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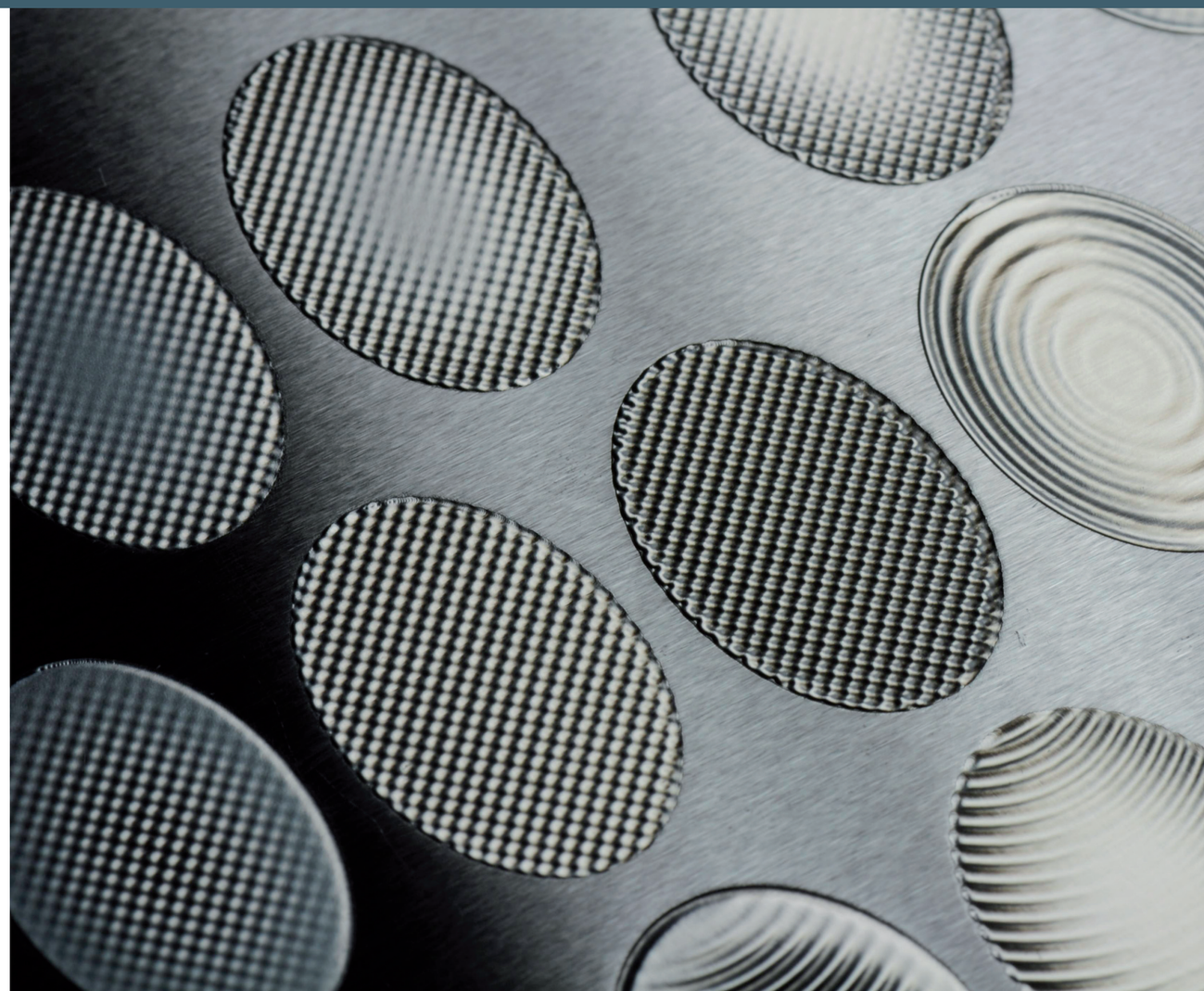
FRAUNHOFER INSTITUTE FOR LASER TECHNOLOGY ILT

»WAVESHAPE« – SURFACE STRUCTURING BY LASER REMELTING



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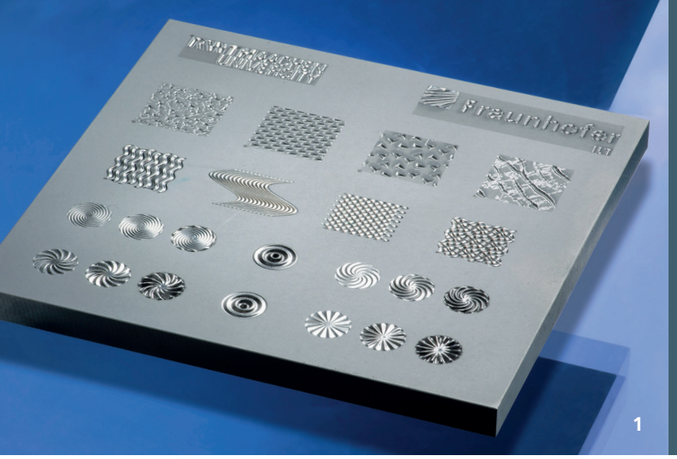
Fraunhofer Institute for Laser Technology ILT

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.



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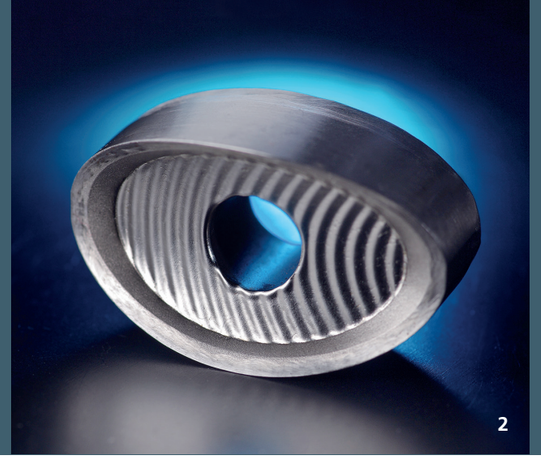
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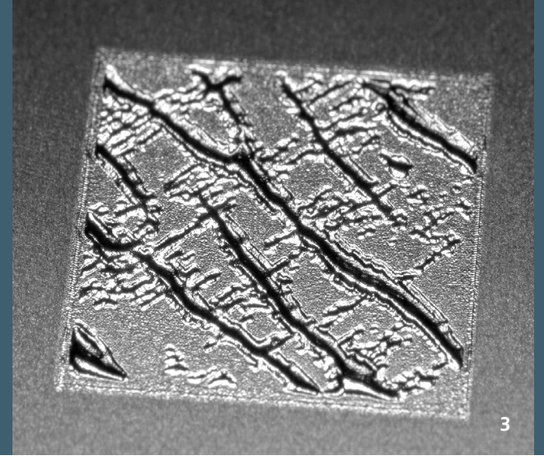
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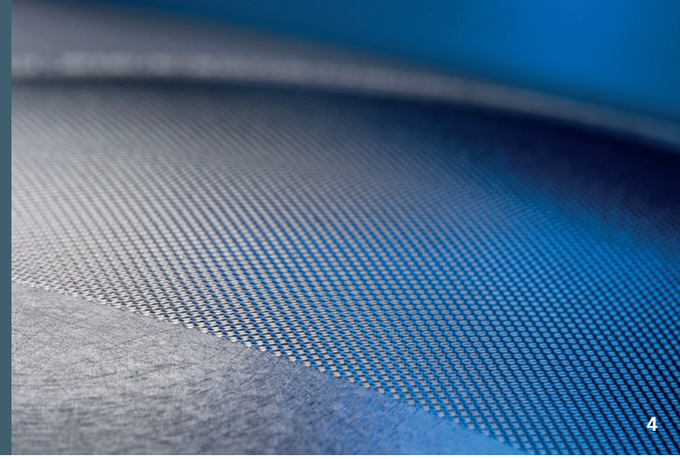
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»WAVESHAPE« – SURFACE STRUCTURING BY LASER REMELTING

Structured surfaces can be found in almost all areas of life. Innovative production processes are required, however, to generate them in an efficient and resource-saving manner. The Fraunhofer Institute for Laser Technology ILT has developed the novel WaveShape process for generating polished structures on metal surfaces by laser remelting. This flexible and non-contact process opens up completely new possibilities for customers from industry and research and shows great potential, e.g. for the 3D processing of complex components in the future.

The »WaveShape« process

Surface structuring by laser remelting is based on a remelting process that uses continuous laser radiation and that simultaneously modulates the laser power. This modulation varies the melt pool volume. When the laser power is increased, the volume of the melt pool enlarges since the melting rate increases. This leads to a bulging of the melt pool. The solidification follows the curved surface of the melt pool, resulting in an elevation. If the laser power is reduced, the mechanisms work in opposite directions and a depression is formed. The elevations protrude above the level of the initial surface, while the depressions are below this level. The neutral mass balance clearly distinguishes the process from other ablative (subtractive) and constructive (additive) surface structuring processes.

In contrast to surface structuring by laser ablation, the WaveShape process already smooths the structures simultaneously after laser remelting since they are created from a continuous melt, as in laser polishing. This eliminates the need for additional post-processing.

So far the process has been used for metallic materials. Defined and reproducible structures are best produced on homogeneous materials. The remelting depth is in the range between 10 and 100 µm. Fiber or disk lasers are usually used as laser beam sources, as they are common in industrial laser material processing. Since a melt is generated, the process is always accompanied by heat input into the component. The formation of structures through multiple remelting is relatively complex. Therefore, the process parameters have to be adapted individually to the material and target structure.

Process features and advantages

- Surface structuring and polishing in one step
- Low mechanical stress on the components, as the process does not contact the workpiece
- Especially suitable for generating periodic structures
- High reproducibility
- Edge layer is homogenized
- Surface structuring by redistribution without material ablation (especially interesting for high-priced materials)
- In future, automated processing of 3D surfaces will also be possible

Range of materials and structures

The materials investigated to date include tool steels from tool and mold making (e.g. 1.2343, 1.2379), titanium materials used in a wide variety of applications (TiAl6V4), as well as materials from aerospace engineering such as nickel-based alloys (Inconel 718) and materials from medical technology such as cobalt-chrome alloys.

Thanks to the principle of local material redistribution, the WaveShape process can be used in particular to produce periodic wave and knob structures with structural wavelengths of several hundred micrometers to several millimeters and structural heights of a few micrometers to one millimeter. Complex scanning strategies beyond parallel processing paths can also be used to generate circular or star-shaped structures. Even the production of aperiodic structures is conditionally possible. Since the structures are created from the melt, soft continuous structural distributions result without hard discontinuous edges. The 3D processing of complex components is the subject of current research and will be possible in the future.

Applications

Surface structuring by laser remelting can be used to functionalize surfaces as well as create design surfaces. The process is particularly suitable for processing plastic injection mold surfaces or other forming and structuring tools. Molded in transparent plastics, the continuous structures are also suitable for light scattering or distribution. The ablation-free structuring also makes the process attractive for the processing of high-priced metals, e.g. in the jewelry industry.

Services

- Feasibility studies for surface structuring by laser remelting
  - Transfer to other materials
  - Generation of special structures
  - Structuring on defined surface geometries
- Production of sample series
- Consulting for the design and realization of systems for surface structuring by laser remelting

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Cover: Wave and knob structures on tool steel produced by means of the WaveShape process.

1 Diversity of structures made with the WaveShape process.

2 Wave structuring on slightly curved surface of a tool insert.

3 Aperiodic WaveShape surface structure.

4 Knob structure on a curved surface.