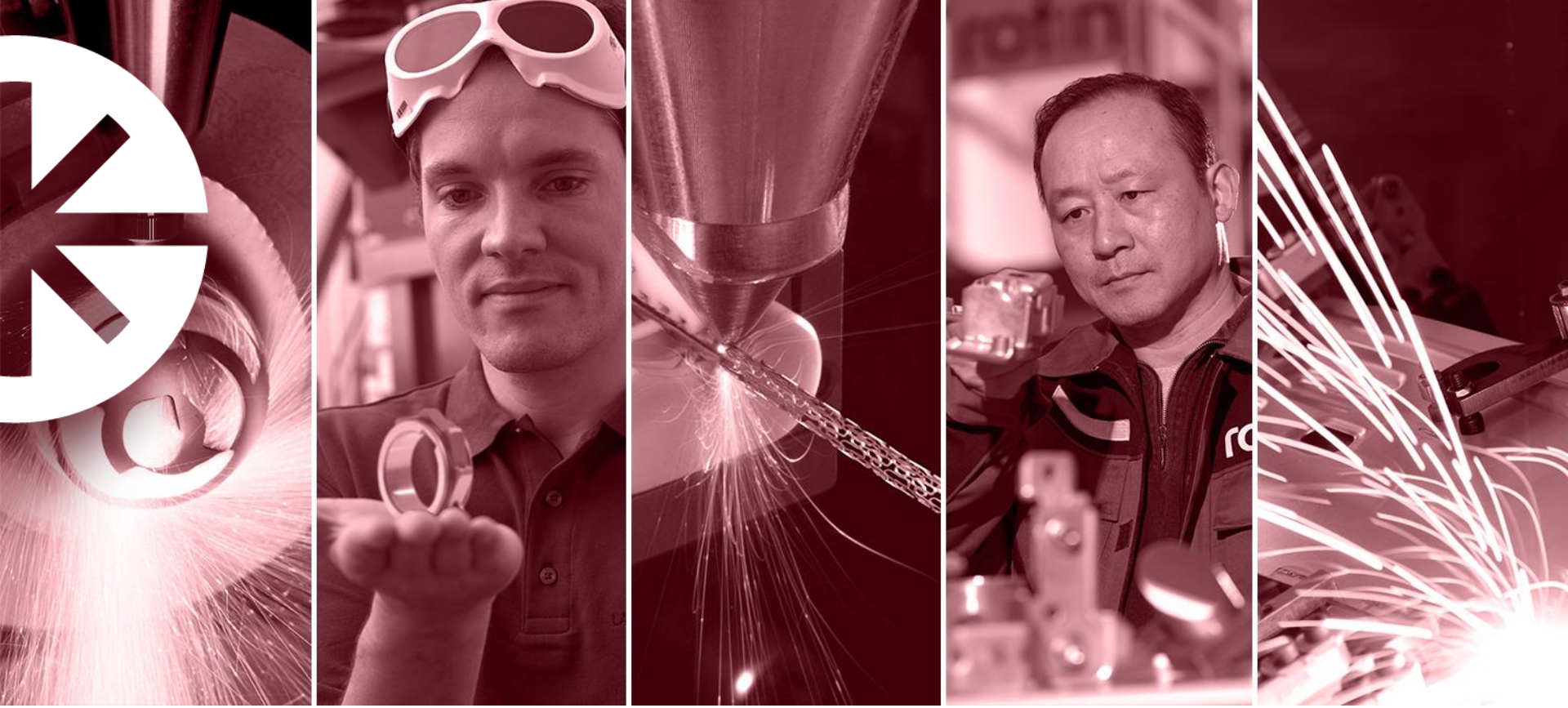


LASER SEMINAR ISRAEL 2017

HP lasers: CO2 vs Fiber High Power Lasers

2017-11

COHERENT | rofin

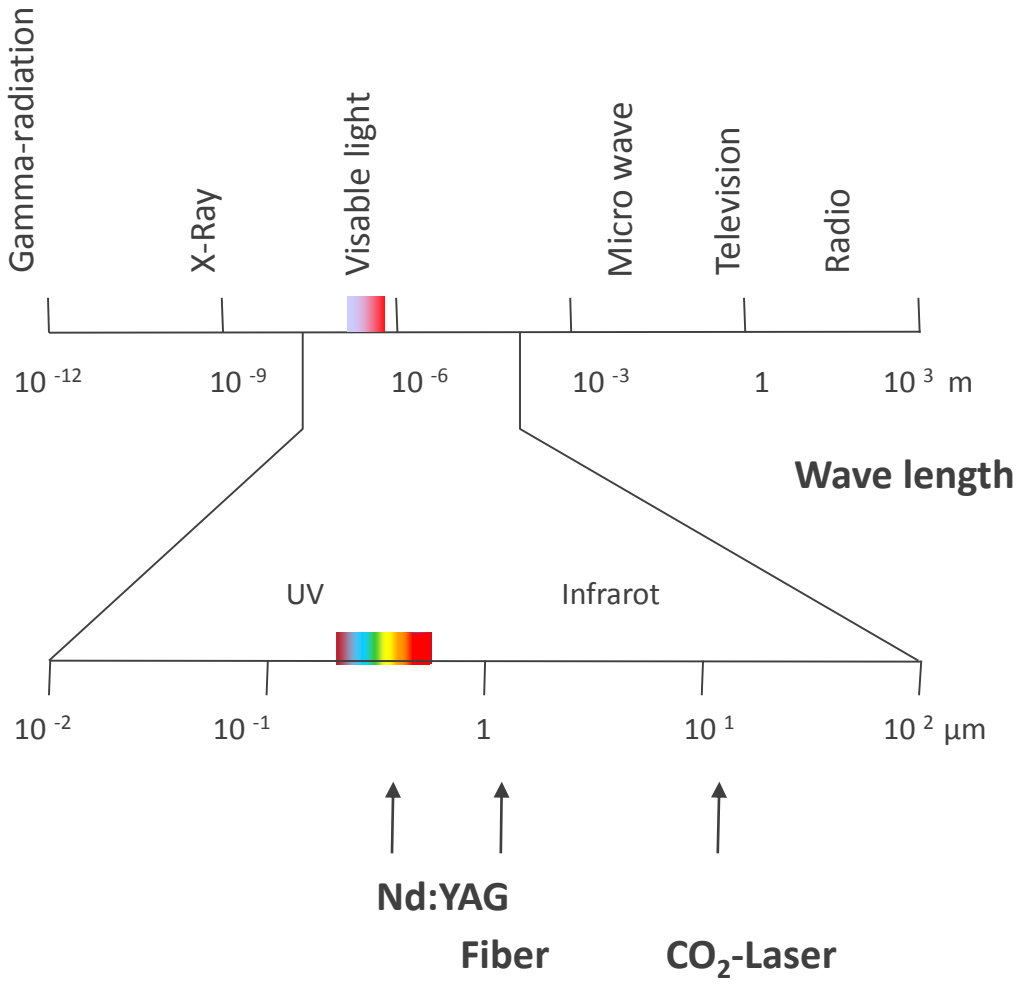
COHERENT | ROFIN

HAMBURG HIGH POWER PRODUCTS: COMPANY PROFILE

- Origin of the ROFIN group
- Founded 1975
- Development, production and sales of high-power laser beam sources for industrial materials processing
  - High-power CO_2 lasers
  - Solid-state lasers
  - Fiber lasers
- Employees: 256 + 20 Temporary Staff
- Engineers / high school deg.: ~ 36 %
- Sales*: US-$ 95 Mio. in FY 2016

* with external and intercompany sales / as per 09/30

SPECTRUM OF THE ELECTROMAGNETIC WAVES



- Rod, disc, fiber lasers:
  - 1030 – 1080nm
  - SHG 532nm
  - THG 355nm
- Diode lasers:
  - 800 – 900nm
- CO2 lasers:
  - 9,2 – 10,6µm

COHERENT | ROFIN

High Power Product Portfolio

CO_2 SLAB LASERS

Diffusion-cooled CO_2 lasers
1,000 – 8,000 W

FIBER LASERS

Fiber lasers
compact version
up to 6.000 W

Fiber lasers
up to 10.000 W

DIODE LASERS

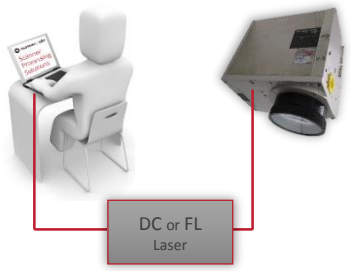
Diode lasers
up to 6.000 W

PULSED LASERS

Pulsed fiber laser
1.000 W

LASER SUB-SYSTEMS // RAILS

Profile Welding System
(PWS)
for CO_2 and fiber laser



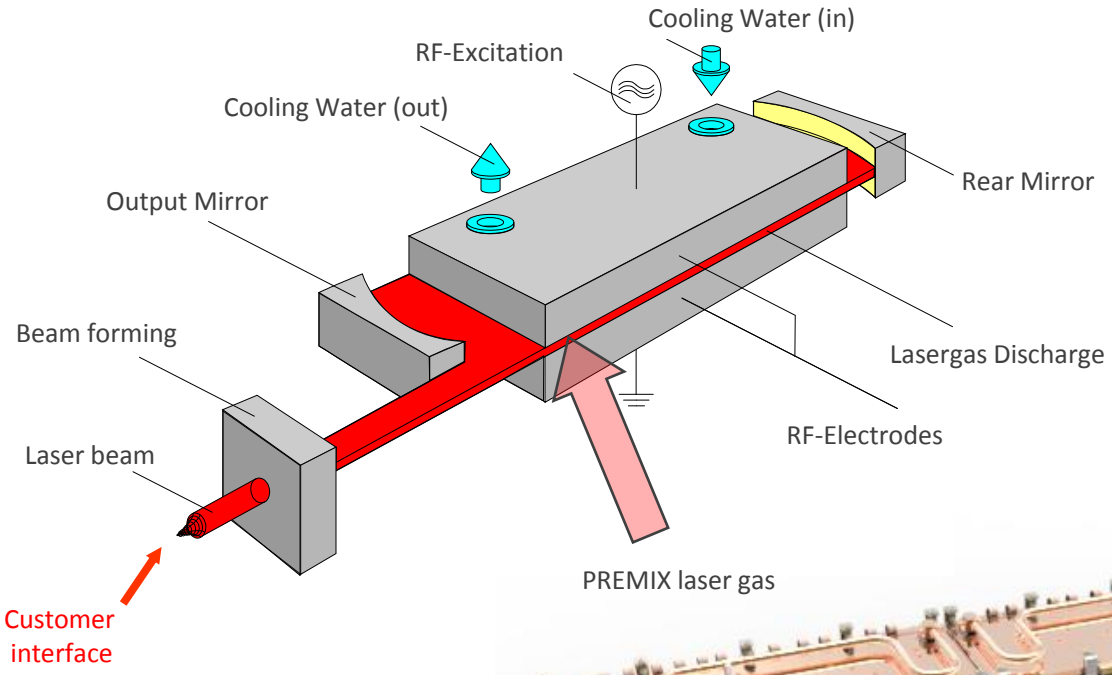
Scanner Processing
Solutions (SPS)
for CO_2 and fiber laser

LASER PROPERTIES

	Fiber Laser	CO_2 Laser
Power	0.5 kW – 8 kW	1 kW – 8 kW
Wavelength	1,07 µm	10.6 µm
Beam quality	0.4 mm*mrad – 45 mm*mrad	3,5 mm*mrad / 7,5 mm*mrad
Beam delivery	fiber	mirrors
Fiber size/beam size	20 µm – 1000 µm	35 mm – 50 mm
Typical focus	30 µm – 2 mm	200 µm – 400 µm

CO2 SLAB LASER PRINCIPLE

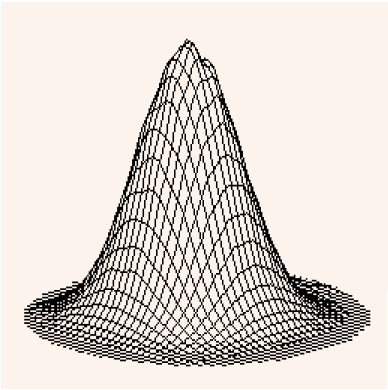
Resonator



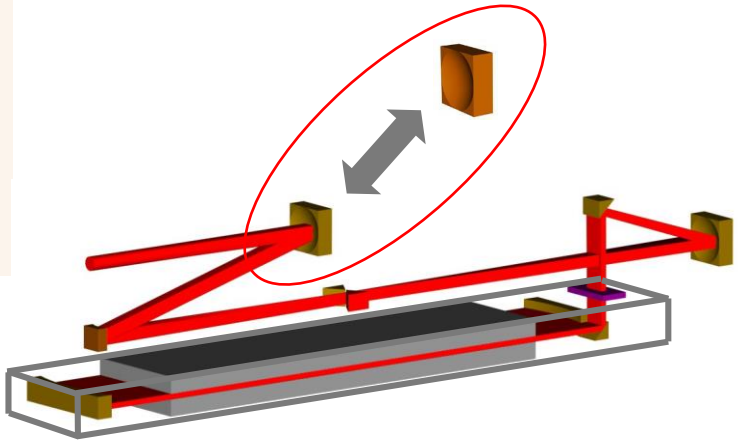
OPTIONS CO2 SLAB LASER

Donut Mode (internal)

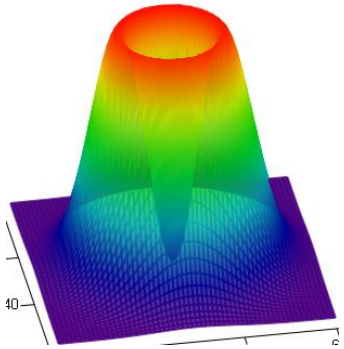
from Standard Mode…



…by changing
the last mirror...



…to Donut Mode



CO2 SLAB LASER PRINCIPLE

Laser head (resonator side)

=> Supplied by authorized gas-suppliers

BENEFITS CO2 SLAB LASER

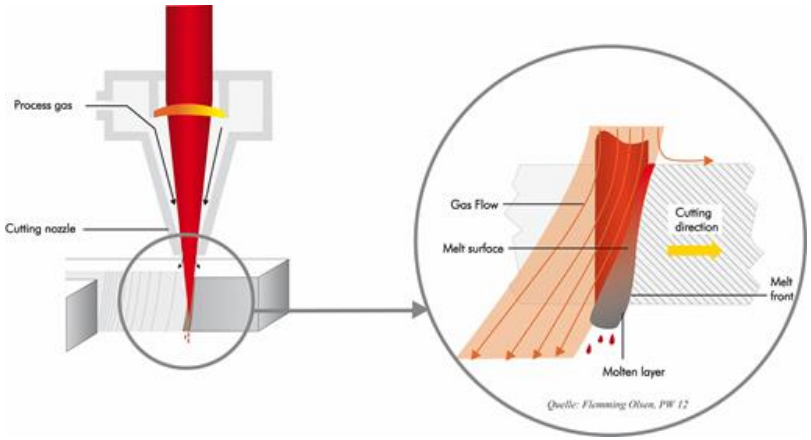
The advantages of Slab Lasers for Cutting and Welding

For cutting applications

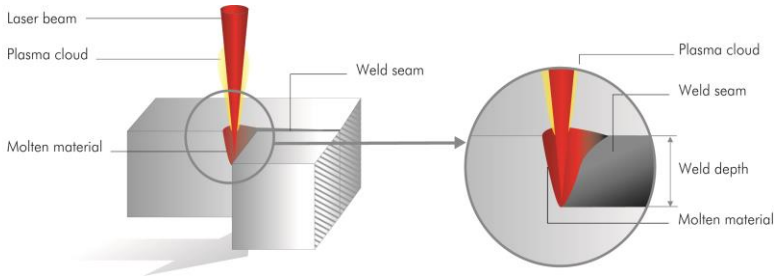
- High beam quality results in greater speed at a given power
- Highest efficiency due to excellent beam quality
- Minimum beam size variation with flying optics

For welding applications

- Distortion free welding thanks to a low heat input into the component
- High welding speeds for shortest processing times
- Easily automated due to industrial interface and RCU
- Highest process efficiency
- Excellent focus ability for fast or deep welding
- Long focal lengths for large working distances
- High power up to 8,000 Watts available
- Donut-mode for welding components with large tolerances



Deep penetration welding



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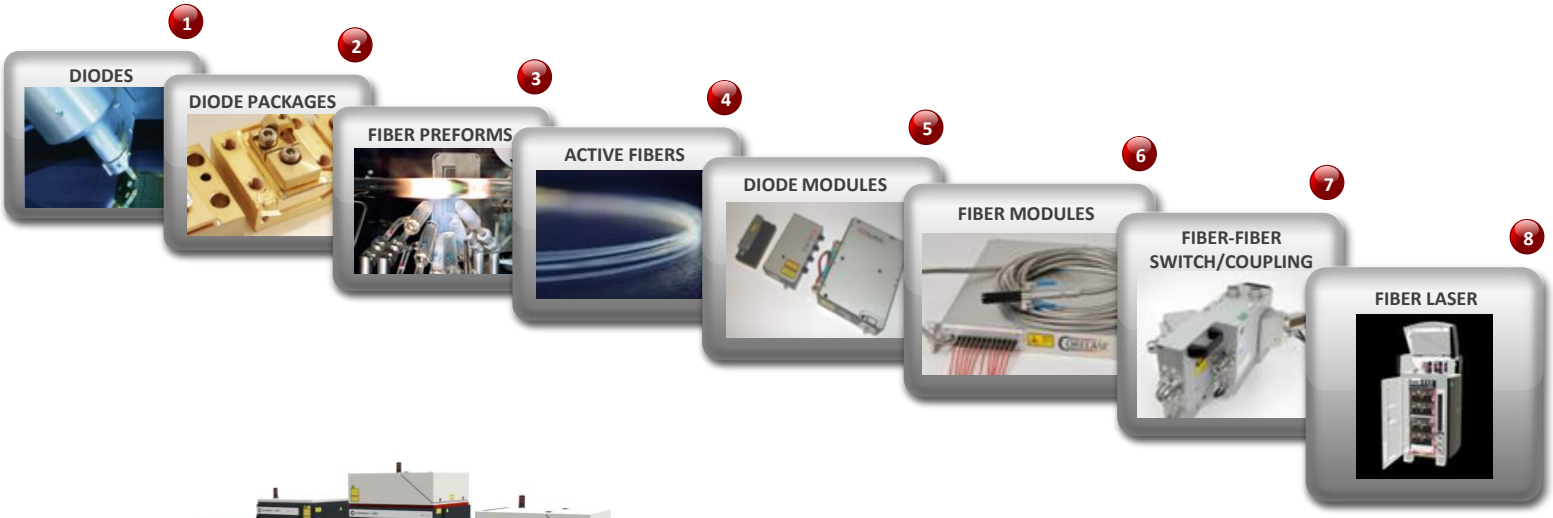
VERTICALLY INTEGRATED FIBER LASER PRODUCTION



FIBER LASER UP TO 10 KW

COHERENT|ROFIN FIBER LASER (STANDARD)

FFC / FFS: adaption of all diameters ≥ 50 µm

FFC (**F**iber to **F**iber **C**oupling device)

- Easiest way to have proper process fiber exchange option
- QBH/QD connector

FFS (**F**iber to **F**iber **S**witching device)

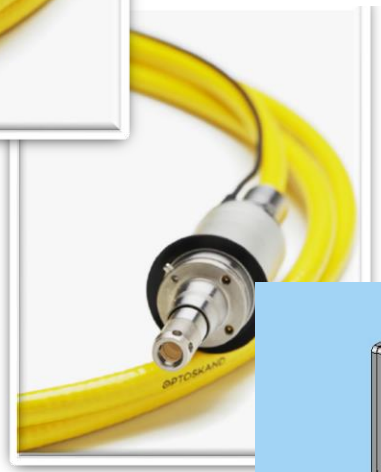
- Safety certified
- up to 4 fiber outputs
- energy sharing with various sharing ratios
- QBH/QD connector

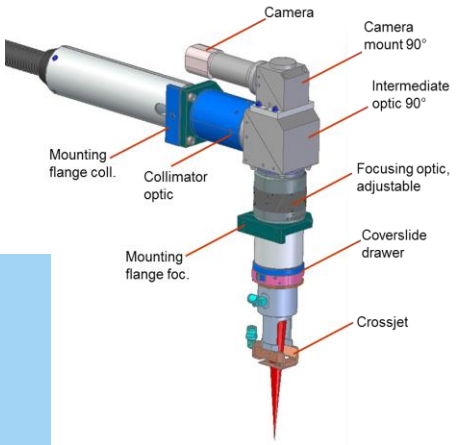
DIMENSION OF THE CORE FIBER

Round fiber

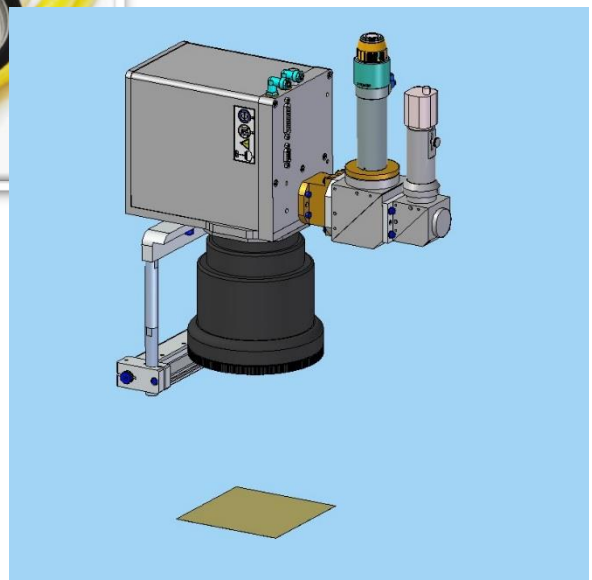
20µm 50µm 100µm 200µm 300µm 400µm 600µm 800µm 1000µm

Square fiber 600x600µm 800x800µm





cutting / welding head



Galvo head

HIGH POWER LASER TOOLS

Universal Workstation Robot

Applications and Fields of use:

- Welding & Ablation processes
  - Metals & Polymers

Universal Workstation 1200 5-axis

Universal Workstation1600 Robot

Applications and Fields of use:

- Welding, Cutting & Drilling

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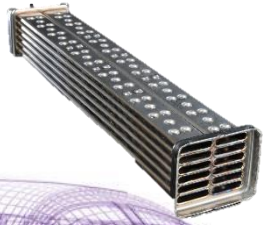
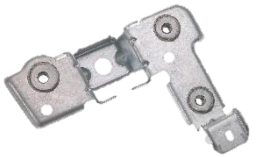
MACRO LASER APPLICATIONS
AUTOMOTIVE INDUSTRY

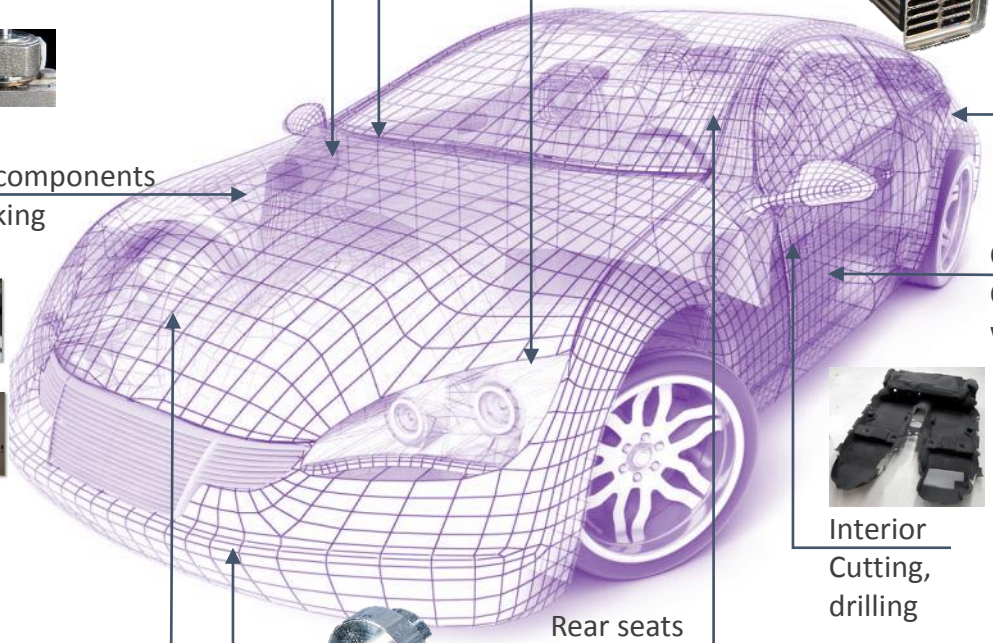
Airbags
Cutting, welding & marking

Exhaust components
Welding





Various filters, sensors
Welding



Car body
Cutting, welding & brazing

Transmission components
Welding, marking

Car doors
Cutting & welding

Interior
Cutting, drilling

Rear seats
Welding

Injection nozzles
Welding, drilling & marking

Air conditioning
Tube – Flange Welding

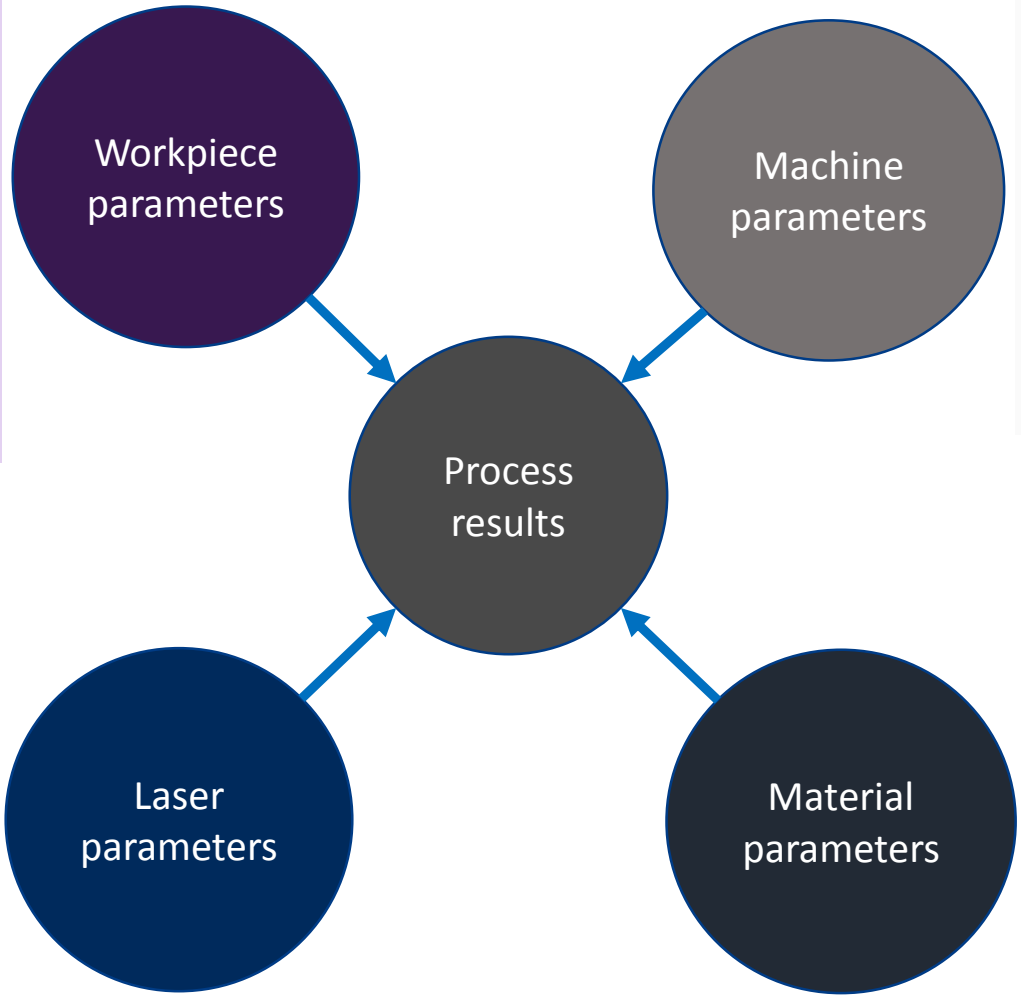
Electrical mobility
Electronic components
Welding

LASER APPLICATIONS
AUTOMOTIVE PRODUCTION

- Light weight constructions
  - High strength steels
  - Aluminum
  - Adapted designs
- Electrification
  - Batteries
  - Electrical engines
- Increased customer demands
  - Design
  - Comfort

LASER APPLICATIONS
PARAMETERS INFLUENCING THE PROCESS RESULT

- seam geometry
- surface properties
- seam preparation
- coating
- thickness
- position



- beam delivery
- optics
- process gas
- speed
- nozzle diameter
- angle of incidence

- pulse duration
- pulse frequency
- pulse energy
- CW laser power
- beam quality
- wave length

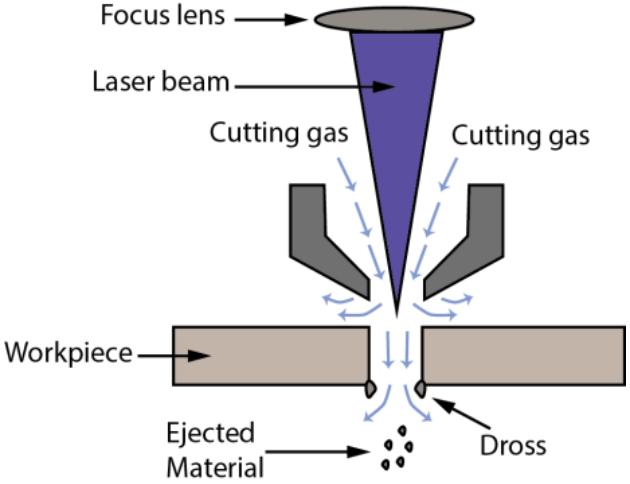
- structure
- specific weight
- heat capacity
- heat conductivity
- beam absorption

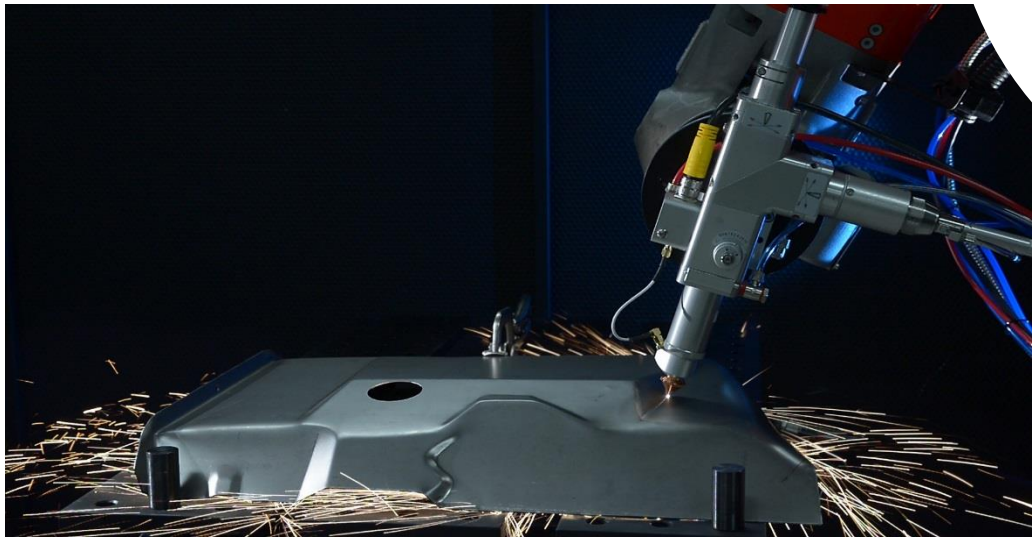
CUTTING

PROCESS PRINCIPLES

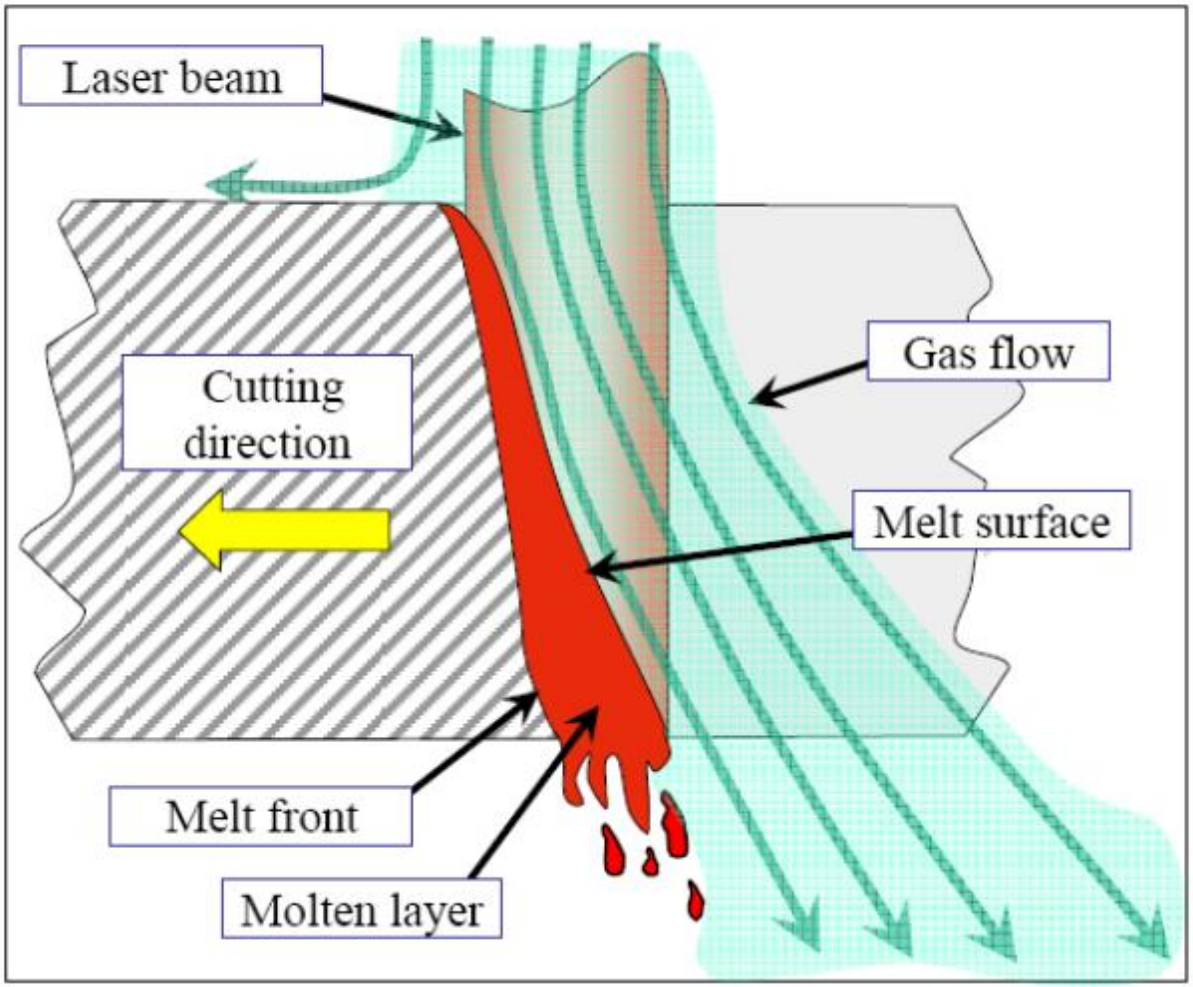
The melt assisted by shearing action of a coaxial stream of inert or active gas assist results in the formation of a molten channel through the material called a kerf (slot)

The process is either called “fusion cutting” or “reactive fusion cutting” depending on the type of assist gas used





Process principles



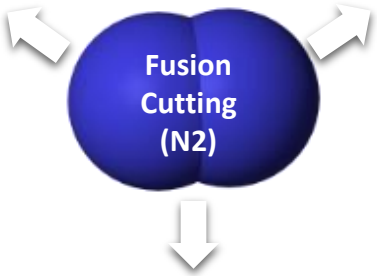
Energy transfer:
to melt surface Though the molten layer to the melt front

Melt ejection by:
Cutting gas jet
Evaporation pressure

PROCESS MECHANISM – FUSION CUTTING

Brass

Aluminum



Stainless

- Fusion cutting or melt and blow
  - Cutting with an inert assist gas (Nitrogen, Argon, Helium)
  - Metal melts and is physically removed with the gas
  - Gas does not react with the metal
  - Material cut with inert gas: Stainless Steel, Brass and Aluminum
  - Recommended pressure range: 10-25 bar
- In almost all cases -> the more gas you can push through the kerf, the better the edge quality. High gas pressure also helps minimize the amount of dross.

Laser fusion cutting materials

- stainless steel
- mild steel
- galvanized or zinc coated mild steel
- aluminium
- brass
- Titanium (Ar)
- Inconel

PROCESS MECHANISM – REACTIVE FUSION CUTTING

Oxygen cutting (exothermic reaction) or reactive fusion cutting

Cutting with a reactive assist gas (Oxygen, Air)

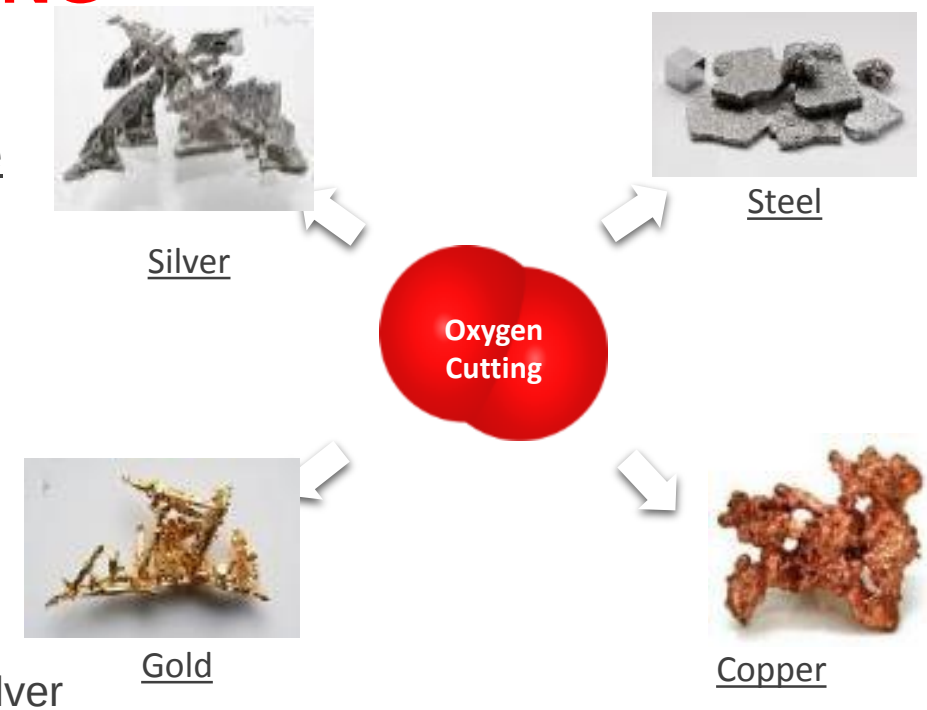
Metal melts and reacts with the gas to generate more heat

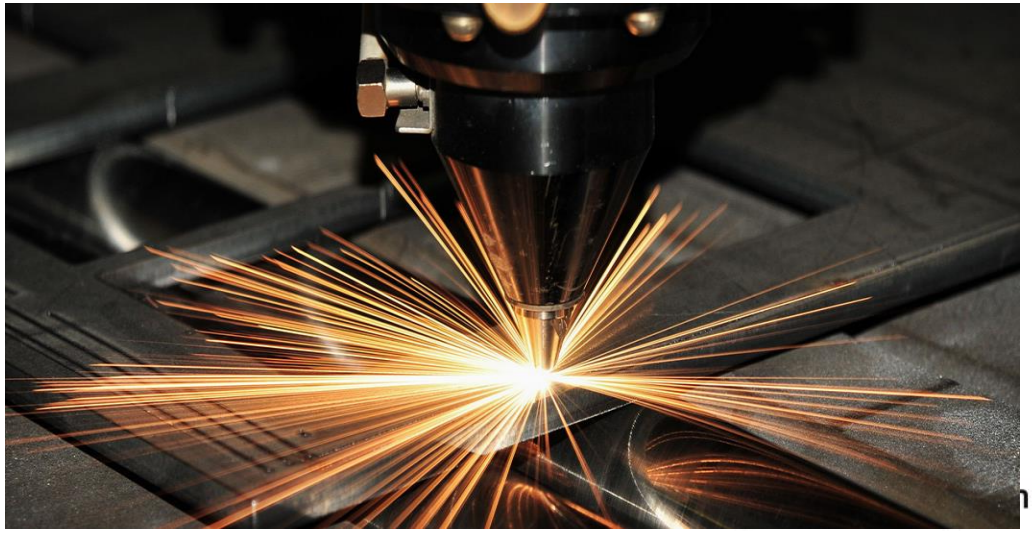
Metal is mechanically removed by the gas

Leaves a brown or black oxide on the cut edge

Material cut with inert gas: Steel, Copper and Silver

Recommended pressure range: 0.5-10 bar





PROCESS MECHANISM – REACTIVE FUSION CUTTING

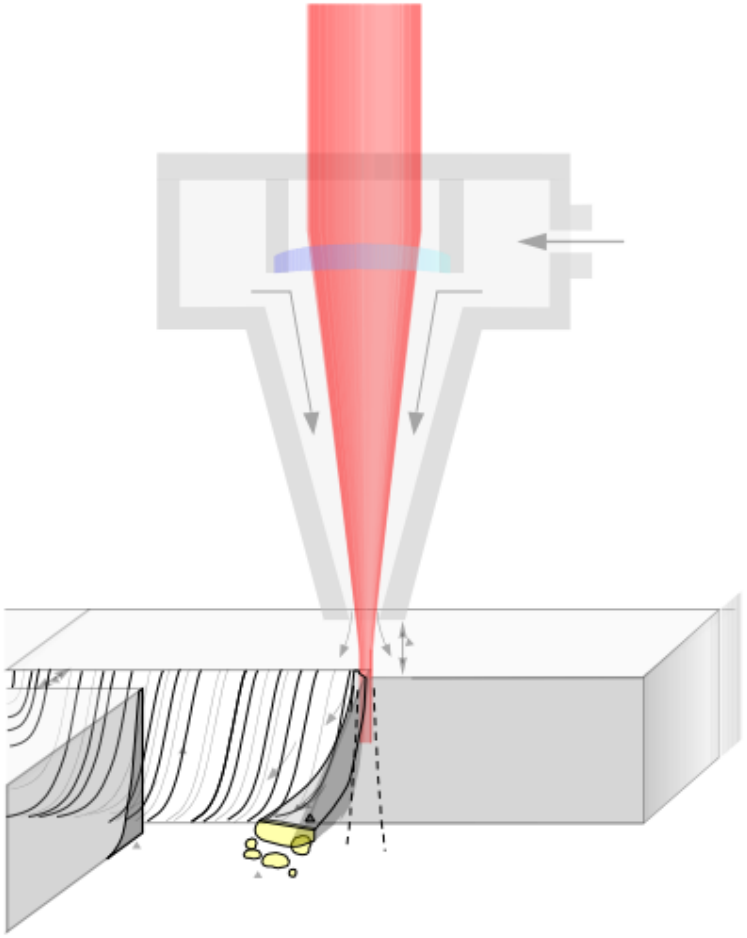
- Mild steel (Lasersteel recommended for thickness > 12 mm)
- Carbon steel
- Domex
- Armox
- Galvanized mild steel

Negative material properties:
Rust, oxidized, sandblasted, shotblasted:
Burrformation, formation of craters
C%<0.1

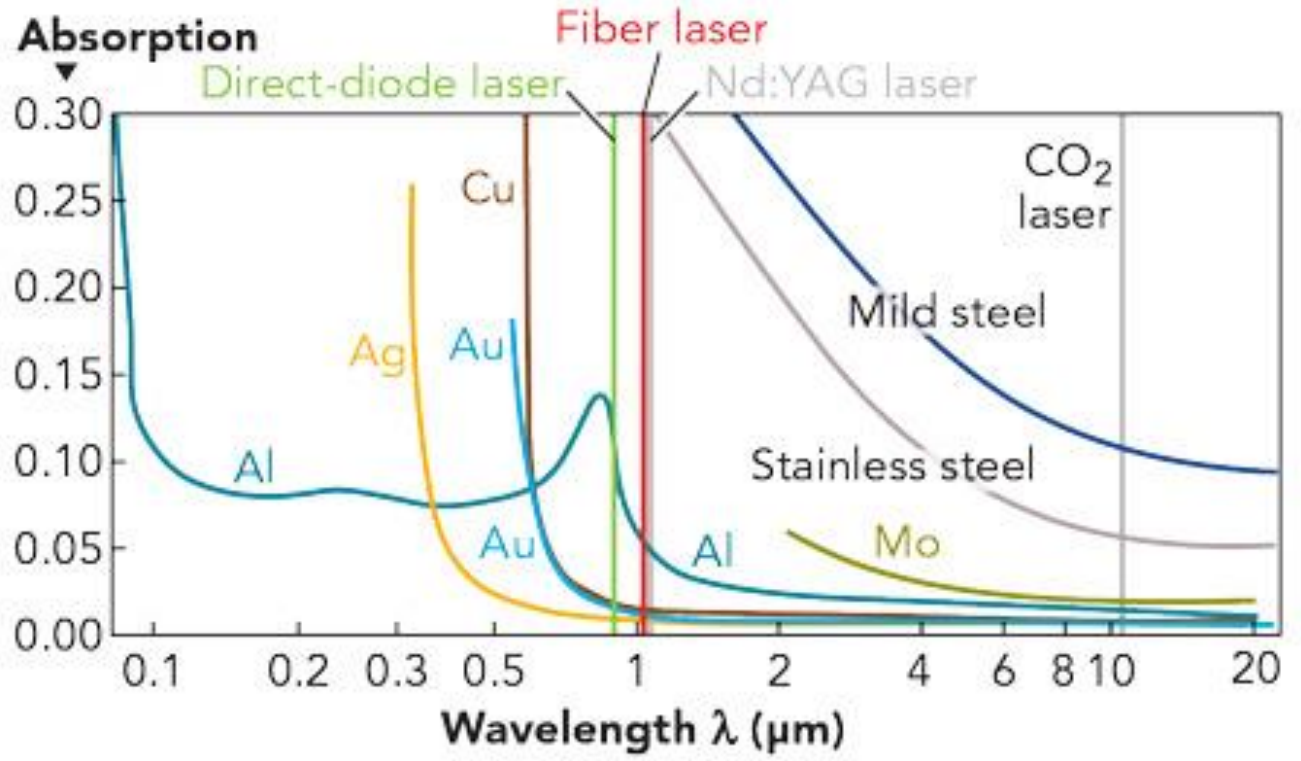
Basics

- Laser cutting mild steel (O_2):
  - results are equivalent for CO_2 and fiber

- Laser cutting stainless (N_2)
  - Fiber laser
    higher efficiency for thin sheets
  - CO2 laser
    higher quality for thickness > 3mm

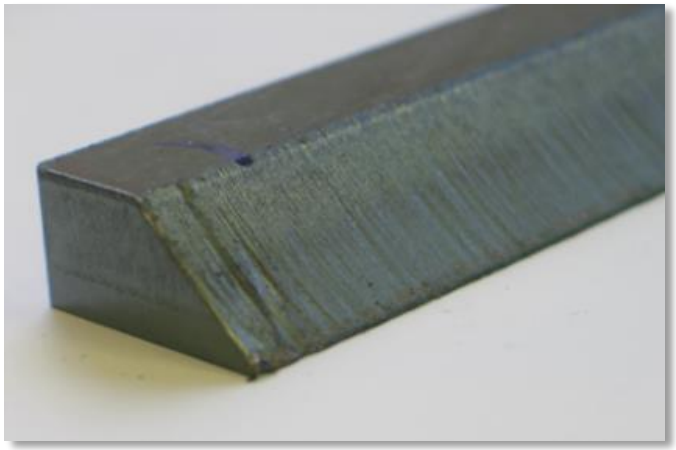


MATERIAL PROPERTY BY WAVELENGTH



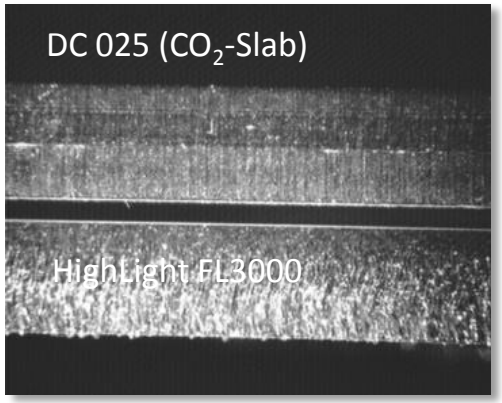
Industrial Laser Solutions – March 2016

LASER CUTTING



Mild steel

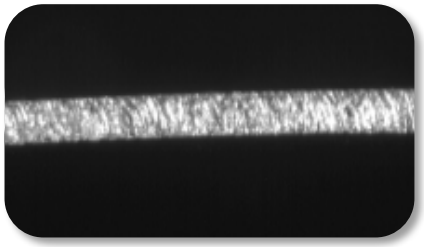
- **O_2**: Speed and quality similar for CO_2 and Fiber laser
- **N_2**: thin material, fiber cuts faster
  thick material, CO_2 cuts better
- **Cu**: Cutting by Fiber Laser only



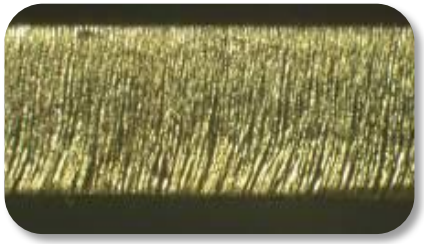
Stainless steel

Copper

HIGHLIGHT FIBER LASER CUTTING BENEFITS

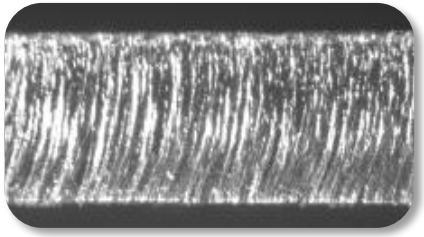


Aluminum @ 500 W
0.1 mm - 350 m/min



Brass @ 2000 W
2 mm - 6 m/min

Copper @ 2000 W
2mm - 1.5 m/min



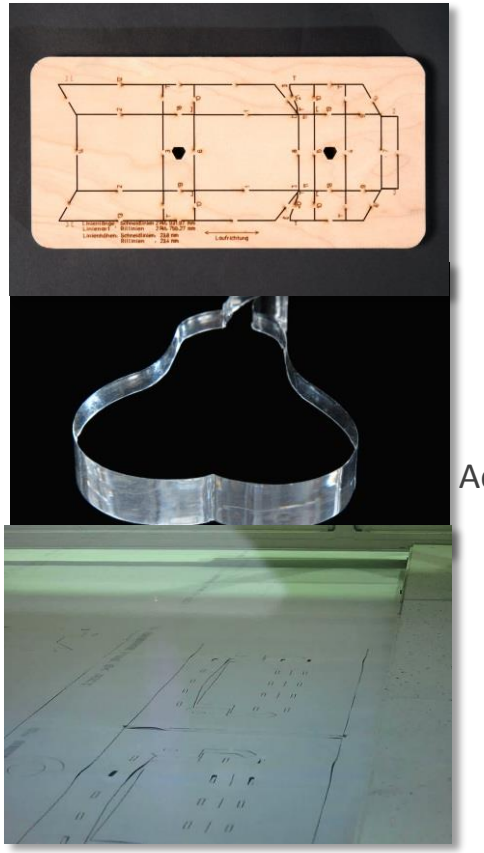
Galvanized steel @ 1000 W
1.5 mm - 15 m/min

APPLICATION EXAMPLES CO2 SLAB LASER

Cutting (Metal & Non-Metal)

Metal

Die Board



Acrylic

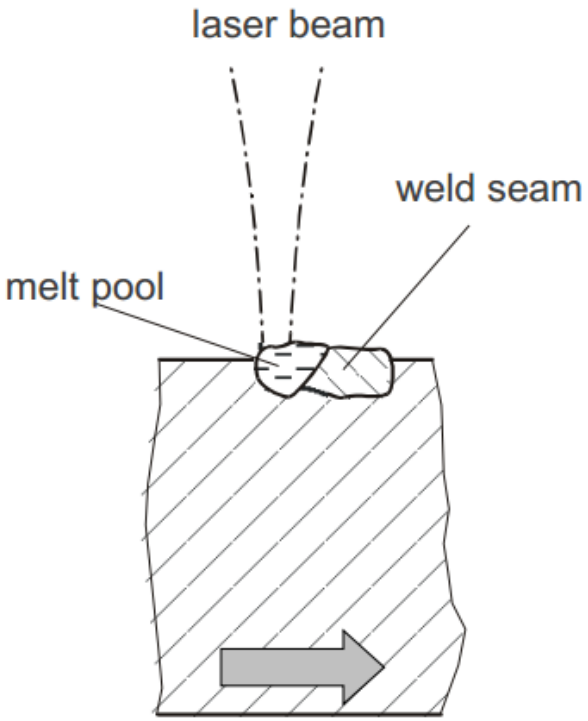
Textile

Packaging

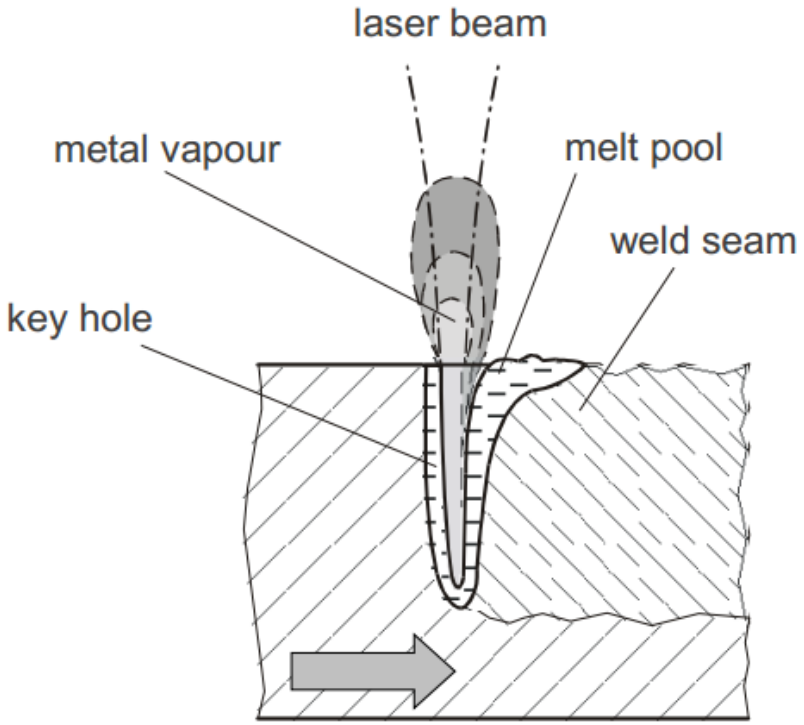
Tableware

WELDING

Welding methods

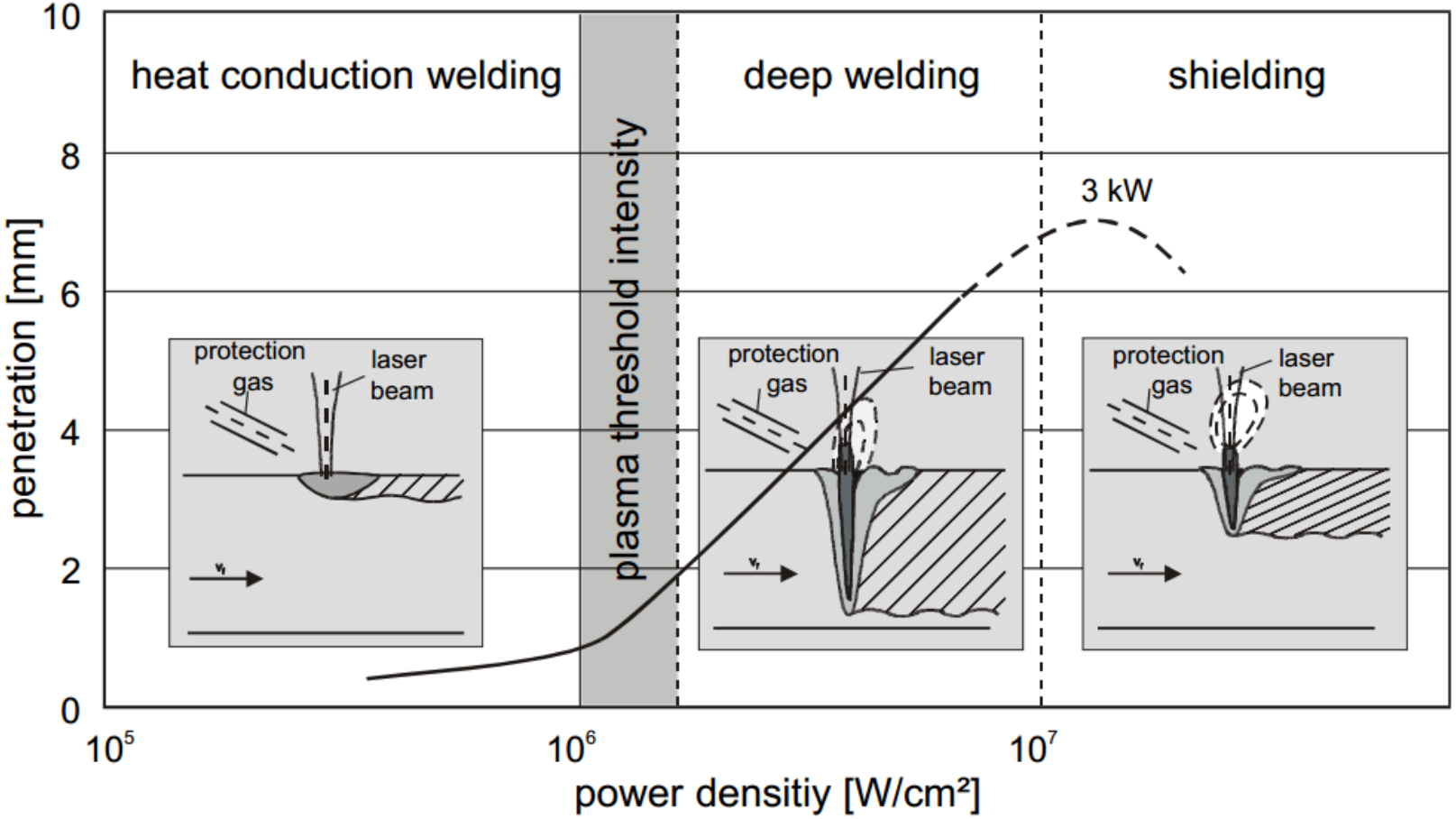


heat conduction welding

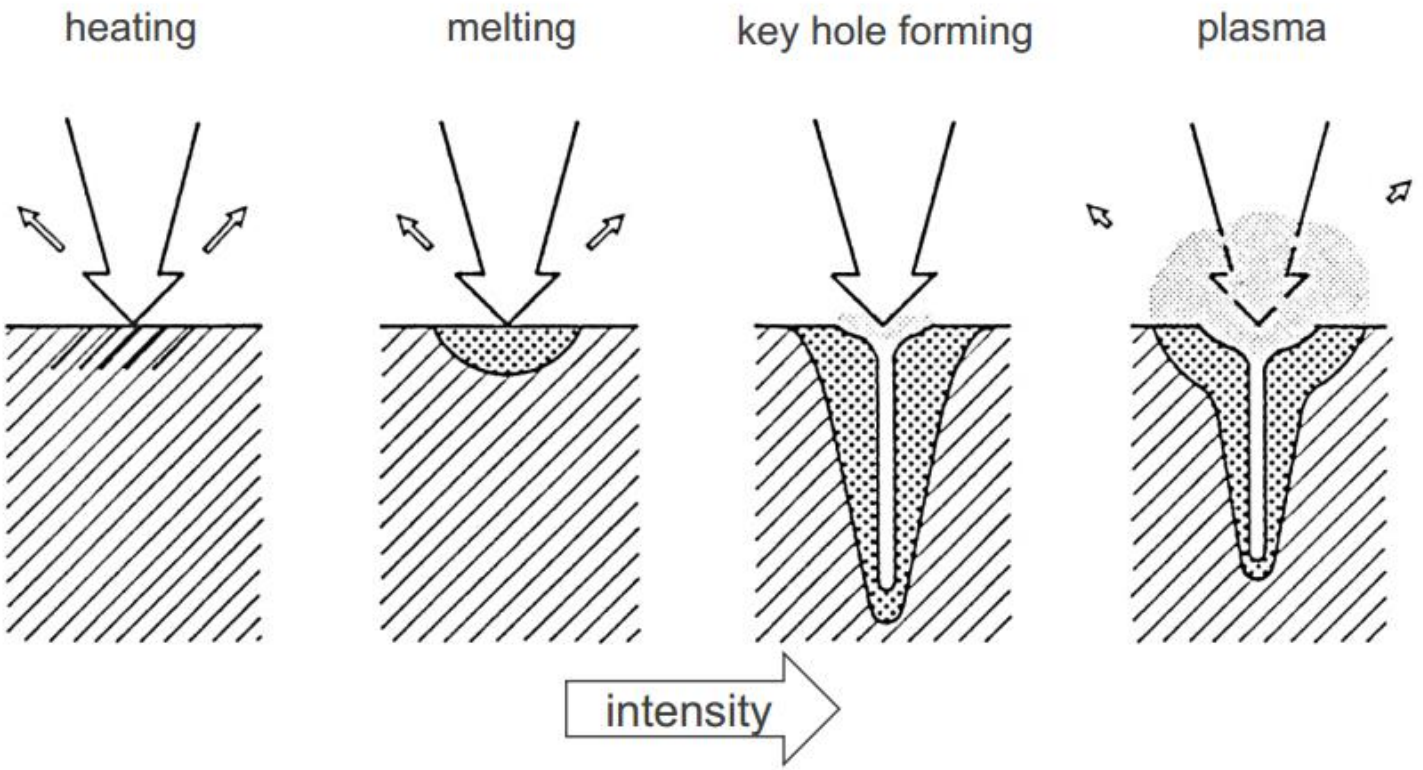


deep welding

Welding methods (CO2 lasers, SSL have lower values)



Key hole welding



Weld seam geometries

d_1

v_1

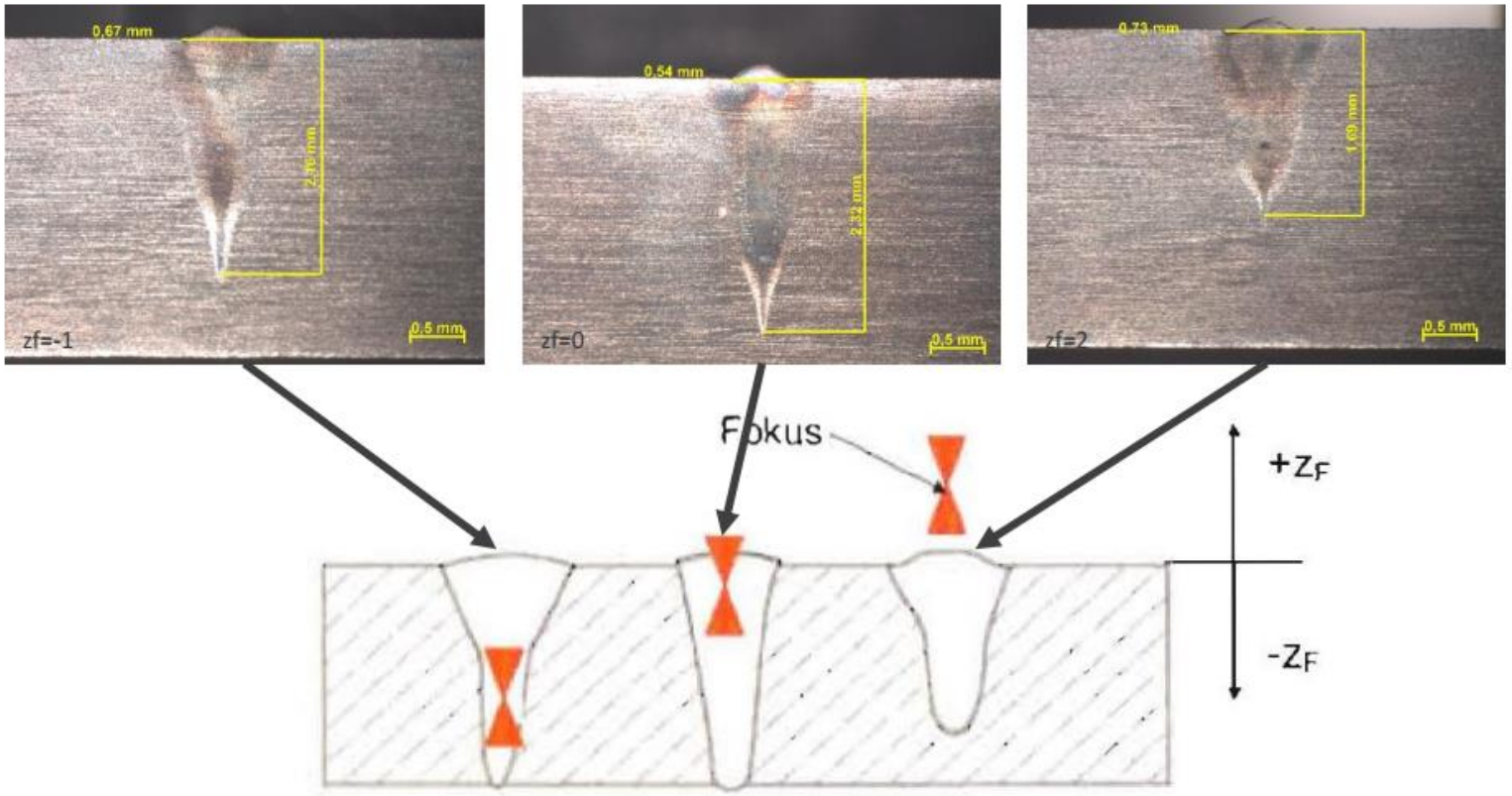
d_1

$v_2 > v_1$

$d_2 < d_1$

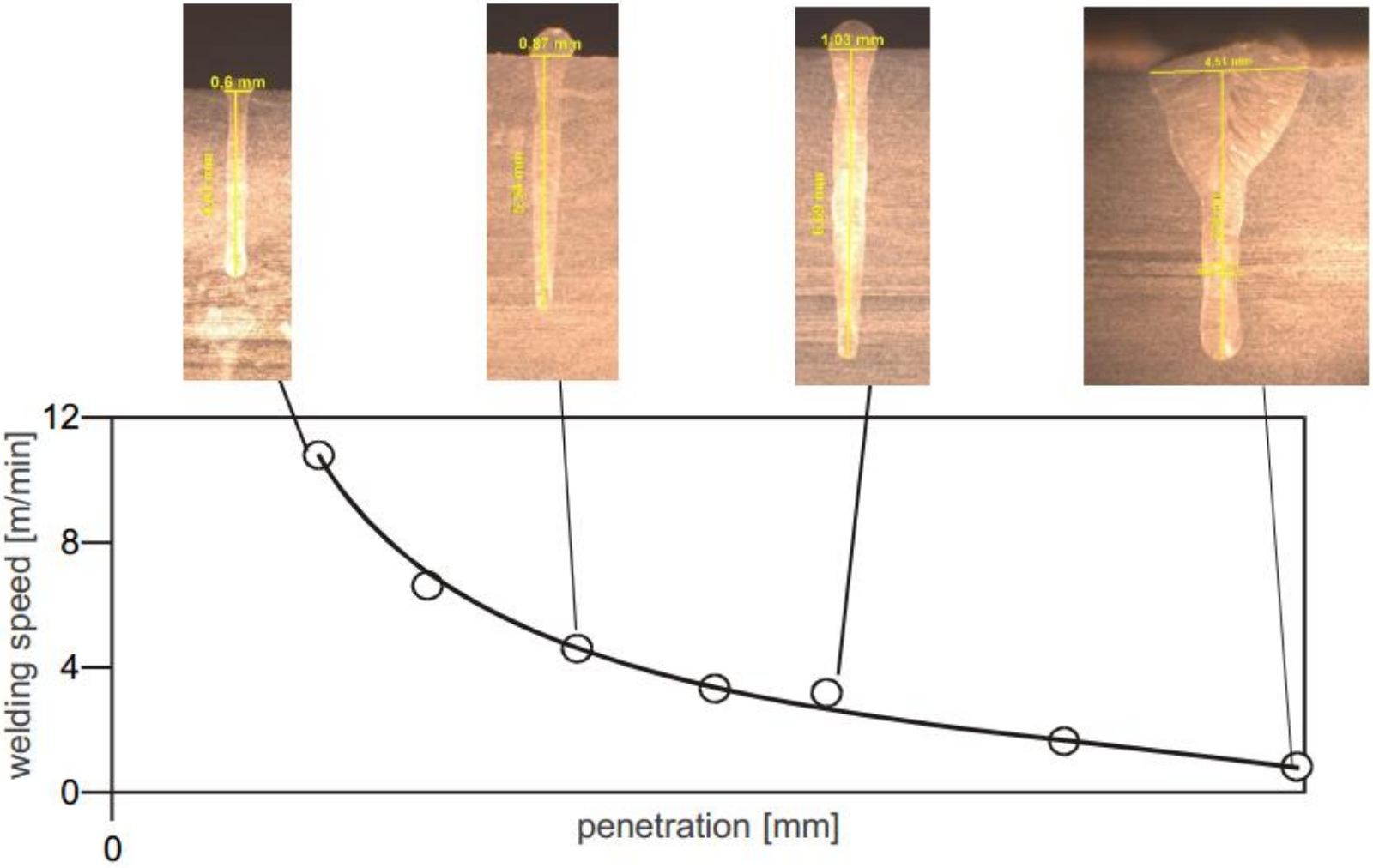
v_2

Seam geometries



source: Laserstrahlschweißen, Leitfaden für die Praxis

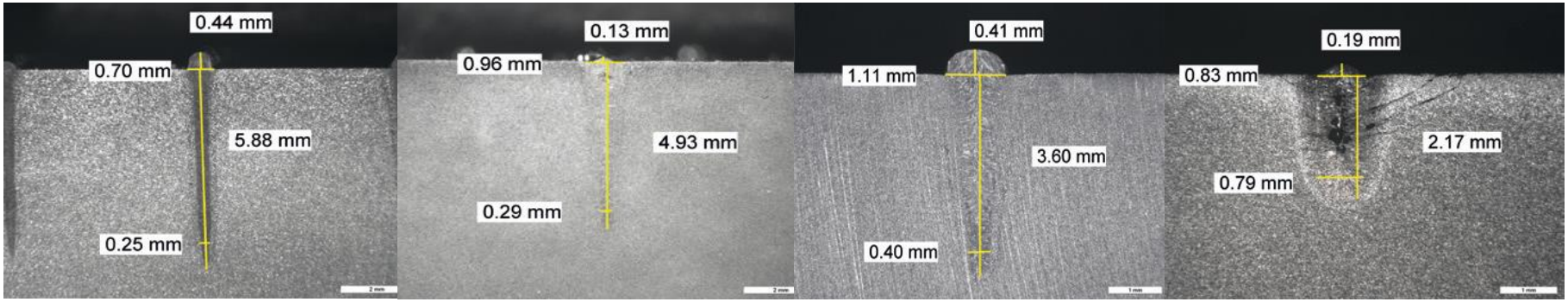
Energy input per unit length



SEAM SHAPING WITH HIGHLIGHT FIBER LASERS

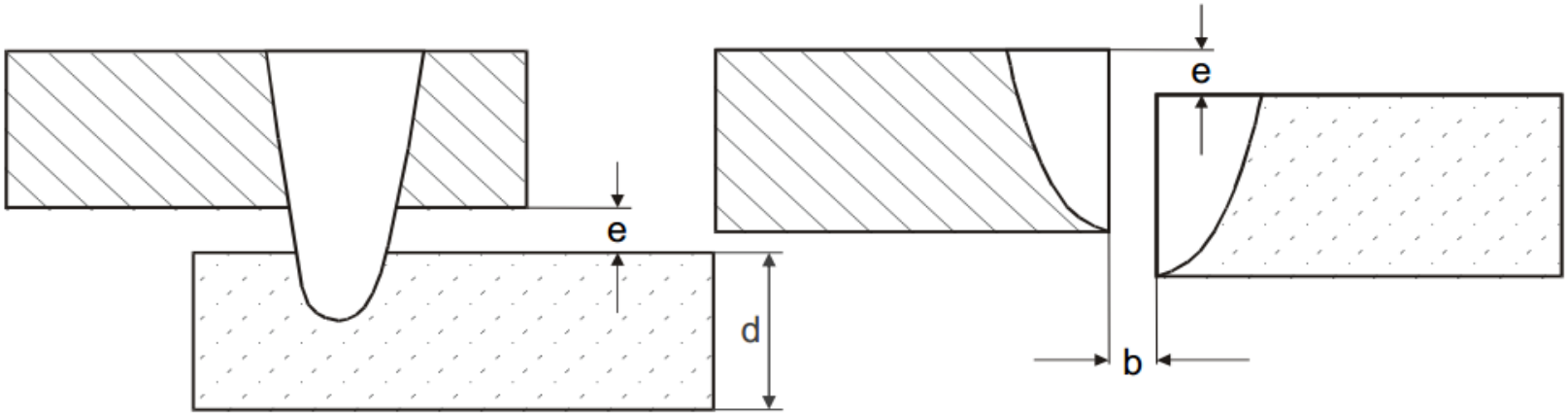
Mild Steel

An easy exchange of the fiber size allows the adjustment of the focus size adapted to the required specification (example at 5 m/min and 4 kW):



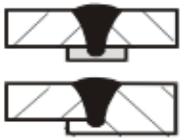
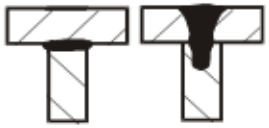
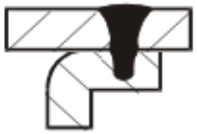
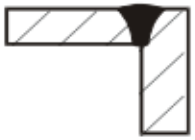
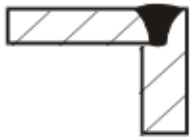
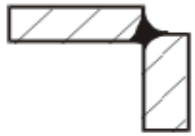
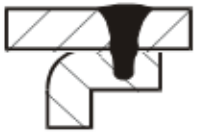
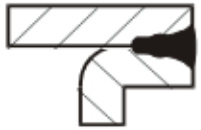
100 µm 200 µm 400 µm 600 µm

Gap bridge ability

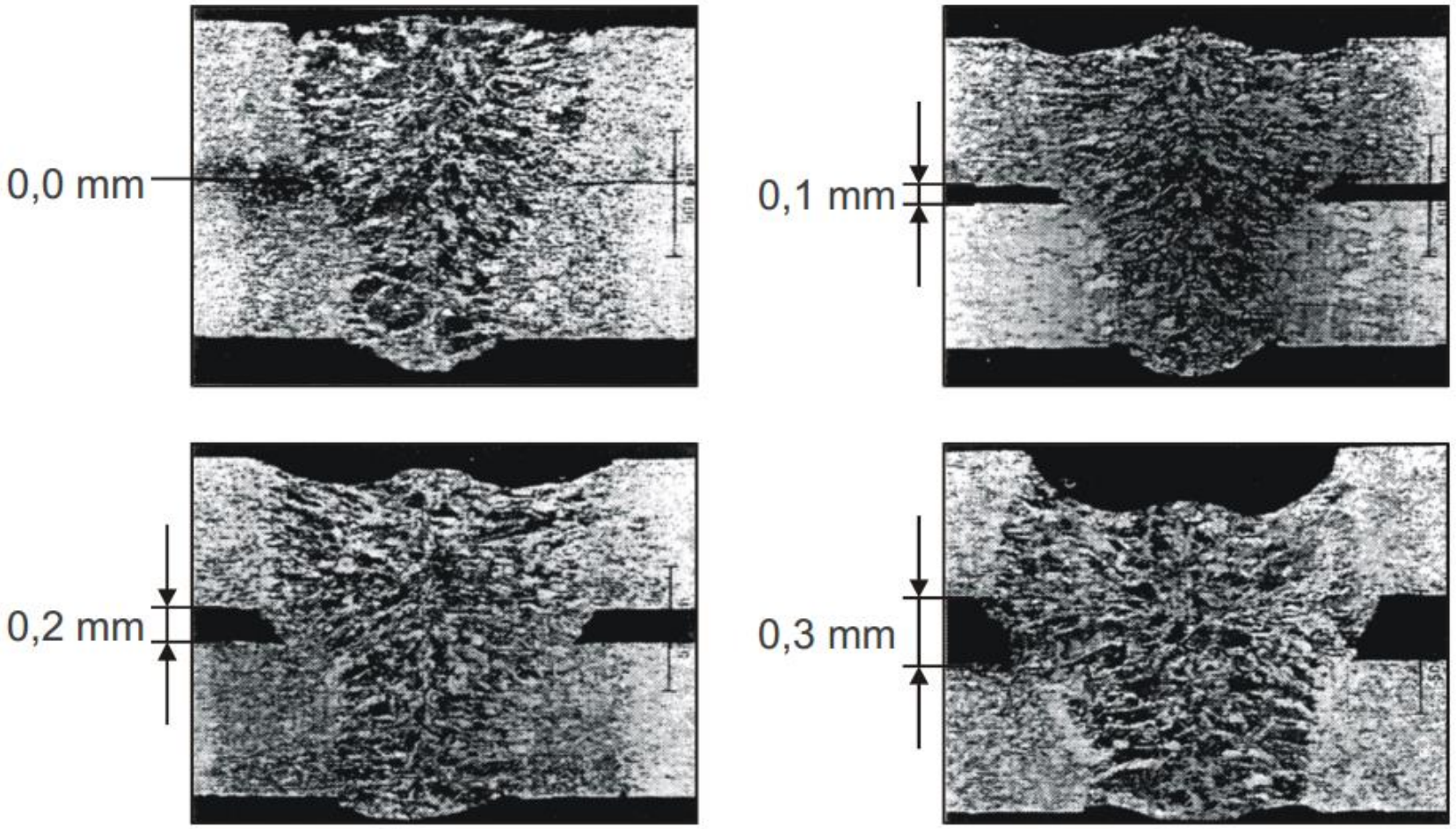


sheet thickness d	gap width b	gap width/mismatch e
0,5 ... 3 mm	0,1 x d	0,15 x d
3 ... 10 mm	0,05 x d	0,1 x d

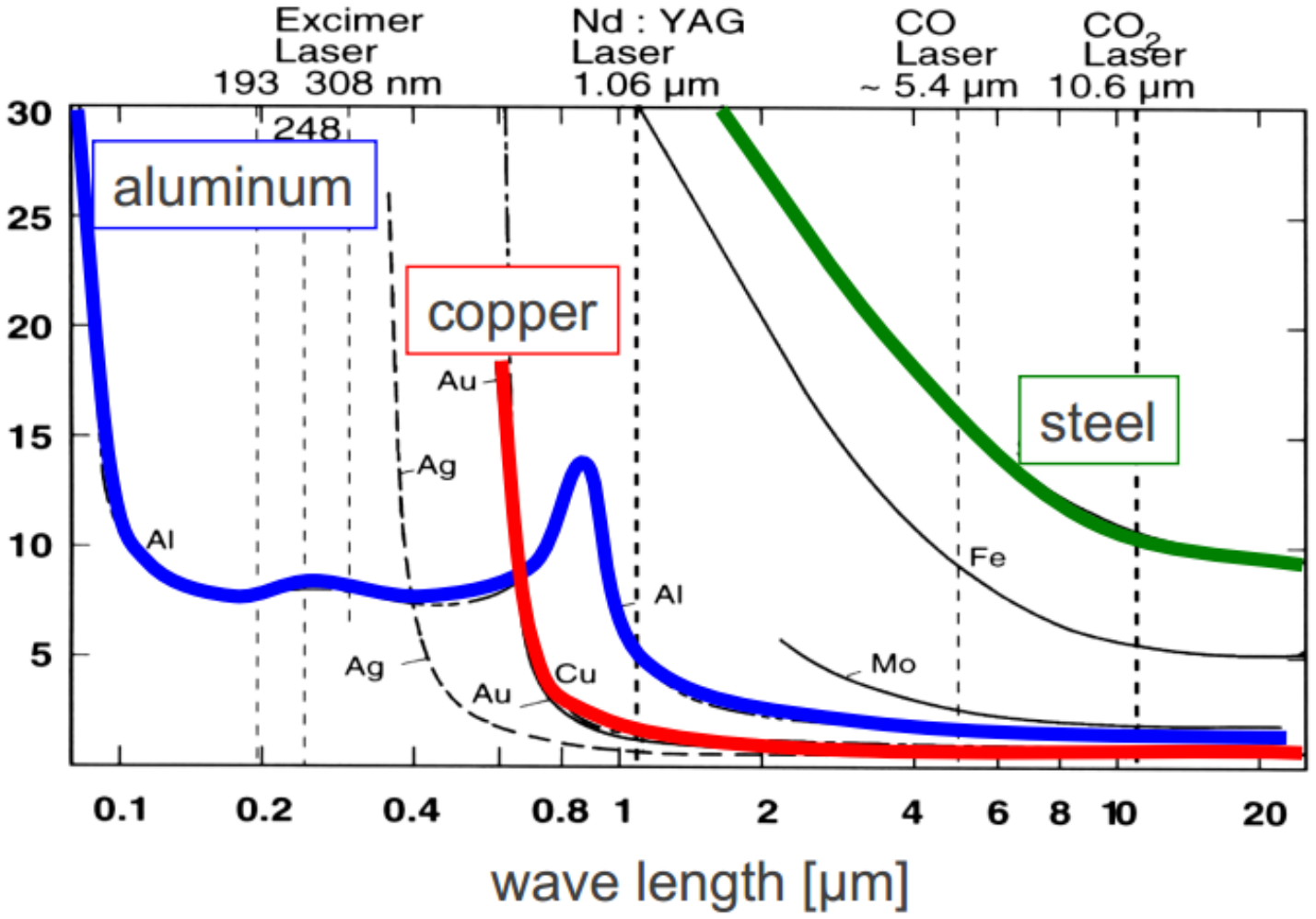
Joint geometries

seam type / type of joint	butt joint	butt joint with backing	fillet weld	flange weld
butt joint				
overlapp joint				
T joint				
T joint overlapp				
corner joint				
corner joint overlapp				

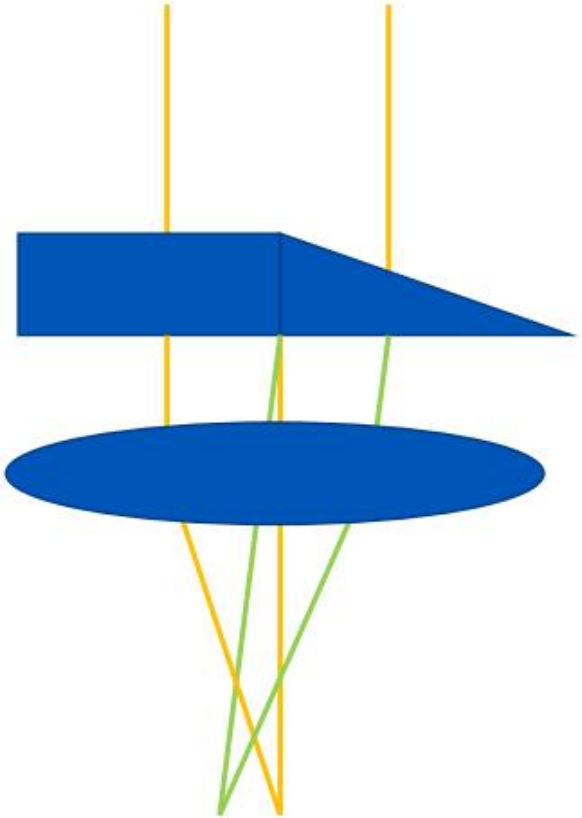
Gap bridge ability



ABSORPTION

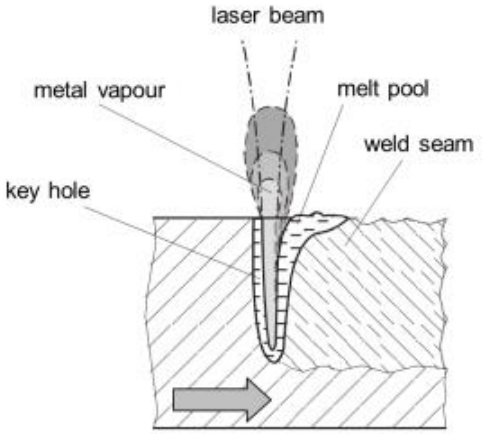

Excimer Laser
193 308 nm
248
Nd : YAG Laser
1.06 µm
CO Laser
~ 5.4 µm
CO2 Laser
10.6 µm
aluminum
copper
steel
Al
Ag
Au
Cu
Fe
Mo
30
25
20
15
10
5
0.1
0.2
0.4
0.8
1
2
4
6
8
10
20
wave length [µm]

Welding of Aluminum, Pores

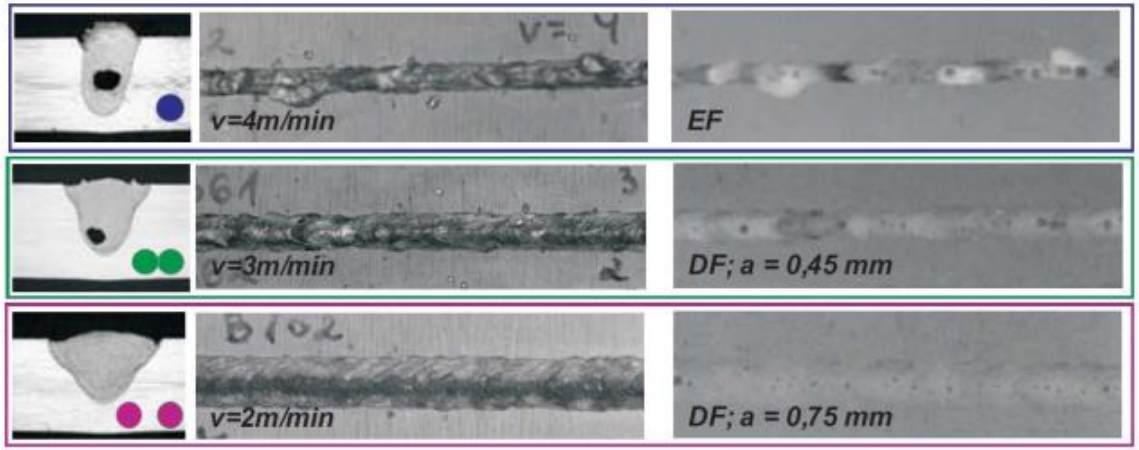


double spot optic

focusing lens



deep welding



source: Laser Magazin; Vom Doppelfokus zur Fokusmatrix

LASER APPLICATIONS
POWER TRAIN

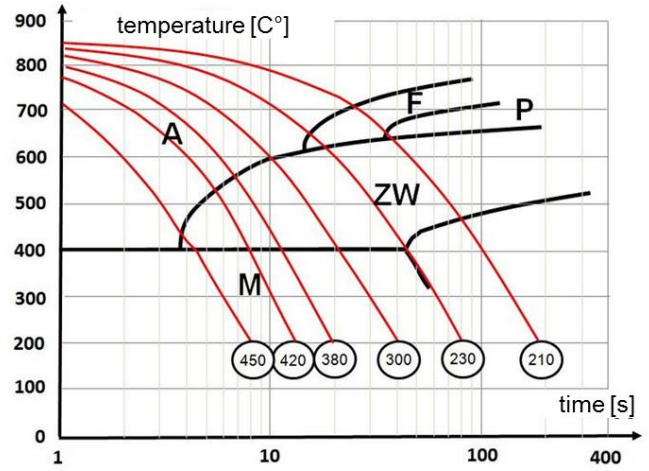
- Light weight constructions make welded parts necessary to reduce number and size of flanges
- Power train components consists often of different steel grades
- High carbon contents lead to hardness levels which reduces the mechanical properties, especially under dynamic loads
- Only low heat inputs are allowed

Source: Mercedes AMG

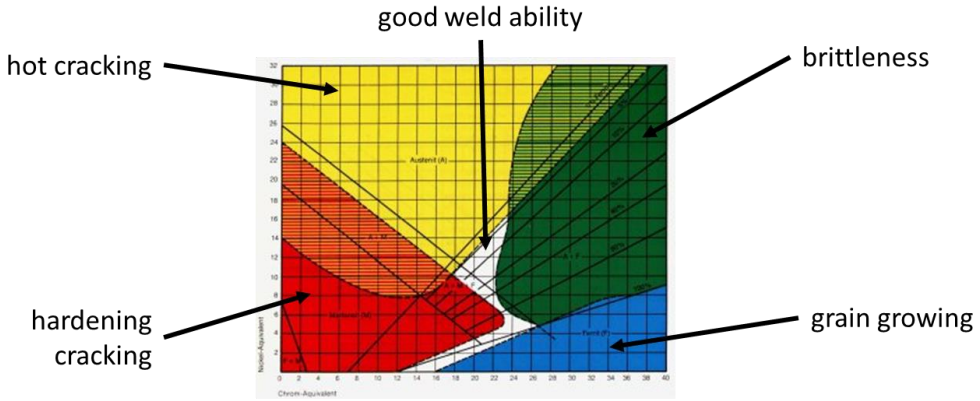
LASER APPLICATIONS
POWER TRAIN – APPLICATION APPROACHES

- Hardenable steel grades with a high CET (carbon equivalent) have a high risk of cracking when welded
- Heating of the work piece reduces cooling rate
- Melt pool has to be alloyed with elements leading to a more ductile seam

TTT (Time Temperature Transformation) diagram



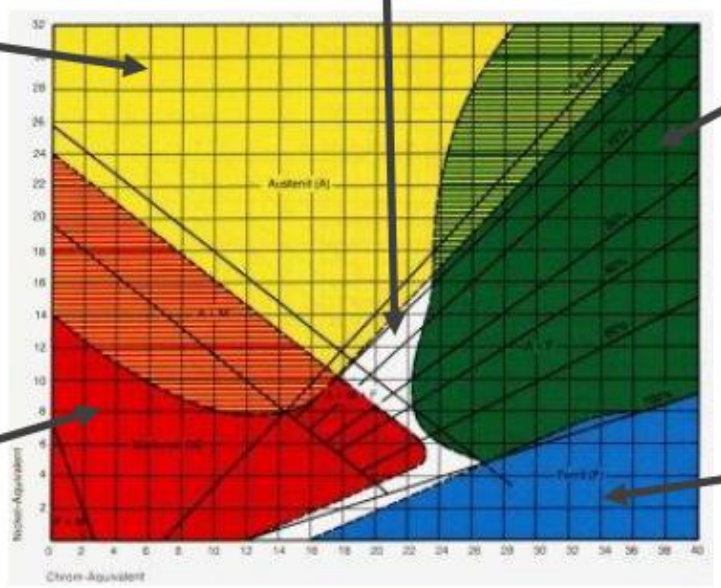
Schäffler diagram



alloy elements can lead to imperfections, depending on their content

Alloying elements

Schäffler diagram



good weld ability

hot cracking

brittleness

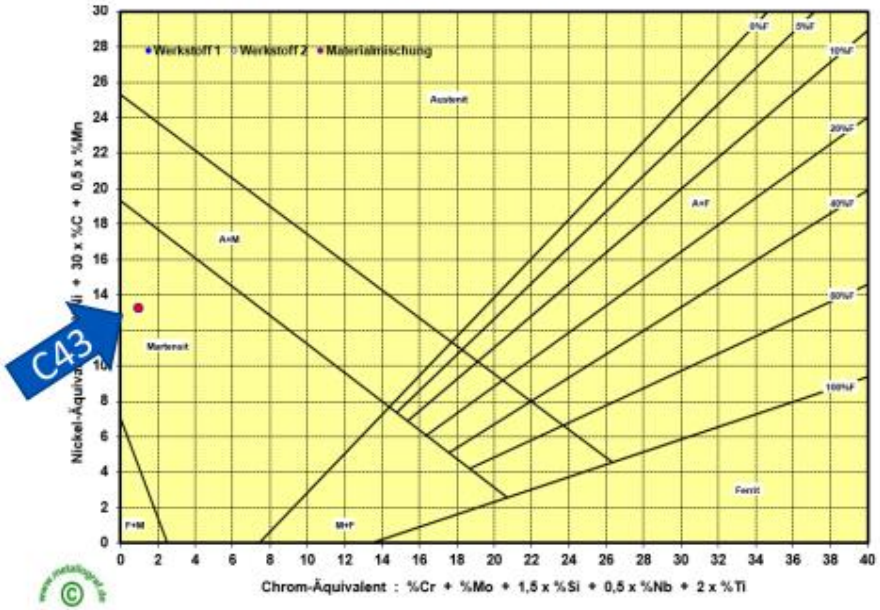
hardening cracking

grain growing

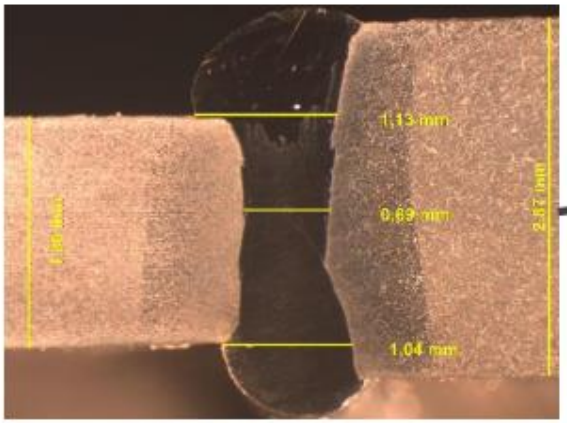
alloy elements can lead to imperfections, depending on their content

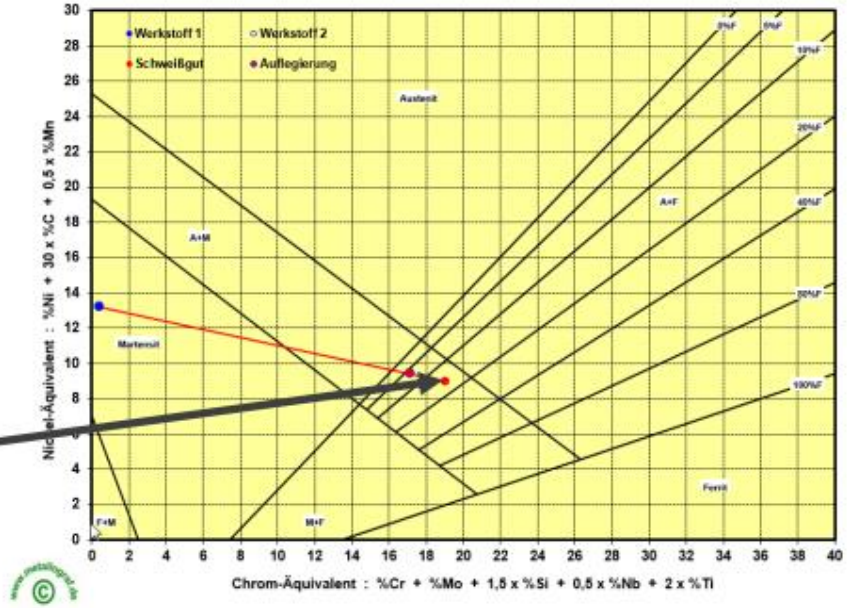
Alloying elements

2 kW fiber laser for gear wheel welding



- steel with high carbon content
- heating not possible
- cracks expected
- Alloying with Cr and Ni





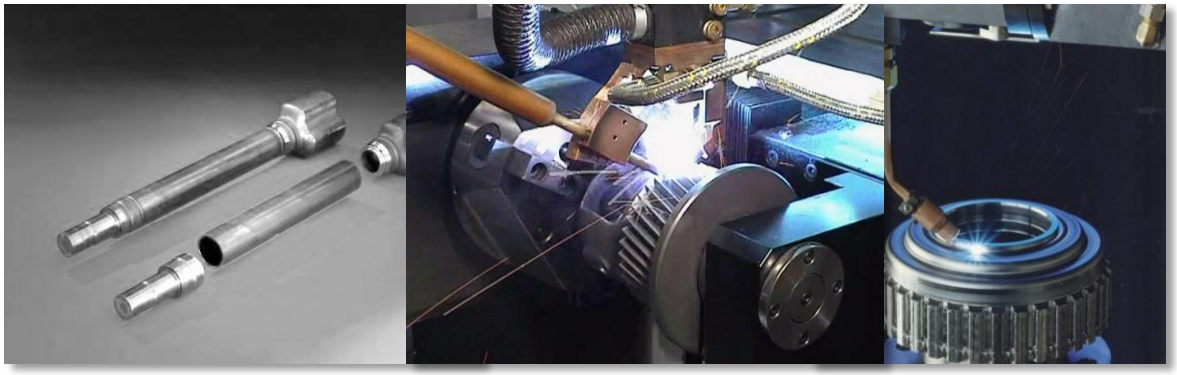
LASER APPLICATIONS
WELDING OF GEAR WHEELS

- CO_2 laser sources are well established in industry
- Reduced energy consumption of modern solid-state lasers is in the interest of gear components manufactures
- Short wavelength also produces a high amount of splatters
- Additional effort for cleaning parts and clamping devices
- Covering the parts and welding at reduced atmosphere pressure

APPLICATION EXAMPLES

Powertrain Components

Gear Wheels



Drive Shafts Differentials

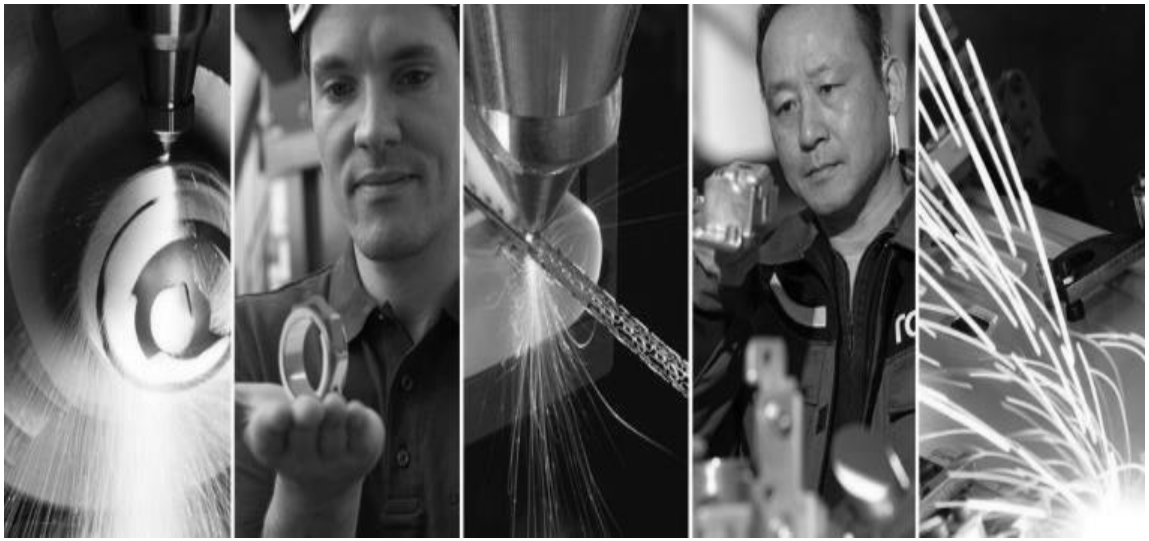
Rotation symmetrical parts for automotive…

- industrial proven technology worldwide
- CO_2 laser advantage: Minimal splatter formation

LASER APPLICATIONS
SUMMARY

JOB DEFINITION	NEEDED LASER SOURCE CHARACTERISTIC	LASER RECOMMENDATION
HIGH REFLECTIVE MATERIALS	SHORT WAVELENGTH TOGETHER WITH HIGH BEAM QUALITY FOR SMALL SPOTS	FIBER LASER
HIGH NUMBER OF WELDS SEAMS	SCANNER COMPATIBLE LASER SOURCE WITH HIGH BEAM QUALITY	FIBER LASER
TEMPERATURE SENSITIVE PARTS AROUND THE WELD SEAM	HIGH BEAM QUALITY FOR SMALL SPOTS	FIBER LASER OR CO_2 LASER
DISTORTION IS NOT ALLOWED	HIGH BEAM QUALITY FOR SMALL SPOTS	FIBER LASER OR CO_2 LASER
BRIDGING BIG GAPS	LARGE SPOT OR BEAM FORMING OPTICS OR SCANNER	FIBER LASER OR CO_2 LASER
MATERIAL IS TRANSPARENT FOR VISIBLE LIGHT OR NON METAL	ABSORPTION ALSO IN TRANSPARENT MATERIALS	CO_2 LASER
SURFACE TREATMENT OR BRAZING	EXTRA LARGE SPOTS	DIODE LASER

THANK YOU FOR YOUR ATTENTION



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