Solving challenging applications with laser micro processing

David Naman & Ronald Holtz (Class 4 Laser Professionals AG)

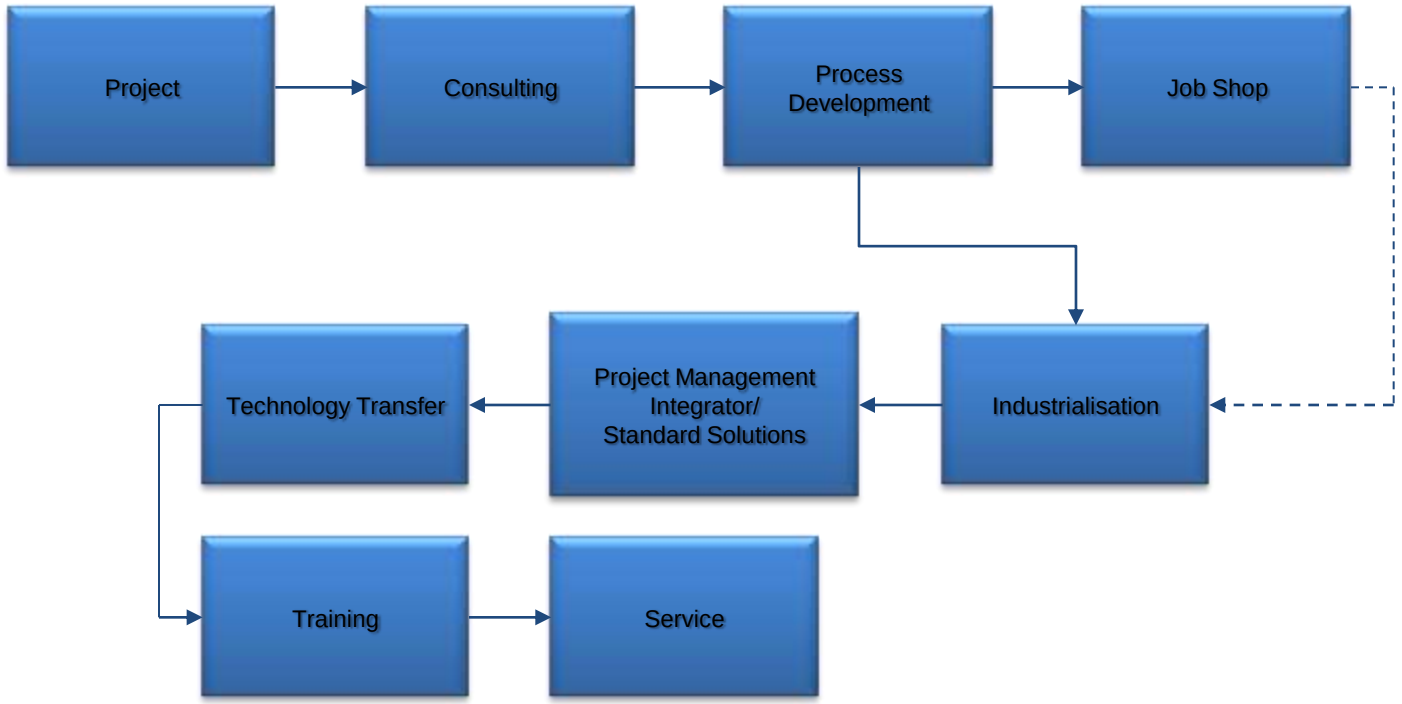
Content

- Market and applications overview
- Properties of pulsed laser technology
- Current application ranges and process limitations
- Application examples
- Comments and conclusions

Presentation of Company

- Class 4 Laser Professionals AG was founded September 2011 as an affiliated company of the Dutch Reith Laser B.V.
- We offer technical and technological support and services with focus on industrial laser processing and laser machinery for end customers but also for laser companies in the market.
- We are specialized in laser applications like precision cutting of metals, crystals and ceramics, micro drilling of holes with highest aspect ratio as well as in welding of challenging metals and dissimilar materials. We use pulsed high-end solid state lasers, fiber lasers and newest ultra-short pulse lasers.
- Depending on requirements we operate worldwide for our customers and partners and provide services, laser process development and customers trainings.
- Class 4 Laser Professionals AG owns a fully equipped laser application center. This allows development of new laser applications, creation of prototypes and production of complete product series with shortest response times at customer requests.

Service portfolio



Departments

Jobshop/ Technology develop.

Systems/ Integration

Ultra short pulse lasers

Equipment

precicut 35/50 5-axis

Prolas FO

microcut stent

PSM 400 blade welder

SLS 200 CL

FLS 352 N

QCW SMF 150

CNC
- 3 axis high precision CNC

Lasers
- Time Bandwidth Products Duetto
- Lasag SLS 200 CL60
- C4L – Ipg QCW 150
- q-switch Coherent 20W
- q-switch IDAR 80W
- DLS 030 pw

Infrastructure:
- Video Measurement Microscope,
- SEM/EDX
- Laser Scanning Microsope
- Machine shop,
- Metallography

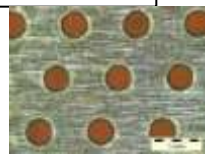
Investments 2013
- Gray room
- precicut 50/50 5-achs
- Exhaust Chemical lab
- Lasag LFS 150

Markets

Medical Engineering

cutting

OTF drilling



SP drilling

Trepanning

Electronics

spot welding

cutting

SP Drilling

Tool

Shaped holes

Perc. drilling

cutting

Welding

Automotive

scribing

OTF drilling

Perc. drilling

Turbine

Perc. drilling

Shaped holes

OTF drilling

Welding

Mechanical Devices

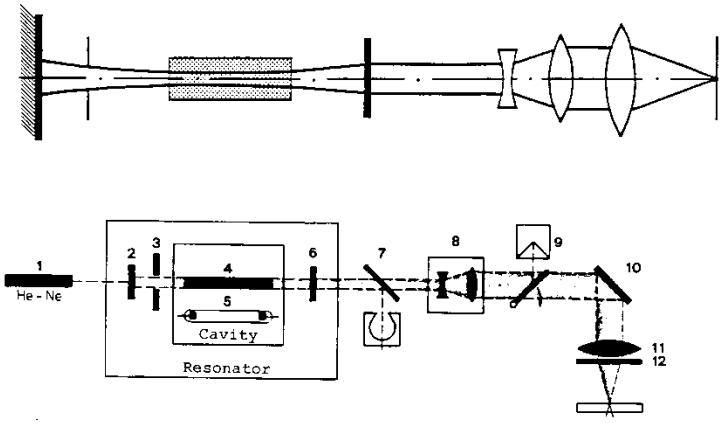
Cutting

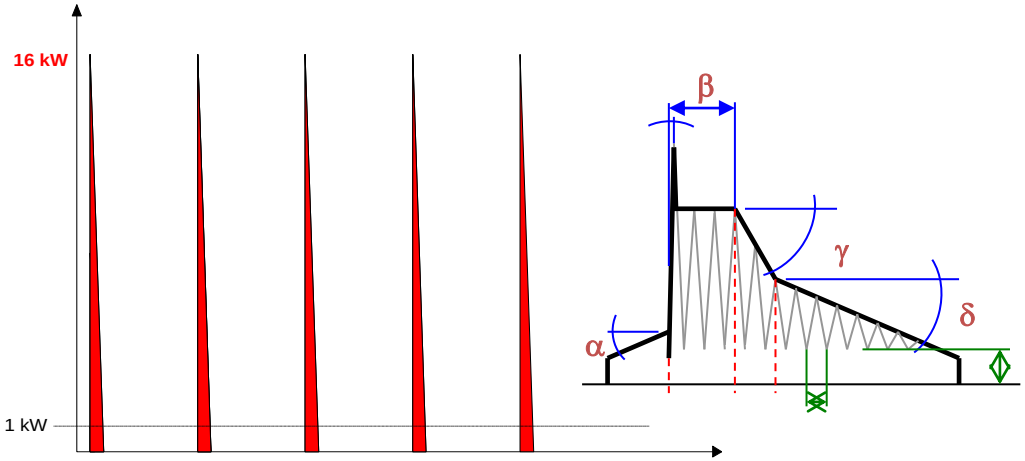
welding

OTF drilling

Perc. drilling

Typical Lasers for Job shop – Micro Applications

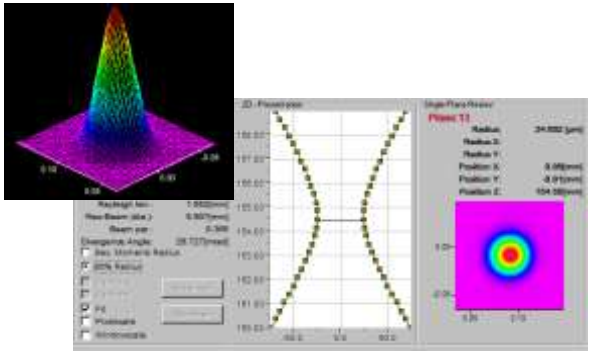




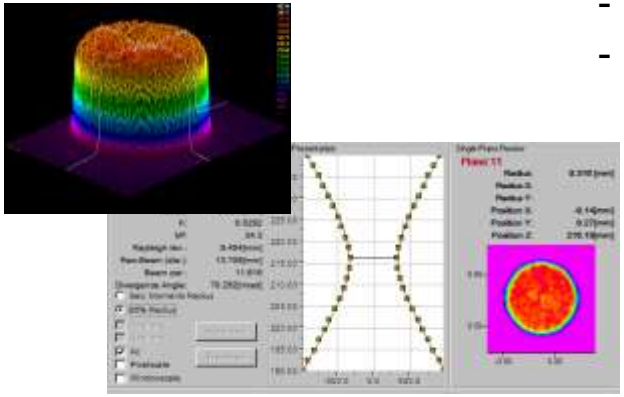
Advantages:
- High flexibility
- High peak power
- Low average power
- Controllable heat transfer
- Pulse shaping
- Pulse modulation

Disadvantages:
- Lamp pumped system
- Low power efficiency
- Low beam quality
- High maintance costs
- High running costs

QCW fiber laser



Rofin-Lasag LFS 150



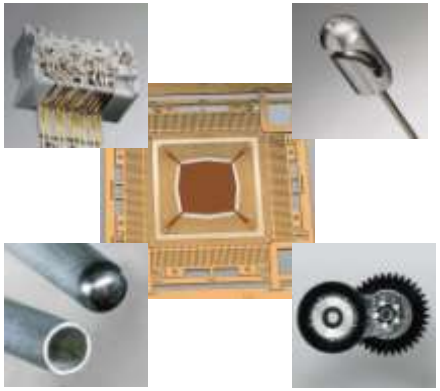
IPG YLS-600/6000-QCW-AC

Properties:

- High peak power
- High beam quality
- Fiber output
- Air cooled
- 2 phase power interface
- Low maintenance
- High power efficiency

Application ranges and limits

Welding

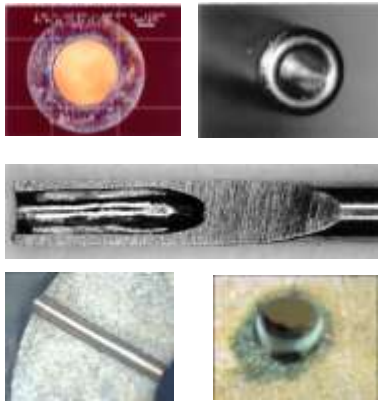


- welding penetration 20 - 3000 µm
- width > 20 µm
- smooth welding surfaces
- helium proofed joints
- low thermal entrance
- low deformations
- high mechanical strength

materials:

- steel materials
- Cu- and Al-alloys
- refractive materials
- dissimilar materials

Drilling

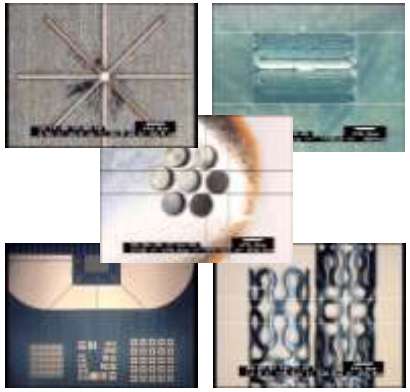


- single pulse, percussion and trepanning drillings
- drilling diameters > 5 µm
- aspect ratios up to 1:250
- low thermal entrance
- high reproducibility
- adjustable taper

materials:

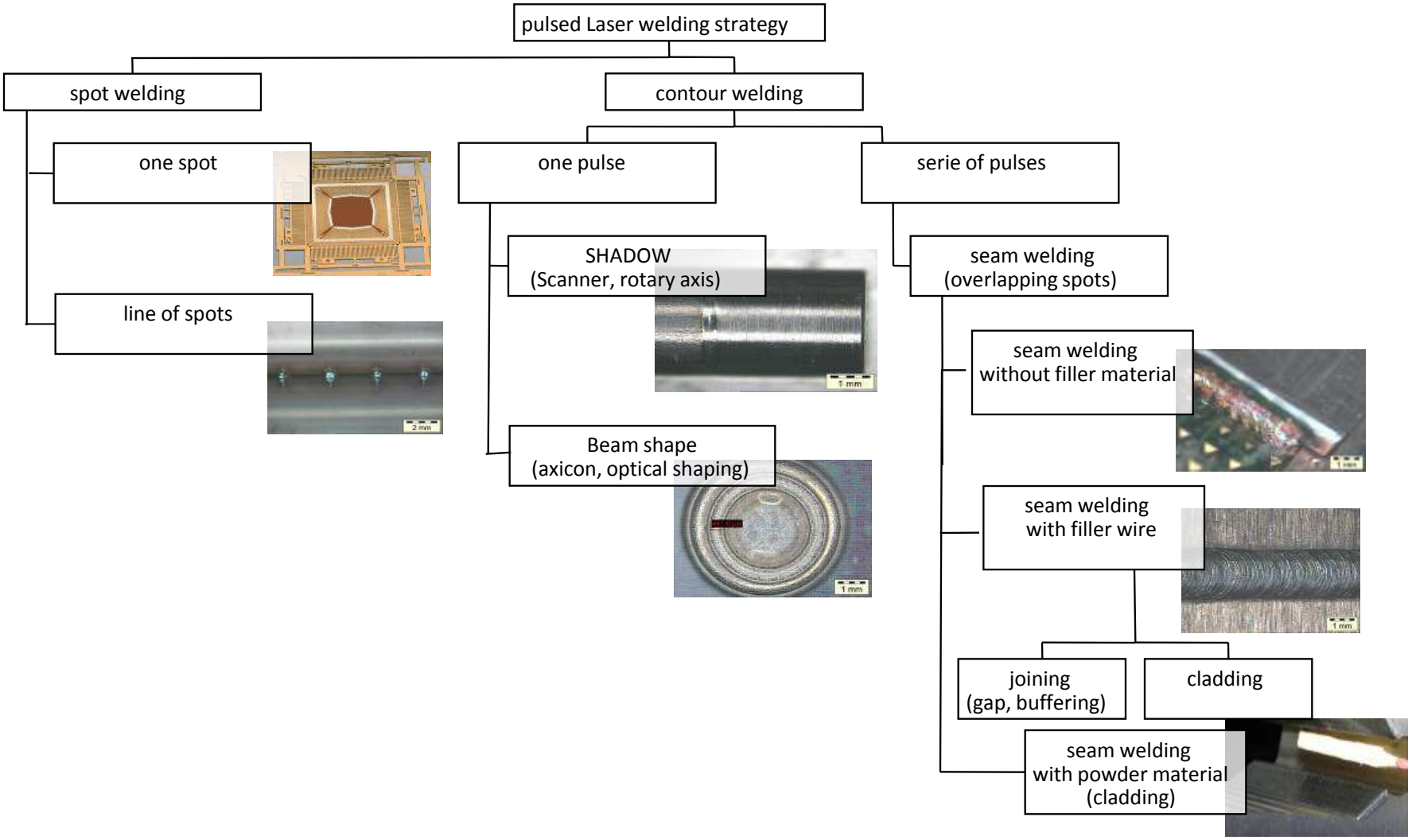
- metals
- crystals
- ceramics

Cutting



- fine and precise cutting
- Cutting gaps down to 10 µm
- aspect ratios up to 1:30
- lowest thermal entrance
- adjustable taper

Pulsed laser welding strategies



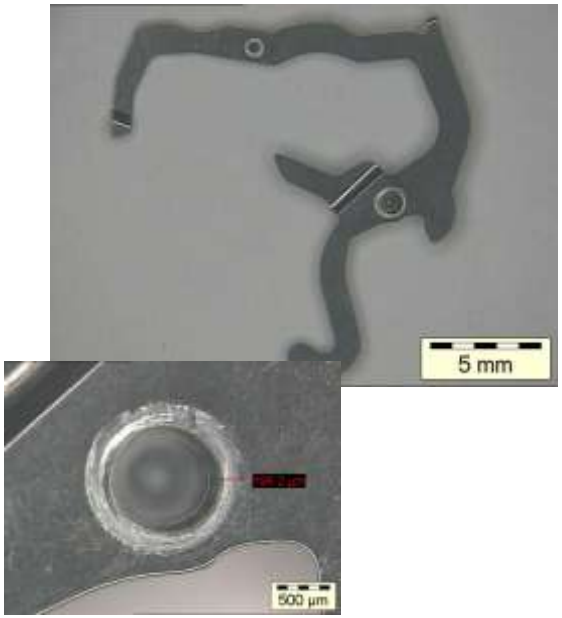
Examples: valves

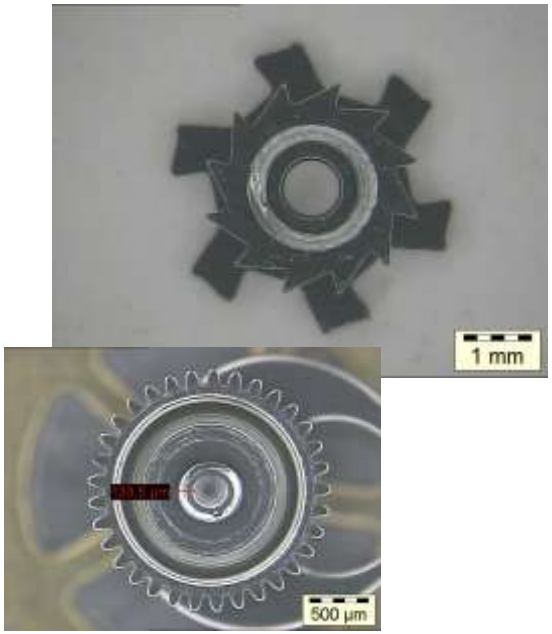
Material: stainless steel
Laser: LASAG SLS 200 CL 60
Parameter: 3.3 kW Peak power, 30 ms Pulse length
specs: 80 mm/s

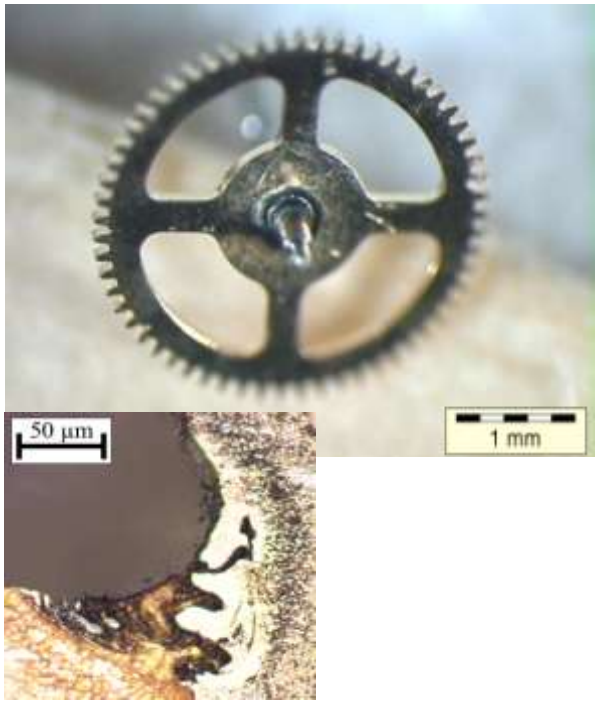
Automotive

shadow

Examples: watch parts





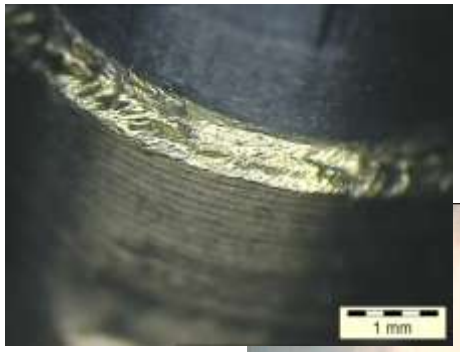


Material:	**stainless steel**
Laser:	**LASAG SLS 200 CL 60**
Parameter:	**0.4 kW Peak Power,**
	20 ms Pulse length,
specs:	**300 mm/s**

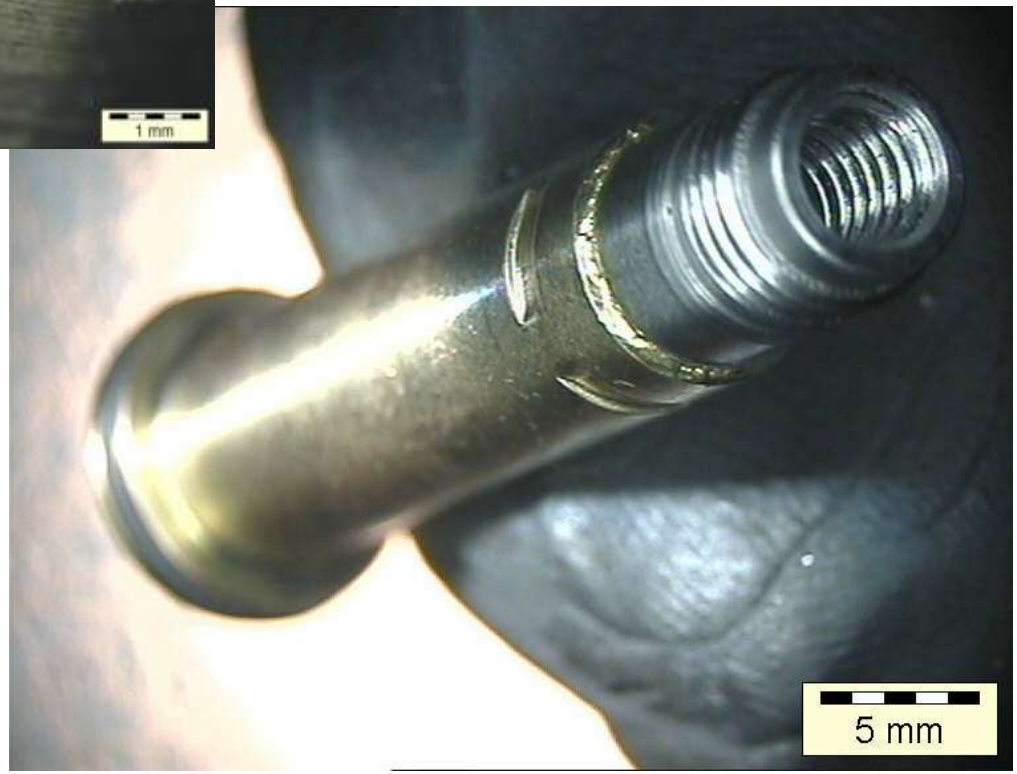
watch

shadow

Examples: sensors



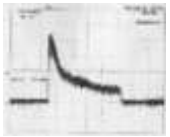
Material: brass – stainless steel
Laser: LASAG FLS 542 C
Paramater: 2.4 kW peak power, 110 J
bis 2 m/min speed



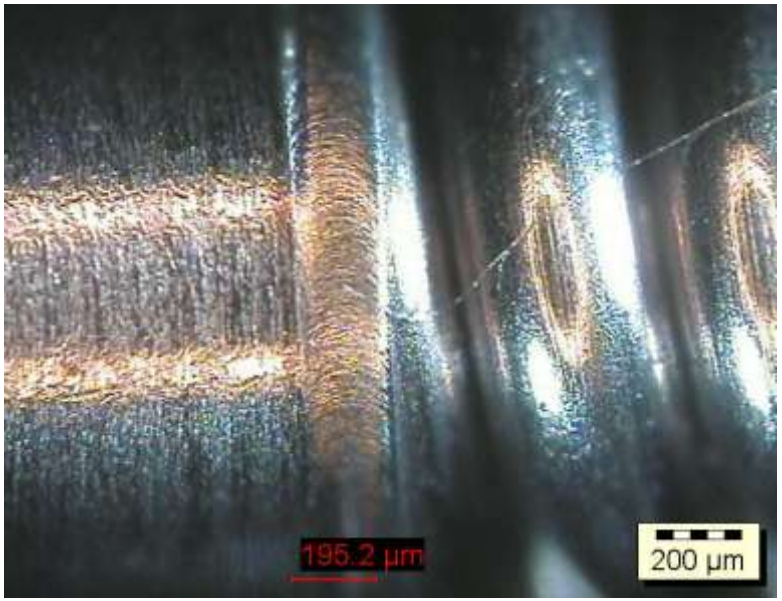
mechanical Devices

shadow

Examples: endoscopes



surface optimization



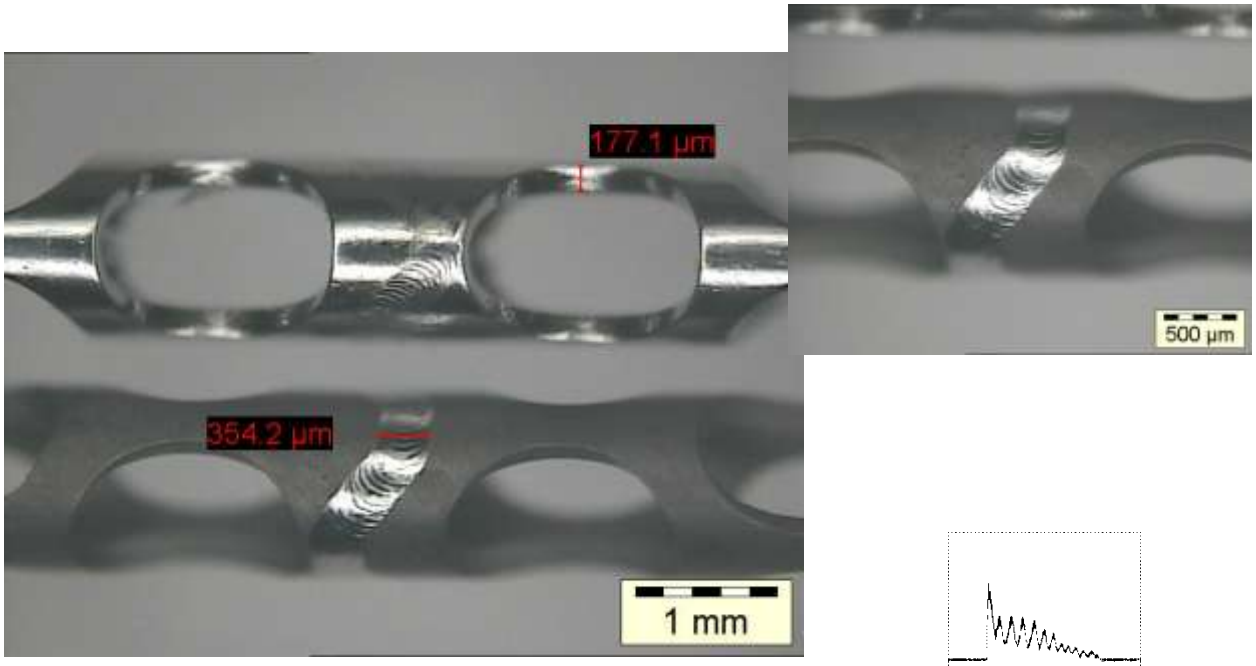
Material: alloy 316L

Laser: LASAG SLS 200 CL 60
Fiber: 200 mm NA0.11
Peak power: 0.15 kW
Energy: 0.5 J
Pulse length: 4.5 ms
depth: 0.2 mm

medical devices

seam welding

Examples: nitinol parts

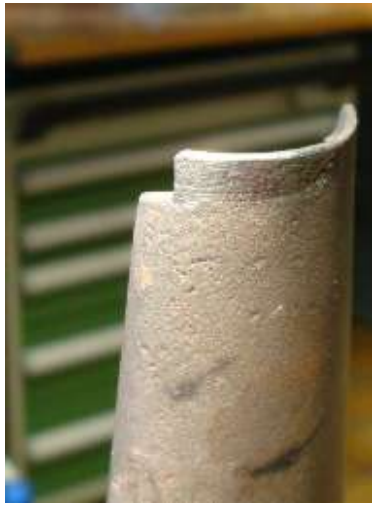


Material: Nitinol
Laser: LASAG SLS 200 CL32
Parameter: 0.065 J Pulse energy,
100 mm/min Speed
Pulse form: modulated, trailing edge

medical devices

seam welding

Applications – repair welding turbine

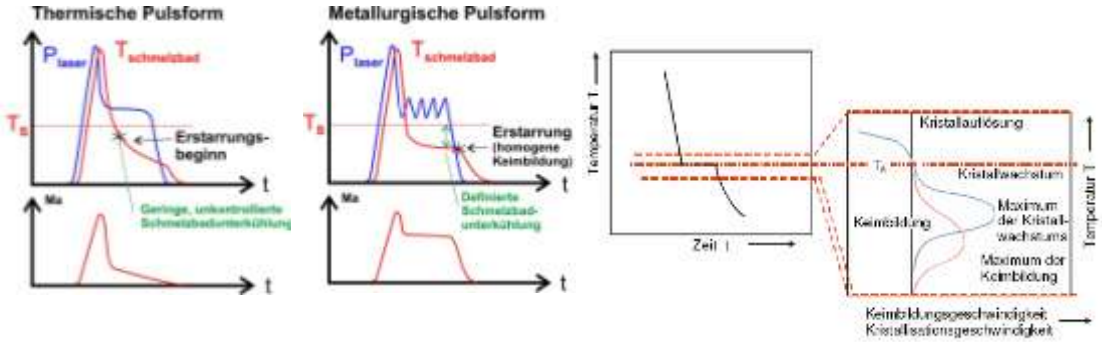


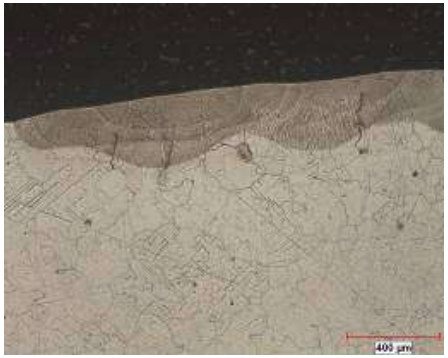
Material: Ni based alloy ЭИ893 (ХН65ВМТЮ)
ГОСТ 5632-72 ТУ 14-1-322-72или ТУ 1-809-541-95

Ni	Cr	W	Mo	Ti	Fe	Al	Si
64,7	16,9	8,81	4,23	1,75	1,69	1,18	0,34

Applications – repair welding turbine

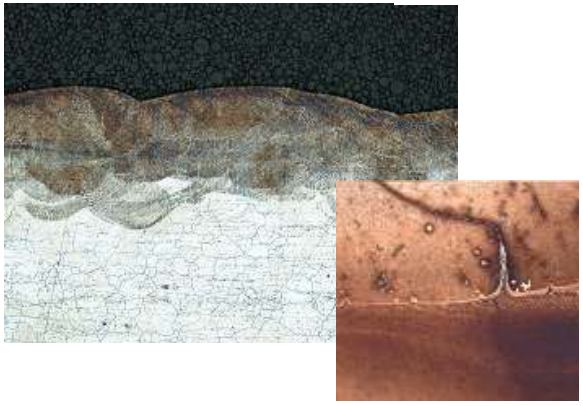
preparation for metallographic tests





hardness	HV1
base mat.	327
weld	256

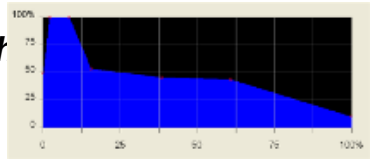
parameter setup 1



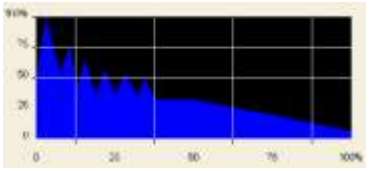
hardness	HV1
base mat.	327
weld	263

parameter setup 2

Material: ***Ni-base alloy,***
ZW Rene 41 ∅0.4 mm
Laser: **Easywelder SLS 200 CL 60**
Parameter: ***4 kW peak power,***
20 ms pulse length
7 Hz frequency

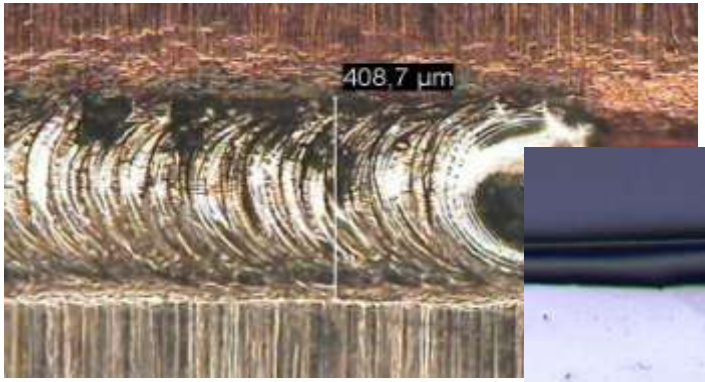


Material: ***Ni-base alloy,***
ZW Rene 41 ∅0.4 mm
Laser: **Easywelder SLS 200 CL 60**
Parameter: ***4.5 kW peak power,***
18 ms pulse length
9 Hz frequency

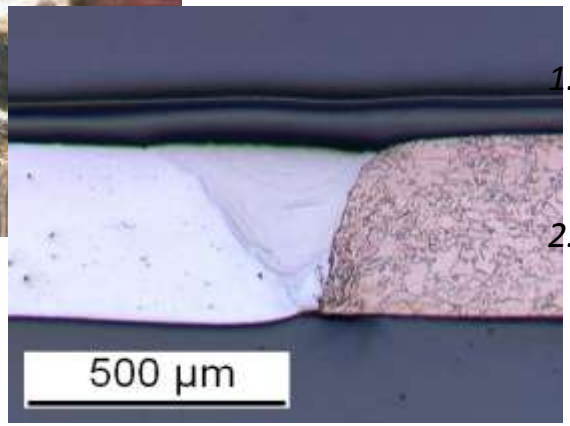


Welding of dissimilar materials

spot welding
of steel, nickel
and german silver contacts



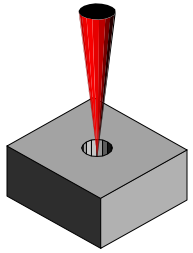
Seam welding of
Al 99.9 mit E-Cu

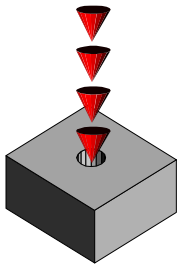


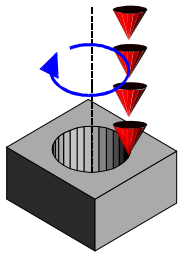
real time power supply:

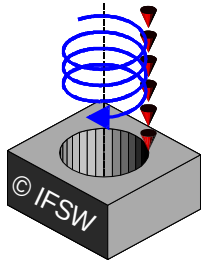
1. *controlled solidificarion cycle by regulation of the thermal pulse shape*
2. *dontrolled melting pool dynamic by modulation of the pulse shape*

Drilling strategies









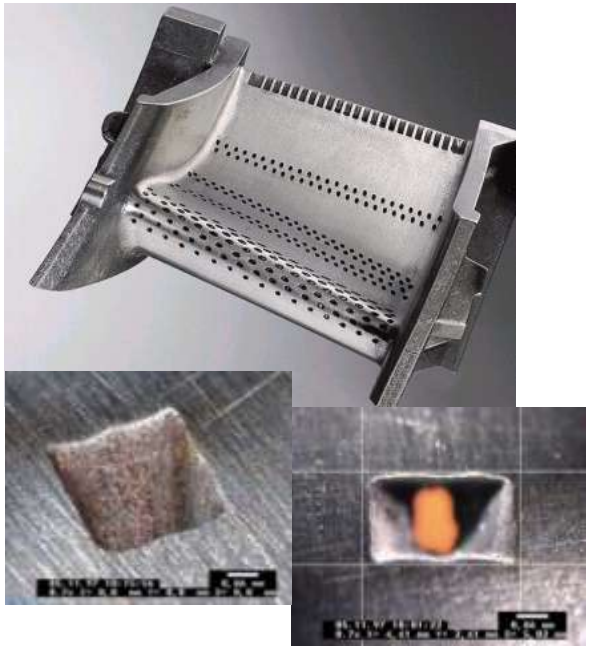
strategy:	single pulse	percussion	trepanning	helix
penetration drilling				
depth (mm):	< 4 mm	some cm	some mm	<mm
aspect (D/T)	< 15:1	< 200:1	<20:1	~
limits (D) (mm):	0.02/1	0.015/1.5	0.08/~	0.08(exit)
blind hole				
depth (mm)	< 2 mm	some cm	-	-
aspect	<10:1	<40:1	-	-
tolerance (%):	10-15	10	5-10	<5
holes/s	<1000	1	<0.1	<<0.1

(D= hole diameter , T = hole depth)

Examples: turbine parts

Material: Ni and Co based alloys
Laser: LASAG FLS 652
Parameter: 25 J Pulse energy, 0.8 ms Pulse length, 2 s/hole
specs: recast, cracks, geometry

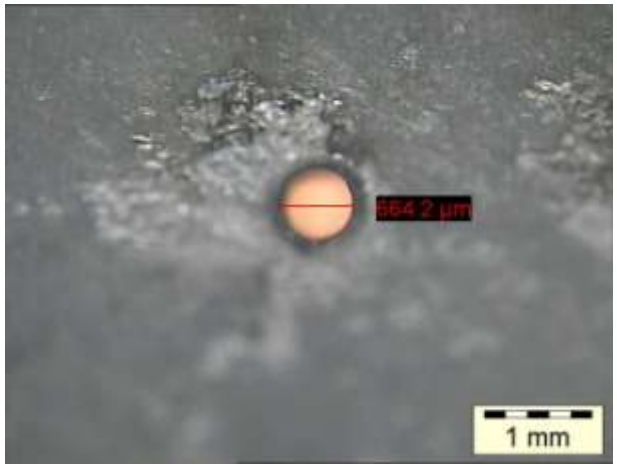
Material: Ni and Co based alloys
Laser: LASAG FLS 352
Parameter: 12 J Pulse energy, 0.6 ms Pulse length, 3 s/hole
specs: recast, cracks, geometry

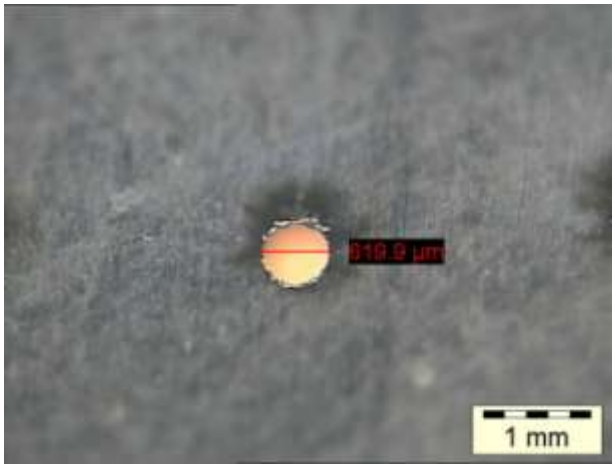


Turbine

trepanning

Examples: mould exhausts



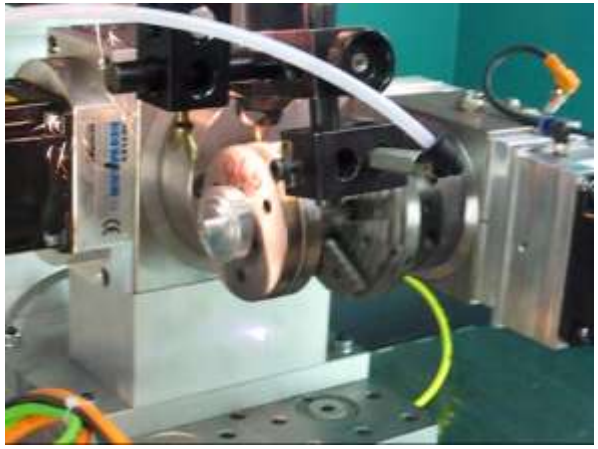


Material: Aluminum
Laser: LASAG FLS 352
Parameter: 9.9 J Energy,
0.3 ms Pulse length
specs: 1.2 s, 10 mm depth, 0.6 mm

mechanical Devices

perc. drilling

Examples: piston rings

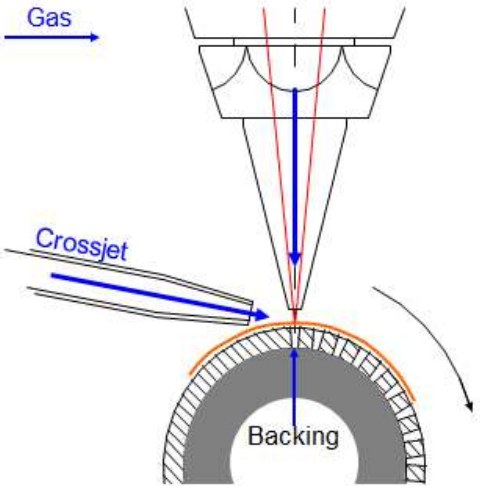


Material: low alloyed steel
Laser: LASAG FLS 552
Parameter: 14 J Energy,
0.6 ms Pulse length
specs: 20 holes/s, 0.5 mm

Automotive

drilling on the fly

Examples: fuel filters

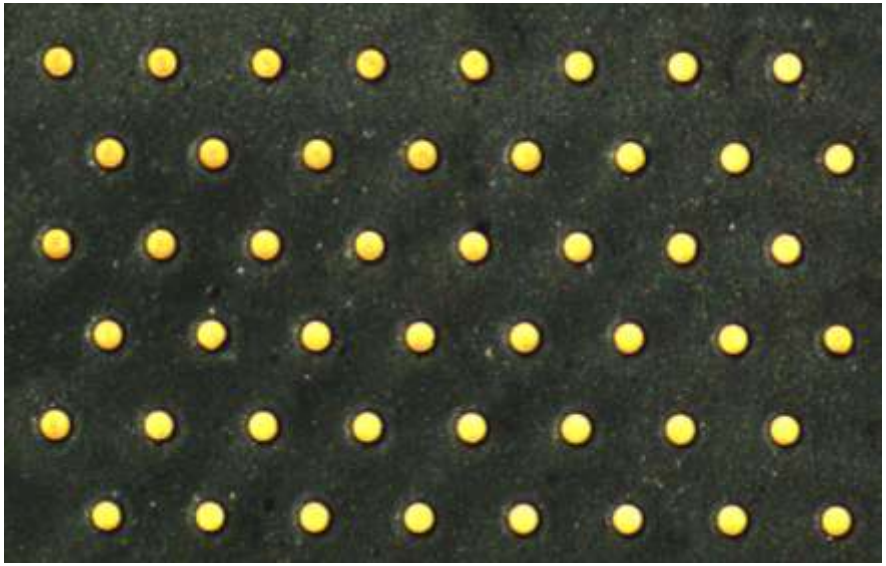


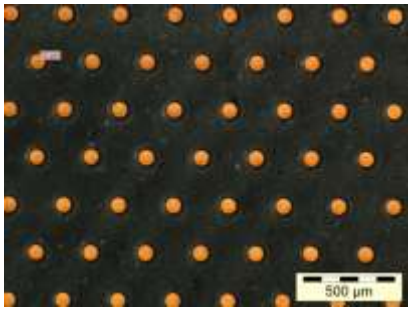
Material: ***1.4301 0.5 mm***
Laser: ***C4L - QCW 150 SM***
Parameter: ***0.8 kW Peak power,***
0.1 ms Pulse length
Comments: ***Air, 500 holes/s***
Diameter: 0.05 mm

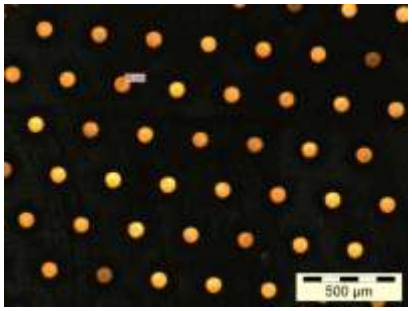
Automotive

drilling on the fly

Examples: graphite drilling





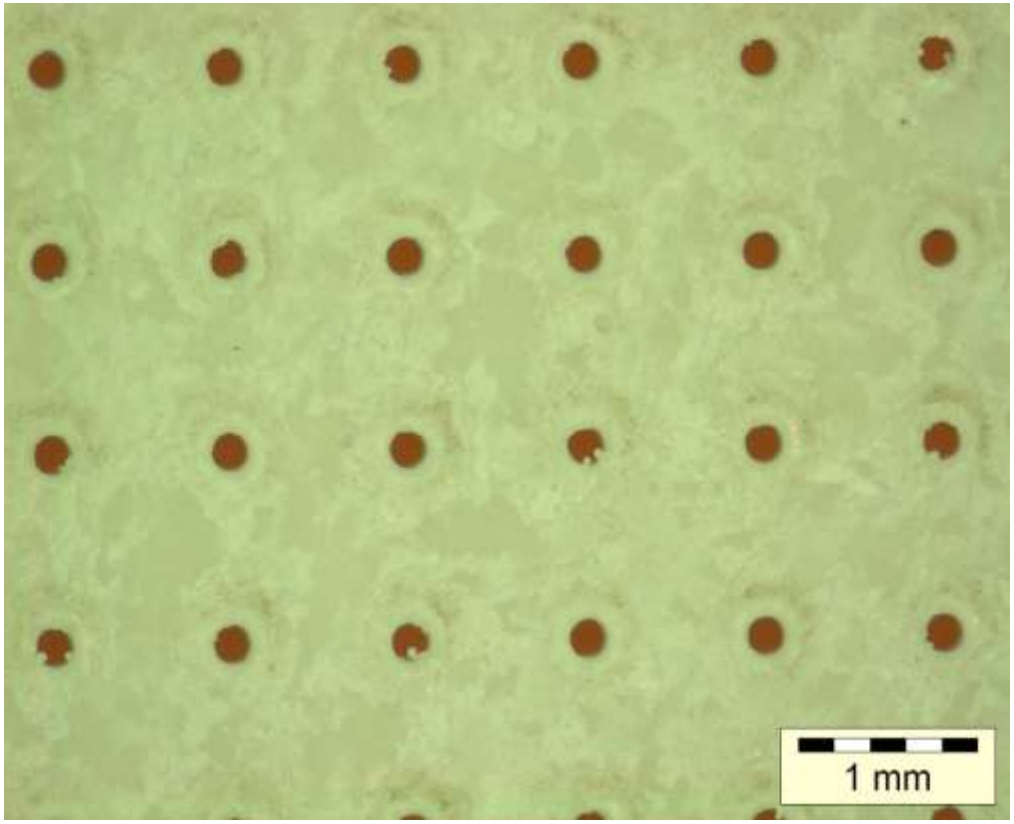


Material: Graphite 2 mm
Laser: C4L - QCW 150 SM
Parameter: 0.75 kW Peak power, 0.2 ms Pulse length
Comments: O2, 0.5 s
Diameter: 0.085 mm

Electronics

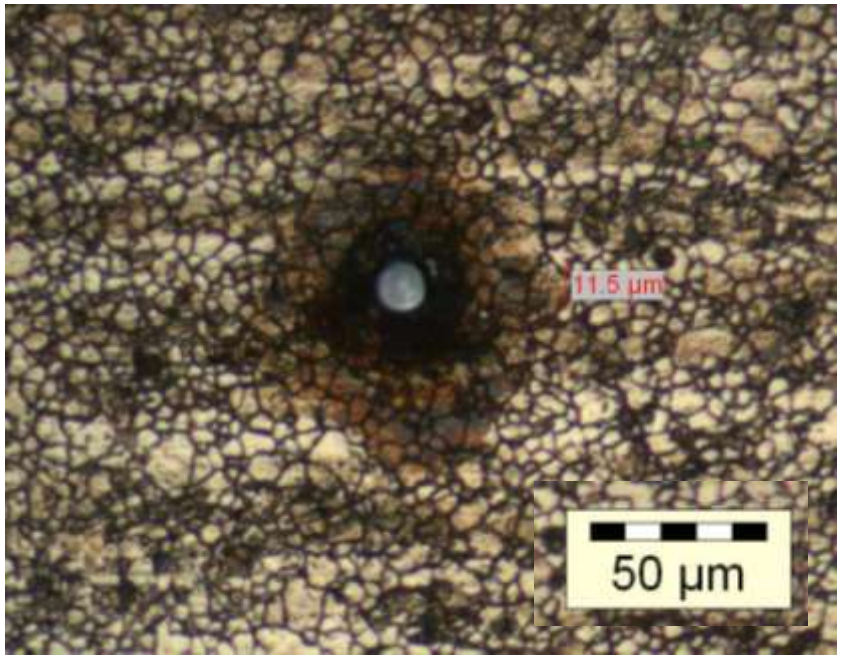
Percusssion drilling

Examples: Aluminium Oxide



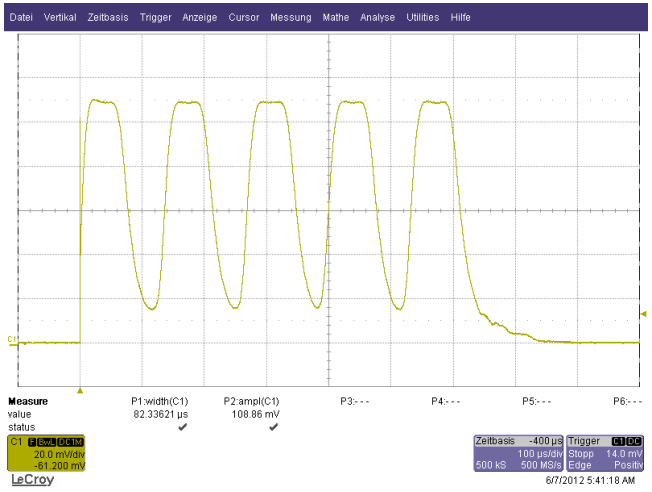
Material: Silicon nitride 0.2 mm
Laser: C4L - QCW 150 SM
Parameter: 1.5 kW Peak power, 0.06 ms Pulse length
Comments: O2, 200 holes/s Diameter: 0.1 mm

Examples: micro holes



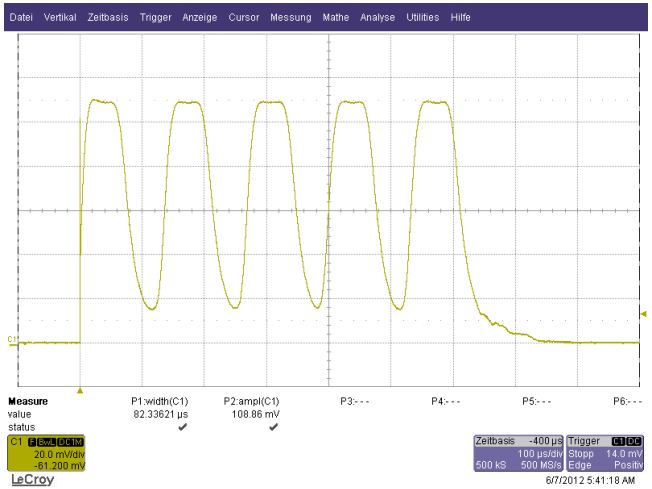
Material: ***1.4301 1 mm***
Laser: ***C4L - QCW 150 SM***
Parameter: ***1.5 kW Peak power,***
0.2 ms Pulse length
Comments: ***O2, 20 s***
Pulse shape with Modulation

Aspect ratio: > 1:100 !



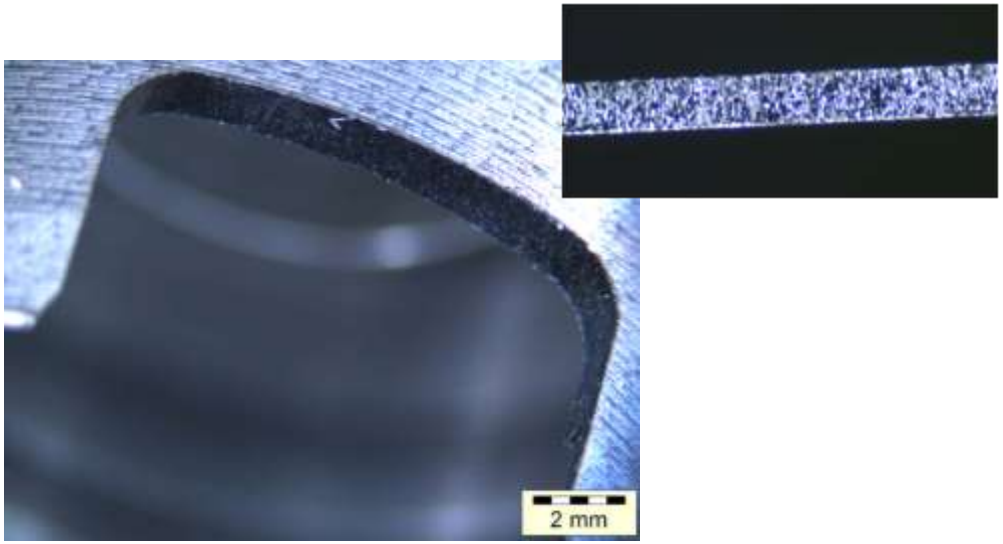
Efficiency improvement by using pulse modulation

Examples: high aspect ratio drilling

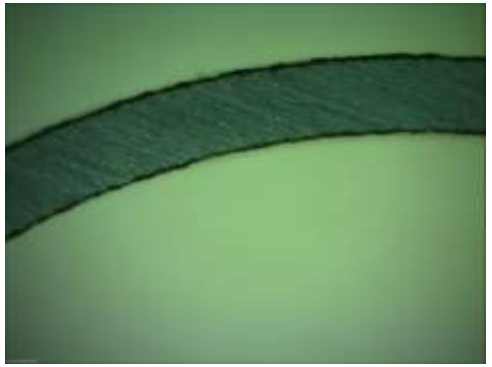


Material:	***Carbon steel 10 mm***
Laser:	***C4L - QCW 150 SM***
Parameter:	***1.5 kW Peak power, 0.2 ms Pulse length***
Comments:	***O2, 50 s***

Examples: steel cutting

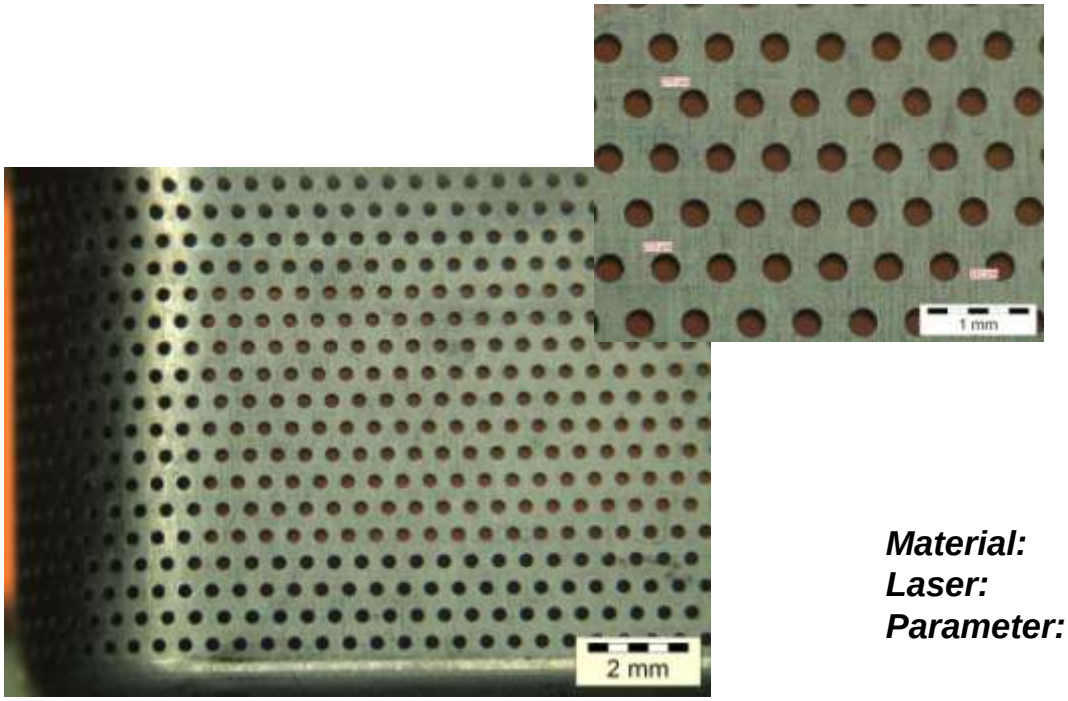


Material: 1.4301 3 mm
Laser: C4L - QCW 150 SM
Parameter: 1.5 kW Peak power,
0.6 ms Pulse length
150 W Average Power
Comments: O2, 100 mm/min



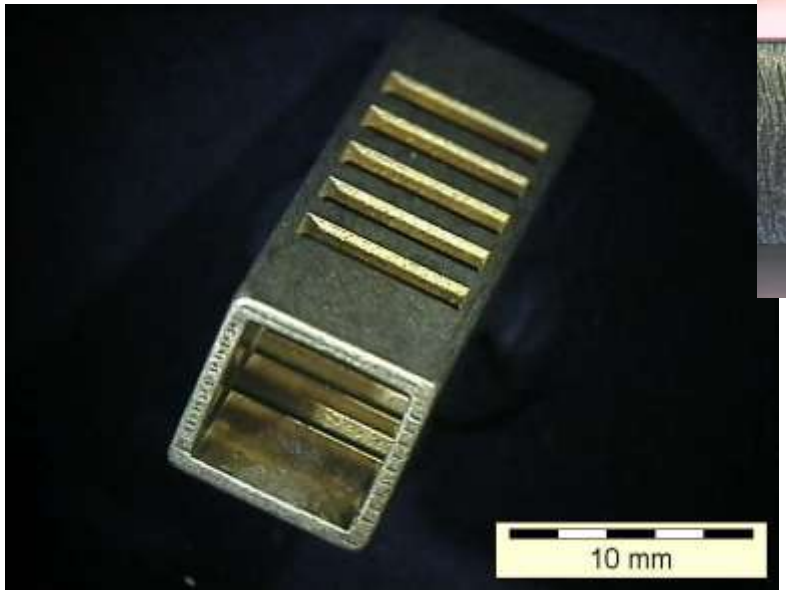
Material: 11 MnPb30 0.5 mm
Laser: C4L - QCW 150 SM
Parameter: 1 kW Peak power,
0.2 ms Pulse length
100 W Average Power
Comments: O2, 1 m/min

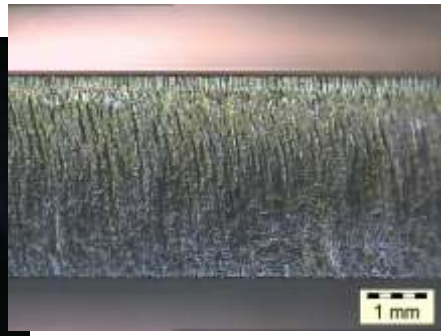
Examples: high speed cutting



Material:	***1.4301***
Laser:	***C4L - QCW 150 SM***
Parameter:	***0.6 kW Peak power,***
	0.2 ms Pulse length
	50 W Average Power
Comments:	***O2, 12 bar, 200 mm/min***

Examples: bearing housing



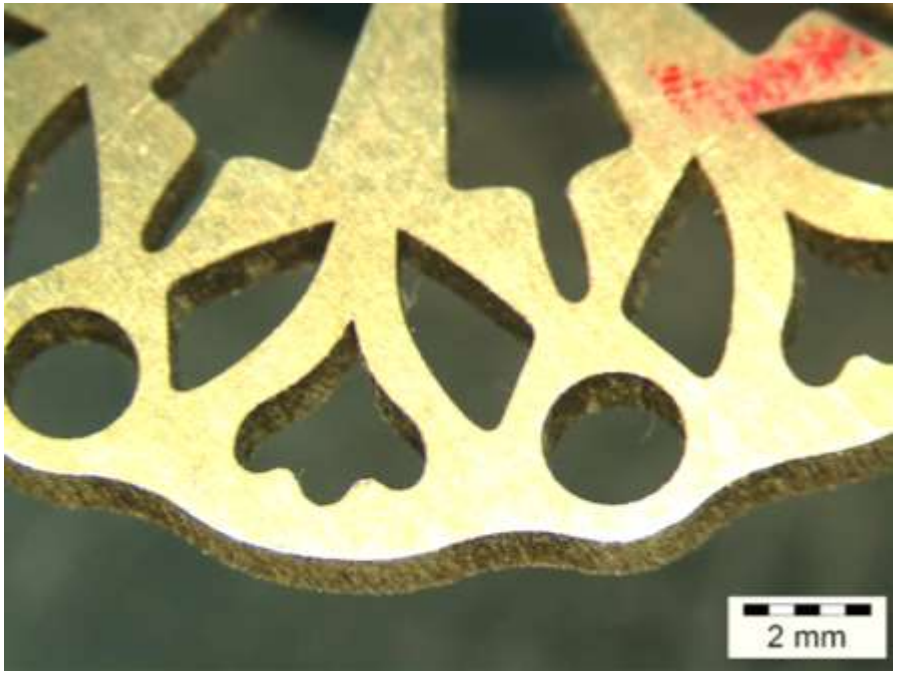


Material: brass
Laser: FLS 352
Parameter: 6.45 J Pulse energy,
1 ms Pulse length
speed: 120 mm/min

mechanical Devices

cutting

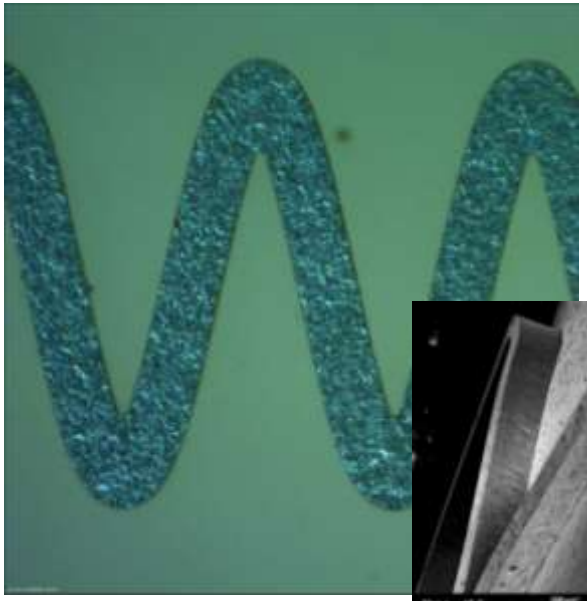
Examples: silver cutting

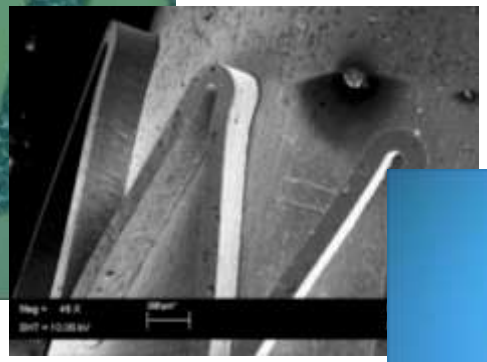


Material: Ag 1.5 mm
Laser: C4L - QCW 150 SM /MM
Parameter: 1.5 kW Peak power,
1 ms Pulse length
150 W Average Power
Comments: O2, 100 mm/min

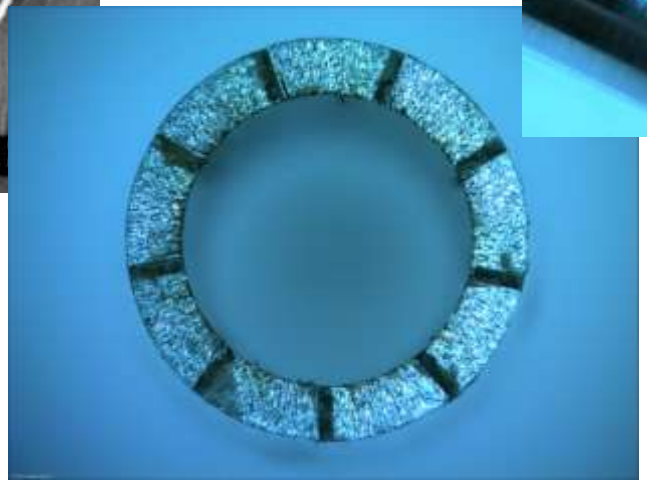
(Comparence to 200 W cw fiber laser: impossible)

Examples: Nitinol cutting





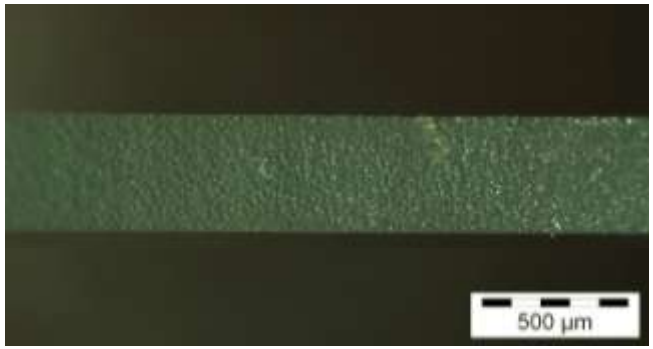
Material: Nitinol 1 mm
Laser: C4L - QCW 150 SM
Parameter: 1.2 kW Peak power, 0.08 ms Pulse length
Comments: Ar2, 150 mm/min



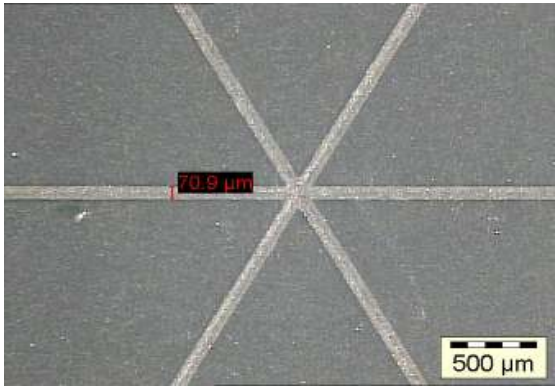
Material: Nitinol 0.2 mm
Laser: C4L - QCW 150 SM
Parameter: 0.25 kW Peak power, 0.07 ms Pulse length
Comments: Ar2, 400 mm/min

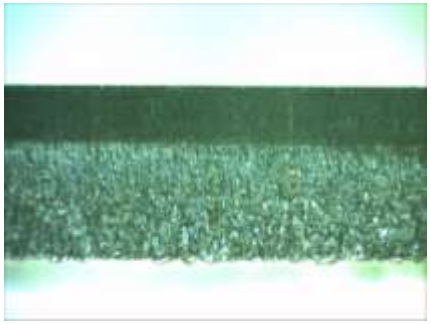
Examples: Sapphire cutting

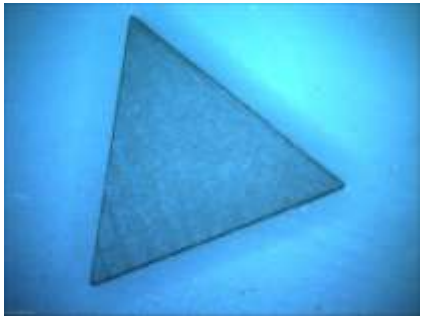
Material: Sapphire 1 mm
Laser: C4L - QCW 150 SM
Parameter: 1.5 kW Peak power,
0.09 ms Pulse length
35 W Average Power
Comments: N2, 3 200 mm/min



Applications – CBN cutting







Material: ***CBN 1.6 mm***
Laser: ***C4L - QCW 150 SM***
Parameter: ***1.5 kW Peak power,***
0.1 ms Pulse length
35 W Average Power
Comments: ***N2, 3 60 mm/min***

Comments and Conclusions

- micro applications offer new opportunities for classical Job shop companies with new applications for many different markets
- Job shop for laser micro applications is not limited to local customers
- Typical applications are welding, cutting, drilling and micro machining
- Application fields can be covered by pulsed laser sources
- Job shop for laser micro applications needs deep knowledge in laser processing, materials, CNC machining

Questions ou commentaires ?

Merci de votre attention !!!

David Naman @ Ronald Holtz
Class 4 Laser Professionals AG
Industriering 43
CH-3250 Lyss
Suisse
Tel. : +41 79 245 00 59
info@class4laser.ch

Vous nous trouverez au stand :

E104