Fraunhofer ILT

FRAUNHOFER INSTITUTE FOR LASER TECHNOLOGY ILT

LASER POLISHING OF PLASTICS

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

Fraunhofer Institute for Laser Technology ILT

Director
Prof. Constantin Häfner

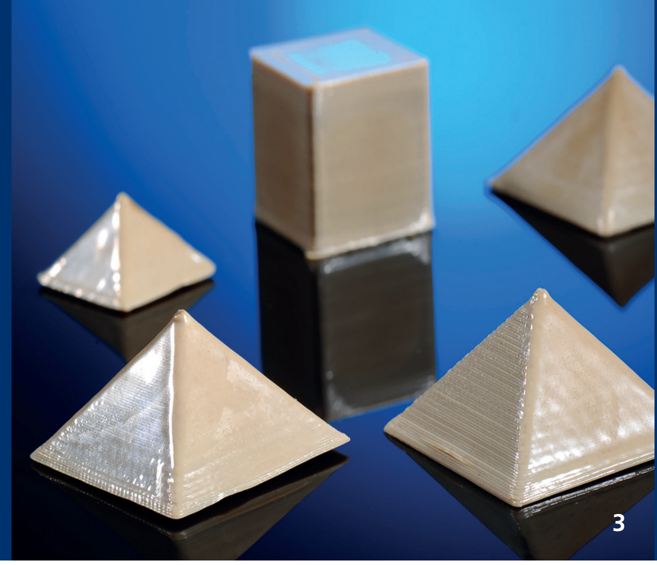
Steinbachstraße 15
52074 Aachen, Germany
Telephone +49 241 8906-0
Fax +49 241 8906-121

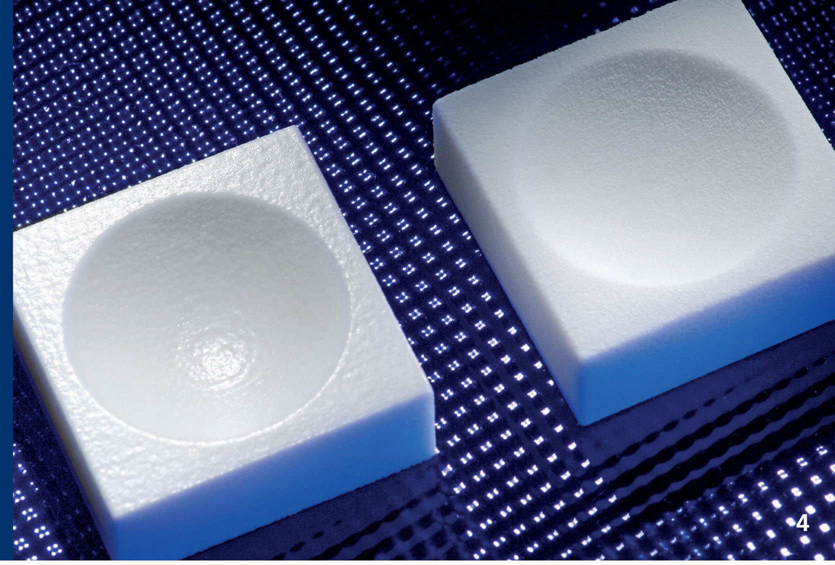
info@ilt.fraunhofer.de
www.ilt.fraunhofer.de

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 PLASTICS

As the use of Additive Manufacturing of plastics continues to grow, so does the demand for flexible finishing processes. To meet this demand, the Fraunhofer Institute for Laser Technology ILT researches and develops new processes and processing strategies specifically for the laser polishing of plastics. Furthermore, laser polishing also provides flexible and efficient solutions for injection molded components, prototypes or plastic optics – solutions that are tailor-made for customers from industry and research.

Challenges in precise surface processing

Additive Manufacturing creates new degrees of freedom in the production of 3D components, but the surface quality is often insufficient – a major shortcoming of this technology. A high surface roughness impairs both the mechanical properties and the optical appearance of the manufactured components. Although the surface roughness of injection molded parts is usually already sufficiently low, in some cases the injection-molded seam must be reworked.

When plastic optics are manufactured, the industry places the highest demands on the surface roughness so that the optics generate the sharpest possible image; when prototypes are constructed, flexible and rapid post-processing is often required. The demand for innovative and flexible post-processing methods is, therefore, high. Indeed, laser polishing provides efficient solutions for many applications.

Cover: Partially polished component made of PA12 with SLS.

1 Plastic microlenses made of an acrylate (left: laser polished).

2 Components manufactured with SLS and made of PA12 and PP with polished or partially polished surfaces.

Surface smoothing by laser polishing

In laser polishing, the component surface is melted by laser radiation in a controlled manner, and subsequently the roughness is smoothened by the surface tension. For a low surface roughness, the generated melt baths not only must be stable, but also have a specific duration. A prerequisite is, therefore, that the plastic components to be processed are thermoplastics; CO_2 laser radiation is normally suitable for this since it is mostly absorbed very close to the surface in plastics. Advantages compared to classical post-processing methods (e. g. manual grinding and polishing, vibratory grinding or chemical etching) are, in particular, the high degree of automation, the high process speed, the flexibility with regard to geometry, the contactless and foreign particle-free processing as well as the possibility of selective processing.

Quasi-top hat scan strategy for flexible and stable machining processes

To ensure a controlled and robust process, Fraunhofer ILT developed the so-called quasi-top hat scan strategy using a temperature-controlled laser power. This way, large areas of the surface to be processed can be heated without needing complicated beam shaping optics. In addition, different intensity distributions can be imaged by the scanning movement so that, for example, the molten surface area can be adapted to the component geometry. The temperature control makes stable process guidance possible. In addition, this processing strategy can reduce the process down to the two essential process variables – surface temperature and melt bath existence time – which makes it much easier to find parameters when the material spectrum is expanded.

Laser polishing of additively manufactured plastics

Thanks to the quasi-top hat scan strategy, almost any 2D geometry can be laser polished. In addition, material processing is particularly easy for flat and slightly curved surfaces since the component does not need to be rotated. Surfaces between approx. 1 and 1,000 mm² can be polished in a single step, even if these surfaces have hard-to-reach areas such as steps or indentations. Even simple 3D geometries such as cubes, pyramids or slightly curved surfaces can be processed efficiently. For more complex components, a handling system must also be used.

Results on materials such as PA12, PEEK, PP, TPU and many others show that the roughness of 3D-printed plastic components can be reduced by a factor of 5 to 50. For example, the roughness of an SLS-printed PA12 com-ponent in a flat 10 x 10 mm² field is reduced from Sa = 10 µm to Sa = 0.5 µm. For PEEK components printed using the FDM process, the roughness can be reduced from Sa = 15 µm to Sa = 0.5 µm.

Post-processing of prototypes and optics

Laser polishing is not only attractive for companies that manufacture plastic components additively, but also for those that construct prototypes without additive processes since the process speed and flexibility with regard to geometry are very high. Optics or optical prototypes made of plastic, e. g. for ophthalmic lenses, can be polished quickly. Turned polycarbonate spectacle lens optics can be efficiently laser polished at a processing speed of 10 cm²/s, for example. Furthermore, the combination of shaping by ablation with ultra-short pulse laser radiation and subsequent laser polishing can be used to produce microlenses. In the case of injection-molded plastic parts, one or more parting seams on the surface often have to be reworked. Although these cannot usually be completely removed by laser polishing, the sharpness and height of an injection molding seam can be significantly reduced.

Contact

Karsten Braun M. Sc.
Telephone +49 241 8906-645
karsten.braun@ilt.fraunhofer.de

Dr. Edgar Willenborg
Telephone +49 241 8906-213
edgar.willenborg@ilt.fraunhofer.de

3 Laser polished FDM components made of PEEK.

4 Laser polished SLS component (left) made of PA12.