HAILTEC

WHITEPAPER

PRECISION LASER CUTTING: TECHNOLOGICAL ADVANTAGE FOR YOUR COMPONENTS

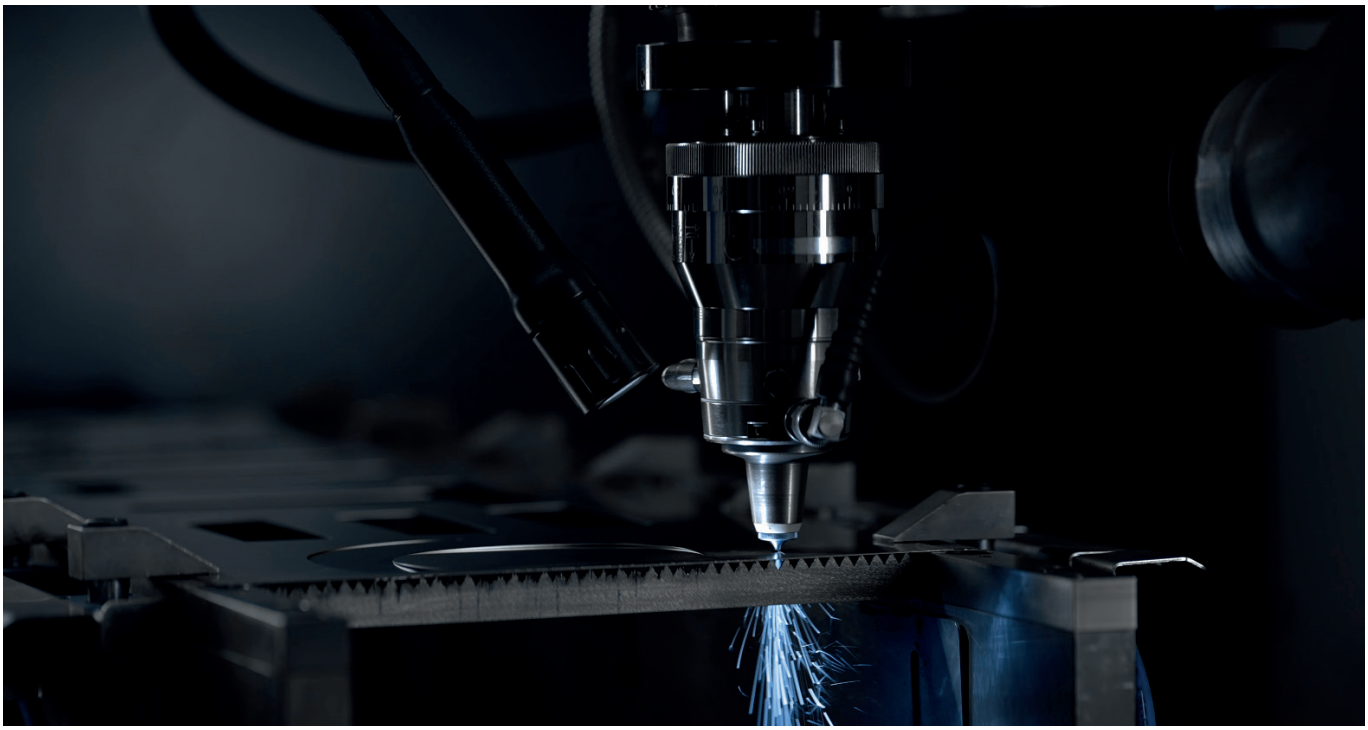
Precision laser cutting, as a non-contact and versatile process, offers enormous potential in manufacturing precision mechanical components and micro-parts.

Which laser cutting process can produce your parts precisely and cost-effectively?

What are the alternatives to established manufacturing methods?

How can we produce sample parts without toolmaking?

This whitepaper provides the answers.



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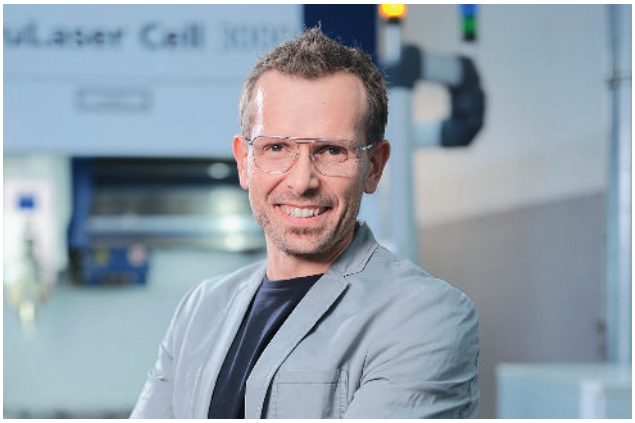
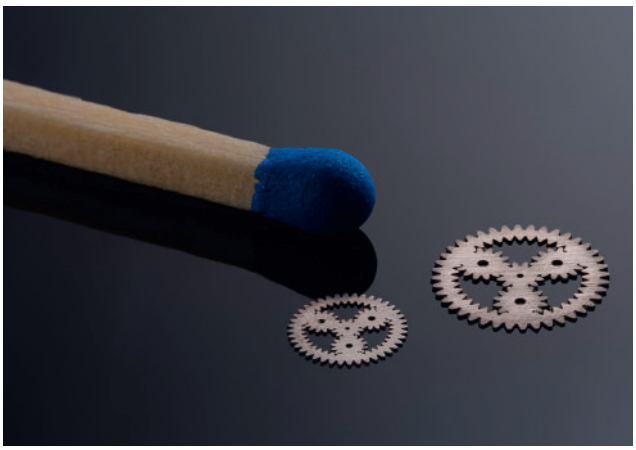


"If you request a sample part from HAILTEC today, chances are you'll still be working with us in ten years. We're a team of tech enthusiasts who love what we do – and you can feel it in every part we deliver."
Alexander Renz, CEO

Whether **automotive, mechanical engineering, electronics, or medical technology:** The trend toward miniaturization is increasing the demand for high-precision components across many industries. Miniaturization means less weight, lower raw material requirements, and less invasive process technologies. While this is advantageous for applications, it poses several challenges for you as a manufacturer.
You may be asking yourself:

1. Which process can manufacture my component precisely and economically?
2. What alternatives are there to established manufacturing processes?
3. How can we get directly to the sample part without tool manufacturing?
4. How do we process the required variety of materials and contours?
5. How can we ensure that our components meet the required dimensions and quality criteria?

In this whitepaper, we explore these questions and examine the potential of precision laser cutting as a non-contact and versatile manufacturing process. DThe underlying expertise comes from years of practical experience: **As a contract manufacturer, we have specialized in laser fine processing since 2005** and support manufacturers in the development and production of precision mechanical components.



Precision laser cutting at its finest: Example parts manufactured by HAILTEC

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OVERVIEW OF LASER CUTTING PROCESSES

Which process can manufacture your component precisely and cost-effectively?

PRECISION LASER CUTTING VS. LASER CUTTING

Precision laser cutting or fine laser cutting works with pulsed laser energy. This results in high pulse peak powers and high power density on the workpiece surface. This high power density causes the material to melt and evaporate. For laser fine-cut components, the focus is on quality: Laser fine cutting works almost burr-free up to a material thickness of one millimeter. Generally speaking, the accuracy ratio between laser cutting and precision laser cutting is 1:5 to 1:10.

DIFFERENCE BETWEEN PULSED & CW LASER CUTTING

While «classic» laser cutting (flatbed laser systems) cuts quickly and economically in continuous CW (Continuous Wave) mode, pulsed laser systems are suitable for small, filigree contours where the machine axes must constantly decelerate and accelerate. Pulsed lasers work with short, high-energy pulses and introduce significantly less heat into the material compared to CW lasers.

The accuracy ratio between laser cutting and precision laser cutting is 1:5 to 1:10

COMPARISON IN NUMBERS

	LASERFEINSCHNEIDEN	LASERSCHNEIDEN
Achievable Tolerances	Between +/- 0.01 mm and 0.04 mm	Between +/- 0.05 and +/-0.1 mm
Axis Drive	Water-cooled linear direct drives	Often via rack and pinion or ball screw
Temperature	Highly rigid machine bed	Often welded constructions
Heat Affected Zone	Very small, as pulsed lasers are used	High, as CW-operated lasers are used
Application Area	Very fine and small contours, tempera-ture-sensitive parts	Edge parts, housings etc.
Reproducibility	Process-reliable through: Ballbar test, laser power monito-ring, distance sensors, high-resolution camera, etc.	
Cutting Range	Max 800 x 500 mm	From 1000 mm and larger
Zero-point Clamping System	Yes	No
Position Monitoring	Additional via glass scales in the linear machine axes (Direct measuring system)	No, only one mea-suring system in axis motor in use (Indirect measuring system)

WHICH LASER PROCESS FOR WHAT?

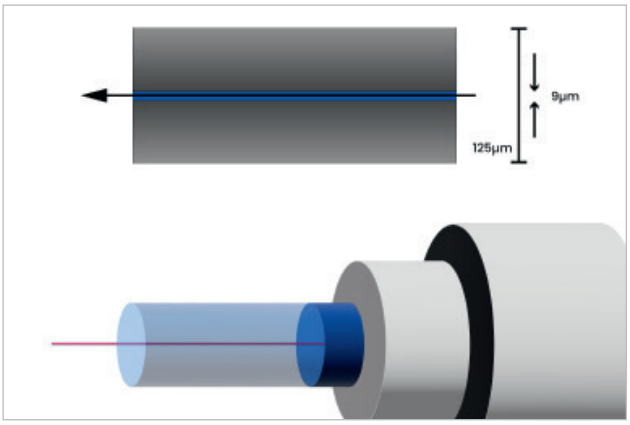
The choice of laser process depends on the type and thickness of the material as well as the required specifications for quality, tolerances, cut edge quality, and kerf width. These parameters then determine the technical settings such as spot size, cutting gas quality, and laser power.

SINGLEMODE AND MULTIMODE LASER

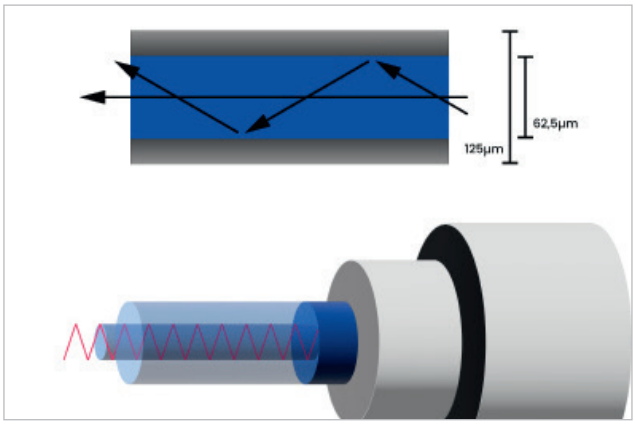
The main difference between singlemode and multimode lasers is: In singlemode, the output beam has only one mode or light type, in multimode it has multiple modes. The diameter in singlemode is smaller than in multimode, making the energy distribution more focused with significantly better beam quality. At HAILTEC, we use both singlemode and multimode lasers to meet the requirements of every task.

HIGH-PRECISION LASER FINE CUTTING SYSTEMS

Laser fine cutting systems differ from classic laser cutting centers in mechanical engineering through exact tolerances and higher positioning accuracies. This is due to the construction and integrated path measuring system: In precision laser cutting systems, the axes have water-cooled linear direct drives, which are monitored live via a glass scale on each axis and adjusted if necessary.



Singlemode-Laser

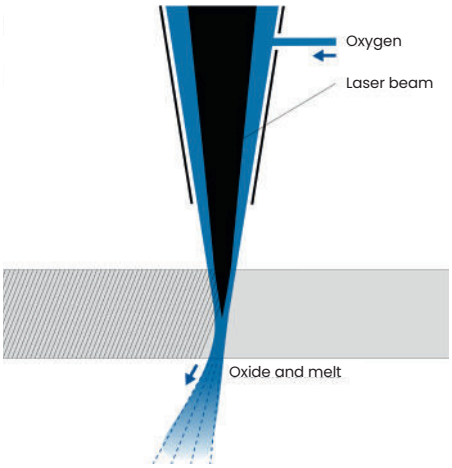


Multimode-Laser

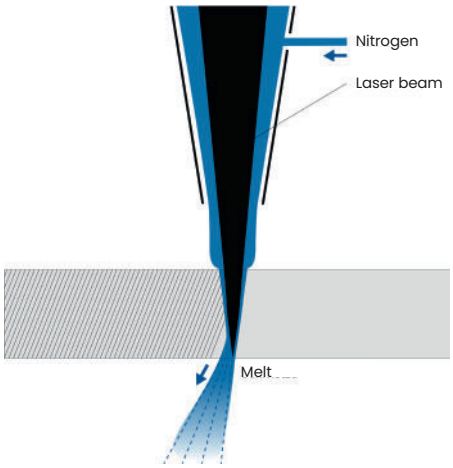
At HAILTEC's laser processing center, we always use the ideal laser process for your component and its specific requirements.

THE LASER CUTS CONTACTLESSLY AND UNIVERSALLY THANKS TO DIFFERENT CUTTING PROCESSES:

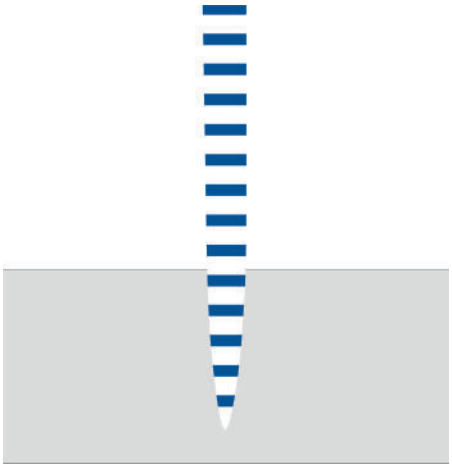
Flame Cutting



Fusion Cutting



Sublimation Cutting



FUSION CUTTING

HOW DOES LASER FUSION CUTTING WORK?

Laser fusion cutting is a separation process using a solid-state laser.
For laser fusion cutting, a reaction-inhibiting cutting gas (argon or nitrogen) is pressed into the cutting gap with up to 23 bar pressure. The gas cools and prevents oxidation at the cut edge.

WHEN IS FUSION CUTTING USED?

The process is suitable for thin sheets and work-pieces that need to meet high optical require-ments. At HAILTEC, laser fusion cutting is the most commonly used laser cutting process because it produces neither an oxide layer nor deposits on the cutting edge. This makes fusion cutting ideal for medical technology, e-mobility, and generally for all applications requiring high-quality parts.

LASER INCREASES TOOL LIFE BY A FACTOR OF 10

From a metallurgist's perspective, Maximilian Voigt of Ceratizit Empfingen explains:
"If you refine a laser-cut contour in a carbide tool using simple blasting followed by polishing, you achieve material properties that even surpass the delivery condition of untreated, sintered carbide. This allows the advantages of ultrashort pulse (USP) laser ablation to be fully exploited.
A tool life increase of up to a factor of 10 compared to sink-eroded carbide forming punches is absolutely possible with this high-end process."

Advantages

- Burr-free cut edges
- Good cut quality
- Cost-effective processing of a wide range of materials due to minimal post-processing required

Disadvantages

- Slower than flame cutting
- Reaction-inhibiting cutting gas (nitrogen/argon)
- Many times more expensive than oxygen or compressed air

Suitable for

Aluminum alloys	Brass
Structural steel	Non-ferrous alloys
Stainless steel alloys	Steel
Copper	Titanium

FLAME CUTTING

HOW DOES FLAME CUTTING WORK?

In flame cutting or laser beam flame cutting, oxygen is blown into the cut gap with up to 20 bar pressure. This enables very high cutting speeds, as the energy generated during combustion accelerates the cutting process. Major disadvantage of flame cutting: The process introduces a lot of heat into the component.

WHEN IS FLAME CUTTING USED?

The process is suitable for thicker sheets than fusion or sublimation cutting. With flame cutting, the laser processes materials whose ignition temperature is lower than the melting temperature of the material.

Sample part Flame Cutting

Advantages

- Cuts very thick sheet metal quickly

Disadvantages

- Much heat in the component = distortion
- The oxide layer on th cutting edge often needs to be removed before the component can be further processed

Suitable for

- Low-alloy or unalloyed steels
- Steel (free-cutting steel, structural steel, spring steel, cold-working steel, tool steel)
- Aluminum
- Stainless steel

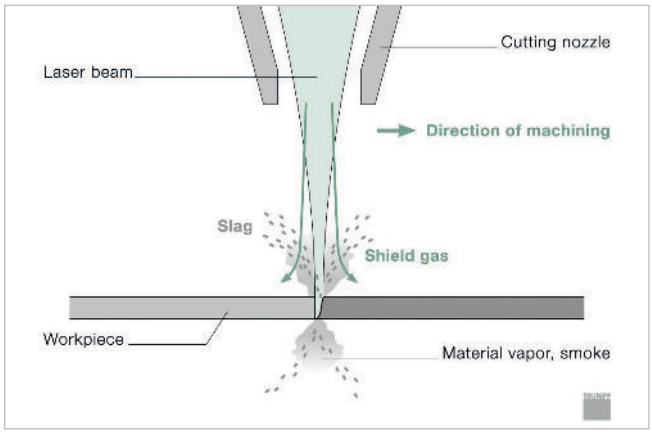
SUBLIMATION CUTTING

HOW DOES SUBLIMATION CUTTING WORK?

In laser sublimation cutting or micro-cutting, the material vaporizes with as little melt as possible. In the cutting gap, the vaporizing material creates high pressure, which ejects the melt. The process gas keeps the cutting edges oxide-free.

CUTTING GASES

Depending on the laser cutting process, different process gases are used. These gases flow through the cutting gap at different pressures. Typical process gases are oxygen, nitrogen, or argon. Unlike oxygen, argon and nitrogen do not react with the molten metal in the cutting gap and shield the cut surface from the surrounding material.



Source: TRUMPF

WHAT ALTERNATIVES ARE THERE TO ESTABLISHED MANUFACTURING PROCESSES?

PRECISION LASER CUTTING VS. WIRE EDM

Thanks to high-precision and temperature-stable systems, precision laser cutters like HAILTEC often replace wire-cut sheet metal cutting. Behind this is intelligent process control, where the laser power and nozzle distance are continuously adjusted and monitored relative to the respective cutting feed rate during the cutting process.

HOW PRECISE IS PRECISION LASER CUTTING?

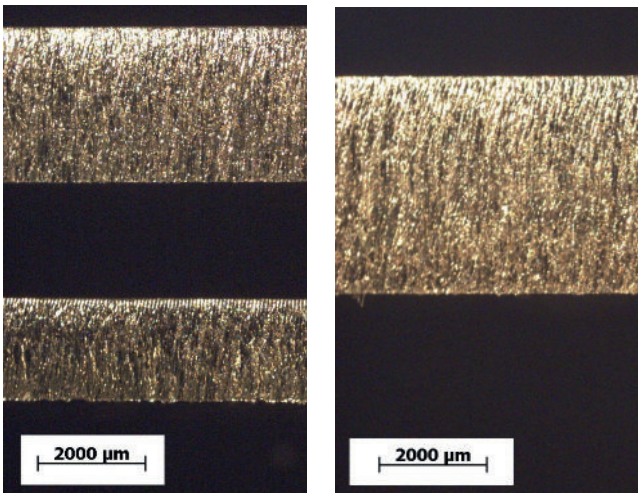
Solid-state lasers are particularly suitable for precision cutting thanks to their short wavelength and good beam quality. Therefore, in our precision laser cutting center*, we rely on Nd:YAG and QCW fiber lasers, and for micro-cutting on ultrashort pulse lasers. Depending on the cutting process, we cut sheet thicknesses from 0.01 to 3.00 mm. For thicker sheets, composite materials, or particularly temperature-sensitive applications, we use micro waterjet cutting.

Depending on batch size, precision laser cutting offers a flexible alternative to punching in thin sheet metal – without setup effort or tooling costs, and free from wear.

Advantages

- +/- 0.01 mm contour accuracy
- 0.05 mm – 3.00 mm cuttable material thicknesses
- <0.025 mm spot diameter
- from 0.03 mm web widths
- from 0.03 mm laser kerf
- max. 800 x 500 mm component dimensions

*the stated values depend on material, thickness, and geometry



3 and 2 mm thin stainless steel cut with 150W QCW with 50µm fiber
4 mm stainless steel cut with 150W QCW with 50µm fiber

(Source: IPG Photonics)

ORIGIN OF PRECISION CUTTING USING LASER

Creating contours thermally was long considered unthinkable. In the late 1960s, work began in the USA on cutting sheet metal using laser beams. Based on Albert Einstein's 1917 published proof of light amplification, American physicist Theodore Harold Maiman had already built a first functional laser in 1960. Since then, laser technology has revolutionized the manufacturing world – and continues to evolve steadily.

WHEN IT COUNTS: SHORT PULSES FOR SMALLEST COMPONENTS

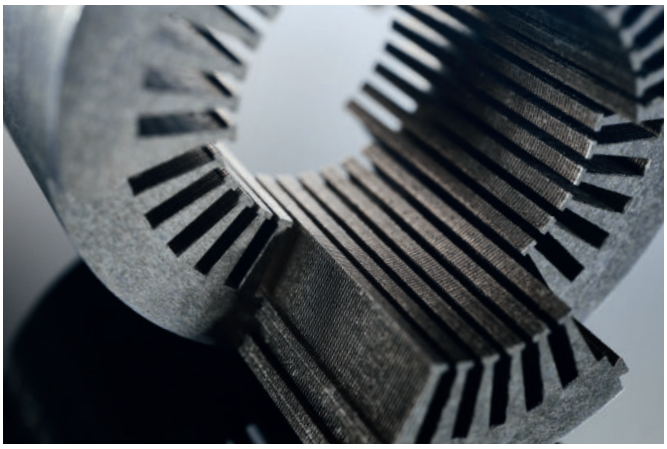
The laser does not wear out and requires no additional tooling. That's why we manufacture sample parts for our clients directly from coil blanks. All parameters are stored product-specifically, ensuring that each part can be reproduced or modified at any time with absolute precision.

VERSATILE TOOL

The laser is a wear-free tool and requires no additional tooling. Therefore, we manufacture sample parts directly from coil cuts for clients. The parameters are stored product-specifically, so that each product can be exactly reproduced or modified at any time.

DEMO PART: PUZZLE STACK

In addition to high-precision laser cutting, the stacking of the 100 individual backlack-coated layers (each 0.2 mm thick) of the stator puzzle part is also impressive: HAILTEC stacks them with a tolerance of just 5 µm.



10 REASONS FOR PRECISION LASER CUTTING

1. Direct to sample or prototype without tool manufacturing
2. Maintenance-free cutting tool
3. Heat Affected Zone (HAZ) very small
4. Low distortion thanks to low thermal impact
5. Low post-processing edges without burr
6. Tight kerf widths
7. Precise, filigree contours
8. Quick plate dimension changes via CAD/CAM system
9. Cutting contours can be quickly and flexibly adjusted
10. Achieves roughness values up to Ra: 1.6 µm Rz: 10 µm

Laser processing gets you from concept to prototype – without toolmaking.

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MATERIALS AND CONTOURS

From aluminum and non-ferrous metals to carbide and titanium: Pulsed laser technology can cut nearly all metallic materials used in industry – as well as non-metallic ones such as diamond, glass, and ceramics. This exceptionally broad range makes the laser arguably the most versatile cutting tool available.

Common materials for precision laser cutting include:

LIGHT METALS

Aluminium is a relatively soft and light material, resistant to corrosion and well weldable. Typical material grades:
AW-5754 / AlMg3
AW 6082 / AlSi1MgMn
AW-1050A (pure aluminum)

Titanium (Ti) is light, biocompatible, and passivatable. At HAILTEC, we frequently use this material for medical technology.

FERROUS METALS

Structural steel
(material grades e.g., 1.0330, DC01 or 1.0338, DC04)

Stainless steel (standard stainless steels V2A like 1.4301, 1.4316; stainless steels V4A like 1.4404, stainless steel 1.4828, 1.4016 etc.)

Carbon steel or C-steel
(material grade 1.1274, C100S, C75S)

Spring steel (material grade 1.4310)

NON-FERROUS METALS

Non-ferrous metals include:

Copper (Cu) - resistant to corrosion, good electrical conductivity, can be formed hot and cold

Copper, nickel, cobalt alloys
(high-melting)

Bronze (hard, wear and corrosion-resistant non-ferrous metal alloy, CW452K)

Brass (good spring properties, cold-formable. CW508L, CW612N)

Nickel (Ni) or MU-metal
(ferromagnetic and particularly corrosion-resistant)

Copper-nickel

OTHER MATERIALS

Ceramics (Si3N4, particularly durable, temperature stable and thermal shock resistant)

Precious metals

Numerous steel alloys

Carbides, PCD diamond

Pre-stamped strips with press-fit zone

Tantalum

Hilumin

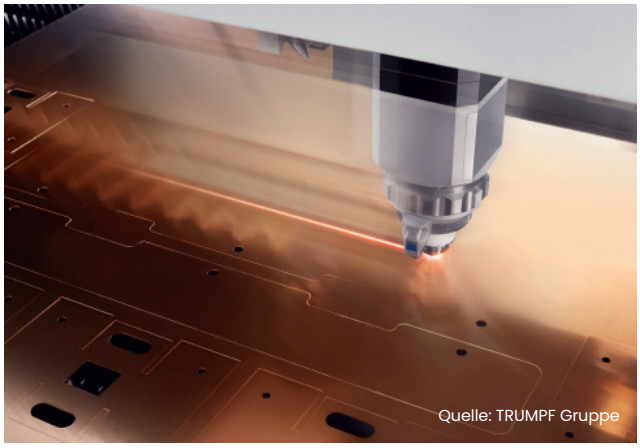
Nickel & nickel alloys

MATERIALS AND CONTOURS

LARGE MATERIAL STOCK

For precision laser cutting, we have a large selection of materials in stock. Additionally, we develop special applications according to your specifications.
We typically have the following materials in stock:

- Carbon steels
- Spring steels
- Stainless spring steels
- Medical-grade stainless steels
- Various beam alloys
- Aluminum
- Copper
- Brass
- Copper alloys
- Titanium



With pulsed lasers, we process nearly any material you need – precisely and cleanly.

DELICATE CONTOURS

The pulsed laser beam heats the material only locally, resulting in minimal thermal stress on the workpiece. The kerf is as narrow as the beam itself. Why is this important? It allows for cutting complex contours smoothly and burr-free. This eliminates the need for extensive post-processing.

Precision Laser-Cut Component from 1.4310 t=0.1 mm

METROLOGY: ULTRA-PRECISE VERIFICATION

If you're installing or selling precision laser-cut components, you need documented proof of their dimensional accuracy. For quality assurance, we rely on in-process measurements and a state-of-the-art in-house metrology lab.

ROUGHNESS AND FORM MEASUREMENT

Optical surface measuring devices analyze components contactlessly and material-friendly. They detect deviations in form and surface structure down to the submicrometer and nanometer range.

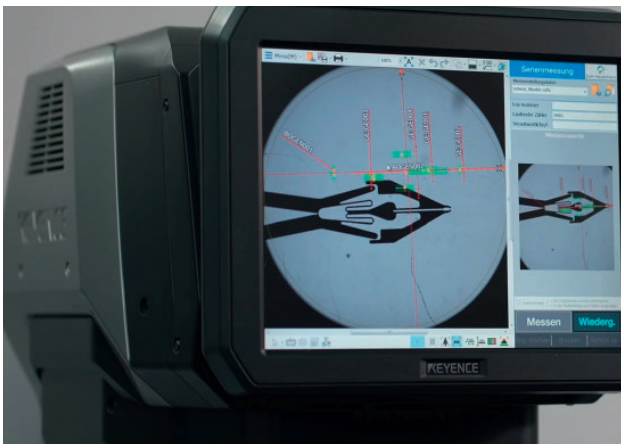
SAMPLING

Prototypes and samples are available including initial sample test report (ISIR) if required.

Messung der Schneidkontur

Digital outside micrometer

In our in-house metrology lab, we ensure that your components meet all specifications.



In-process measurement with micrometer accuracy using digital measurement projectors

COMPLETE PROCESSING – FEWER INTERFACES, GREATER IMPACT

From raw material to finished part, many process steps are typically involved. Up to now, we've focused on precision laser cutting in isolation. This section takes a broader perspective – on the entire process chain. And that's exactly what benefits many renowned manufacturers who rely on us as an A-supplier.

HOW YOU BENEFIT FROM HAILTEC'S END-TO-END PROCESS CHAIN

1. Toolmaking and engineering simplify the production of your prototypes and sheet metal samples
2. Feasibility studies, consulting, and concept development included
3. Batch traceability and reproducibility ensure consistent quality – from the first prototype to full-scale production

» With our expertise, you get the parts you want – economically, quickly, and reliably. «

Alexander Renz
CEO HAILTEC

TASK

What exactly do you need? Together with you, we assess the feasibility of your application.

DEVELOPMENT

Which parameters and technologies suit your material? We determine the strategy for your best possible result.

PRODUCTION

Based on the defined parameters, we manufacture your components with 100 % reproducibility.

QUALITY

Is your part up to spec? Using nanometer-precision metrology from Alicona, we verify your application fast and accurately.

SAVINGS

With HAILTEC's express service, you access high-tech on demand – no investment needed, no costly downtime.

LASER FINE CUTTING CENTER

We have specialized in precision laser cutting and welding for micro-processing applications since 2005. For highly accurate laser cuts, we use QCW-pulsed fiber lasers and Nd:YAG laser systems from DMG MORI and TRUMPF. These laser sources introduce minimal energy into the component. Less heat means less distortion – enabling ultra-fine cuts.

SYSTEM TECHNOLOGY AT A GLANCE

In HAILTEC›s laser fine cutting center, you currently have a wide range of laser cutting systems at your disposal.

Laser sources available at HAILTEC

- pulsed Nd:YAG lasers
- Single and multimode QCW fiber lasers
- disk lasers
- ultrashort pulse lasers

What that means for you

Controlled quality from the first to the last part

Contour accuracy of ±10 µm

IDEAL CONDITIONS

HAILTEC's laser fine cutting center provides you with the ideal conditions for your requirements:

INTELLIGENT PROCESS MONITORING

- Active laser power measurement
- Distance sensors
- Precise positioning and control of the machine axes

SPECIFICATIONS

- Pulsed laser power from 80 to 3000 watts
- 2D and 3D laser cutting and laser welding
- Spot sizes flexibly variable from 25 to 185 µm thanks to beam shaping optics
- Sheet thicknesses 0.05 - 3.0 mm
- High-resolution camera system for precise capturing of your individual parts
- EROWA zero-point clamping systems

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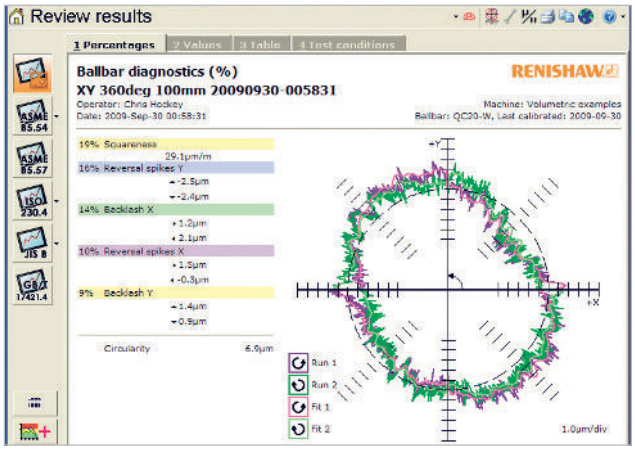
PROVEN QUALITY

On modern systems and with a great deal of expertise we cut, weld and mark your components and process their surfaces on request.

SYSTEM TECHNOLOGY AT A GLANCE

1. **Cutting:** Four in-house cutting technologies to choose from (punching, micro waterjet cutting, precision laser cutting, and ultrashort pulse laser micro-cutting)
2. **Forming Technology:** Stamping, offsetting, micro-bending, combined processing, or precision drilling
3. **Ultrashort Pulse Laser Processing**
   Ablation/structuring/cutting/black marking
4. **Surface Treatment and Post-Processing:** EDM, CNC machining, deburring, satin finishing, etc.

Regular Ballbar Tests of Our Laser Axes and Measurement Systems Ensure 100% Reproducibility



Circularity Measurement / Ballbar Test Verifies the Accuracy of (Laser) Machines at HAILTEC

EXACT RESULTS

At HAILTEC›s precision laser cutting center, we regularly ensure the accuracy of our laser cutting systems using circularity measurement, also known as the Ballbar Test. This test provides a quick check of positioning accuracy according to international standards. It delivers meaningful results and identifies potential sources of errors or maintenance needs.

FROM BATCH SIZE 1 TO 1 MILLION

SHORT SETUP TIMES

A special zero-point clamping system at HAILTEC ensures repeatable fixture positioning, resulting in short setup times. This is particularly useful when cutting pre-punched strips with press-fit zones or when re-aligning already processed components. Pre-punched strips can be ideally positioned and aligned, as the laser systems are equipped with a high-precision camera.

POST-PROCESSING

One thing you can rely on: You will not receive any parts with burrs or other irregularities from us.

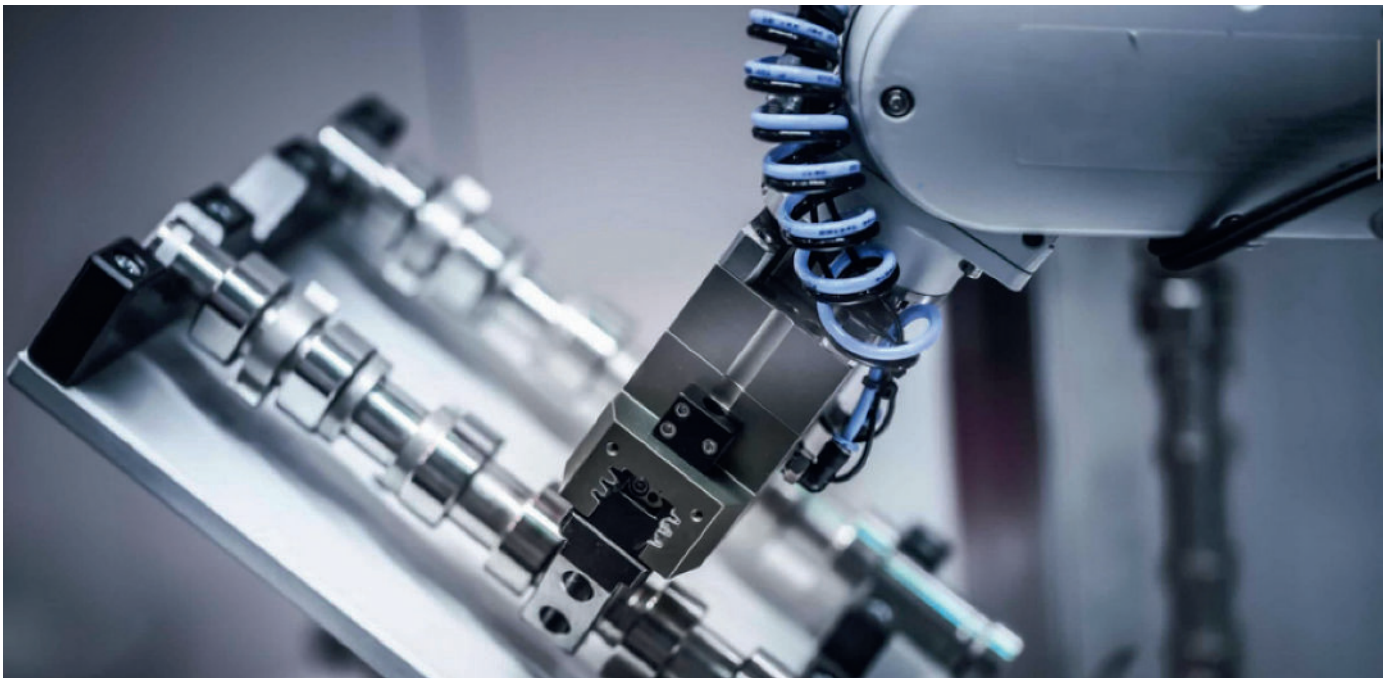
- As a standard, we process laser-cut parts by satin finishing, scotching, or brushing. After satin finishing, we visually inspect your components, manually break them out of the sheet metal, and package them for shipping. Of course, we also offer cleaning of the parts.
- We coordinate the attachment tabs (microjoints) on the component with you. These are necessary to hold the parts in the sheet after laser cutting and to protect them from slag splashes or heat.

AUTOMATED SERIES PRODUCTION

When the prototype meets the requirements, demand often increases rapidly. To deliver reproducible quality at an economical price, even under time pressure, we rely on automated series production and digital manufacturing control. Additionally, we use mobile robot cells for autonomous shifts. With a technology like precision laser cutting, exact dimensional accuracy is crucial. Automated robot loading ensures secure processes, flexible production capacities, and tremendous speed.

Components from quantity 1 to 1 Million

- Fast
- Efficient
- Reproducible
- Achievable tolerances +/-10 µm



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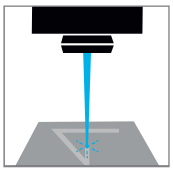
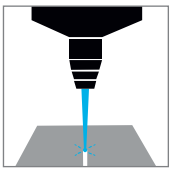
HAILTEC AT A GLANCE

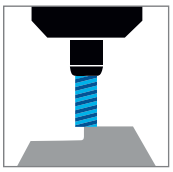
Courageous, inventive, and micrometer-precise, HAILTEC GmbH helps clients stay one step ahead – from application development through to series production. On the Swabian Alb, HAILTEC manufactures intricate components and complete assemblies. The certified company has a unique technology toolkit that includes ultrashort pulse lasers, micro waterjet cutting, laser fine cutting, and AI-supported measuring technology. HAILTEC is certified according to DIN EN ISO 13485, DIN EN ISO 9001, and DIN EN ISO 14001.

HIGHTECH-ARSENAL


Ultra-Short Pulse Laser Processing


Laser Fine Cutting

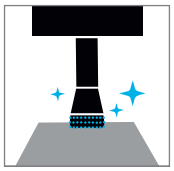

Micro Water Jet Cutting


CNC Precision Manufacturing

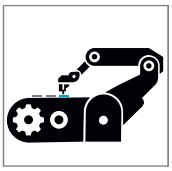

Precision Forming Technology


Cleaning and Cleanroom


Metrology


Finishing (Surface Finish)


Toolmaking and In-house Design


Automated Production Systems

As an agile supplier, we are digitally positioned throughout. Regardless of whether you are looking for a long-term partner for development and series production or want to cushion short-term order peaks: **Talk to us.**

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