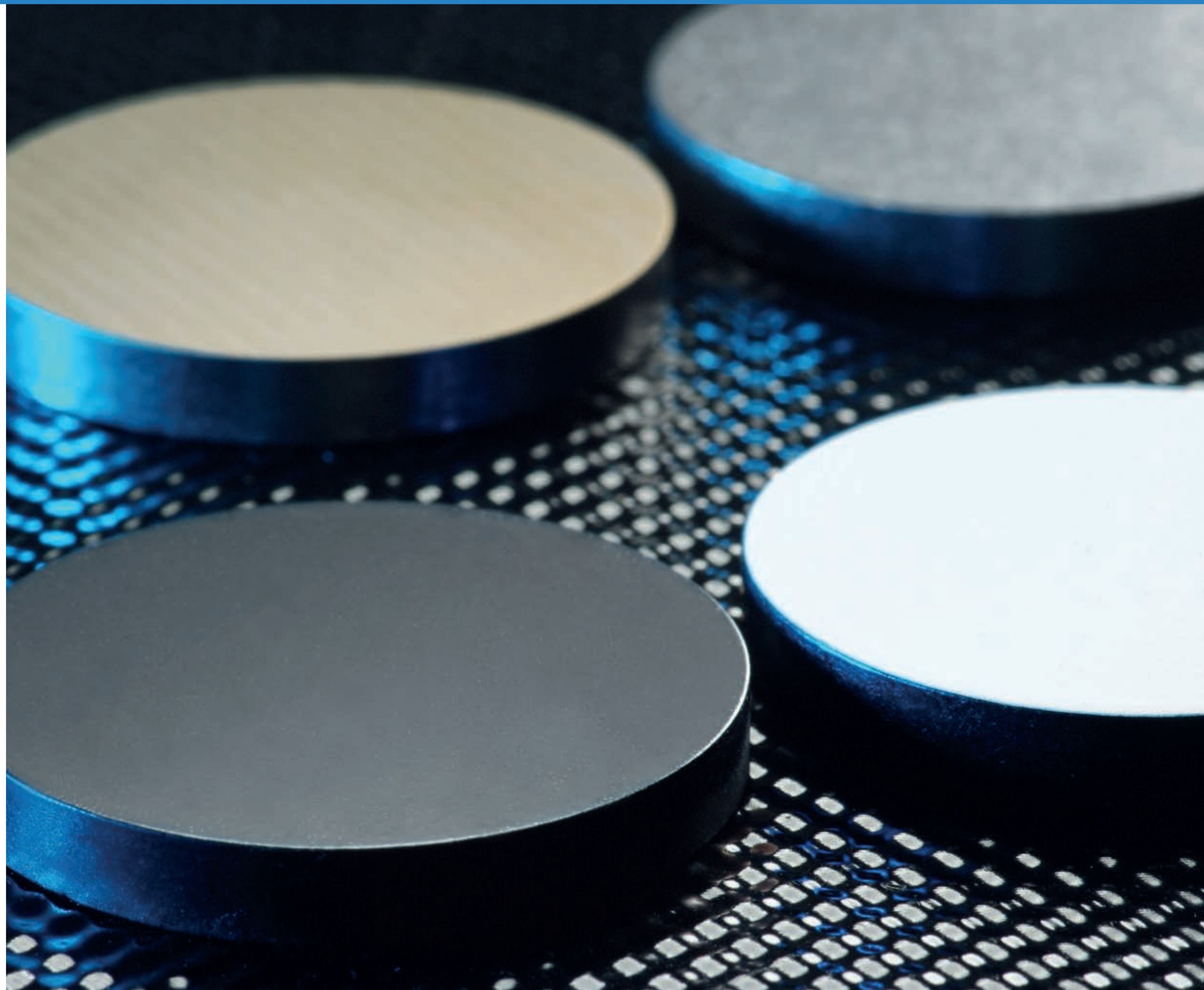
FRAUNHOFER INSTITUTE FOR LASER TECHNOLOGY ILT

LASER PROCESSES FOR TRIBOLOGICAL COATINGS AND CORROSION PROTECTION



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Fraunhofer Institute for Laser Technology ILT

The Fraunhofer Institute for Laser Technology ILT is worldwide one of the most important development and contract research institutes of its specific field. The activities cover a wide range of areas such as the development of new laser beam sources and components, precise laser based metrology, testing technology and industrial laser processes. This includes laser cutting, caving, drilling, welding and soldering as well as surface treatment, micro processing and rapid manufacturing.

Furthermore, the Fraunhofer ILT is engaged in laser plant technology, process control, modeling as well as in the entire system technology. We offer feasibility studies, process qualification and laser integration in customer specific manufacturing lines. The Fraunhofer ILT is part of the Fraunhofer-Gesellschaft.

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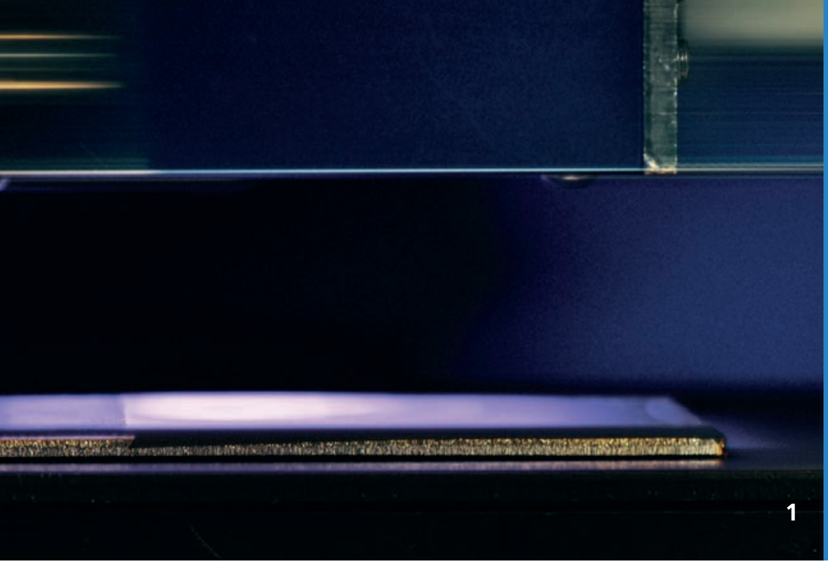

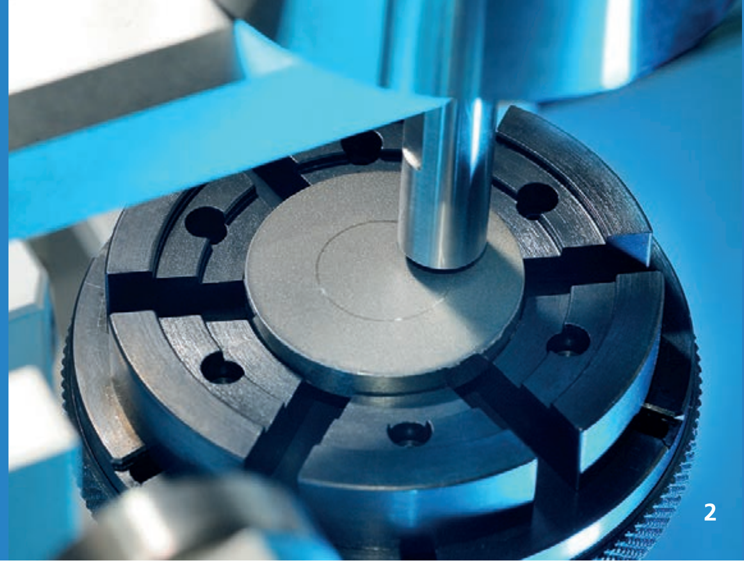

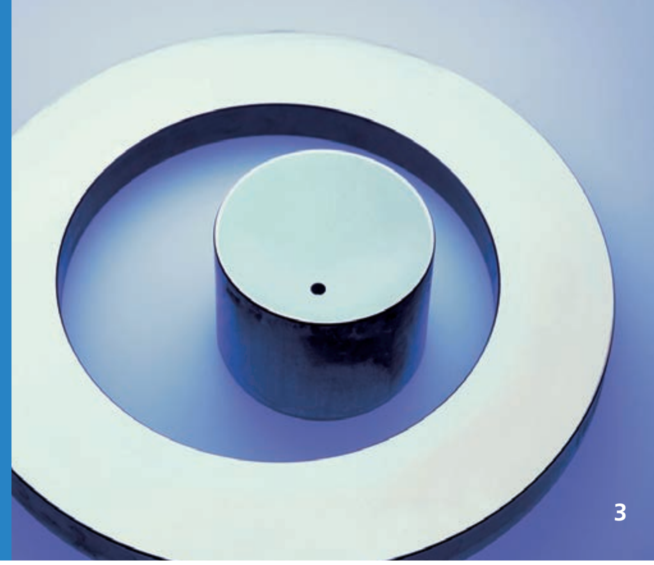

LASER PROCESSES FOR TRIBOLOGICAL COATINGS AND CORROSION PROTECTION

The Fraunhofer Institute for Laser Technology ILT develops energy-efficient, site-selective and sustainable laser processes for producing coatings that increase the temperature resistance of components, reduce friction or protect against wear and corrosion. Such tribological coatings are mainly used in applications in which the functional requirements of components exceed the performance of the base materials. As the cross-industry trend towards functional integration continues to develop, the requirements are becoming increasingly complex. Laser technology can provide economical solutions for innovative and sustainable coating concepts.

Laser-based Production of Functional Coatings

Producing tribological coatings often involves a process step with which the previously wet-chemically applied coating materials are thermally functionalized (e.g. curing, sintering, melting, compacting). Conventionally, this step takes place by means of oven-based methods, but has the significant disadvantage that the entire component must be heated to the functionalization temperature of the coating. On the one hand, this results in low energy efficiency and, on the other, a significant limitation of the material spectrum: Temperature-sensitive materials, such as industrially relevant roller bearing steels and aluminum alloys, can thus only be used in very few cases or not at all.

One promising alternative is a laser-based coating process with which the thermal energy is introduced directly into the coating and not into the entire component. The spectral, temporal and spatial controllability of the laser radiation allows an application-adapted modulation of the temperature profiles in the component.

Since large heating and cooling rates can be achieved in defined small volumes, the energy input into the component can be reduced and the thermal load thus minimized.

Compared to conventional methods, this laser process has, for example, ecological and economical advantages: The laser, as a non-contact and wear-free tool, processes the coatings quickly and efficiently. The process developed has been designed for the industrial changes triggered by Industry 4.0 (i.e. for machine networking and integrated data management).

Polymer-based Coatings for Tribological Applications and Corrosion Protection

High-performance polymers are predestined for use as coating materials for applications in which there are additional requirements for temperature and corrosion resistance, in addition to tribological loads. Furthermore, this class of materials allows an application-specific additivation, for example, to selectively modify the friction behavior. Previous work in this area includes, in particular, polyether ether ketone (PEEK) based coatings on metallic components.

The polymer layer thickness typically ranges from 10 to 50 µm. For steel substrates, the interaction time needed to fully functionalize the polymer can be reduced to a hundredth compared to furnace-based processes. The corresponding energy requirement is reduced by 90 percent or more.

This method can be used to produce polymer-based multiple layers (e.g. from PEEK or PA12) with iterative repetition of layer application and laser-based functionalization. Such layers have thicknesses of over 50 µm and are particularly suitable for applications in corrosion protection.

Ceramic Wear-protection Coatings

Ceramic wear-resistant coatings have enormous potential and are being used in the automotive industry, among others, to optimize the tribo-mechanical properties of highly stressed engine and transmission components. Nanoparticulate materials, e.g. in the form of sol-gel systems, can be applied as protective layers on components with little technological effort through energy and resource-saving processes. Highly stressed areas can be selectively provided with coatings using printing and spray processes.

The central challenge of the coating process consists in a complete sintering of the ceramic material at temperatures above 1000 °C without functionally influencing the sometimes temperature-sensitive carrier materials. To date, coatings with a thickness of 0.1 to 1 µm and a microhardness of more than 1000 HV have been produced on hardened steel. In functional tests, laser-based coatings show just as good wear resistance as conventional PVD coatings.

Friction-reducing Paint Coatings

Thermosetting lacquers (e.g. MoS_2-based materials) have great potential for wide industrial application in the area of friction reduction at medium to high temperatures. The lacquers are used primarily for coating steel materials, e.g. for aerospace applications. When Vertical Cavity Surface Emitting Laser Beam Sources (VCSEL) are used, the process time of up to 30 minutes in furnace processes can be reduced to just a few seconds. In addition, the wear coefficient measured by calotte grinding decreases by a factor of six.

Pretreatment and Cleaning

Fraunhofer ILT has many years of experience in the field of laser-based cleaning as well as the pre-treatment and structuring of component surfaces. On the basis of these competencies, Fraunhofer ILT develops processes for the pretreatment of components to be coated; such processes can improve, for example, the wetting behavior of the wet-chemical deposited layers. In addition, the bond strength of coating and component can generally be significantly increased by a targeted oxidation of the surface or a modification of the surface topography.

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Cover: Steel components with polymer coatings in different production stages.
1 Laser-based curing of lacquers.

2 Tribological examination of a coated sample.
3 Engine and bearing components with ceramic wear protection layers.
4 Metal surface before (left) and after (right) laser pretreatment.