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FRAUNHOFER INSTITUTE FOR LASER TECHNOLOGY ILT


# LASER POLISHING OF METALS

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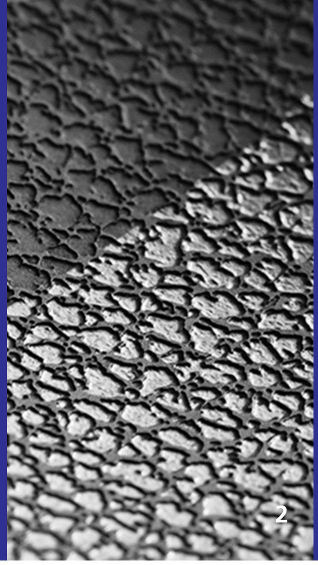
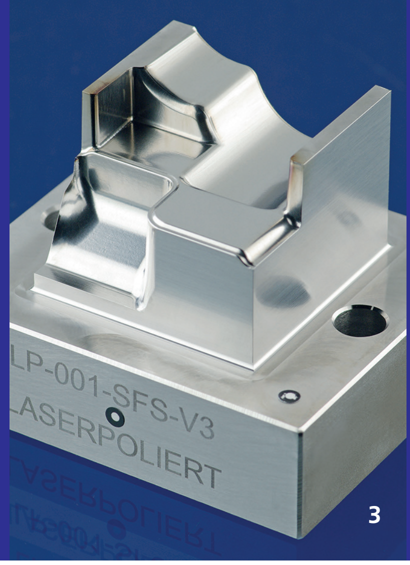
*Subject to alterations in specifications and other technical information. 04/2018.*

**Fraunhofer Institute for Laser Technology ILT**

The Fraunhofer Institute for Laser Technology ILT is one of the most important development and contract research institutes in laser development and application worldwide. Its activities encompass a wide range of areas such as developing new laser beam sources and components, laser-based metrology, testing technology and industrial laser processes. This includes laser cutting, ablation, drilling, welding and soldering as well as surface treatment, micro processing and additive manufacturing. Furthermore, Fraunhofer ILT develops photonic components and beam sources for quantum technology.

Overall, Fraunhofer ILT is active in the fields of laser plant technology, digitalization, process monitoring and control, simulation and modeling, AI in laser technology and in the entire system technology. We offer feasibility studies, process qualification and laser integration in customized manufacturing lines. The institute focuses on research and development for industrial and societal challenges in the areas of health, safety, communication, production, mobility, energy and environment. Fraunhofer ILT is integrated into the Fraunhofer-Gesellschaft.






# LASER POLISHING OF METALS

The Fraunhofer Institute for Laser Technology ILT uses laser radiation to automatically polish components with complex 3D surfaces. With this new process, users from various industries, such as those from tool and mold industry or medical technology, can avoid tedious manual processing and save both money and time.

### The Process

When laser radiation is used to polish metals, a thin surface layer of the workpiece is remelted and the surface smoothed due to interfacial tension. The innovation of laser polishing lies in its fundamentally different mode of action (remelting) compared to conventional grinding and polishing processes (ablation). For metallic materials, diode-pumped solid-state lasers are generally used. If the surfaces already have a low roughness, e. g. after grinding, pulsed lasers with pulse durations of several 100 ns can be used. If the surfaces are rougher, e. g. after milling or additive manufacturing, continuous lasers are used. The remelting depth is between a few 100 nm when pulsed lasers are used and up to 100 µm with continuous lasers.

### Process Features and Advantages

- Automated processing of 3D surfaces
- Polishing result independent of the operator
- High process speeds, especially when compared to manual polishing
- High reproducibility
- Selective polishing of selected areas
- Low mechanical stress on the components, because of the non-contact process
- No grinding and polishing waste
- No incorporation of grinding and polishing agents into the surfaces

### Tool and Mold Making

For the processes used in tool and mold making, the state of the art is manual polishing, which has processing times of often more than 10 min/cm². Therefore, there is a great need, particularly in this industry, for automated polishing processes for complex 3D surfaces. The roughness it requires is often in the range of Ra = 0.05 to 0.3 µm.

On the tool steels 1.2343, 1.2311, 1.2379 and 1.3207, laser polishing can be used to smooth milled and eroded surfaces with a roughness of Ra = 1 to 4 µm down to a roughness of Ra = 0.05 to 0.2 µm. The surface rate here is about 1 cm²/min, but can be increased to up to 10 cm²/min by material-adapted intensity distributions. Injection molding and embossing tools with laser-polished surfaces have comparable service lives to those of manually polished tools.

In addition, when the process parameters are modulated, the gloss level on tool surfaces can be adjusted with high local resolution (150 µm), which also makes it possible to produce two-color and multi-gloss effects. In leather grain, for example, only the recesses of the grain are polished in the tool, the webs remain unprocessed.

*1 Machine tool for laser polishing.*
*2 Dual gloss effect on selectively polished leather grain.*
*3 Laser-polished active surface cutout of a slide for die casting.*

### Deburring and Shape Melting

Burrs and edges can be removed by laser machining and remelted as a function of the requirements. In this case, when a defined shape is melted, for example, uniform rounding can be achieved.

### Medical Technology

Titanium materials are often used in medical technology. While these can be polished with conventional, cutting processes, there is a great expenditure of time and personnel. When this process is automated using laser polishing, machining time and cost can be significantly reduced. Laser-polished surfaces have a high degree of geometrical accuracy owing the principle involved and, therefore, allow tight tolerances. The absence of grinding and polishing agents also means that the surfaces have a high chemical purity after laser polishing, which is particularly important for implants.

On diamond-milled surfaces with an initial roughness of Ra ≈ 0.3 µm, a roughness of Ra ≤ 0.1 µm can be achieved when polished with pulsed laser radiation. The processing time is only 3 s/cm² and, thus, significantly shorter than that of manual polishing.

### Range of Materials

Laser polishing is particularly well suited for nickel, titanium and cobalt/chromium alloys. Even with an initial roughness in the range Ra = 1 to 15 µm, a roughness of Ra < 0.2 µm can be achieved with an area rate of 1 to 5 cm²/min. Other steels and cast alloys can also be polished. The polishing result depends on the material and its homogeneity.

### Machine Technology and CAM-NC Data Chain

Together with partners from the industry, Fraunhofer ILT has developed a machine tool for laser polishing of complex 3D components. The laboratory results and experience have been transferred to a robust machine technology suitable for industrial production. The basis is a five-axis portal machine, which positions the workpieces and performs slow feed movements. In combination with a highly dynamic three-axis laser scanner, the machine can reach the required process speeds of up to 1 m/s.

Due to the machine kinematics with 5+3 axes, special demands are placed on the CAM-NC data chain. Fraunhofer ILT develops solutions that enable the user to use a well-known CAM system for milling, but also for path planning in laser polishing. A downstream technology processor, which combines the functions of a post-processor with specific adjustments, converts the milling paths into laser polishing paths. The 3D laser scanner is controlled by a flexible software system that can be seamlessly integrated into the NC control of the machine. The machine and the CAM-NC data chain are available for component- and application-specific test series at Fraunhofer ILT.

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*4 Partially laser-rounded sheet edges made of stainless steel (sheet thickness 1.5 mm).*
*5 Unprocessed and laser-polished knee joint,produced additively.*