - Chiller: $P_{cooling}$ = 350 W @ 20° C
  - Cooling medium: Non flammable, no greenhouse gas emission
- Cooling facts:
  - $T_{homogeneity}$ = 1 K @ 10 – 80 ° C
  - Min. $T_{cooling\ medium}$ = - 20 ° C (short-term)

Contact:

Dr. Thomas Gischkat
Optical coating expert





Example cooling test:
SiO_2 Process:
- U_{accel} = 250 V
- U_{beam} = 1250 V
- I_{beam} = 600 mA

$T_{cooling\ medium}$ = - 9° C
$T_{substrate}$ = 1° C
($T_{sat.\ chamber}$ = 66° C)

Division Optical Coating: Research Activities

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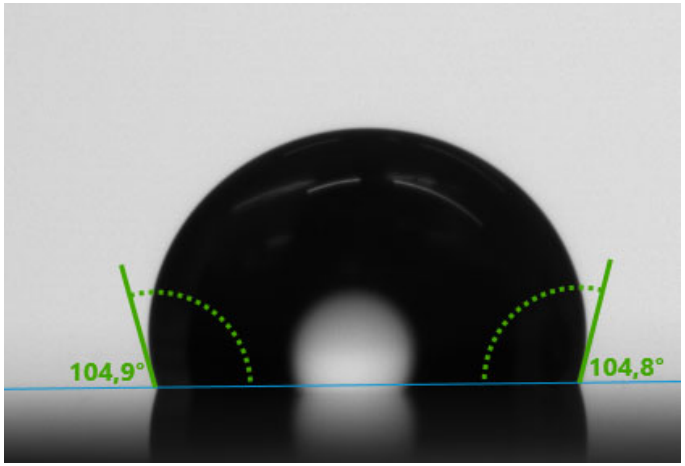
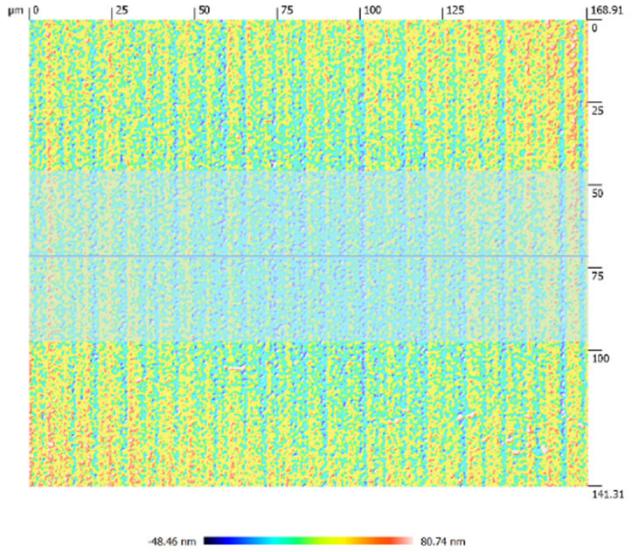
Hydrophobic oxide coatings

- Develop novel structured oxide materials for easy to clean applications
- Combination of surface structuring with hydrophobic materials
- Stability against mechanical, chemical influences and laser radiation



Above: Water droplet on structure coated surface



Above: Coated nanostructures

Contact:

Dr. Zoltan Balogh-Michels
Analytics expert

FH Vorarlberg
University of Applied Sciences

Division Optical Coating: Research Activities

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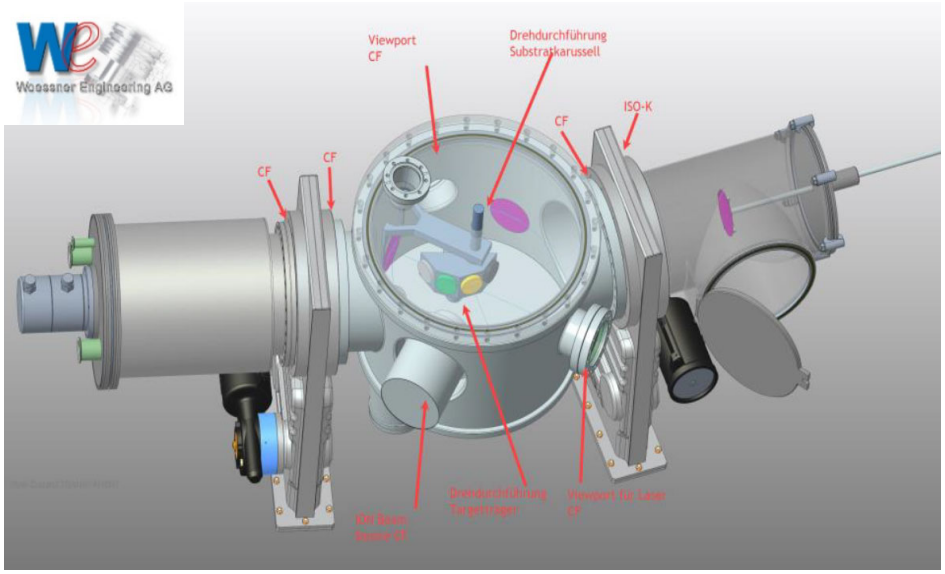
ForzA: Flexible Coating System

- Design, build and utilize a new coating tool
  - Ion Beam Sputtering (IBS)
  - Pulsed Laser Deposition (PLD)
  - Further features
    - *Final pressure approx. 2x10-9 mbar*
    - *Loadlock*
    - *In-situ substrate cleaning*
    - *Substrate heating*
    - *Post-Treatment: Laser- and Flashlamp- annealing*
    - *Reflection High Energy Electron Diffraction : RHEED*



- Demonstrate potential of the new developed technology and processes:
  - Flexible R&D system for various applications
  - Eg. Synthesis of 2D materials

ETH zürich
Institute of Electromagnetic Fields (IEF)

OST
Ostschweizer
Fachhochschule

Contact:

Dr. Thomas Gischkat
Optical coating expert

Division Optical Coating: Research Activities

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Innosuisse Project *EmerALD*

Develop innovative, cost-effective ALD manufacturing processes to enable conformal coating on freeform components for optical applications

Focuses on:
- Conformal coating on freeform substrates
- Technology and process development

Start: Nov. 2020 (3 years)
Consortium: 8 Project partners
Volume: ~1.2 Mio CHF

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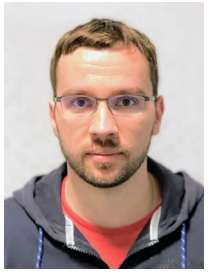

Dr. Theodor Weiss
ALD expert

OST Ostschweizer Fachhochschule

BÜHLER evatec process systems FISBA Innovators in Photonics INFICON SCHOTT glass made of ideas SWISSOPTIC BERLINER GLAS GROUP

OCLA through the years
To mention but a few of the memorable moments…

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*"development of international standards in coatings characterisation **extremely enhanced during the last two decades**"*

- Prof. D. Ristau, LZH (OCLA 2015)

*"Post processing techniques that have been applied in the ns regime … **could also be of potential interest** [for the sub-ps regime]"*

- Prof. L. Gallais, Institut Fresnel (OCLA 2017)

*Devastative contamination on DUV Laser mirrors and **dreams for laser processing***

- Prof. P. Hoffmann, EMPA Thun (OCLA 2016)

Assessing critical imperfections of high-end optical coatings

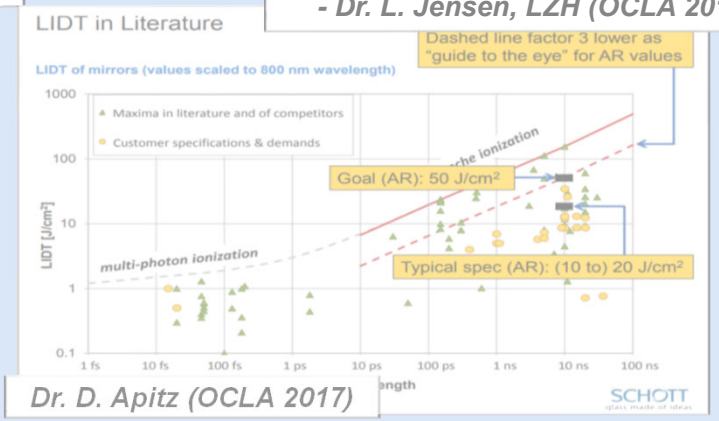
- Dr. S. Schröder, Fraunhofer IOF (OCLA 2019)

Laser-induced damaged in ALD films

- Dr. L. Jensen, LZH (OCLA 2019)

"LIDT: …porous coatings structures (thermal processes) perform better in the ns-regime. higher packing density coatings (sputtering) are good choices for shorter pulses (ps-fs)"

- Prof. D. Ristau, LZH (OCLA 2019)



Dr. D. Apitz (OCLA 2017)

*Crystalline Coatings: **a new paradigm in optical coating technology***

- Prof. M. Aspelmeyer, Uni. Wien (OCLA 2016)

*"For **further progress** with the high energy laser oscillators … we need high-dispersion mirrors."*

- Dr. V. Pervak, LMU Münich (OCLA 2016)

Nanostructured diffractive optics for high-energy laser applications

- Dr. F. Döring, XRNanotech (OCLA 2021)

***A dream of next generation interference coatings**: is it possible to overcome intrinsic laser damage resistance?*

Prof. A. Melninkaitis, Vilnius University (OCLA 2017)

*"…**new processes and/or new materials have to be developed to improve the film properties and to enable synthesis of new materials.**"*

- Prof. N. Kaiser, Fraunhofer IOF (OCLA 2016)

The future goal:
Bespoke mass production of optical components

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METROLOGY

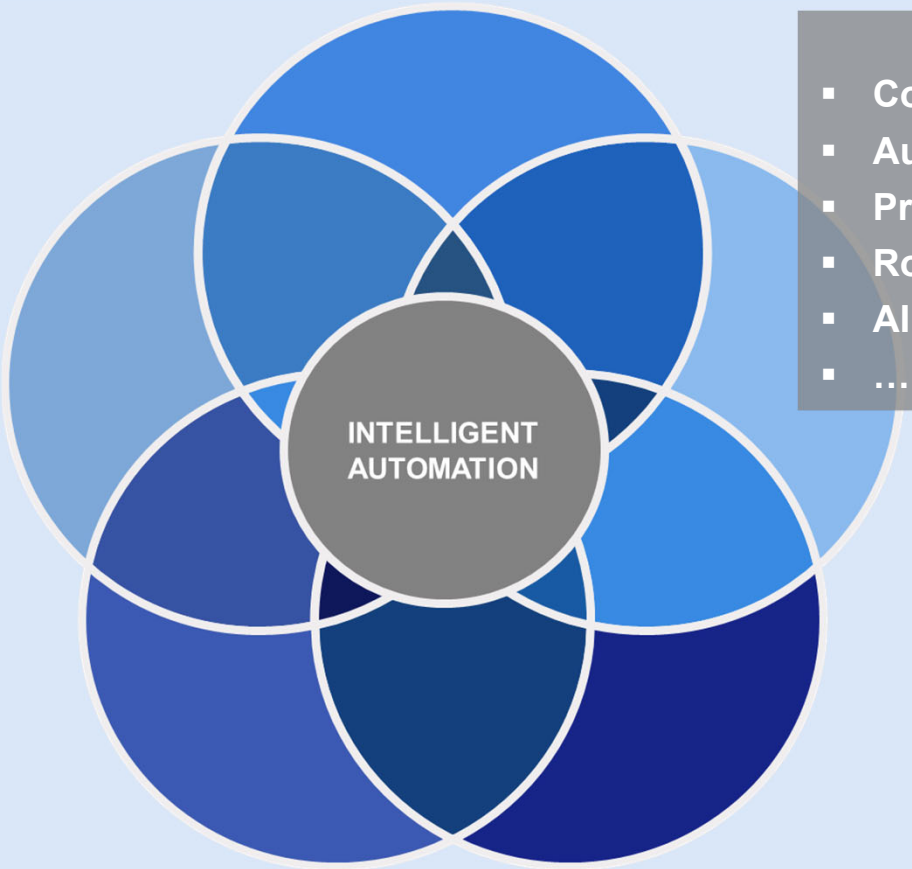
PRE-MACHINING

GRINDING AND POLISHING

SURFACE TREATMENT

STRUCTURING

COATING



- Combined / new process workflows
- Automated closed loop processes
- Process control
- Robotics
- AI
- …

Summary

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- **Broad variety of competences, infrastructure and research activities**
  - One-stop-shop @ RhySearch
- **OCLA Symposium**
  - Platform for discussion, learning and keeping up to date with new trends
- **Optical components becoming increasing in complexity and requirements**
  - Future manufacturing trends focus on autonomous closed loop processes for ultraprecision surfaces, optical coatings and functional surfaces

Acknowledgements

Beni Muller and Olivia Müller from *Swissphotonics*

Thomas Gischkat, Bärbel Selm, Agnes Zeiner and Silvia Rutz from *RhySearch*

SWISS PHOTONICS

OST Ostschweizer Fachhochschule

EOS European Optical Society Coherence for Europe

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EOS European Optical Society Coherence for Europe

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Thank you for participating in OCLA 2021!

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Save the date for OCLA 2022

Wednesday, 13th April 2022

www.europeanoptics.org

EOSAM 13-17 September 2021 Rome, Italy

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Topical meeting: *Optical System Design, Tolerancing and Manufacturing* includes sessions on

- Optics for high-power laser applications
- High quality optical coatings and laser-induced damage threshold testing
- Optical coatings – challenges and solutions