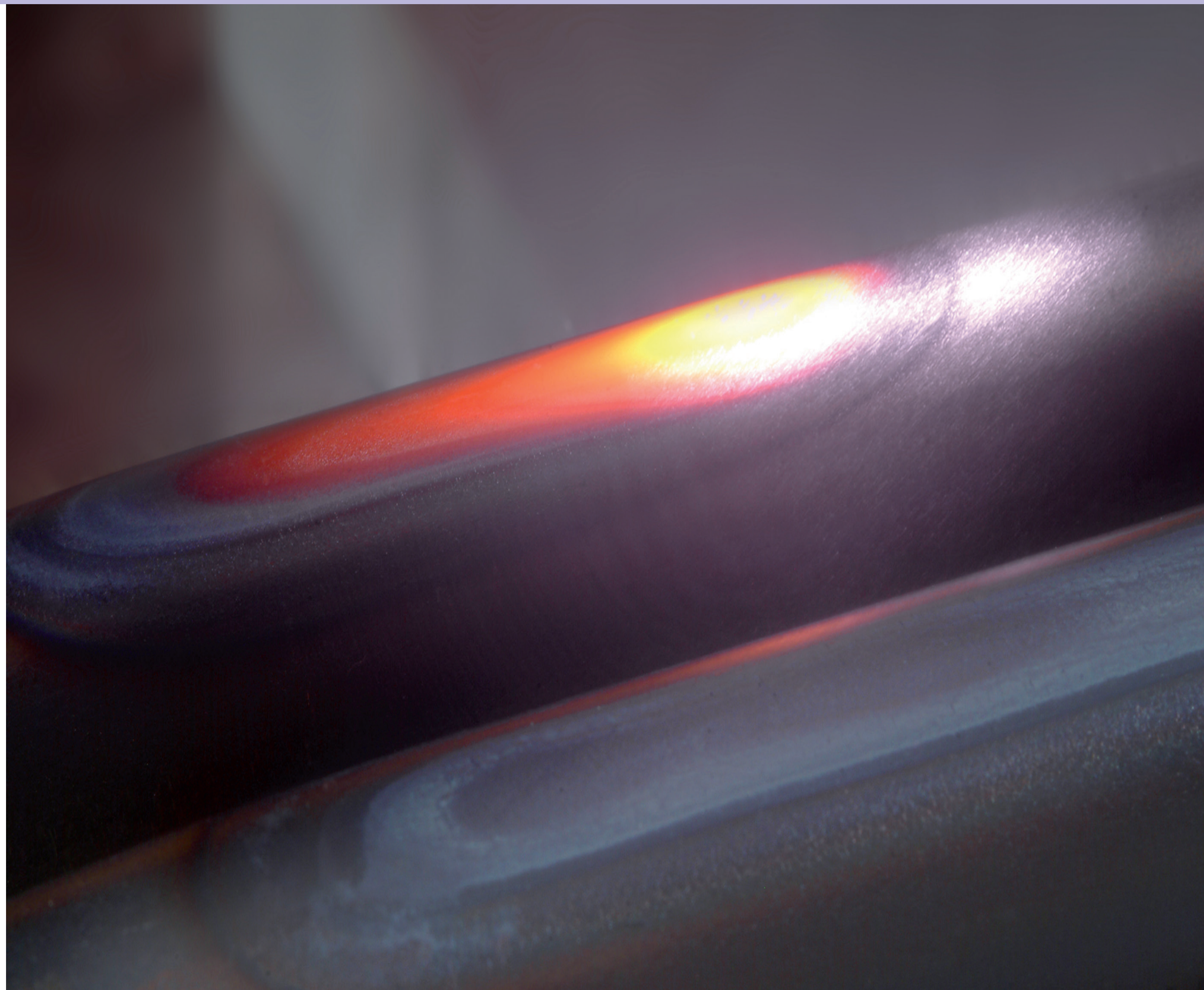
FRAUNHOFER INSTITUTE FOR LASER TECHNOLOGY ILT

HEAT TREATMENT WITH LASER RADIATION



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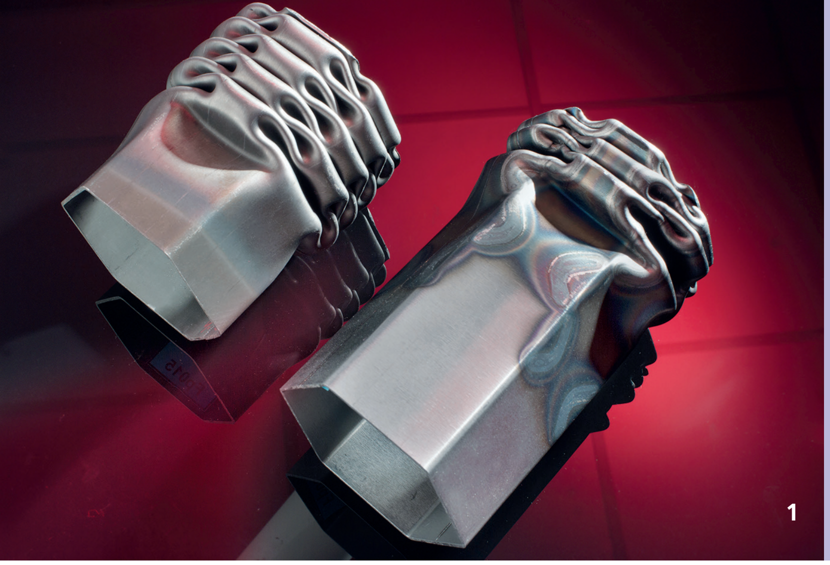
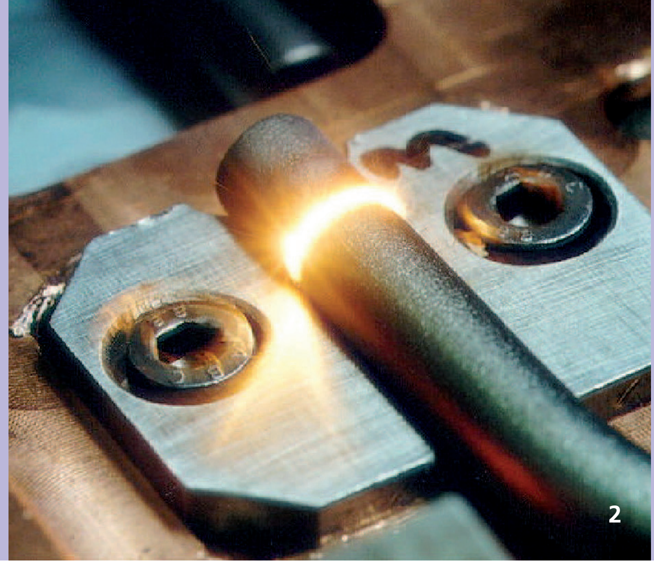
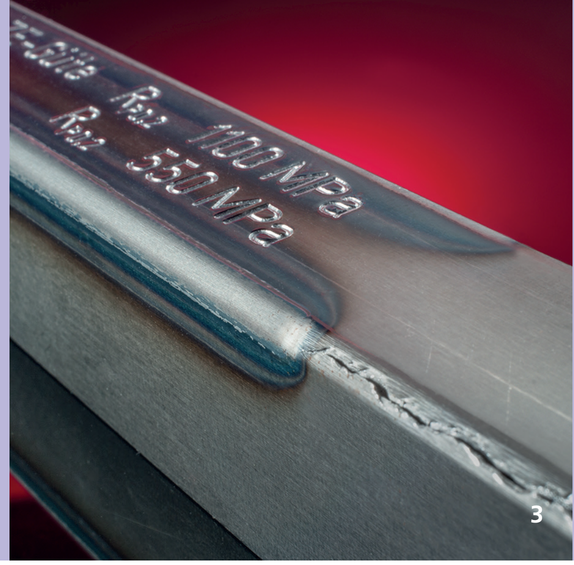
Fraunhofer Institute for Laser Technology ILT

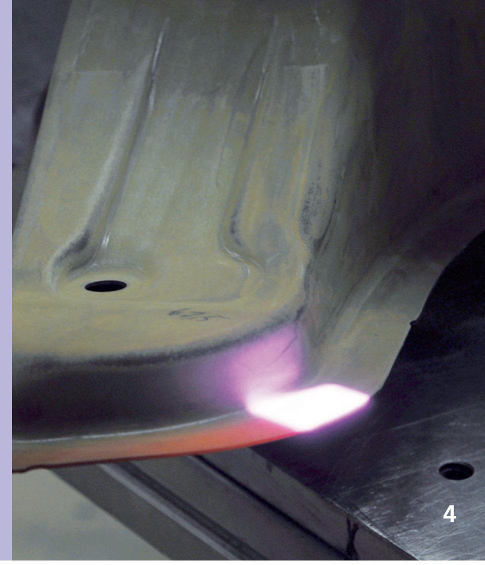
The Fraunhofer Institute for Laser Technology ILT is one of the most important development and contract research institutes in laser development and application worldwide. Its activities encompass a wide range of areas such as developing new laser beam sources and components, laser-based metrology, testing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

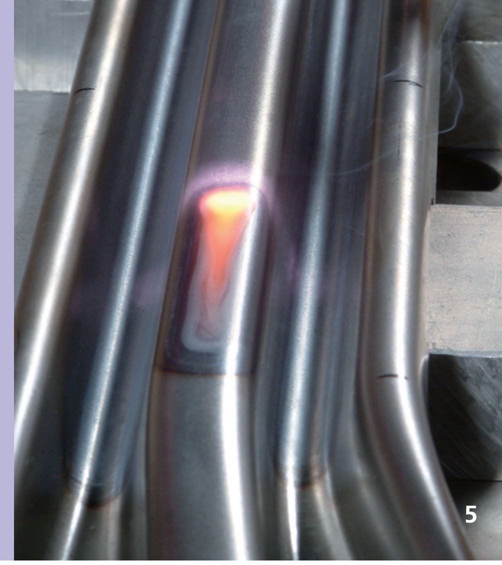
Overall, Fraunhofer ILT is active in the fields of laser plant technology, digitalization, process monitoring and control, simulation and modeling, AI in laser technology and in the entire system technology. We offer feasibility studies, process qualification and laser integration in customized manufacturing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











HEAT TREATMENT WITH LASER RADIATION

Laser radiation is ideally suited for the precise and localized heat treatment of metallic materials, thereby making it possible to locally adapt a component's properties to specific requirements. To accomplish this, the Fraunhofer Institute for Laser Technology ILT develops solutions tailored customers' tasks in the area of heat treatment.

The Process

During heat treatment with laser radiation, a material is heated for a short-time to a temperature below its melting temperature. The wall thickness determines whether just the surface layer or, in the case of sheet metal, the entire cross-section is heated. In contrast to furnace treatment, the material is only exposed to heat treatment for a very short period – with cycle times in the range of a few seconds. Parameters such as heating rate, maximum temperature and cooling rate are adjusted as required. By controlling the temperature with a pyrometer or camera, a user can achieve reproducible results for series production.

Surface Layer Hardening

When a component made of steel or cast iron is hardened, the surface layer is austenitized for a short period of time. Subsequently, the heat introduced rapidly flows into the cold volume as the material cools. This self-quenching effect turns austenite into martensite. For thin-walled components, an external cooling medium may also be required. Up to a depth of about 1 mm, this phase transformation can be achieved.

The martensite formation increases the hardness of the material, which improves the wear resistance of the component. The microstructure of the bulk volume remains unaffected, so that, for example, toughness and wear resistance can be optimally combined. In addition, the residual compressive stresses induced during martensite formation make it possible to improve the fatigue behavior of components subject to oscillation loads.

Optics and Laser Sources

With beam-forming optics, the laser beam can be individually adapted to the respective task or to the geometry of the track to be hardened, if necessary also during the process. Very well suited are zoom optics with a rectangular cross-section, which produce homogeneous intensity distributions. High-power lasers in the wavelength range around 1 µm (diode laser, disk laser, fiber laser) generally do not require an absorber layer on the workpiece to increase absorption.

Application: Hardening of Torsion Springs

In torsion springs of door hinges, wear occurs in the contact area to the guide rollers. With the so-called two-beam technique, the contact area over a circumference of 170° and a length of 10 to 12 mm can be hardened with diode laser radiation, thus retaining the volume properties of the torsion spring.

Softening

During softening, a hardened or work-hardened structure is tempered or recrystallized by heating for a short period of time. The degree of hardness and strength of the material decreases and at the same time the ductility increases.

Potential Application for Press-Hardened Steels

Local softening can be used in press-hardened steel sheets. Numerous automotive components are made by press hardening. However, this material's high strength – of up to 1500 MPa – impairs the crash behavior, for example, of a B-pillar. In critical areas such as spot welds, local softening with laser radiation can help.

Improving the Formability of Cold-formed Steels

Hardened, ferritic steels such as IF- or micro-alloyed steels are generally recrystallization annealed for subsequent forming and stamping operations after cold rolling. The local softening with laser radiation in critical areas increases the formability and enables further processing in the cold rolled state, opening up potential for lightweight construction. Furthermore, local heat treatment can be used to improve the crash properties of components by imprinting soft zones.

Local Softening of Hardened Components

Another potential application is the local softening of hardened bulk components. Adapted steel alloys and tempering processes now make it possible to set the highest hardness in a component, resulting in weight reduction or improved wear protection. In this type of component, however, there is a risk of premature failure owing to brittle fracture or fatigue in critical areas such as its radii. When the component is tempered in the edge zone, thereby softened in a selected location, the risk can be prevented without changing the bulk properties.

Intrinsic Heat Treatment in Additive Manufacturing

With laser-based additive manufacturing, the adjacent and underlying solid volume undergoes cyclical heating and cooling for each applied cladding path. As the distance from the welding track increases, this cycle takes place at lower temperatures. In so-called intrinsic heat treatment, this temperature cycle is used specifically for aging or tempering. Depending on the chemical composition of the material and correspondingly high precipitation kinetics, this method can already generate precipitates in the additive process so that subsequent precipitation hardening in the furnace is no longer necessary.

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Cover Picture: Local hardening of a cold-formed component.

1 Crash boxes without and with local softening (in cooperation with IBF – RWTH Aachen University).

2 Hardening of a torsion spring.

3 Local softening of cold-formed steel (in cooperation with BILSTEIN).

4 Local softening of a press-hardened B-pillar.

5 Local hardening of a cold-formed component.