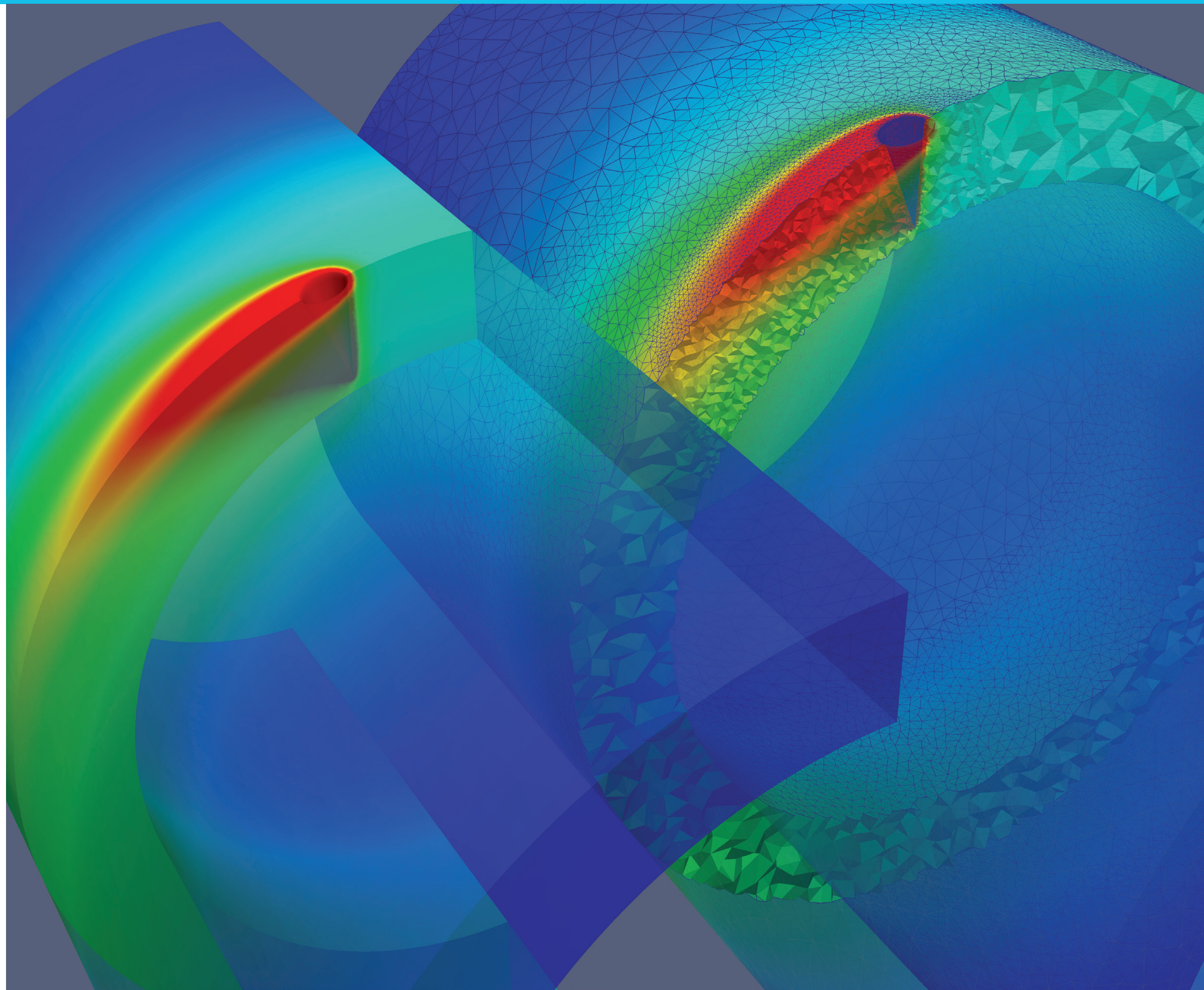
FRAUNHOFER INSTITUTE FOR LASER TECHNOLOGY ILT

MODELLING AND SIMULATION



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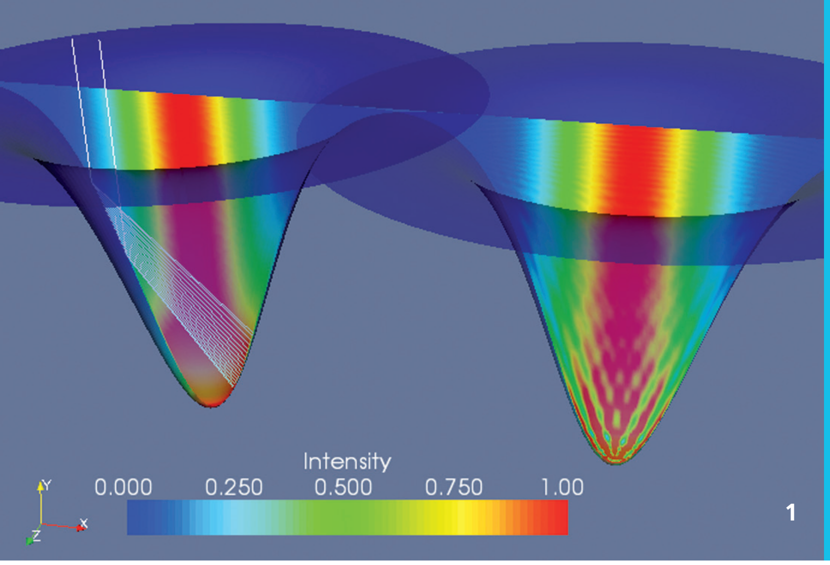
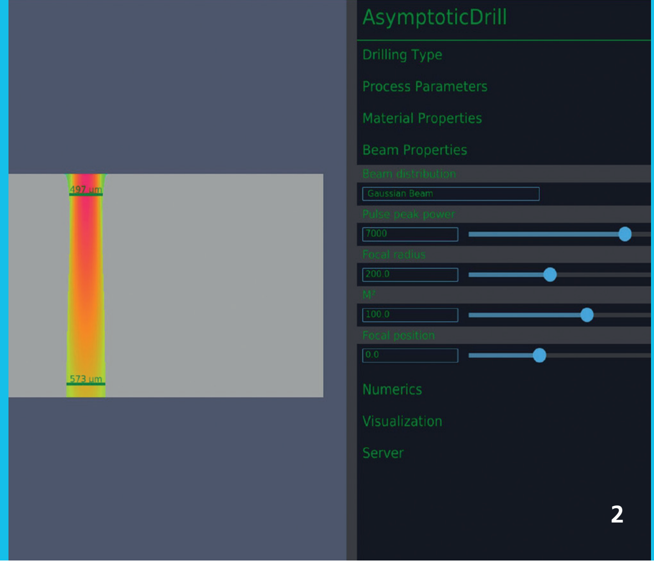
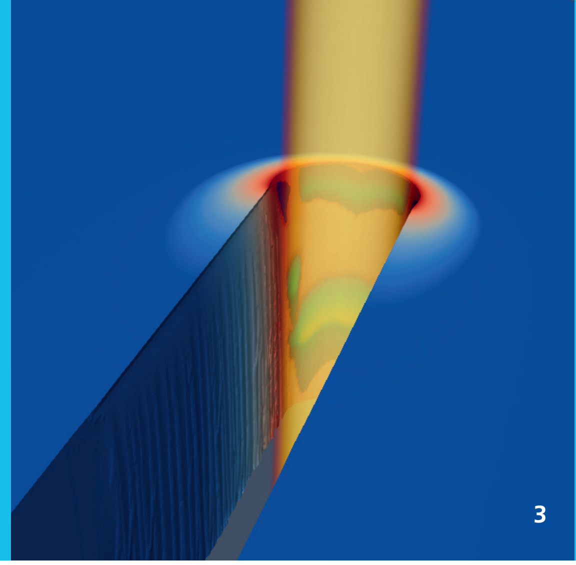
Fraunhofer Institute for Laser Technology ILT

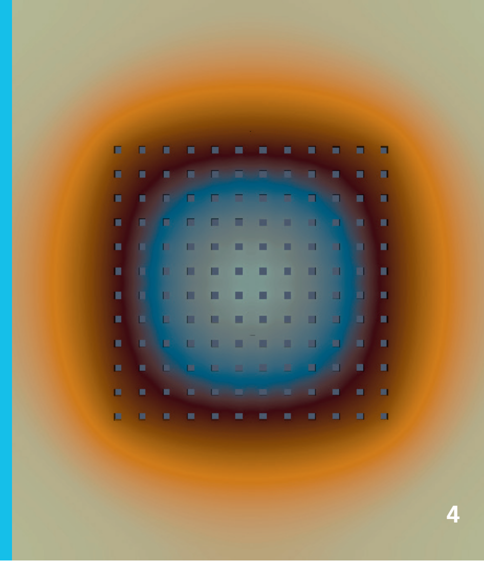
The Fraunhofer Institute for Laser Technology ILT is one of the most important development and contract research institutes in laser development and application worldwide. Its activities encompass a wide range of areas such as developing new laser beam sources and components, laser-based metrology, testing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

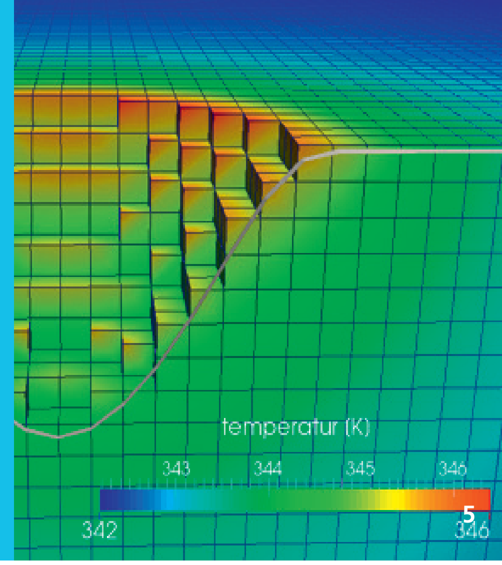
Overall, Fraunhofer ILT is active in the fields of laser plant technology, digitalization, process monitoring and control, simulation and modeling, AI in laser technology and in the entire system technology. We offer feasibility studies, process qualification and laser integration in customized manufacturing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











MODELLING AND SIMULATION

The Fraunhofer Institute for Laser Technology ILT engages in fundamental work on the description of technical processes as well as their monitoring, control and regulation. With the combination of a deep physical understanding of laser processes and modern computational engineering techniques, Fraunhofer ILT provides the basis for tailor-made laser processing.

Our core competences include the modelling of radiation sources – in particular, high-power lasers and gas discharges – as well as their application in manufacturing technology. The involved physical processes range from generation, propagation and absorption of radiation to transport processes and phase transformations induced in the material by radiation. We apply methods of computer engineering to analyse the measurement data and to monitor the processes. These include, in particular, numerical methods for simulation and visualization of the processes as well as algorithms for interpretation of measurement data.

Our experienced team includes researchers in the areas of applied mathematics, physics and computer engineering. Together, we offer our customers model-based solutions for technical tasks. We develop and analyse individual approaches based on the knowledge of our customers and our expertise as well as the properties of existing models.

1 Beam propagation simulation in drilling (geometrical optics, wave optics).
2 »AsymptoticDRILL« – Customer simulation tool for drilling.
3 Sheet metal cutting simulation.
4 Multi-beam processing – temperature distribution.
5 Multi-beam processing – comparison of simulation and experiment.

Core competences

- Design of resonators for gas, solid and high-power diode lasers
- Optimization of the beam guidance in optical systems
- Radiation propagation in gas and vapor
- Subsonic and supersonic fl ows in liquid, gas and vapor
- Mass fl ow and heat transfer
- Dynamic simulation for ablating, cutting, patterning, additive manufacturing and drilling
- Digitalization concepts in computational physics
- Modular dynamics of ultrashort pulse processing
- Simulation of laser processing in photovoltaics
- Control of manufacturing processes
- Algorithms for analysis of measurement data
- Programming of graphical user interfaces for simulation and visualization
- Numerical methods and calculation approaches, such as Cluster-In-Cell (CIC), Finite Element (FE), Finite Volume (FV), Discontinuous Galerkin (DG) and model reduction methods in time-variant domains
- Meta-modelling of physical phenomena and manufacturing processes

Digitalization

In order to share our knowledge with customers, we offer a »Simulation as a Service« platform named »SimWeb«. The platform provides our highly individual simulation and analysis tools without a time-consuming installation process also on mobile devices.

Patterning

High power ultrashort pulsed lasers enable high precision ablation of a multitude of materials resulting in unprecedented manufacturing possibilities. In order to bring this precision into a larger build volume, our team investigates processing strategies based on a deep understanding of the underlying physics. Using a multi-scale approach, which takes our knowledge about single pulse laser ablation and maps it to a multi-beam matrix, to predict distortions and to optimize process parameters facilitates the patterning of thin films used in the production of e. g. water filters.

Additive manufacturing

Additive manufacturing is a game changer in production techno-logies. However, the layer-by-layer construction of geometries is still an erroneous task and many prototypes have to be dis-carded due to unforeseen defects. For this reason we develop »StrucSol«. A thermo-mechanical simulation which allows the analysis of tracks, hatches, layers, up to an entire part. In the future, »StrucSol« will enable manufacturers to select scan strategies, which fulfi ll the requirements for e. g. deformations and residual stresses within the component and thus pave the way towards a 'first-time-right' approach for components in additive manufacturing.

Drilling

The model creation and simulation for drilling with lasers are directed primarily at avoiding recast on the drill hole wall for a long pulse length (microseconds) and at increasing the drilling speed for a smaller pulse length (sub-picoseconds to nanoseconds).

Through analysis of drilling with long pulse length, we can identify four different phenomena that interact dynamically to cause the formation of recast on the drill hole wall. In the analysis of drilling with short and ultrashort pulse lengths and higher laser beam intensity, we also take into consideration the inertia of the melt, recondensation of the vapour on the hole wall, refl ection of the beam and changing of the state equation upon nearing the critical temperature. This knowledge was successfully used to improve e. g. processes for the production of cooling ducts in turbine components. By the customer simulation tool »AsymptoticDRILL« the asymptotic shape of the bore can be described when drilling metallic materials with long-pulsed laser radiation.

Cutting

The combination of diagnostics and simulation yields a systematic definition of the relationships between cut quality and cutting parameters. Through analysis of the cut quality, we can identify at least three different types of ripples and four different types of adherent dross. The formation of the various score mark and burr types can be described by a straightforward set of parameters as well as their dynamic interactions during cutting. Our vision of a cognitive cutting machine comprises intelligent configuration and systematic error diagnosis. With the cognitive cutting machine, we advance developments in cutting processes to the physical limits of the laser beam, machine and process, with a defined level of quality.

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