FRAUNHOFER INSTITUTE FOR LASER TECHNOLOGY ILT

ULTRAFAST LASERS

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

Fraunhofer Institute
for Laser Technology ILT

Director
Prof. Constantin Häfner

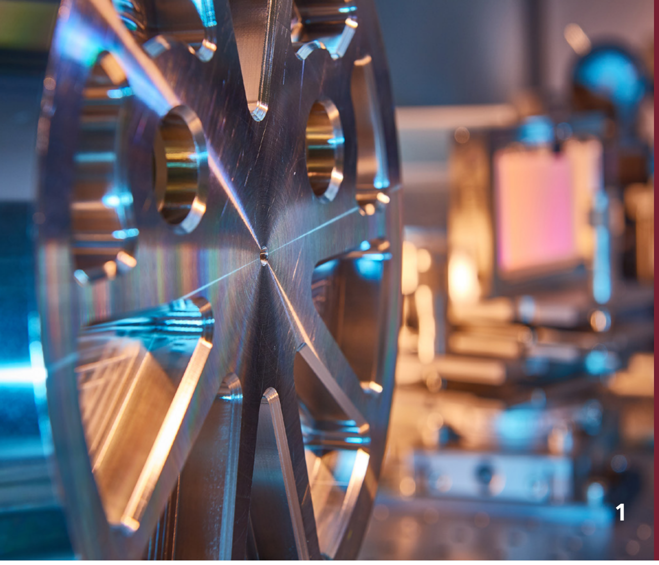
Steinbachstraße 15
52074 Aachen, Germany
Telephone +49 241 8906-0
Fax +49 241 8906-121

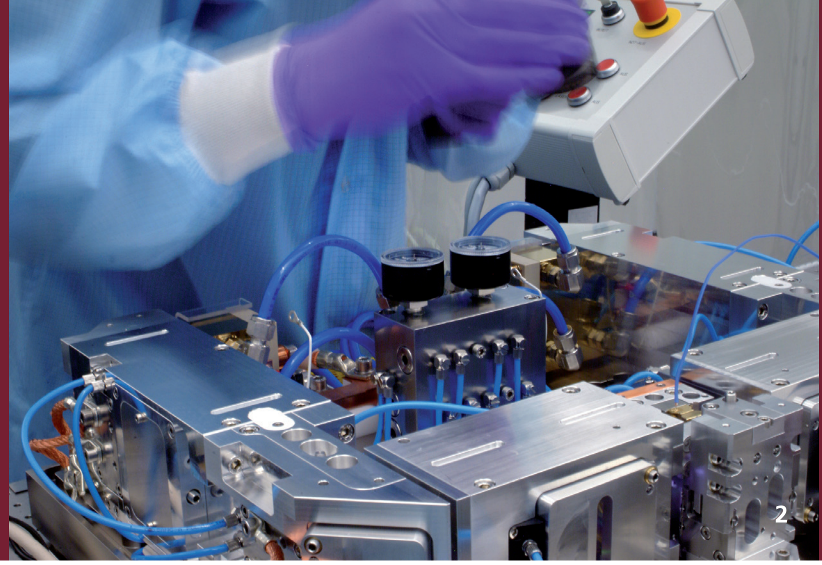
info@ilt.fraunhofer.de
www.ilt.fraunhofer.de

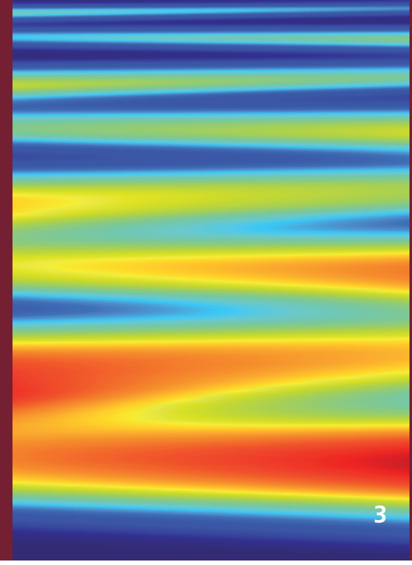
Fraunhofer Institute for Laser Technology ILT

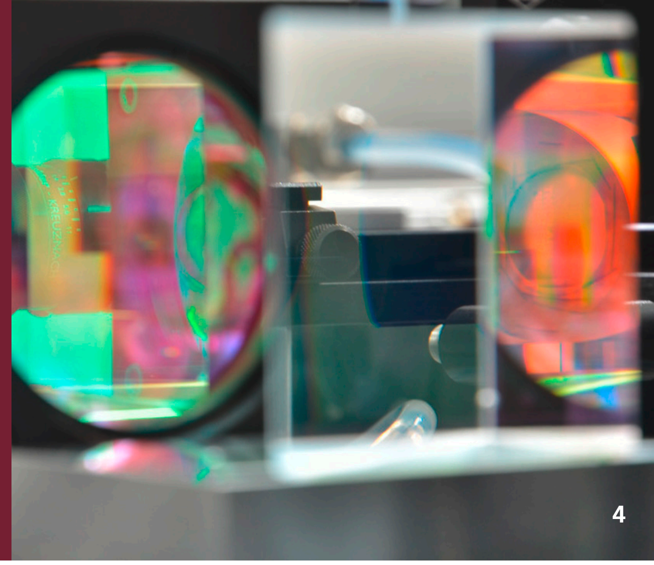
The Fraunhofer Institute for Laser Technology ILT is one of the most important development and contract research institutes in laser development and application worldwide. Its activities encompass a wide range of areas such as developing new laser beam sources and components, laser-based metrology, testing 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.

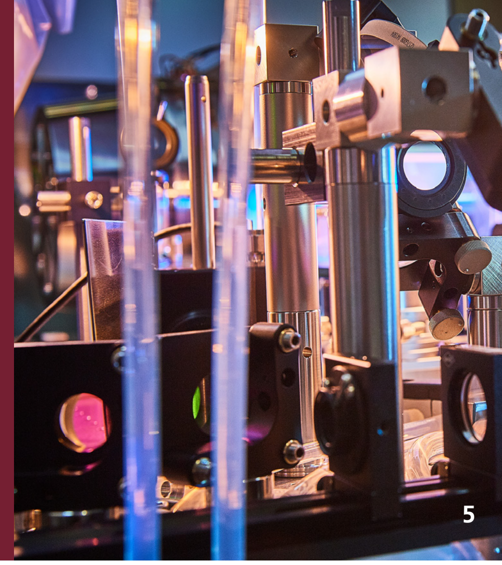
Overall, Fraunhofer ILT is active in the fields of laser plant technology, digitalization, process monitoring and control, simulation and modeling, AI in laser technology and in the entire system technology. We offer feasibility studies, process qualification and laser integration in customized manufacturing 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.











ULTRAFAST LASERS

Ultrafast lasers are becoming increasingly popular not only in science and research, but also in the industry. In its research activities, Fraunhofer Institute for Laser Technology ILT has been generating, characterizing and applying ultrafast laser pulses for more than 20 years. At Fraunhofer ILT, we offer customized laser sources for different power ranges from a few watts up to several kW, pulse energies from µJ up to multi-10 mJ with pulse durations from less than 30 fs up to 10 ps and more.

Tailor-made high performance ultrafast amplifiers for the industry

The Fraunhofer ILT experts use a broad portfolio of different laser amplifier designs based on Yb-doped crystals; depending on the average power, this includes rod, multi-rod, INNOSLAB and disk amplifiers. The amplifiers are characterized by diffraction-limited beam quality and bandwidth-limited pulse durations. With pulse durations of several 100 fs, the institute's developments are addressing average powers from 1 W to 10 kW, repetition rates from 10 kHz to 100 MHz and pulse energies from 10 µJ to 10 mJ.

One of Fraunhofer ILT's core competencies is the INNOSLAB technology that it has developed and patented. With Yb:YAG as the active medium, single-stage (two-stage) output powers > 500 W (> 1000 W) with beam qualities M^2 ~ 1.10 x 1.40 are achieved at pulse durations of 700 fs. These can be improved by spatial filtering of the output beam to M^2 ~ 1.10 x 1.10.

As part of the Fraunhofer Cluster of Excellence Advanced Photon Sources CAPS, the output power of these laser sources is to be scaled to over 5 kW.

An essential part of the work is the tailor-made adaptation of the INNOSLAB platform to the requirements of customers from the industry and research in terms of compactness, alignment, long-term stability and special pulse parameters. In addition to INNOSLAB amplifiers, the institute is also adapting other laser platforms such as fiber, rod or disk lasers, which are being combined and further developed to customers' specifications.

Fraunhofer Cluster of Excellence Advanced Photon Sources CAPS

In the Fraunhofer Cluster of Excellence Advanced Photon Sources CAPS, initiated in 2018, the Fraunhofer-Gesellschaft is currently combining the expertise of 13 Fraunhofer institutes in the fields of laser source development, system technology and applications of ultrafast lasers. Fraunhofer ILT is coordinating this project together with the Fraunhofer Institute for Applied Optics and Precision Engineering IOF.

By 2022, ultrafast laser systems with average output powers in the 10 kW range will be implemented for applications in industry and research. For this purpose, laser sources will be developed that exceed the average power of current ultrafast lasers by one order of magnitude. These beam sources enable the institutes to scale ultra-precise manufacturing processes and develop new pulse duration and wavelength ranges for basic research and metrology.

The centerpiece of the cluster infrastructure at Fraunhofer ILT is the establishment of a user facility in which the worldwide unique beam sources are made available to partners from industry and fundamental research for application experiments.

Nonlinear pulse compression

While the output pulse durations of Yb-based high-power ultrafast lasers are limited to several 100 fs due to their limited gain bandwidth, shorter pulse durations are increasingly in demand for applications in the industry and research.

With a flexible and compact additional module developed and patented at Fraunhofer ILT, the pulse duration can be significantly reduced by non-linear spectral broadening in a multi-pass cell with subsequent dispersion compensation. The process achieves a high efficiency of over 90 percent without influencing the beam quality and is currently used for output powers of up to 500 W. The process can be scaled in the pulse energy range from some µJ up to more than 10 mJ. The shortest pulse durations demonstrated so far are 25 fs with a compression factor of > 20.

Simulation

Extensive software tools have been developed for design, layout and optimization and can be used to map the effects relevant for ultrafast and high-power lasers. These enable a complete three-dimensional analysis of the systems under investigation:

- Wave-optical calculation of the propagation of laser radiation and its transformation using active and passive optical elements
- Modelling of 3- and 4-level gain media
- Consideration of gain, pump light distribution, rate equations, heat conduction, Kerr effect, self-phase modulation, dispersion and parasitic lasing

Contact

Dr. Peter Russbueldt
Telephone +49 241 8906-303
peter.russbueldt@ilt.fraunhofer.de

Dipl.-Ing. Hans-Dieter Hoffmann
Telephone +49 241 8906-206
hans-dieter.hoffmann@ilt.fraunhofer.de

Title: Multi-pass ultrafast thin-disc amplifier.
1 Module for non-linear pulse compression.
2 Yb-INNOSLAB amplifiers with 500 W output power.

3 Modeling of INNOSLAB amplifier beam paths.
4 Detailed view of a nonlinear pulse compression module.
5 Detailed view of a kW laser system.