Prospects of Laser Polishing for Small and Complexly Shaped Parts

High Speed / High Precision Laser Microfabrication June 18, 2014

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Polishing of Complexly Shaped 3D Parts

State of the art

Many 3D parts are polished manually

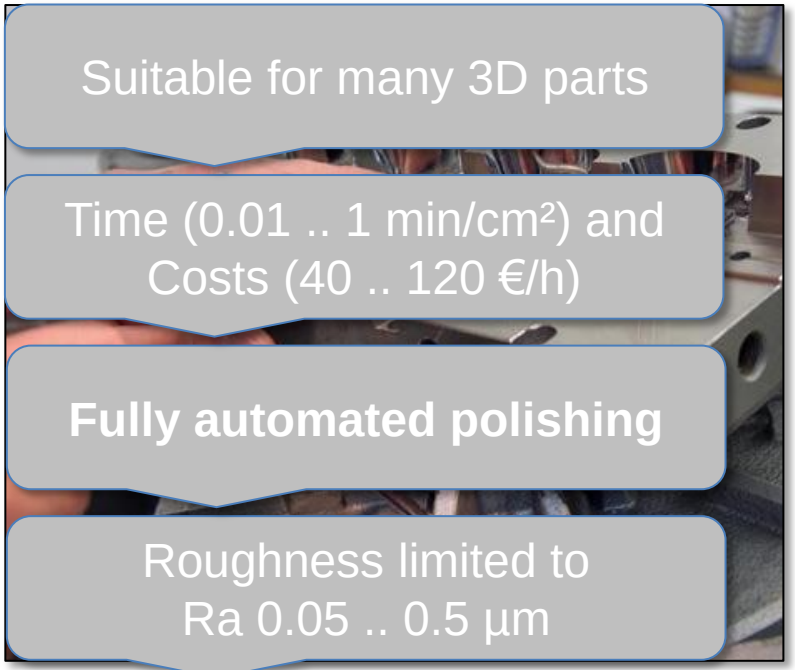
Time (1 .. 60 min/cm²) and Costs (30 .. 100 €/h)

Lack of suitable laborers

Roughness Ra down to 0.005 µm

High demand for **automated polishing**

Laser polishing



Suitable for many 3D parts

Time (0.01 .. 1 min/cm²) and Costs (40 .. 120 €/h)

Fully automated polishing

Roughness limited to Ra 0.05 .. 0.5 µm

Laser polishing has potential for many applications

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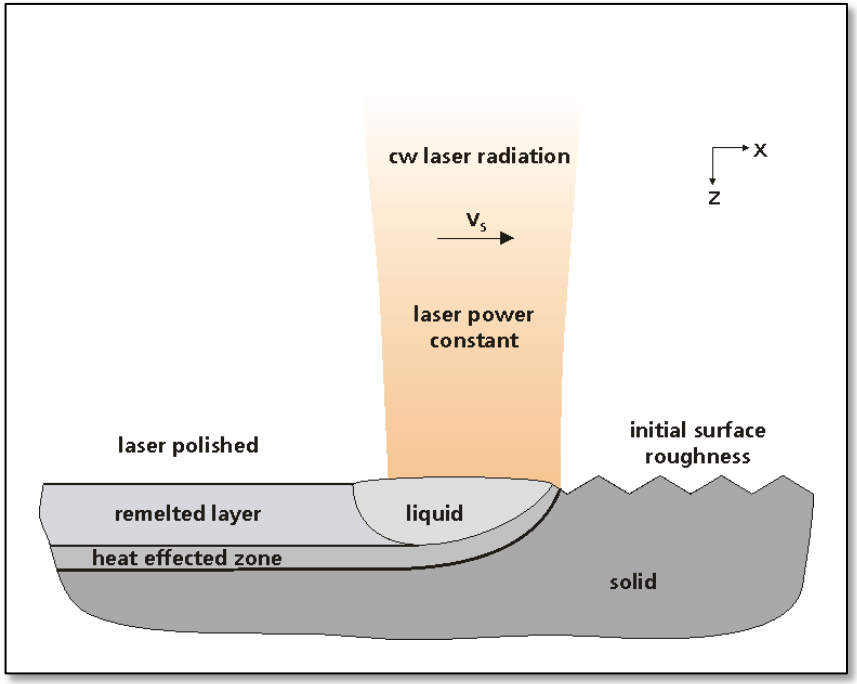
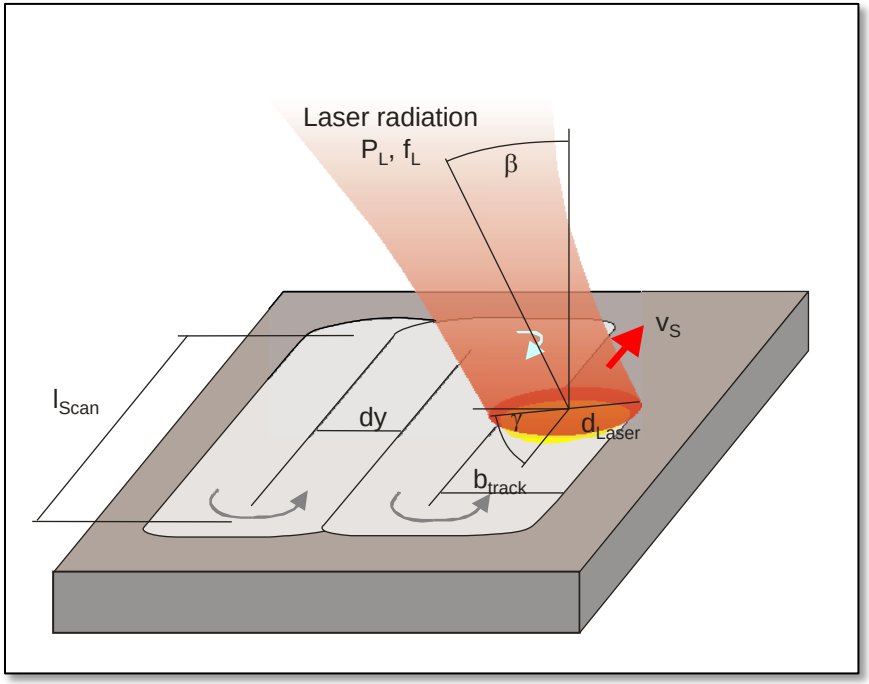
Laser Polishing of Metals
Process principle

- Remelting of a thin surface layer and smoothing the surface through surface tension
- Nearly no material removal → high shape retention
- Solid state laser source: continuous wave / pulsed, laser power 40-500 W





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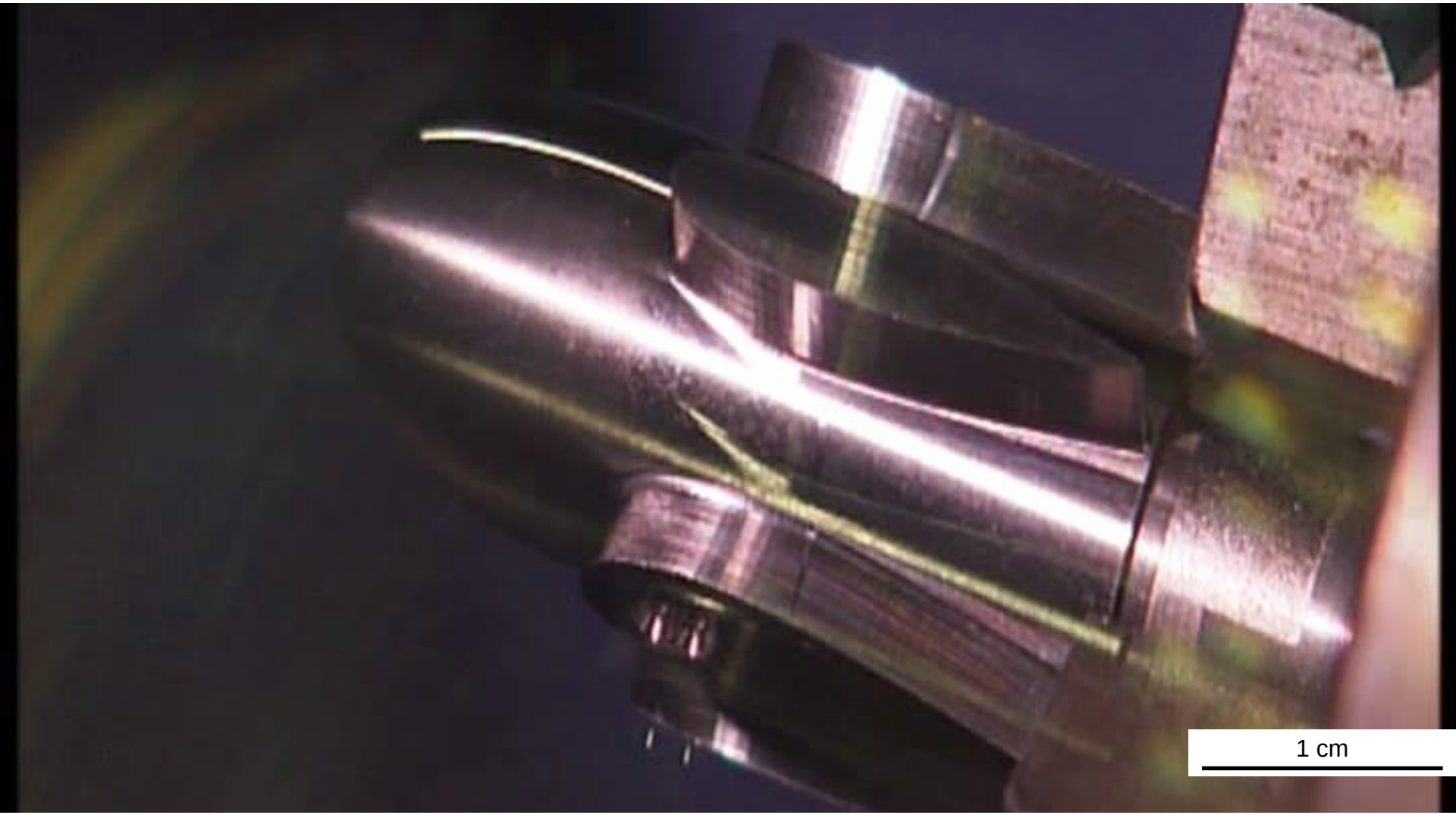
Pulsed Laser Polishing of Guide Vane for VAD (Ti6Al4V)



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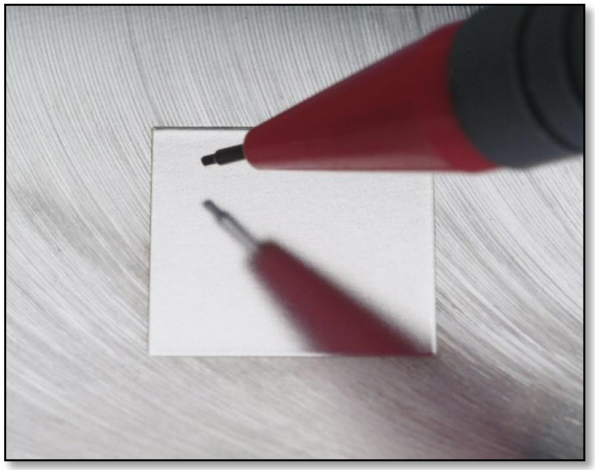

- Introduction / Process principle
- Machine Tools for Laser Polishing
- Application Examples
- Conclusion

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Machine Tools for Laser Polishing
Machine Tool for Small Parts



- **3-axis laser scanner** and **6-axis robot** with pneumatic gripper
- Suitable for complexly shaped parts up to 1 kg
- Glove box process gas chamber with airlock
- Solid state laser (continuous wave or pulsed)
- Optional: triangulation sensor;
  inner processing optics for bore or tube polishing

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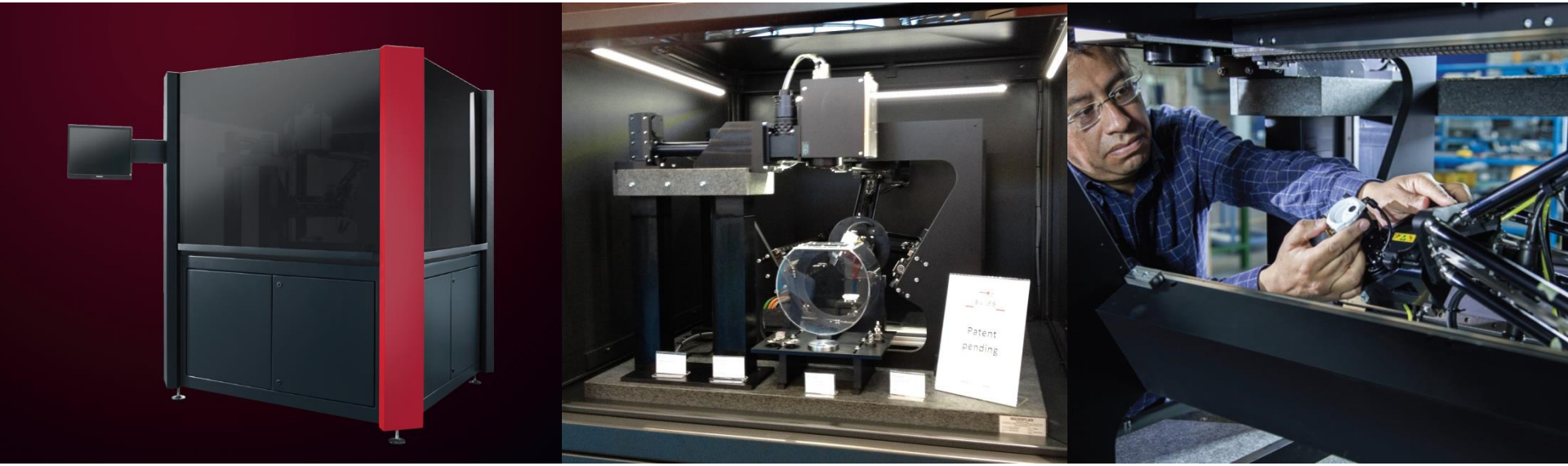
Machine Tools for Laser Polishing

Machine Tool for Small Parts by Unitechnologies



- 2 or 3-axis laser scanner and XYZ - delta robot with 2 rotational axes BC
- Flexible process gas chamber for complex shaped parts
- Different machine platforms:
  Standalone cell or integrated in automatic production lines
- Suitable for laser polishing, structuring and welding
  (depending on selected laser source)
- CAM-NC data chain for laser polishing by Fraunhofer ILT

Source: Unitechnologies SA, Gals, Switzerland

sylas LASER SYSTEMS

www.unitechnologies.com

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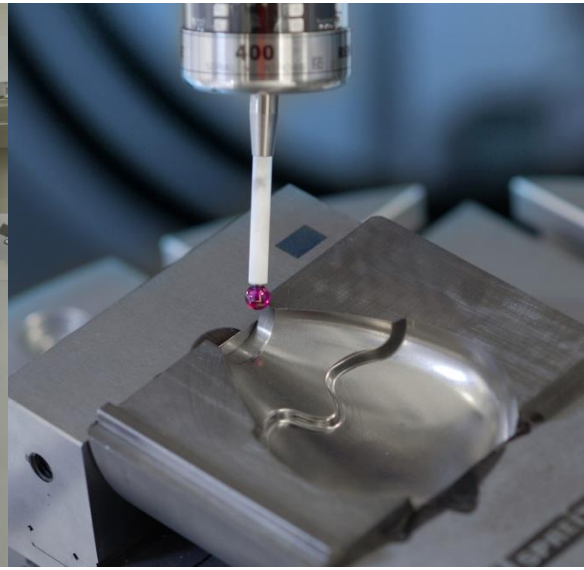
Machine Tools for Laser Polishing

Machine Tool for Medium-large Parts



- 3-axis laser scanner and 5-axis portal machine with XYZ-AC kinematics
- Designed for parts with up to 100 kg (crane loading is possible)
- Ergonomic process chamber
- Solid state laser source (continuous wave or pulsed)
- Optional: Tactile probe for determination of part orientation
  Process gas system with more than one inert gas

arnold RAVENSBURG

S&F Systemtechnik GmbH

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Machine Tools for Laser Polishing

Polishing of a Mold for Glass Forming

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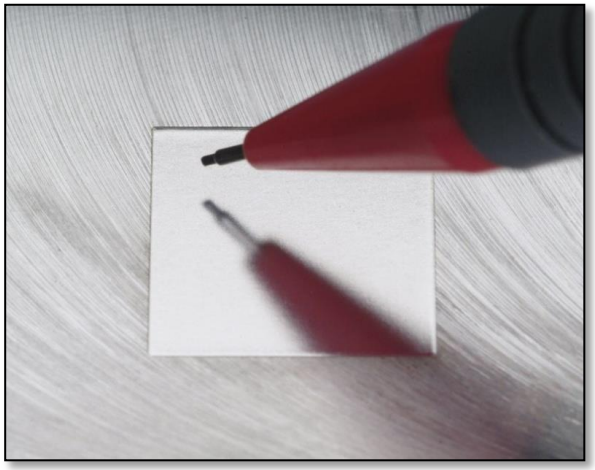

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- **Application Examples**
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Application Examples

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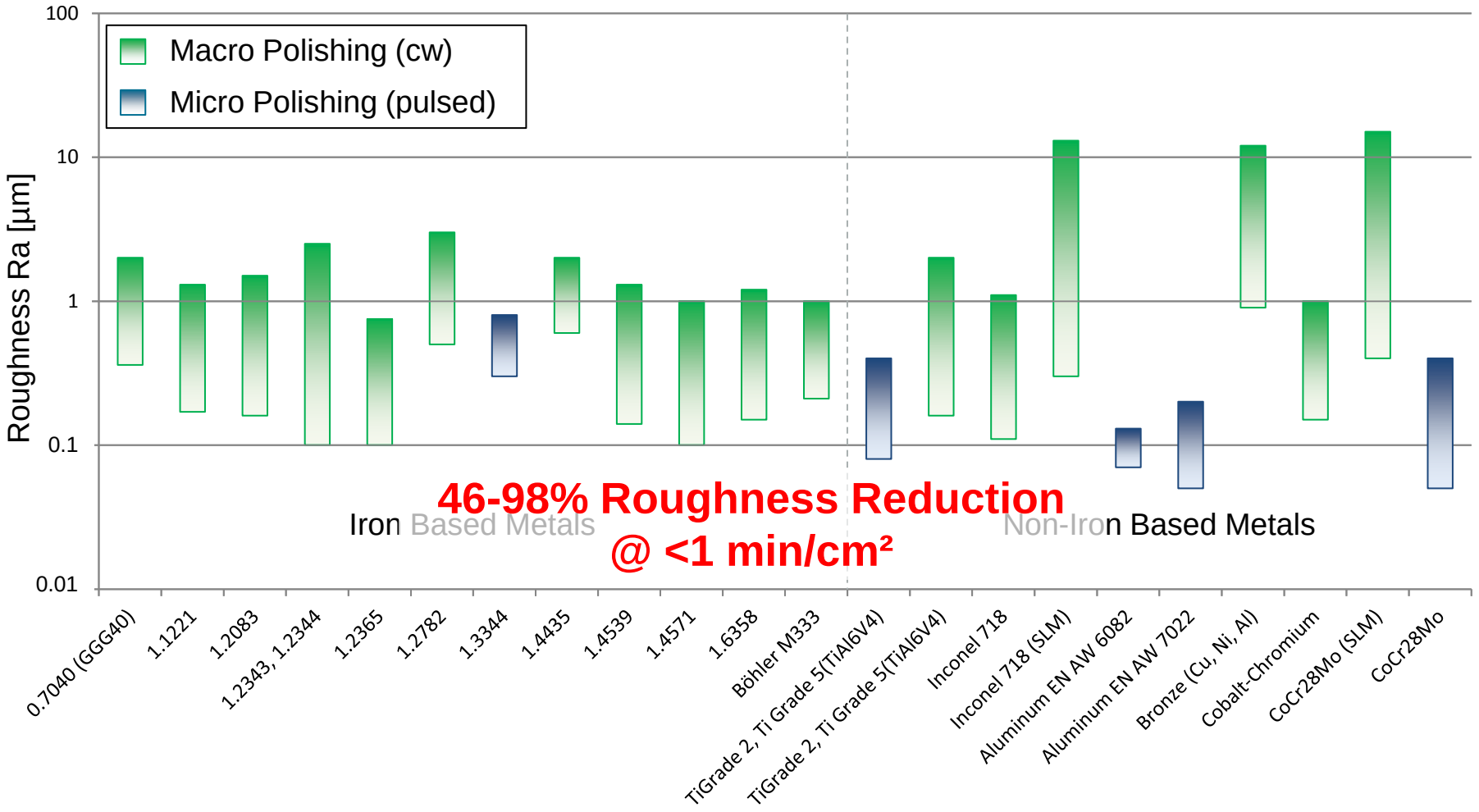
Application Examples
Overview of Investigated Materials



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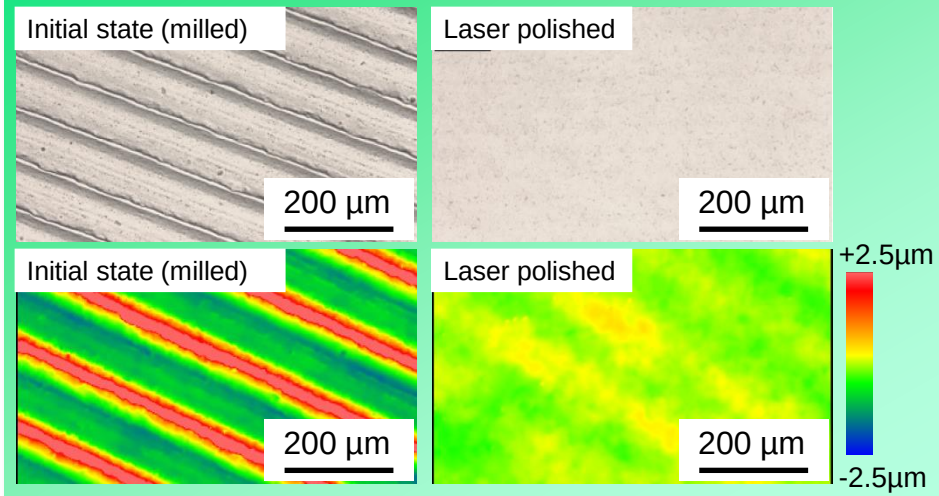
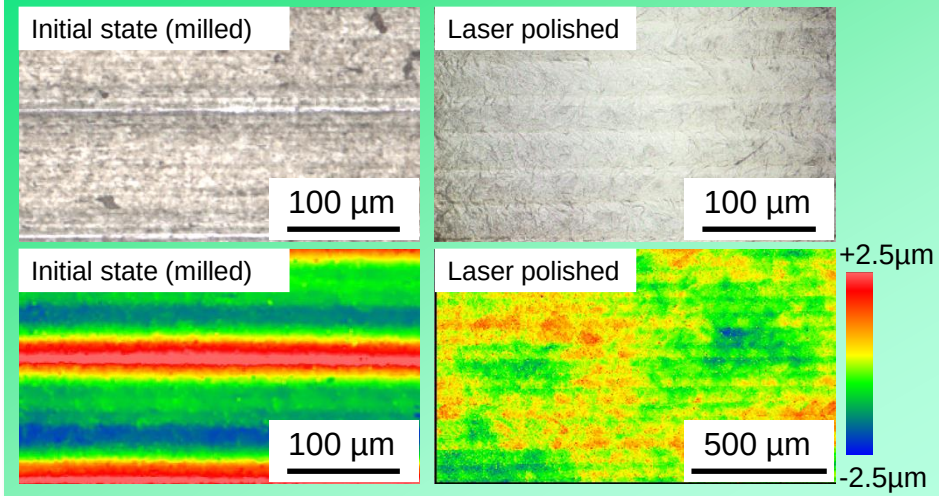
Application Examples

Ti6Al4V



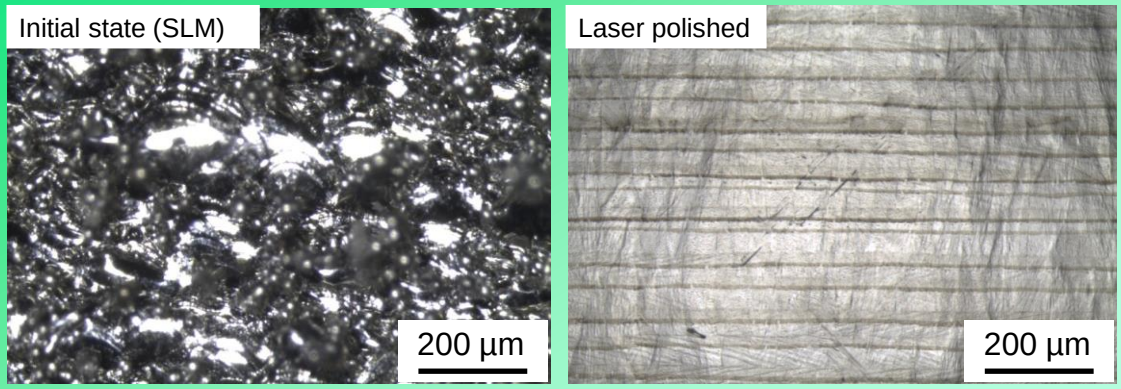
Ra-Reduction: 1.1 µm → 0.12 µm @ 3,3 s/cm²

1.1221



Ra-Reduction: 1.26 µm → 0.17 µm @ 20 s/cm²

Inconel 718



Ra-Reduction: 12-20 µm → 0.19 µm @ 27 s/cm²

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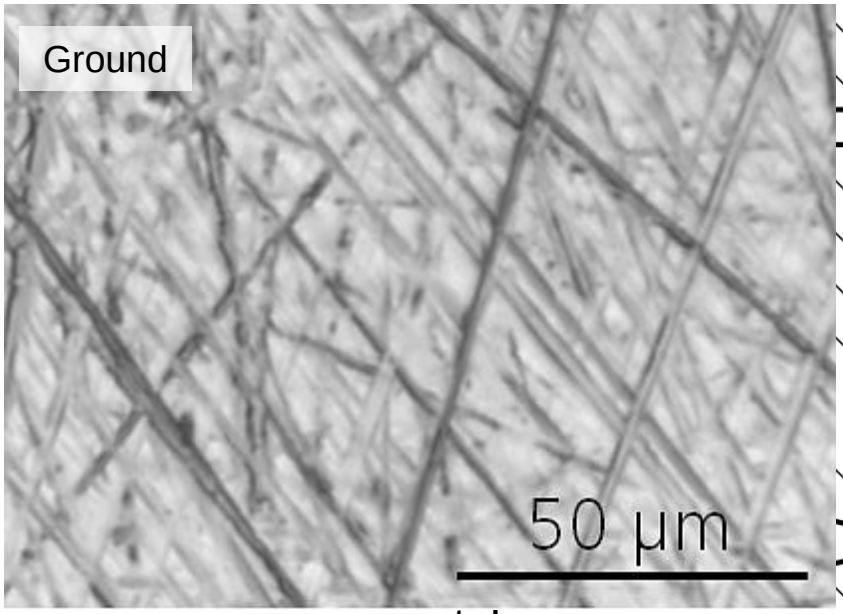
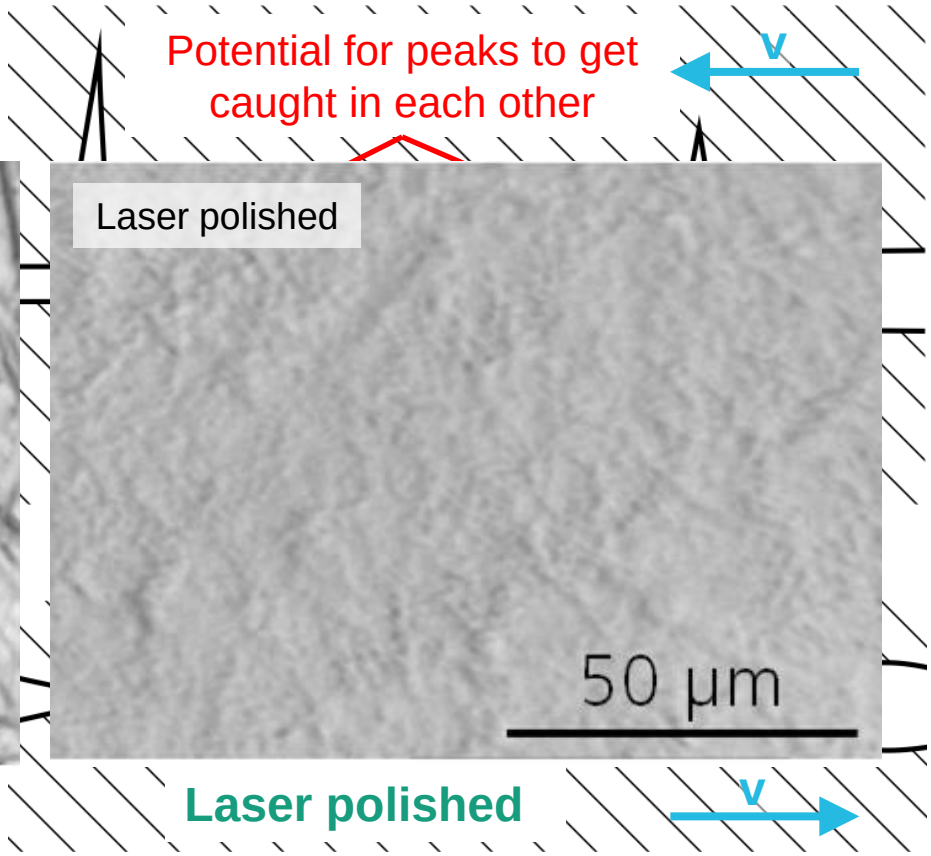
Application Examples

Grinding vs. Laser Polishing – Tribological Surfaces



no scratches



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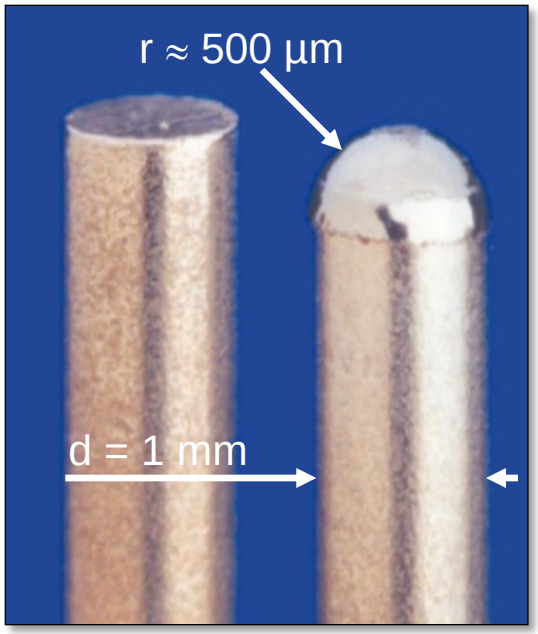
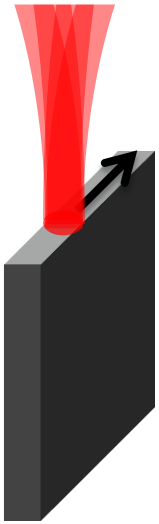
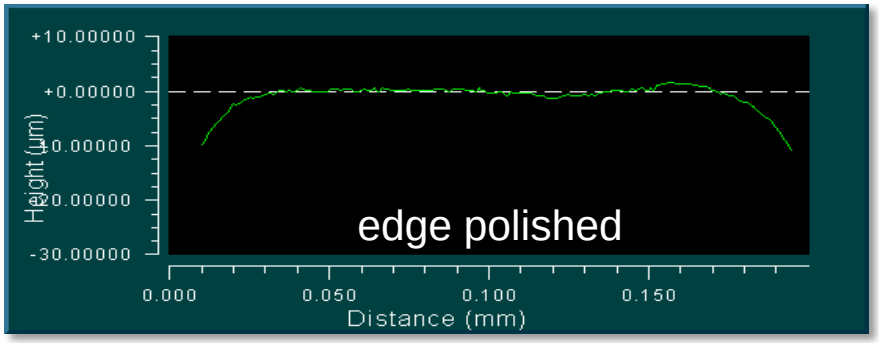
Application Examples
Edge Polishing and Rounding / Deburring

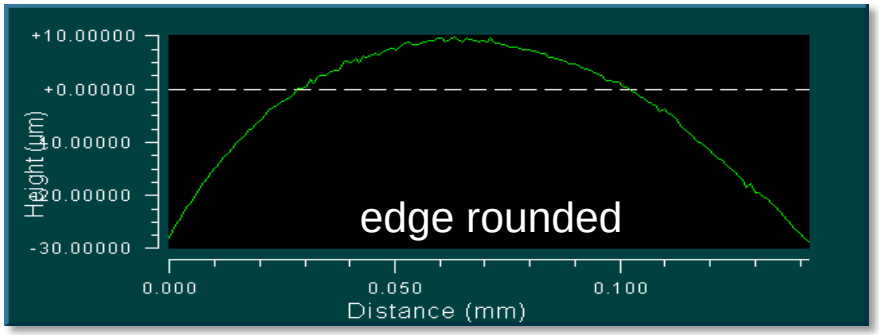
- Rounding of steel-pins
- Processing time 0.2 s



- Polishing or rounding of the cutting edge of sheet metal







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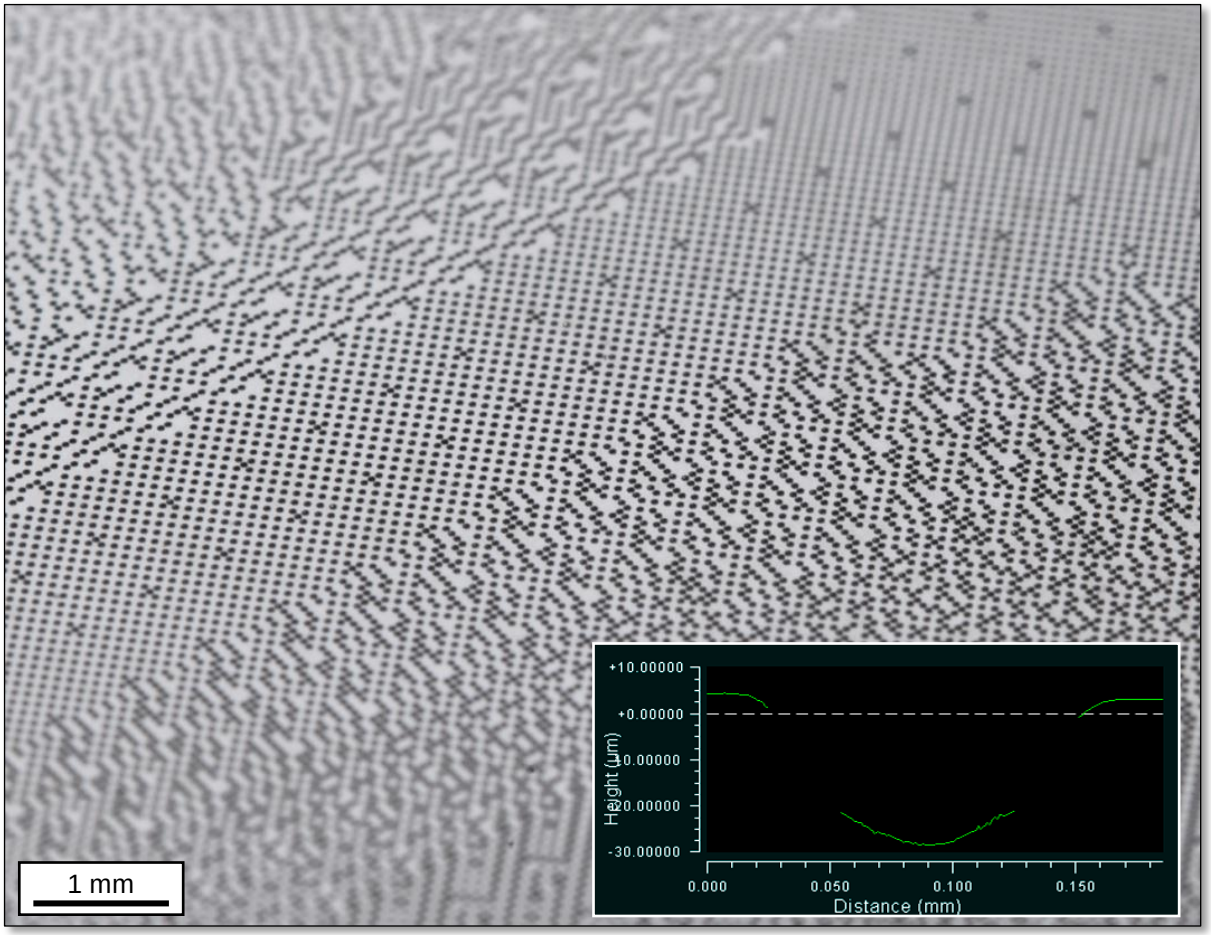
Tooling Industry
Polishing of Micro-Lens Arrays

- Light scattering surfaces by
  - 1. laser ablation (ps-Laser) and
  - 2. laser polishing (ns-Laser)
- Tool steel 1.2343
- Structure depth 35 µm
- Structure width 120 µm



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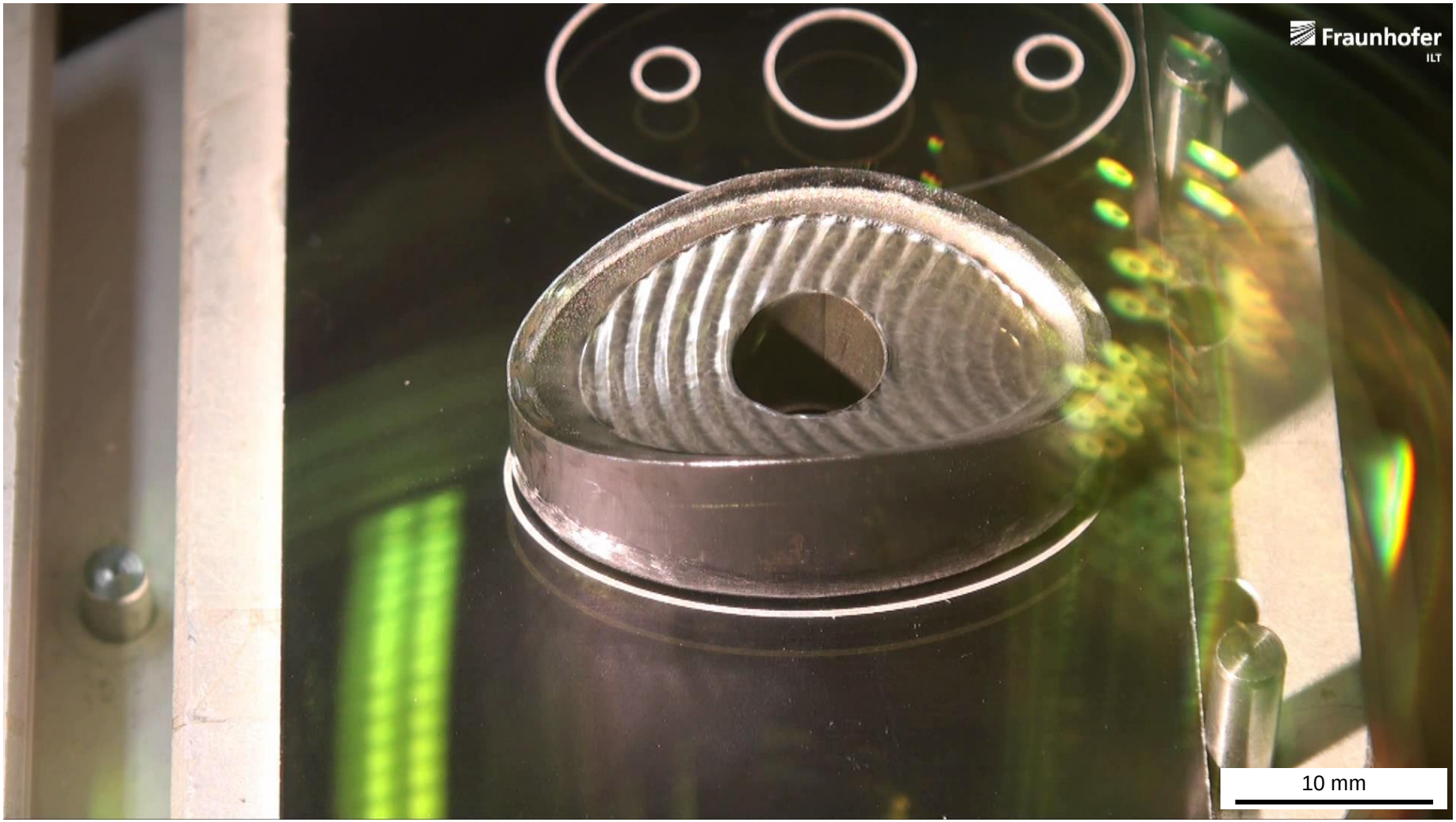
Application Examples
Increasing the Gloss Level



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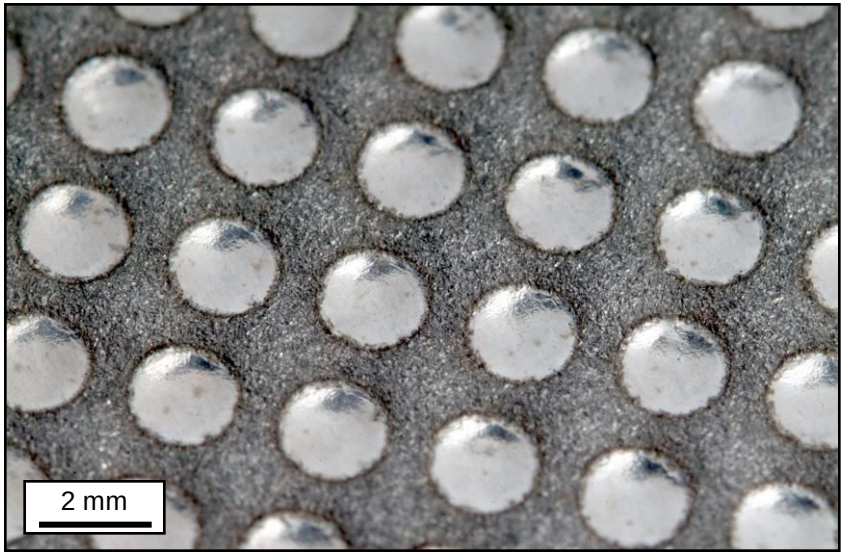
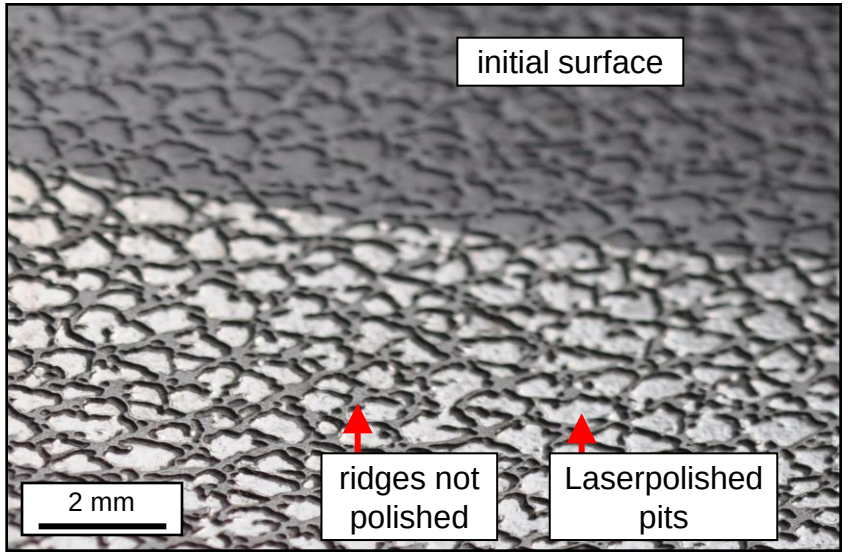
Application Examples

Two-Gloss-Level Design by Selective Laser Polishing

- Selective laser polishig of matt surfaces
- Circle pattern



- Selective laser polishing of photo chemical etched surfaces
- Polishing **only** of the pits in the tool



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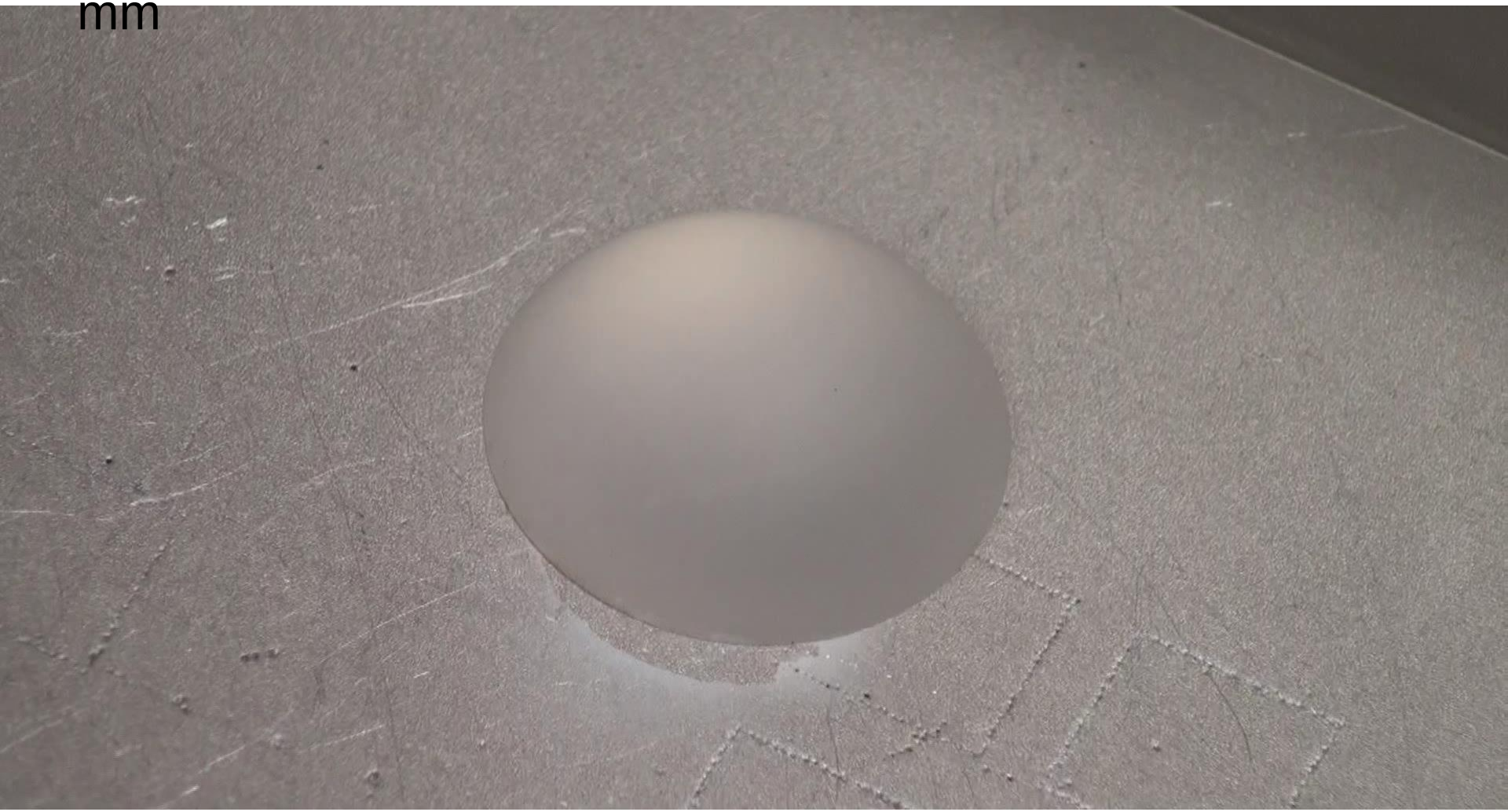
Application Examples

Glass Polishing – Ground Spherical Lens, Fused Silica, ∅25 mm



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AGENDA

- Introduction / Process principle
- Machine Tools for Laser Polishing
- Application Examples
- **Conclusion**

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Conclusion

- Laser polishing is
  - feasible for **3D** geometries,
  - **automated** and
  - **fast** (almost independent of complexity).
- Offers **new possibilities** for
  - functional and tribological surfaces,
  - medical applications,
  - design surfaces
  - and many more…

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Save the Date

2nd Conference on Laser Polishing - LaP 2016
April 26 to 27, 2016 in Aachen, Germany

Thank you for your attention!
Questions?

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GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung

SEVENTH FRAMEWORK PROGRAMME

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VolkswagenStiftung

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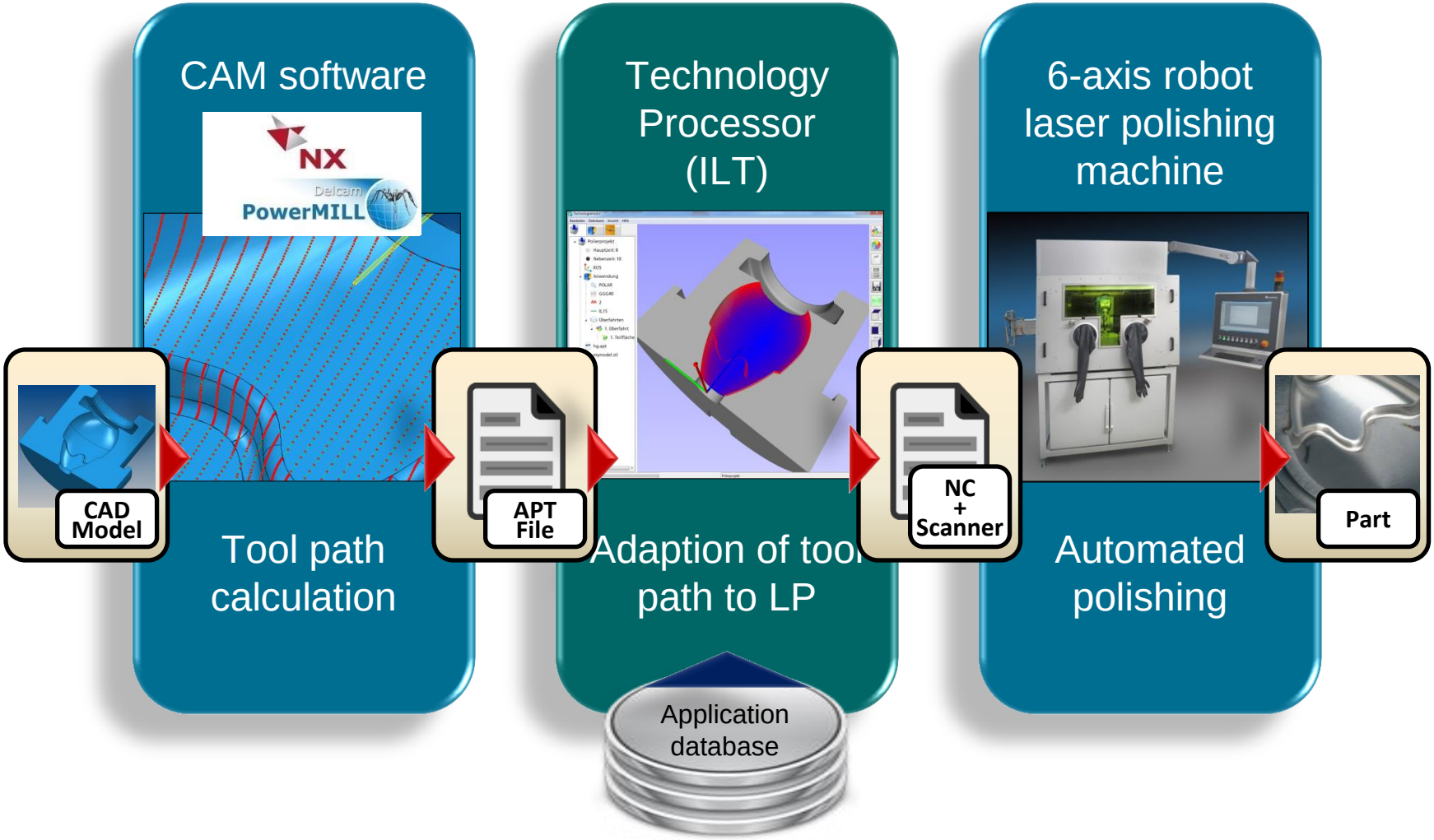
CAM-NC Process Chain

Fully Integrated Process Chain



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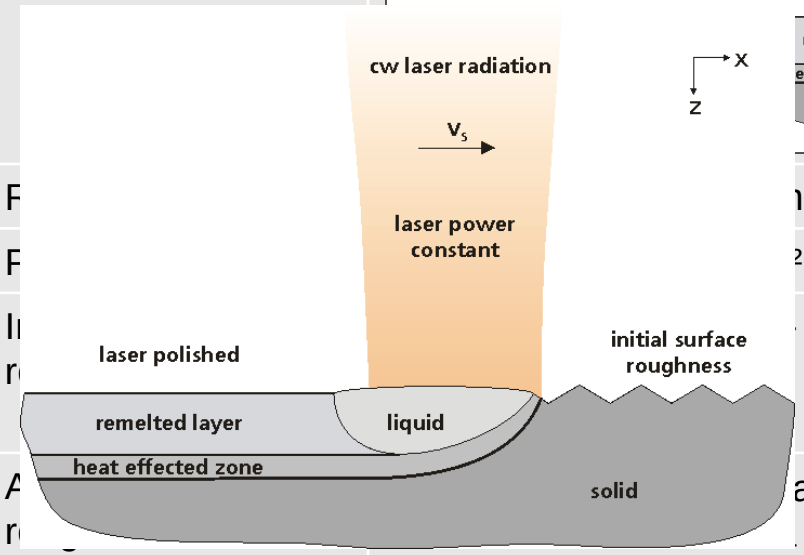
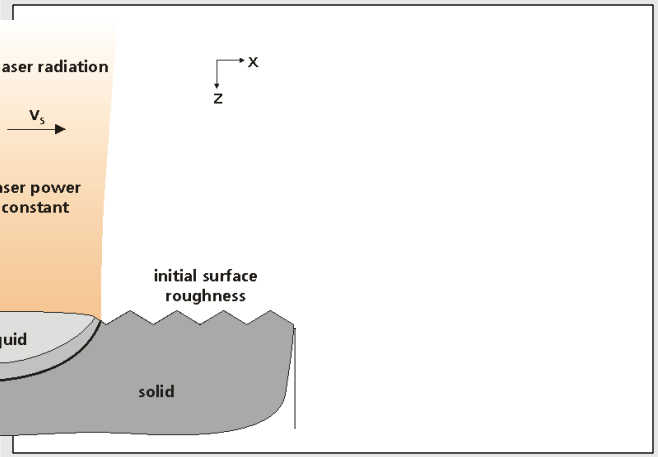
Laser Polishing of Metals
Process variants

	Macro polishing	Micro polishing
Laser radiation	continuous wave (cw)	pulsed (100 - 1000 ns)
Schematic drawing		
F	n	< 5 µm
F	2	1 - 10 s/cm²
I r	processed	▪ ground and fine-milled ▪ Ra = 0.2 - 0.8 µm ▪ adjusting the gloss level
A r	aterial, quality of material and initial roughness = 0.05 - 0.50 µm / Rz = 0.4 - 3 µm	

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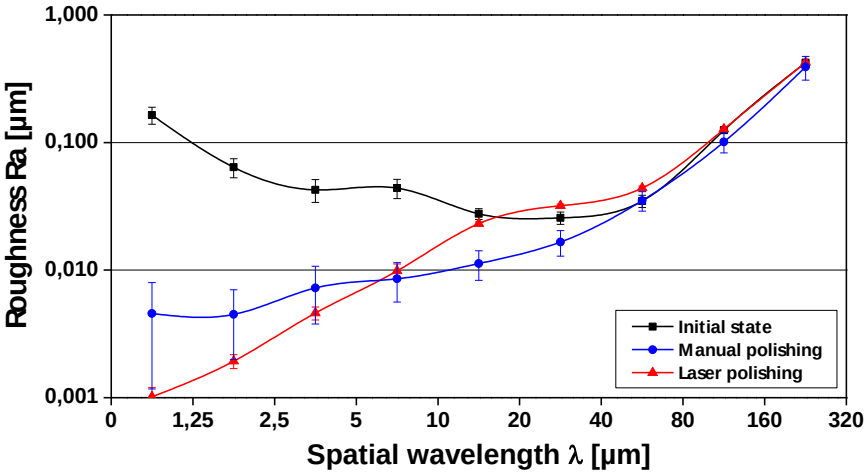
Medical Engineering

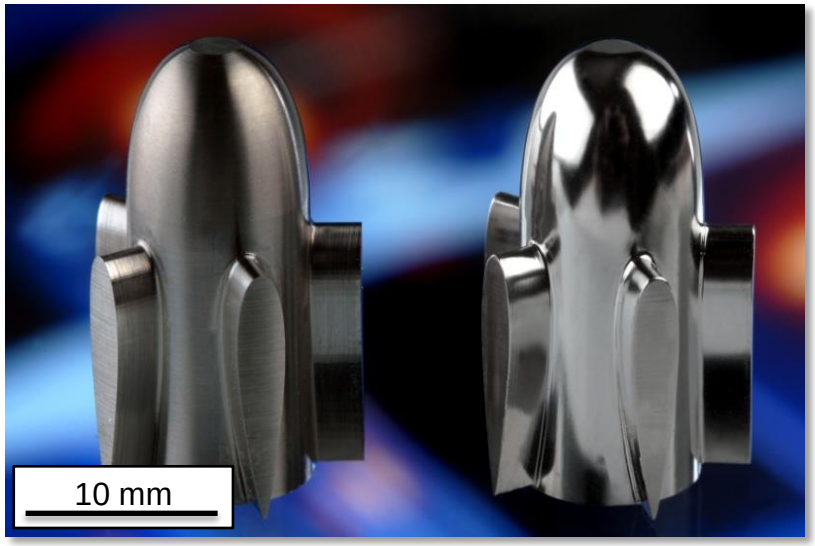
Guide Vane of Ventricle Assist Device (VAD)

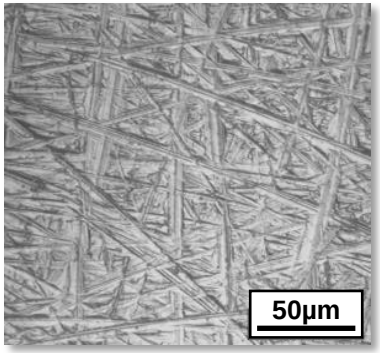
- Polishing of the entire surface except the exterior of the wings
  - Manual polishing: 3h
  - Laser polishing: ca. 5min

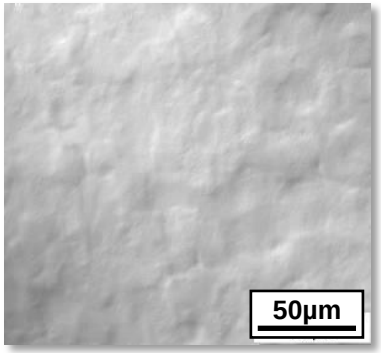


Initial state (milled)

Laser polished







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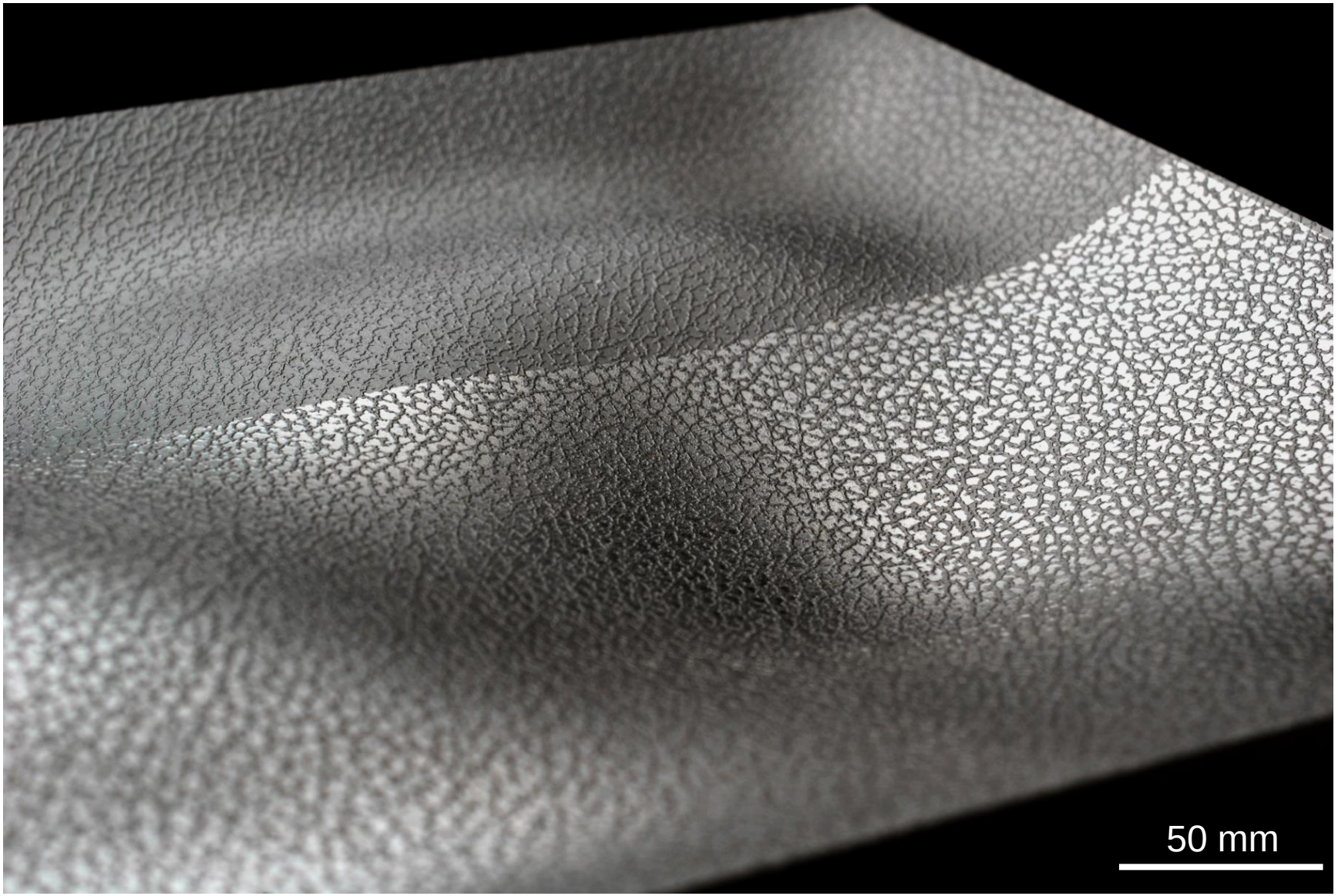

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