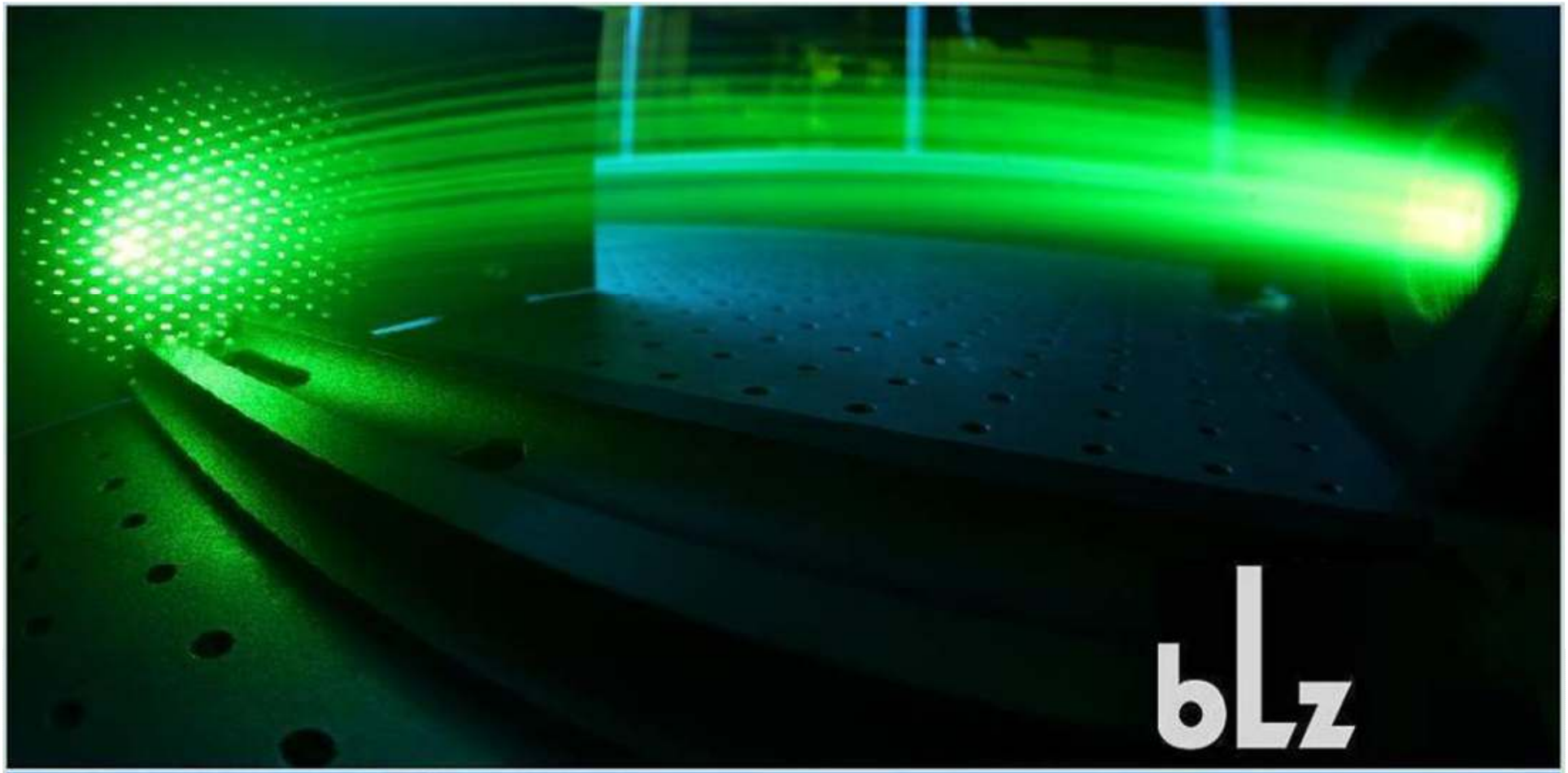


BAYERISCHES LASERZENTRUM

New Trends in Laser Material Processing

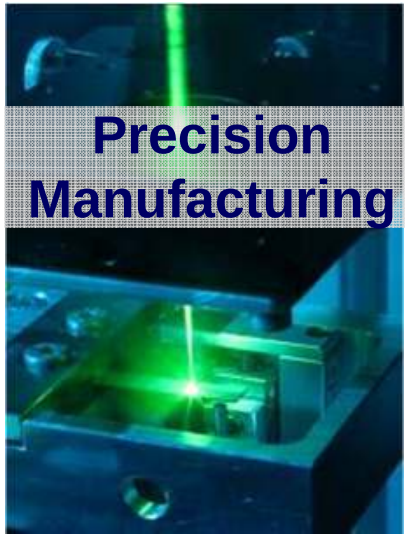
Dr. Stephan Roth

Company profile

Inspiration for Economy & Science

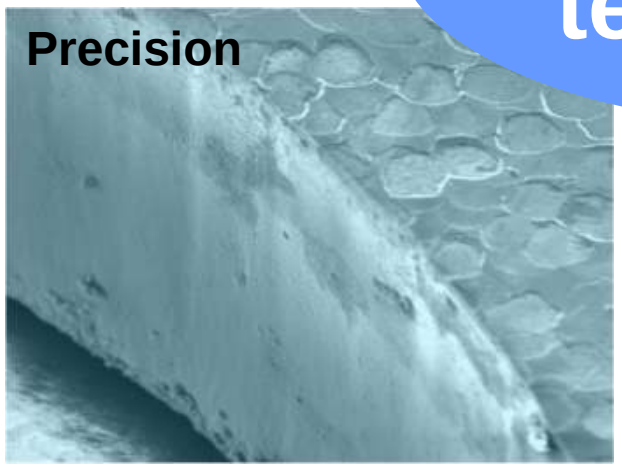
- Link between research and industrial application
- Non-profit Ltd. with 32 employees
- Total annual turnover (2013) ~3.3 million €
- Executive Board:
  Prof. M. Schmidt, Dr. S. Roth
- Associates: Förderkreis e.V., IHK, LGA
- Company history:

Key process technologies at blz



Why laser technology?

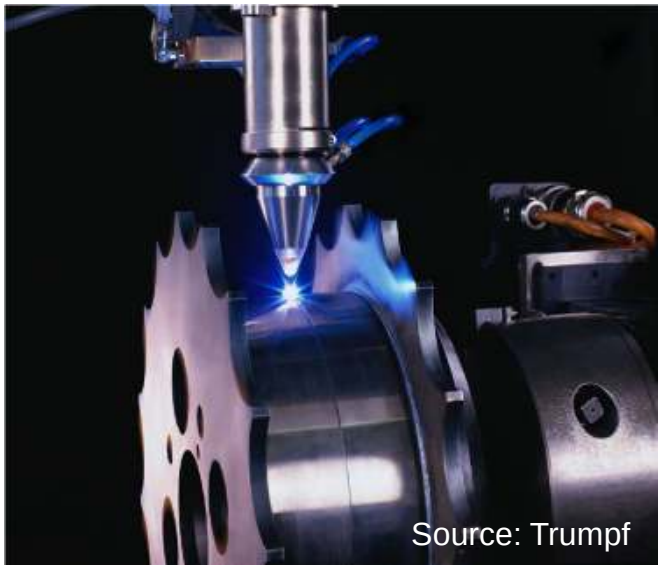
Laser technology



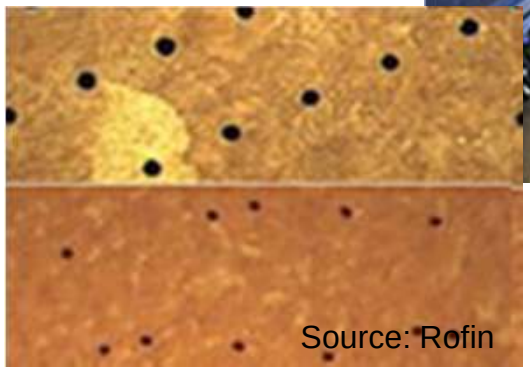
Laser in production today

Aerospace

Automotive industry



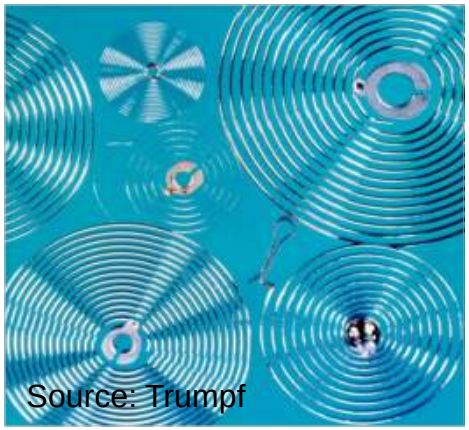
Production technology



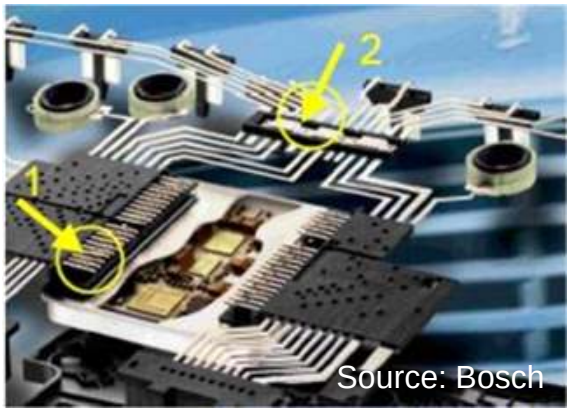
Tobaccos

Laser in production today

Medical technology

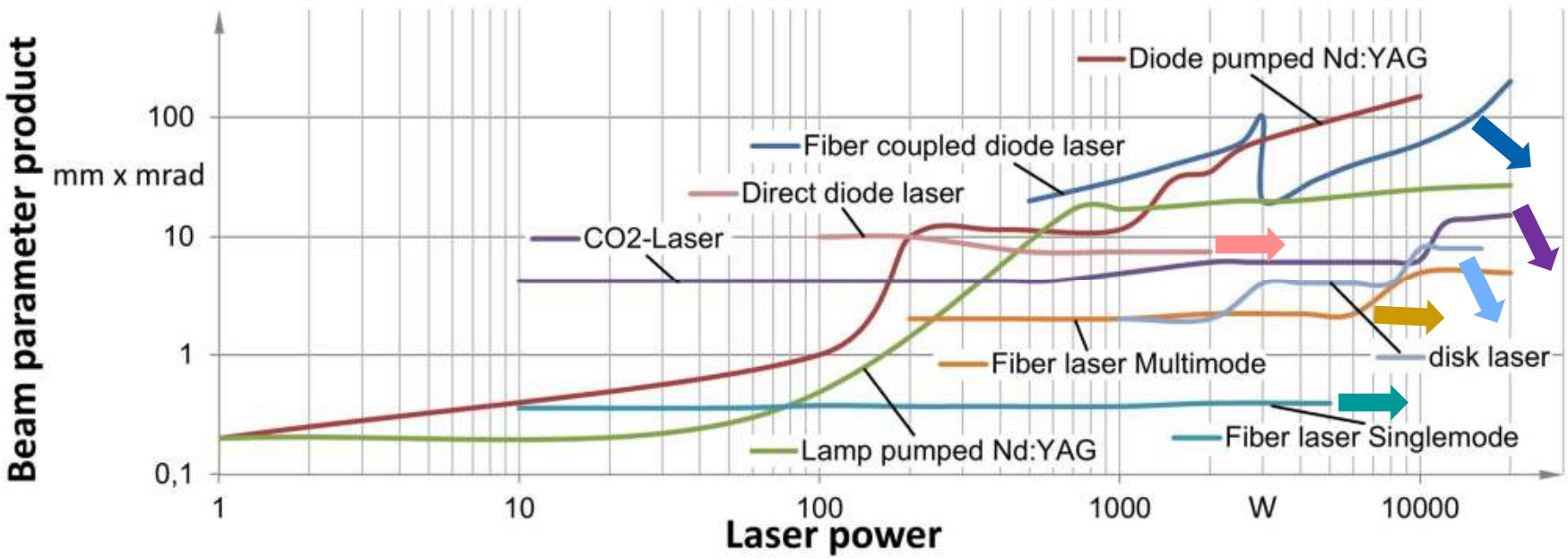


Watch industry



Electronics production

Recent development of laser sources



Sources: IPG Laser, Trumpf; Rofin, Direct Photonics

- Higher laser power
- Better beam quality ► smaller beam diameter

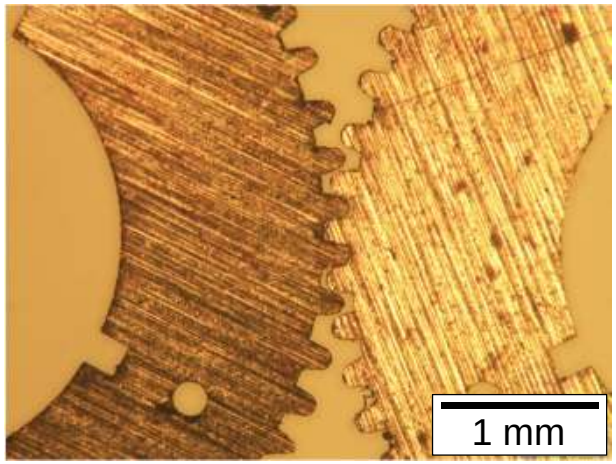
Recent trends in laser material processing

Material efficiency

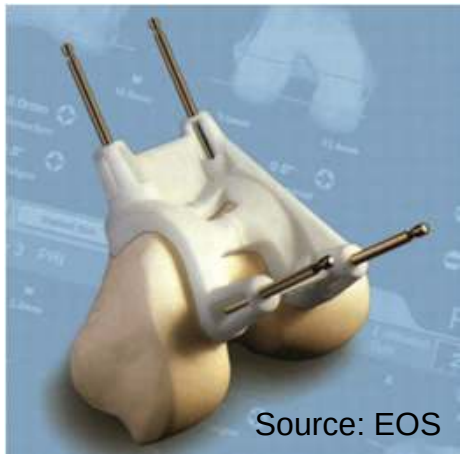
Energy efficiency

Process efficiency

Higher precision

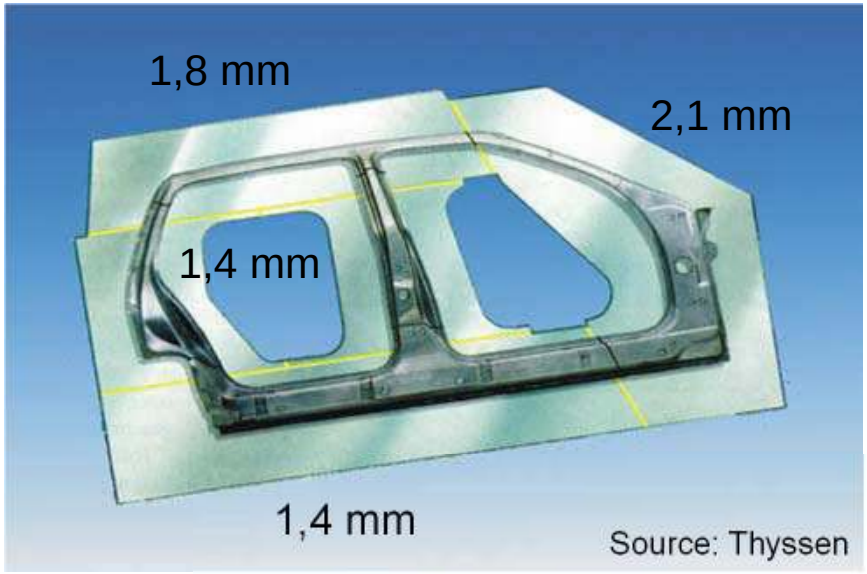


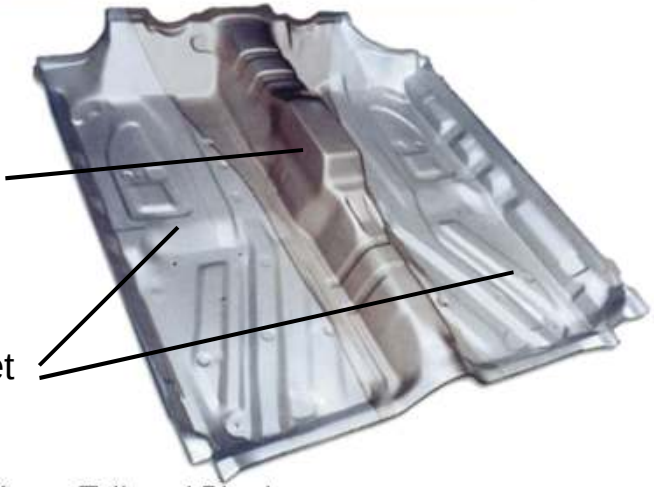
Additive Manufacturing



Material efficiency: Tailored parts

- **Tailored Blanks**
  - Laser welded blanks with different materials and coatings
  - Locally different sheet thicknesses possible
    - ► Lightweight construction
- **Tailored component properties**
  - Narrow weld seams with small heat effected zones
  - Formability is retained after laser beam welding
    - ► Most flexible production chain

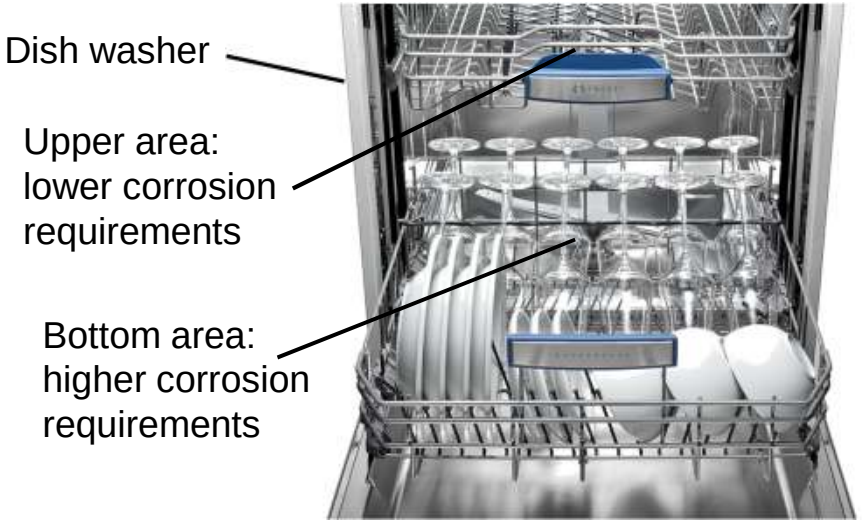




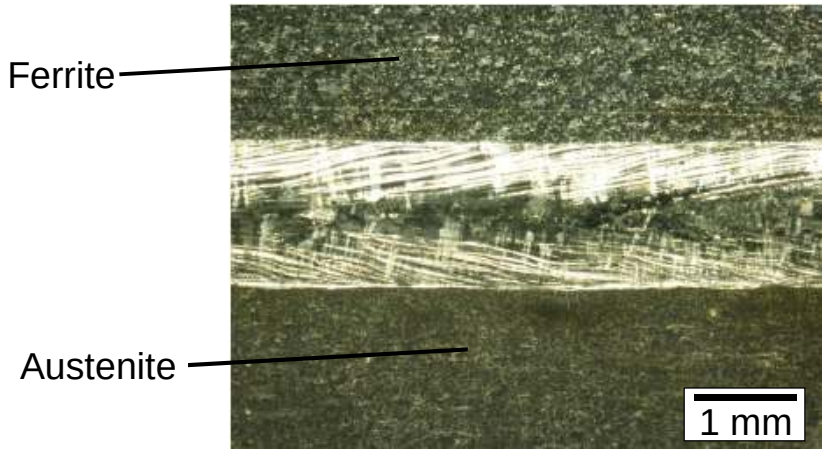
Source: Thyssen Krupp Tailored Blanks

Material efficiency: Dissimilar metal joints

- **Ferritic and austenitic stainless steel**
  - Laser beam welding of dissimilar materials
  - Selection of materials due to the local corrosion requirements
- **Preservation of corrosion resistance**
  - Laser welding with low heat input, thus no concentration of alloying elements
  - Substitution of nickel
    - ► Increase in corrosion resistance of tailored welded stainless blanks



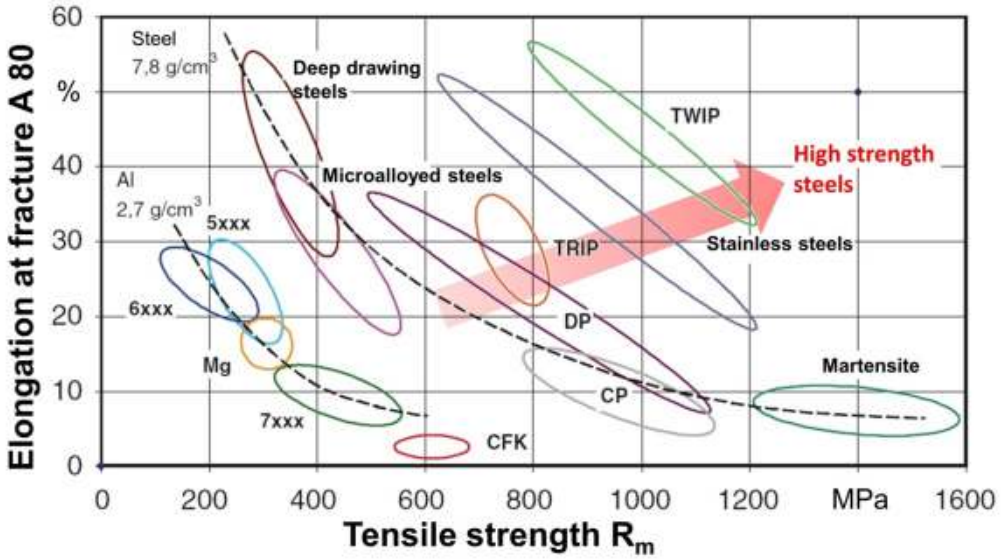
Source: Bosch Siemens



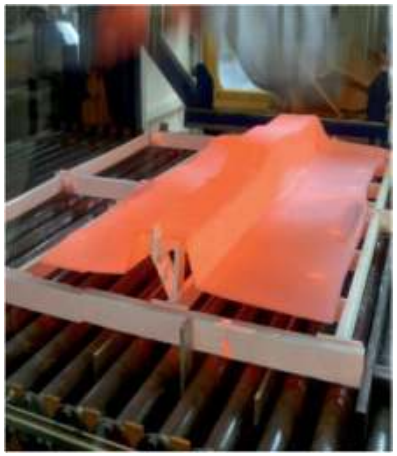
Material efficiency: High strength steels

- **Lightweight construction**
  - Higher tensile strengths enhance crash-behavior performance
  - Lower sheet thicknesses possible
- **Cold and hot forming possible**
  - Different hardening mechanisms
  - Increase in tensile strength during production process achievable

► Enhanced safety



Source: Lightweight construction in vehicle manufacturing

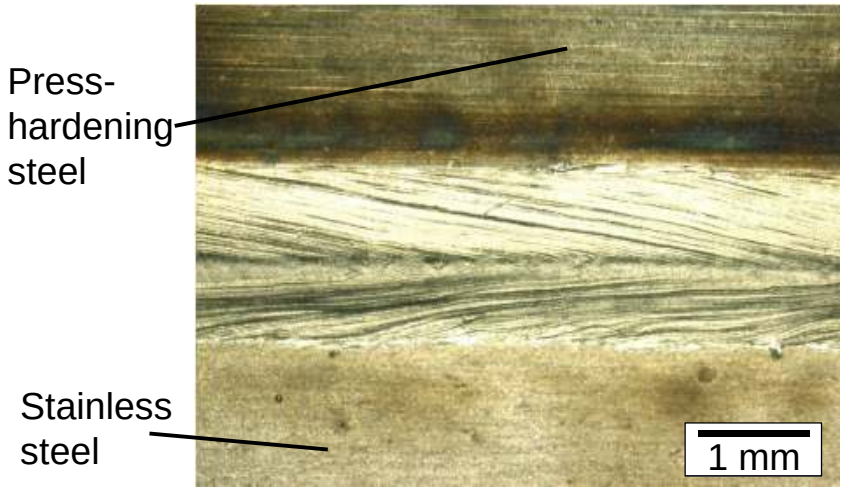


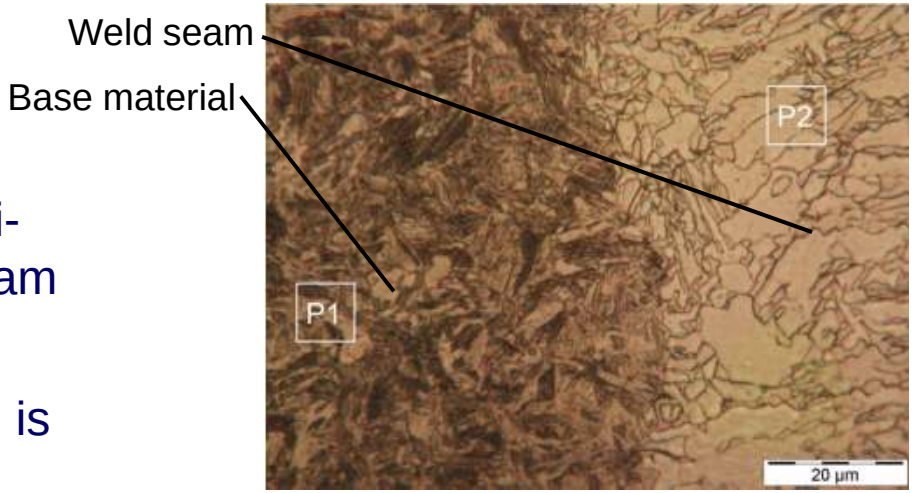
Sources: Trumpf

Material efficiency: High strength steels

- **Laser welding of high strength steels**
  - Reduction of heat input and heat effected zone with laser beam welding
  - Homogeneous strength in weld zone due to low heat input
- **Strategies for welding high strength steels**
  - Welding with filler material
  - Modelling the temperature distri-bution after welding through beam oscillation

    ► Hardness of base material is reached



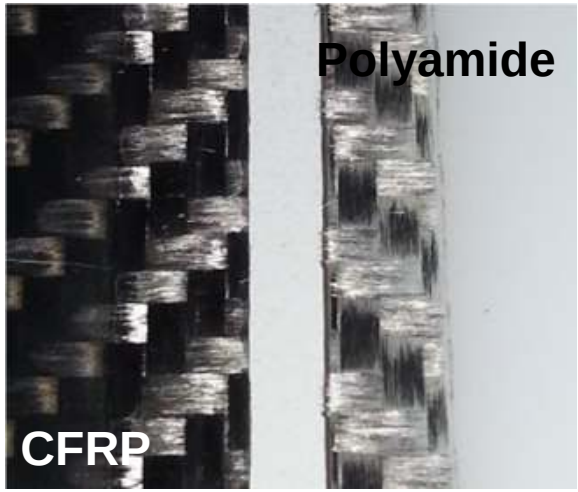


Material efficiency: Dissimilar plastic joints

- **Laser-based joining of dissimilar materials**
  - Challenge for common joining techniques
  - Structuring of surfaces leads to strong connections

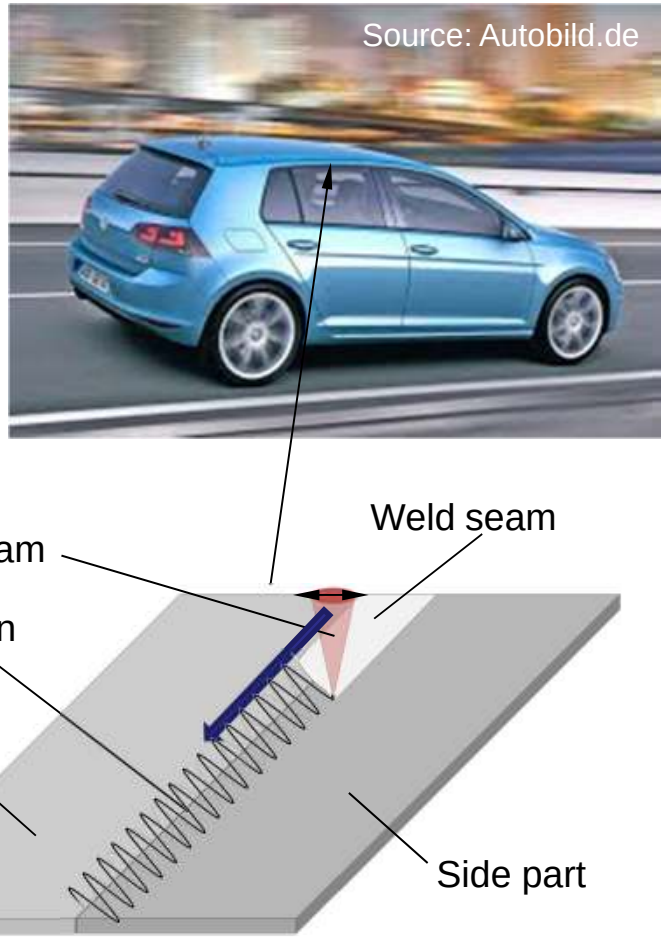
- **Multi-material lightweight design**
  - Joining thermoplastics with metals or fiber-reinforced plastics
  - Transmission and heat-conduction joining possible

Fracture behavior



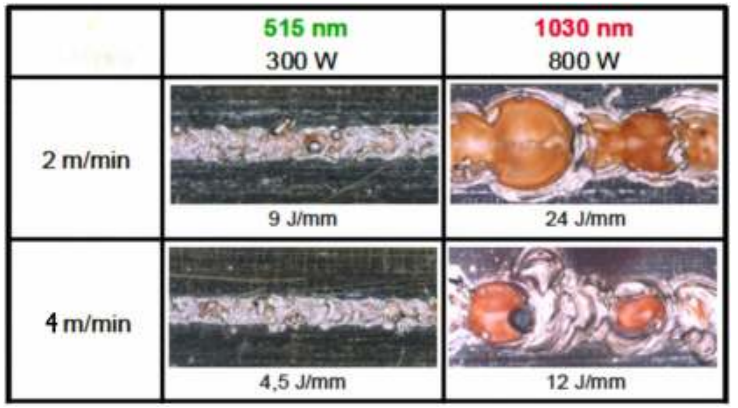
New welding strategies

- **Advantages of beam oscillation**
  - Brilliant laser sources and fast scanners enable beam oscillation
  - Improved gap bridging
  - Low heat input
  - Higher weld seam width
    - ► Enhanced strength
- **Golf 7: Roof weld seams are welded with beam oscillation**
  - Linear welding direction with superimposed oscillation
  - Beam is oscillated at a high frequency

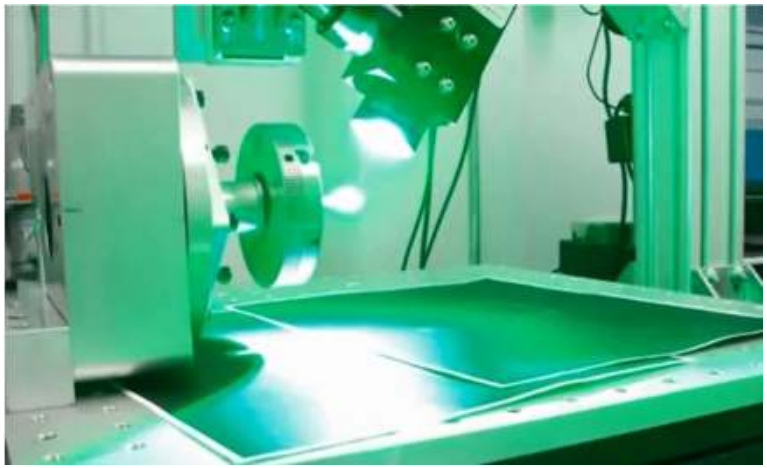


Energy efficiency: beam sources

- **Copper welding with green lasers**
  - Higher absorption of green laser radiation compared to infrared radiation in metals at room temperature
  - Reproducible copper welds with lower laser power
  - Combination of green and infrared radiation: Initial heating and melting with green, welding with infrared
- **Generating green laser radiation**
  - Wall-plug efficiency of green laser sources is lower
  - Cw-laser power so far in sub-Kilo-watt range available



Source: Ramsayer (Bosch)



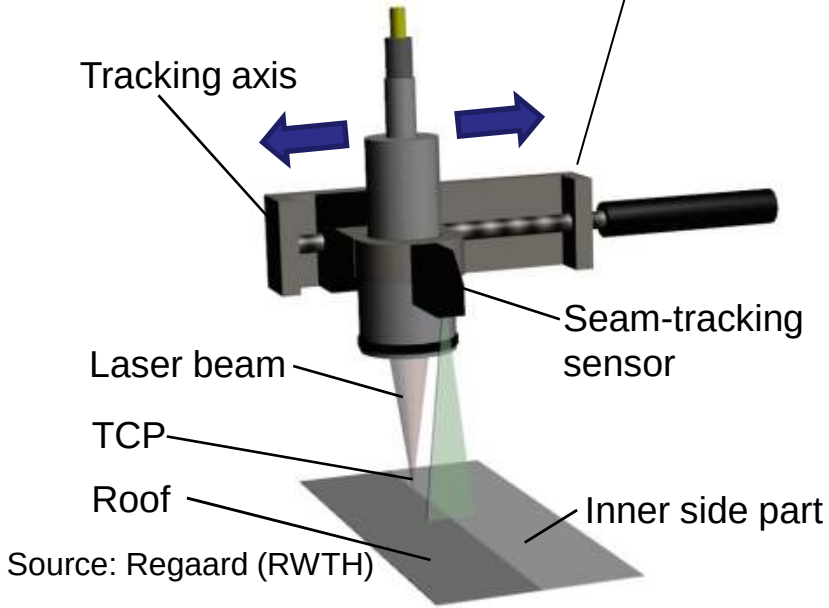
Source: AmadaMiyachi Europe

Process efficiency: welding on the fly

- **Efficiency by automation**
  - Solid state lasers enable the use of fiber-guided systems
  - Use of 6-axis industrial robots in combination with remote scanners

- **Seam tracking systems**
  - Higher production tolerances
  - Smaller flanges possible
  - Less rework necessary

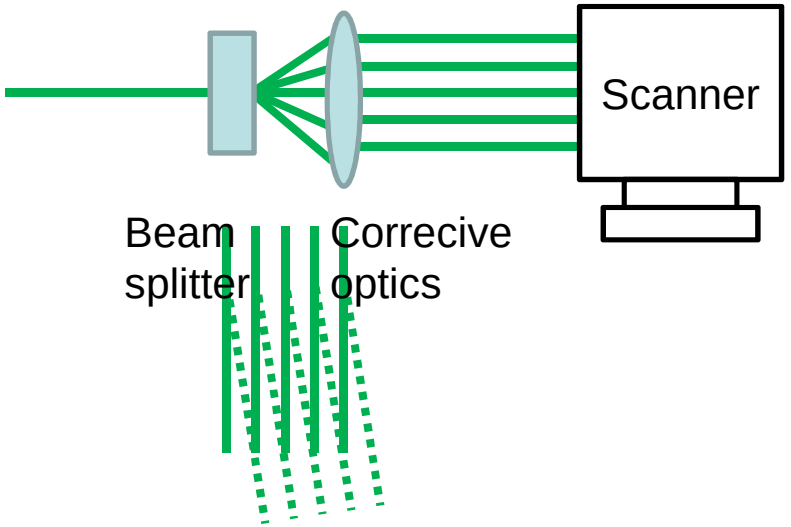
    ► Reduction of production costs

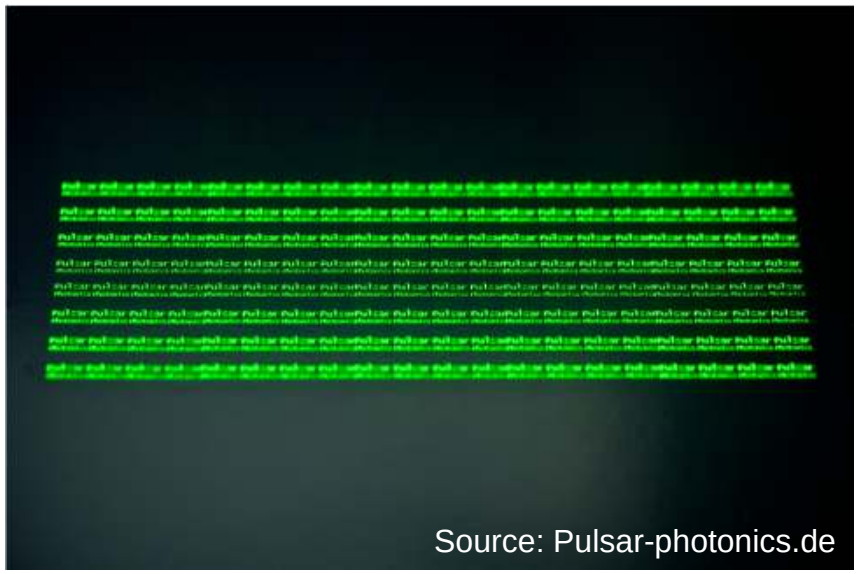


Source: Regaard (RWTH)

Process efficiency: parallelization

- **Multi spot scanning**
  - Splitting the beam to achieve numerous parallel sub-beams
  - Use of special optical element to split beam
  - Fixed number of sub-beams, depending on splitting element
  - enable the use of fiber-guided systems
  - Optical setup designed for
    - Aberration correcture
    - Parallelization
- **Arbitrary beam splitter**

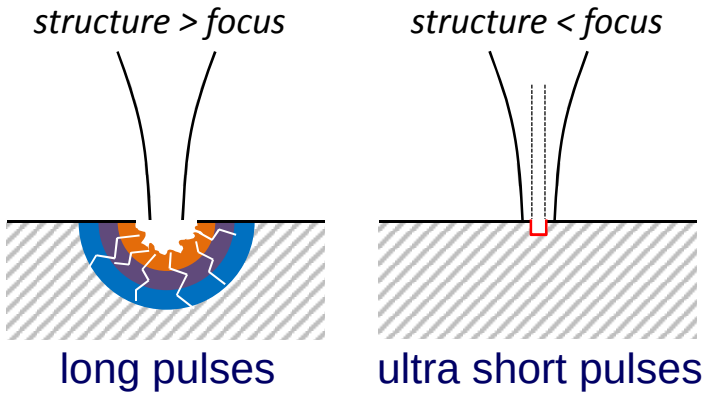



Source: Pulsar-photonics.de

Precision manufacturing: ultra short pulsed laser (USP)

Definition by non-linear absorption

- Extremly high intensity of focused beam enables non-linear effects (e.g. non-linear absorption)
- Quasi instantaneous transition between original phase and plasma
- Plasma expansion „removes“ heat from material



long pulses ultra short pulses

Advantages of ultra short pulses

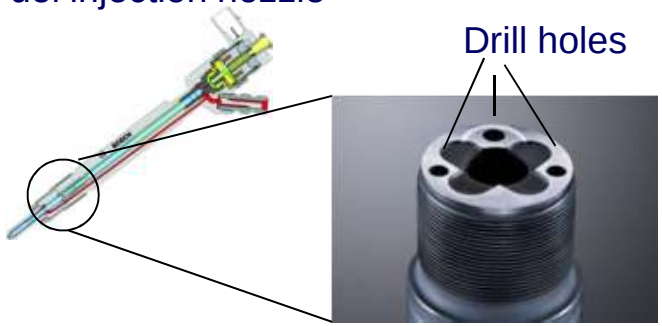
- No melting or thermal damage
- Very small structure sizes, highly precise processing
- Processing of:
  - temperature sensitive materials (e.g. brittle materials, organics)
  - transparent or reflective materials (e.g. glass, polished metals)
  - dissimilar material mixes

USP laser in production

Micro processing of metals

- Industrial use of lasers since years
- Requirements:
  - Smaller feature sizes at higher accuracy
  - Short processing times and high throughput

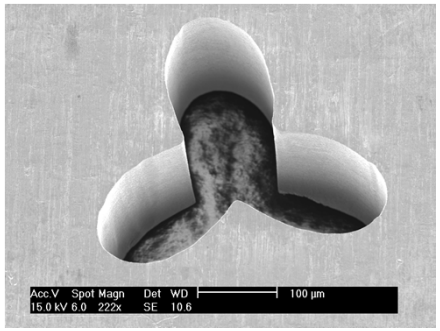
Fuel injection nozzle

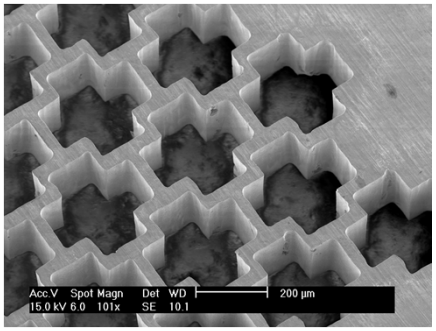


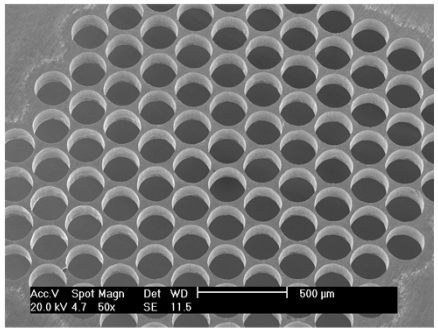
Source: Bosch

Application: Laser beam drilling

- Robustness and stability of structure quality → reproducable ablation at high precision
- Moving beam → arbitrarily shaped micro holes and hole arrays





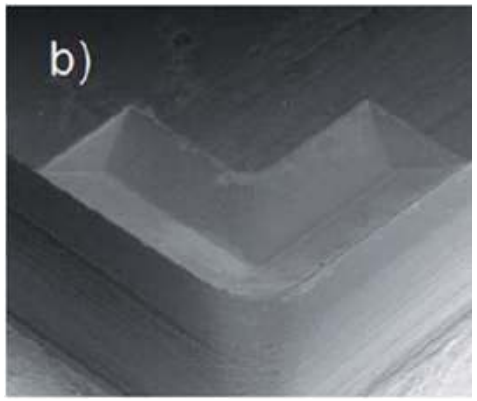


USP laser in production

Application: Structuring metal forming tools

- Lubricant supply during cold and hot forging of nonferrous metals such as valves
- Challenge: Avoidance of structural changes and melt formation esp. burr
- Small stuctures at high processing speed

Source: Diamond business



Chip breaker

Application: Ablation of ultra hard materials

- Processing of high performance cutting tools
- Coated tools with ultra-hard material lead to longer life-time and higher precision in mechanical tooling
- Conventional processing (electrical discharge machining or grinding) not suited for ultra-hard mat.

Additive Manufacturing - Prediction

Development of sales (worldwide)

"Additive manufacturing technologies create a world of possibilities that can take an organization in an entirely new direction and help launch new businesses and business models."

Source: Terry Wohlers, 2012

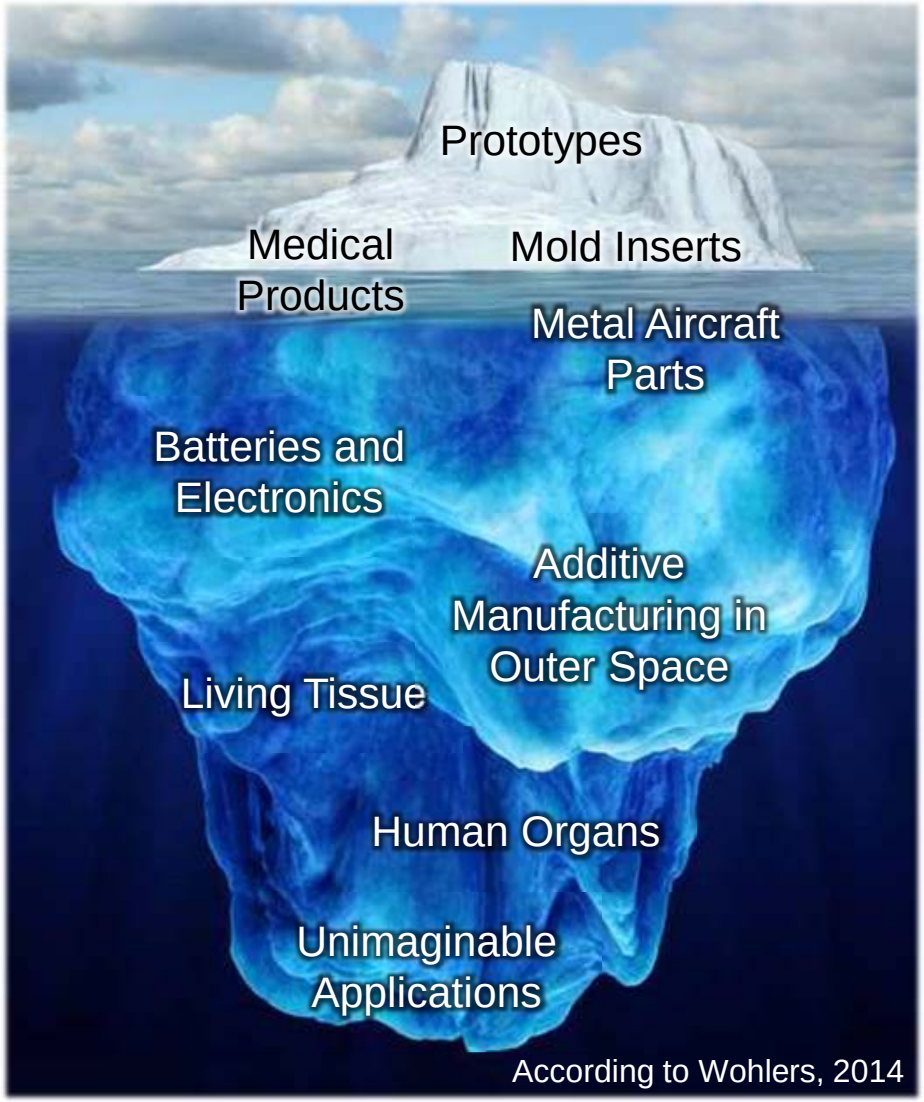
Additive Manufacturing of Metal Components

Gear Wheel (1.2709, 1.4542)

Source: Rapidobject

Dental Prostheses (Cobalt-Chromium)

Source: EOS



According to Wohlers, 2014

Mold Insert (1.2709)

Source: Jell

LEAP engine fuel nozzle

Source: GE Aviation

Laser Beam Melting of Metals in Powder Bed

Industrially used since 1999

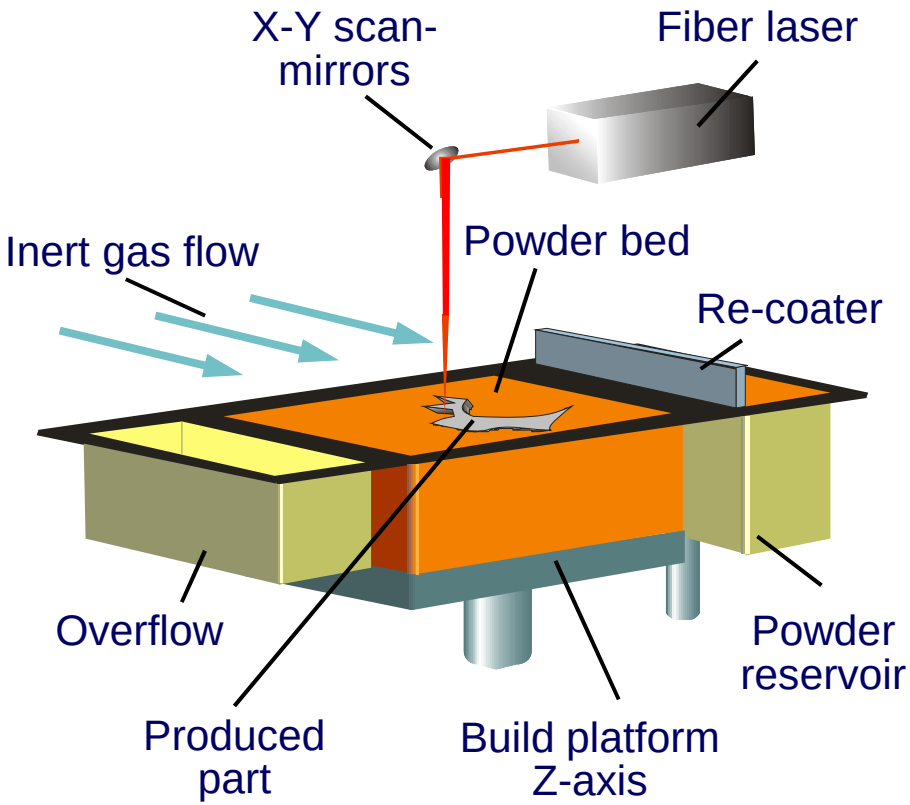
- Individualized products
- Complex geometry

Layer-by-Layer Manufacturing Technology

- Selective melting of micro-sized metal powder
- Fully dense 3D metal structures
- Mechanical characteristics similar to conventional fabrication

Challenges

- Material availability
- Process stability



Future in laser based Additive Manufacturing

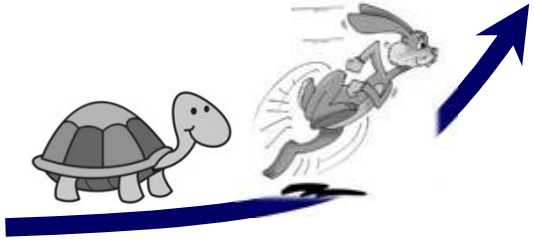
Material

- In situ alloying
- New and modified powder systems
- Combining materials

Process

- Combination of additive, subtractive and formative manufacturing technologies
- Process monitoring and control
- Increase in productivity, accuracy and reproducibility

Productivity



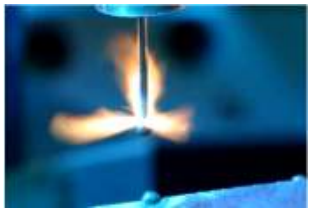
Serially produced turbine blades

Source: Morris Technologies

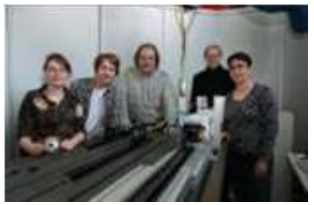
► Use of Additive Manufacturing technologies in serial production

Success of blz

Synergy from Inter-disciplinarity



Cutting-edge from Knowledge

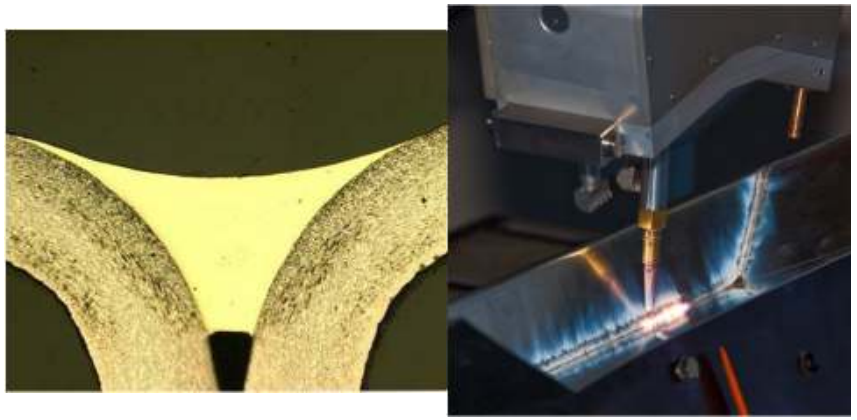


Success from Flexibility

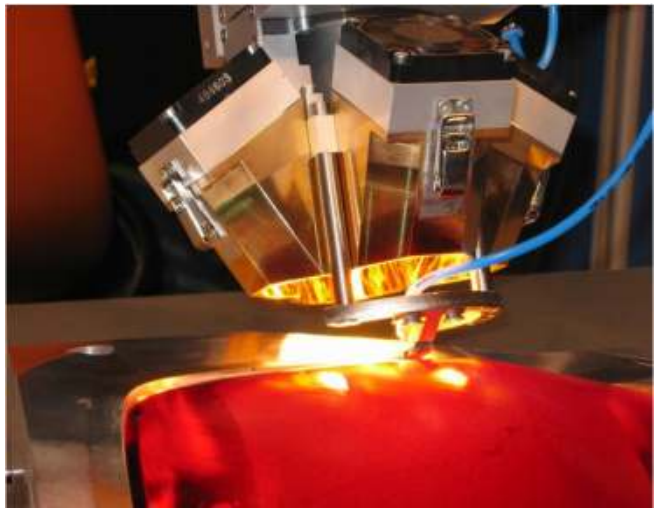
Progress from Experience

Technology transfer by blz: laser joining

- **Laser beam brazing of bodywork components**
  - Even seam surfaces (Class A)
  - Flux free brazing
  - Process velocities up to 5 m/min
  - Use of cheap copper filler materials



- **Laser hybrid welding**
  - Combination of IR and laser radiation
  - Short processing times and high process stability
  - Flexible seam geometries
  - Hermetically sealed seam
  - Reduced stress within larger components



Thank you
for your attention!

Contact

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