

LASER TECHNOLOGY FOR REPAIR AND FUNCTIONALIZATION



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DIN EN ISO 9001:2015
Reg.-No. 069572 QM15

Fraunhofer Institute for Laser Technology ILT

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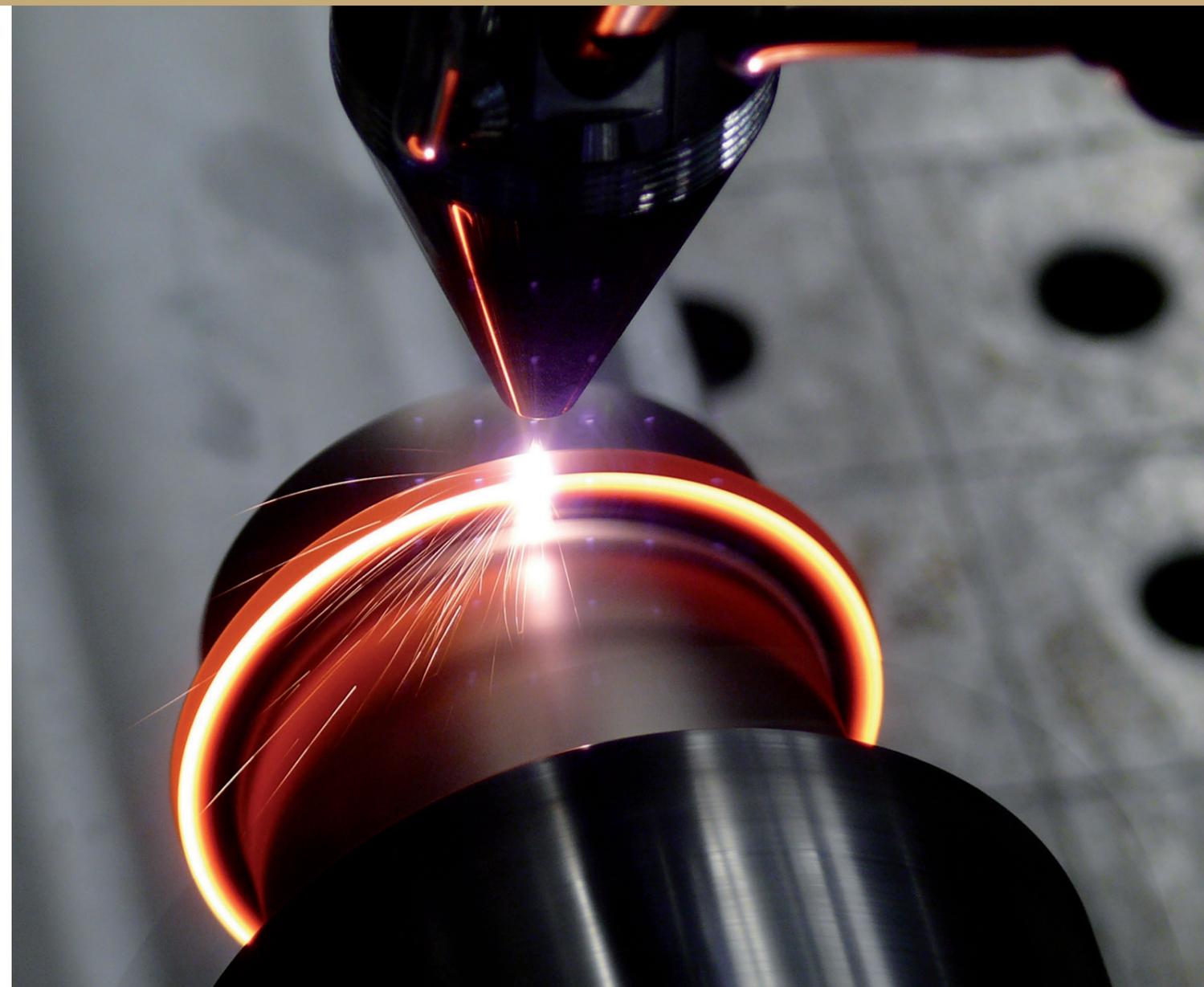
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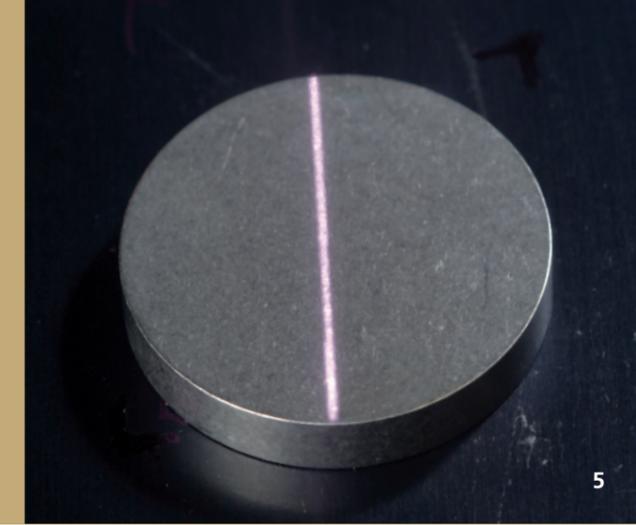
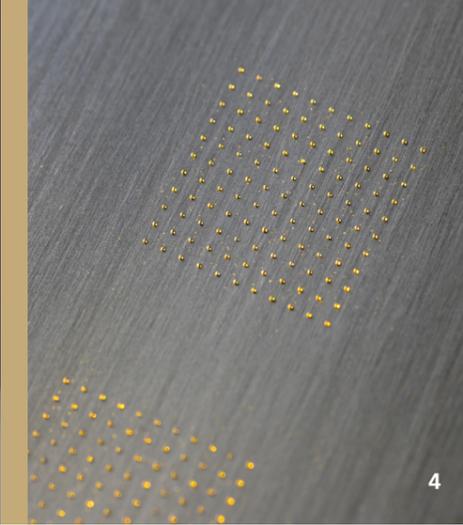
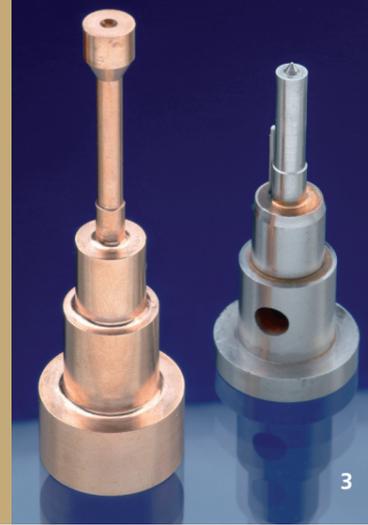
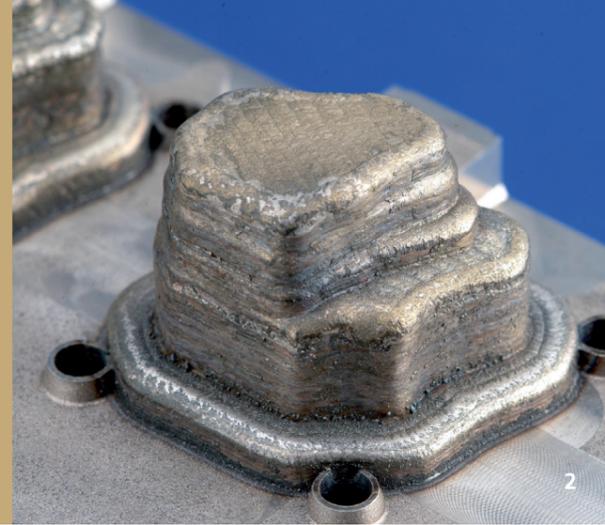
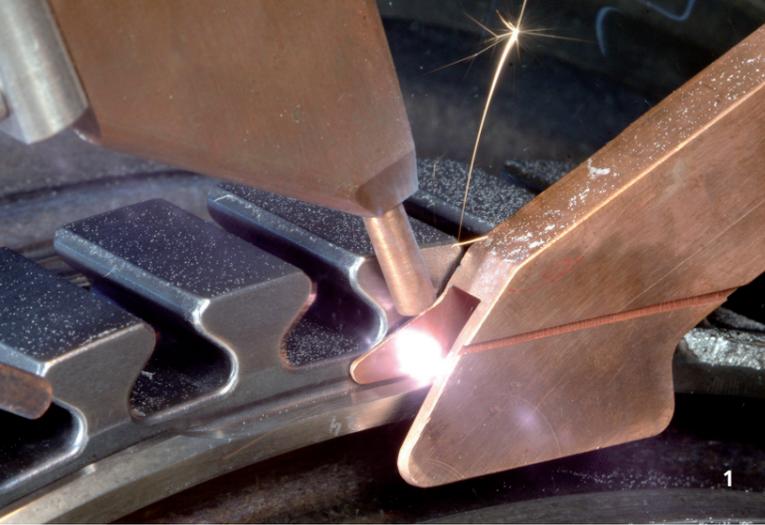
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Fraunhofer Institute for Laser Technology ILT

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.





LASER TECHNOLOGY FOR REPAIR AND FUNCTIONALIZATION

The Fraunhofer Institute for Laser Technology ILT uses laser radiation to repair high-grade components and tools, and significantly extend their lifecycle. Laser beams are also used to protect materials against wear and corrosion.

The Process

Laser technology can be used in two distinct coating processes. Either material can be deposited directly, or a coating which has been deposited using another process, can be post-treated. The first variant is called laser cladding; a filler material is melted using the laser beam and fused with the base material. The filler material is added in the form of powder or wire. The high precision of the material deposition, the outstanding controllability of the process and the low thermal and mechanical stresses on the components have helped turn laser cladding into a standard process in the tool- and mold-making industry as well as in the aerospace industry. Recent process developments have also opened up laser cladding for applications where some tenths of a micrometer have to be deposited (e.g. electrical contacts). Different processes can be used for the post-treatment of a layer that has already been deposited. Thermal sprayed layers are, for instance, consolidated using a melt process. Dense oxide-ceramic coatings can be manufactured from sol-gel layers by means of a sintering process.

Repair and Additive Manufacturing

Damage or normal wear on turbine components, machine parts, tools, molds and components can prove enormously costly. The parts affected often have to be replaced, in which case repair proves a viable option. Given the material and accuracy requirements as well as the safety considerations associated with engine technology laser cladding is an appropriate method for this. The closed process chain is an important consideration. Based on a three-dimensional data model of the virgin component or tool, the laser beam deposits the original material on the damaged parts using a powder feed nozzle, in a highly precise, layer-by-layer process. This enables a near-net-shape regeneration of the worn material. The extremely low input of heat into the weld zone means the deformation remains within the close tolerances. The fine microstructure of the deposited material meets, and in many cases exceeds, the mechanical and tribological requirements for the original parts.

This repair technique can also be used for additive manufacturing, e.g. for the production of tool inserts using graded materials.

Functionalization of Surfaces

The large range of materials for laser cladding ensures that the layer is optimally tailored to the particular function. For classic wear-protection options range from materials such as high-alloy tool steels, cobalt and nickel-based alloys, carbides to graded materials. All the standard metallic materials can be coated. One such example for wear protection is laser cladding of tools for oil exploration. The process can also be used to provide corrosion protection, including post-galvanizing of welds or cut edges in galvanized sheets. Within the smallest dimension the process can be used amongst others to produce electrical contact points of gold (e.g. on bipolar plates for fuel cells).

Innovative processes based on nanoparticulate materials have increasingly been used over the past few years to manufacture functional layers. The used nano-dispersions or sol-gel mixtures are deposited selectively on a substrate using printing processes. However, the layers applied as a dispersion or sol-gel with typical thicknesses of 0.1 to 5 μm must be post-treated thermally in a furnace at temperatures of up to 1000 $^{\circ}\text{C}$ to form a crystalline layer. Due to the thermal load at such high temperatures sensitive substrates cannot be coated. The laser beam enables ultrashort interaction times with the work piece and thus significantly reduces the thermal stresses induced in the substrates. The combination of wet-chemical processes and laser machining processes opens up the possibility of integrating the entire coating process into an inline production system, which, in turn, significantly increases the throughput of coated components in production.

System Technology

To develop customized processes and carry out feasibility studies, the Fraunhofer ILT offers system technology from laser sources and handling systems with up to six axes, beam-forming optics, powder feed nozzles, process diagnostics and software to generate NC programs. In close cooperation with laser and machine-tool manufacturers, we also offer our customers plant-specific implementation of processes in production.

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- 1 Repair of the front rotor of a jet engine.
- 2 Additive manufactured tool insert made of a gradient material.
- 3 Mold core made of copper cladded with a wear protective alloy.
- 4 Micro gold spots on stainless steel.
- 5 Thin film laser treatment of a 100 Cr 6 test specimen.