



The Synergy of Water and Fire

Green Fiber Laser MicroJet Processing of Watch Parts

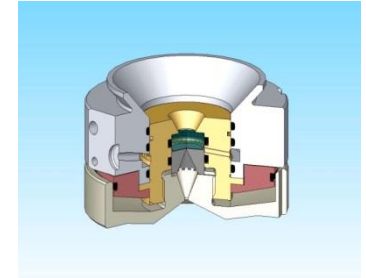
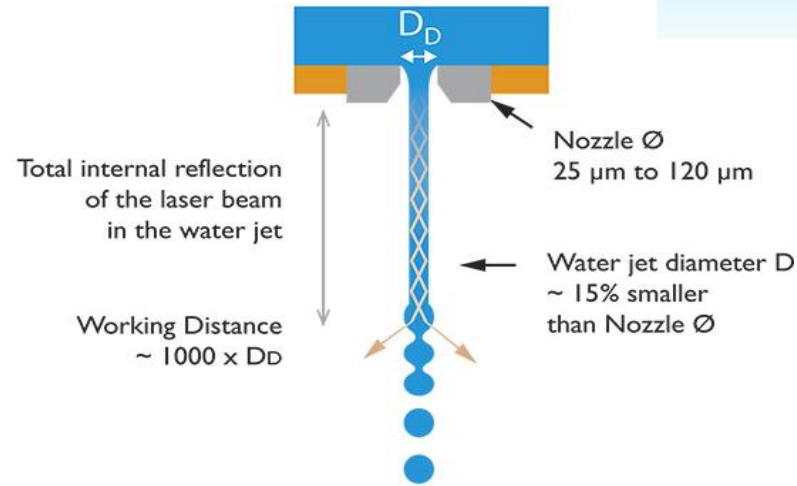
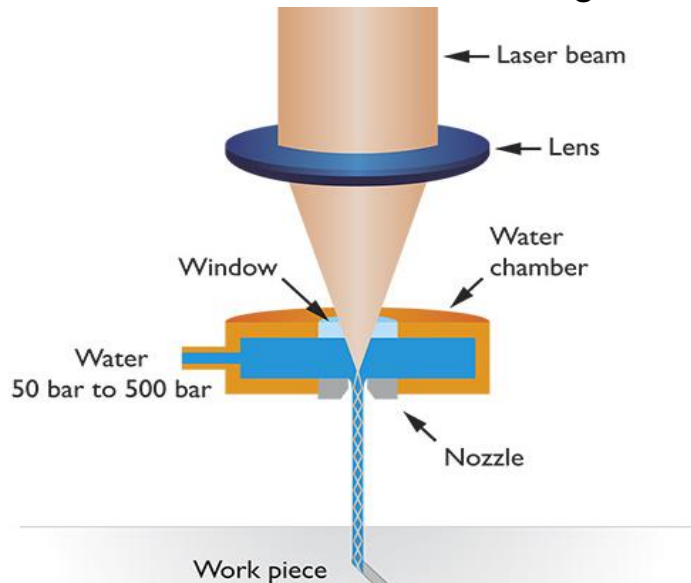


Dr. Helgi Diehl,
14th September 2017

Laser Microjet Technology - a simple principle

A Revolution in Micromachining

- For the first time ever, it is possible to combine the advantages of both water and laser cutting in one operation.



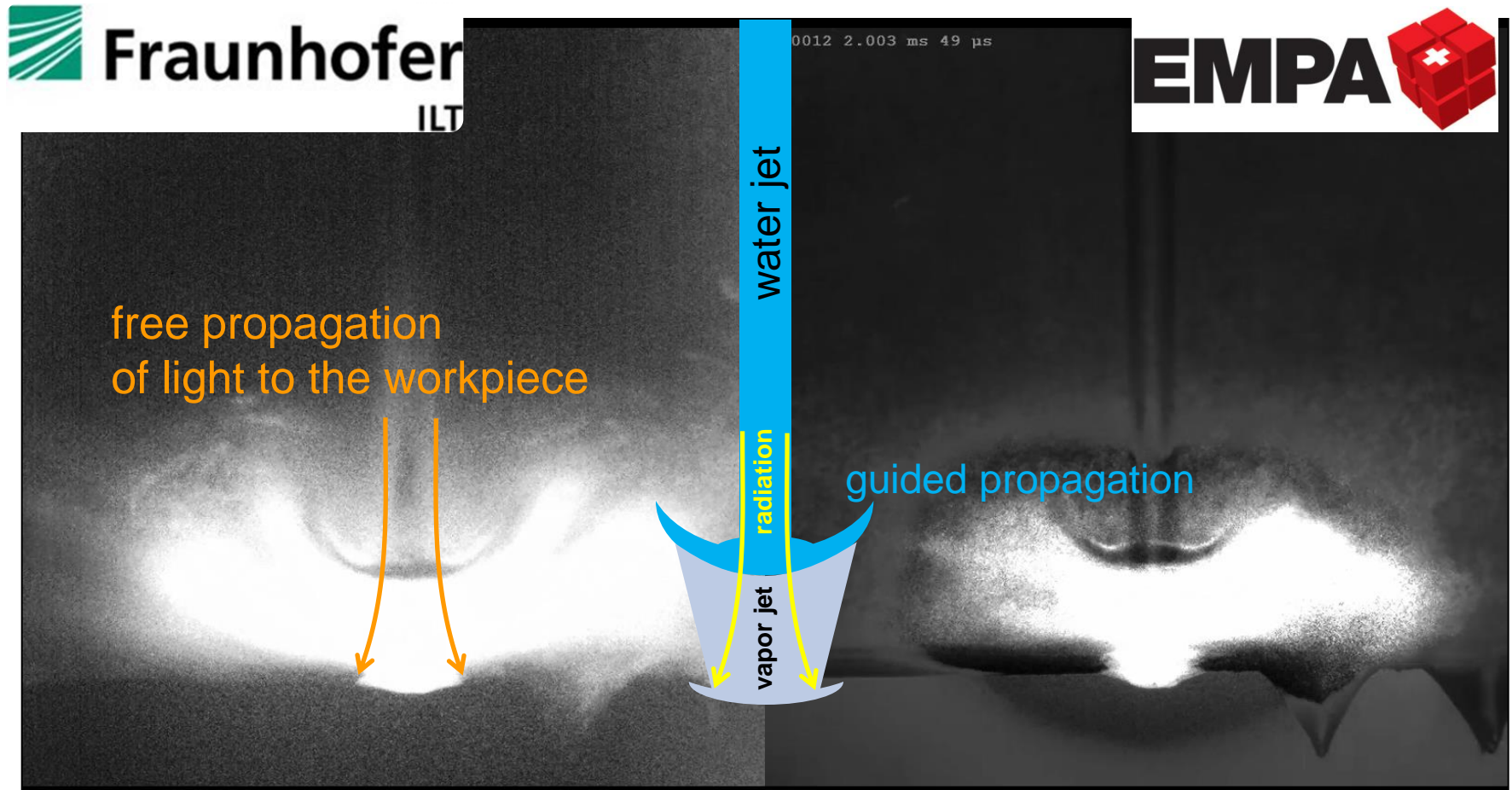
- Utilizing the difference in the refractive indices of air and water, the technology behind Laser MicroJet® creates a laser beam that is completely reflected at the air-water interface.
- The laser is, therefore, entirely contained within the water jet as a parallel beam, similar in principle to an optical fiber.



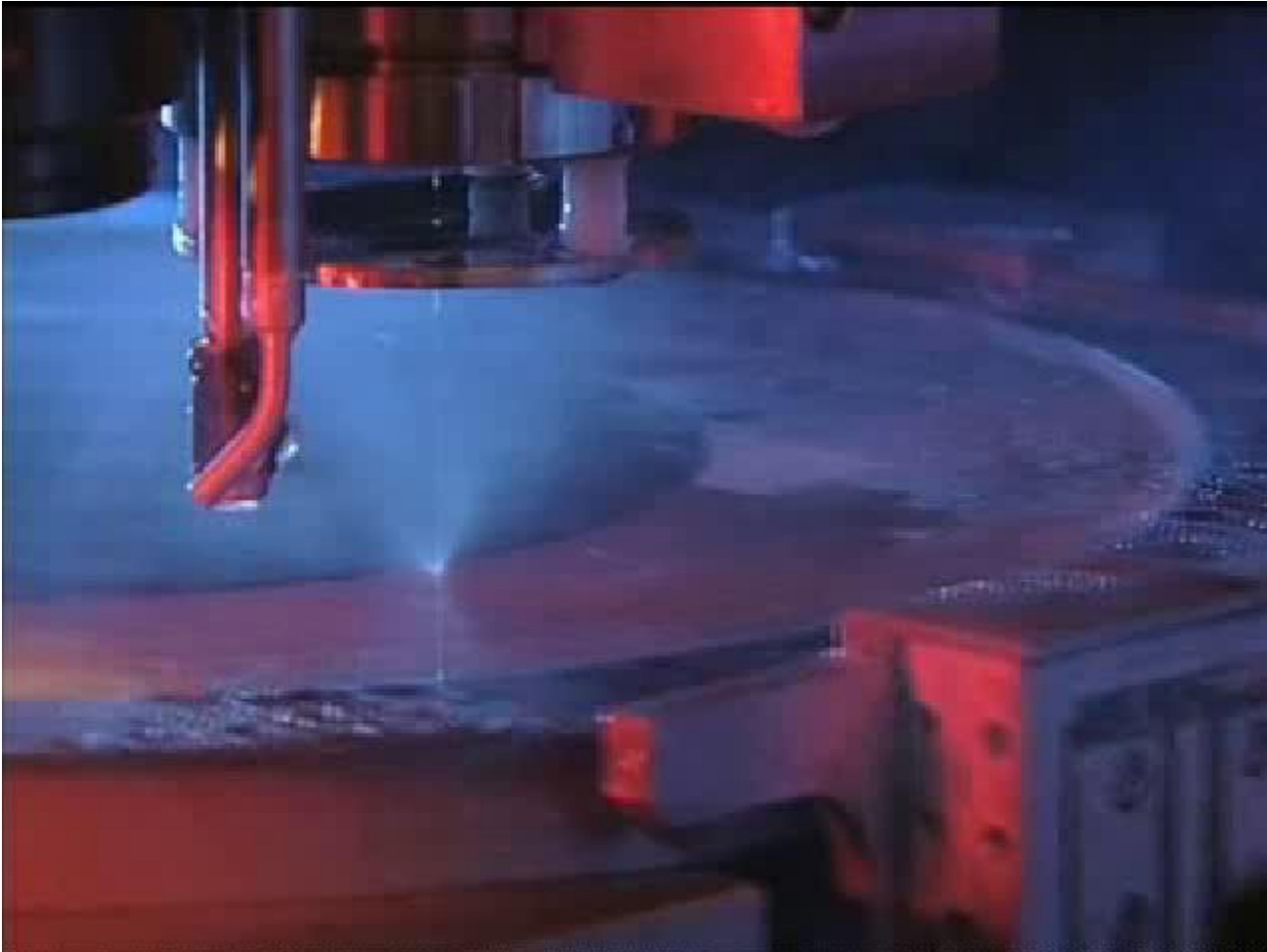
The Plasma-Jet lift-off effect

Identification of jet liftoff

Plasma and vapor lift the jet off the material

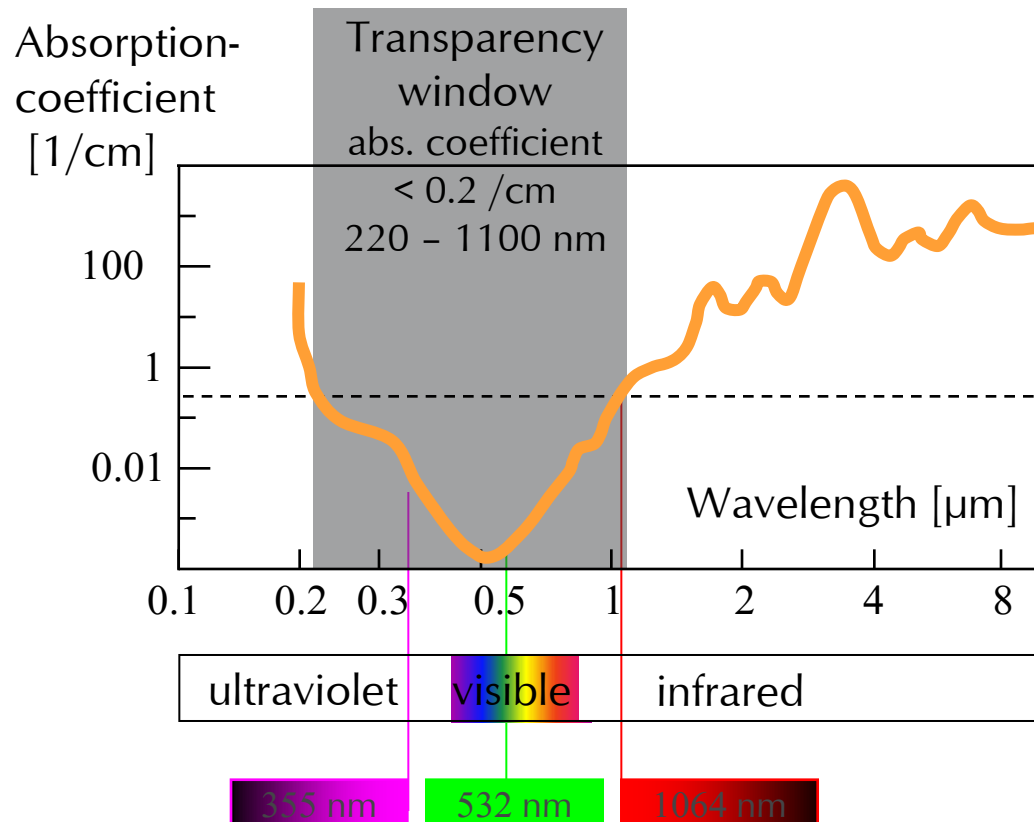


Simulation



Laser choice = Wavelength choice

Water is sufficiently transparent in the range between 220 nm and 1100 nm:



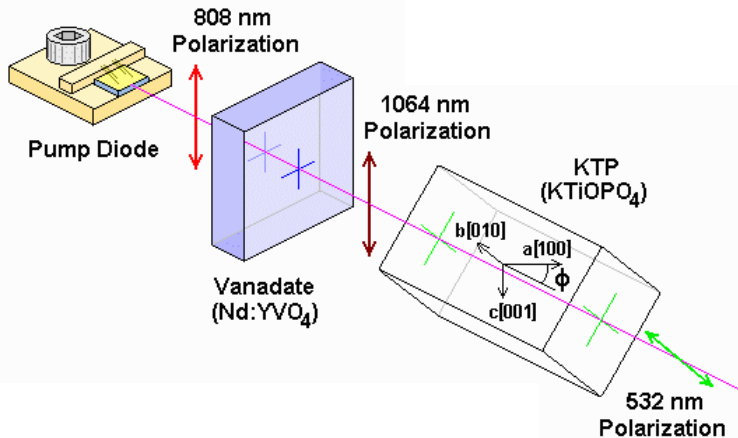
The green laser is very close to the optimum due its very low absorption.



Laser choice: DPSS lasers and applications

Advantages of DPSS lasers

High pulse energy
Mature technology
Efficiency



Used parameter range

Average Power	5 W - 350 W
Repetition rate	5 - 40 kHz
Pulse energy	7 mJ – 50 mJ
Pulse duration	80 ns – 500 ns

DPSS laser application areas

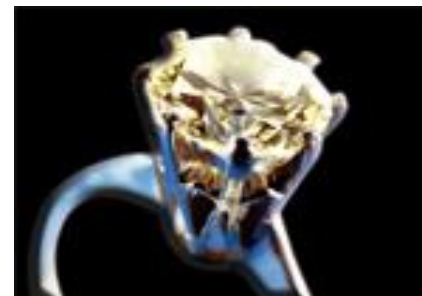


Ceramics and hard materials

AlN, AlO, SiN,
AlTiC, LTCC, ZrO,
CBN, PCD

Composites

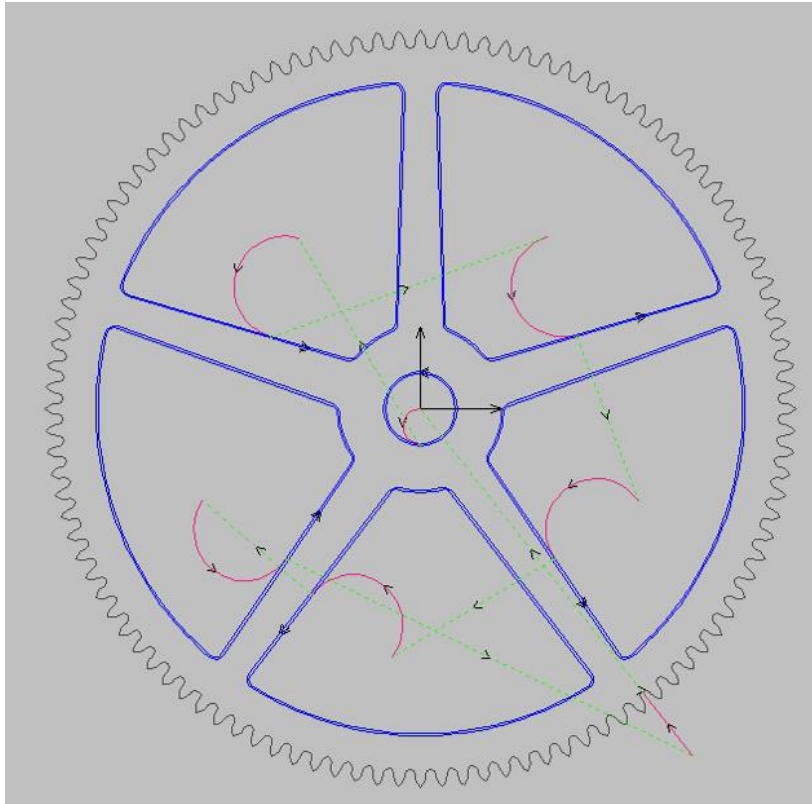
Carbon fiber reinforced composites



Diamond



Laser choice: Watch applications

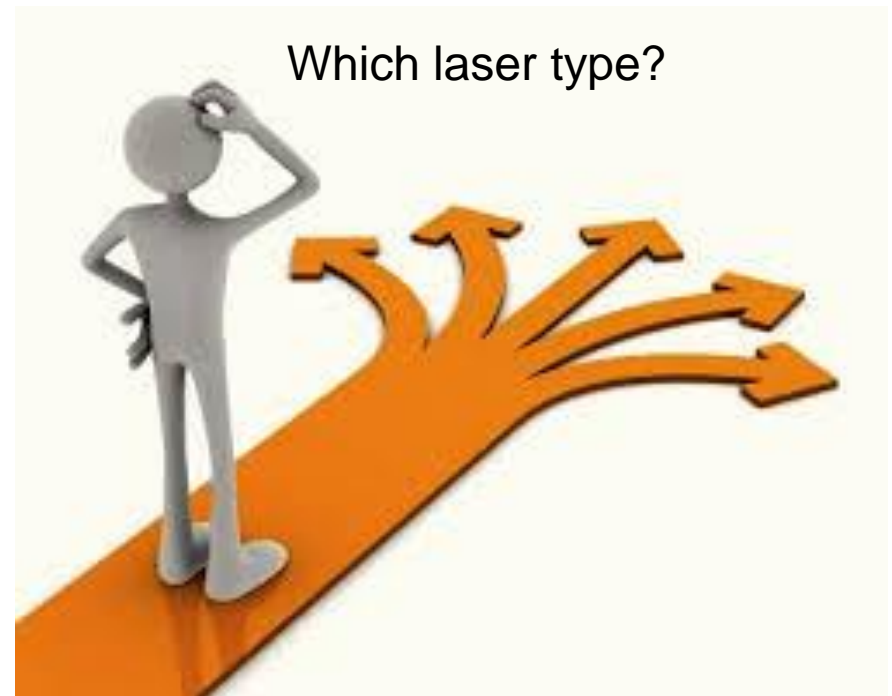


Customer requirements

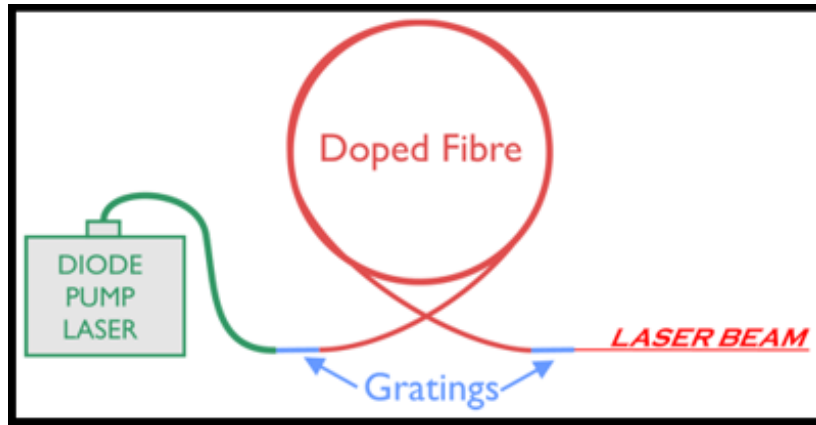
Thickness	0.1 – 0.8 mm
Ra	100 – 200 nm
HAZ	<5 μm (visually)

Required laser parameters

Average Power	5-20 W
Pulse Energy	50 μJ – 200 μJ
Repetition Rate	Up to 150 kHz
Pulse Duration	6 ns - 20 ns



Laser choice: Fibre lasers for watch applications



Univ. Southampton

Advantages of fibre lasers

Flexibility

Easy beam delivery

Compact size

Reliability and Vibrational Stability

Parameter range

Average Power up to 30 kW possible

Repetition rate Hz - MHz

Synova's choice

V-GEN-20-G



Laser parameters for watch applications

Average Power 9-10 W

Pulse Energy 90 μ J – 100 μ J

Repetition Rate 100 kHz

Pulse Duration 12 ns

Peak power 10 kW

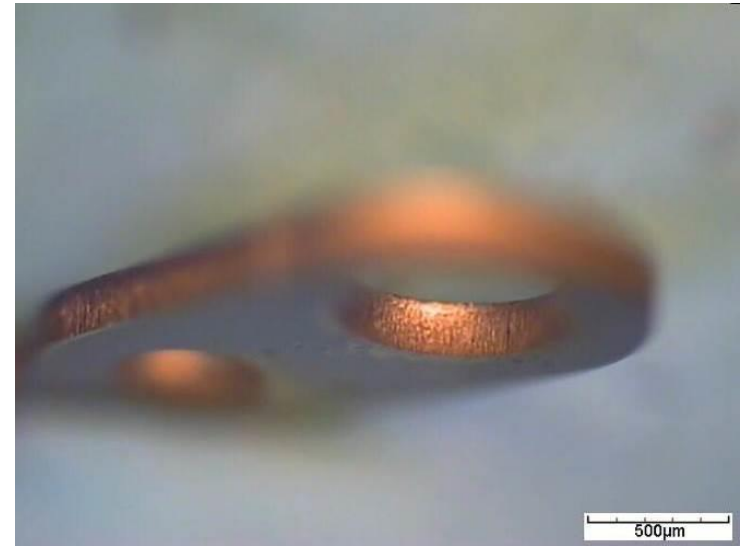


Application: Durnico (X2NiCoMo) 0.2 mm

Spring hook



Processing strategy	Multi-pass
Roughness Ra, nm	200
Overall Speed, mm/s	0.05

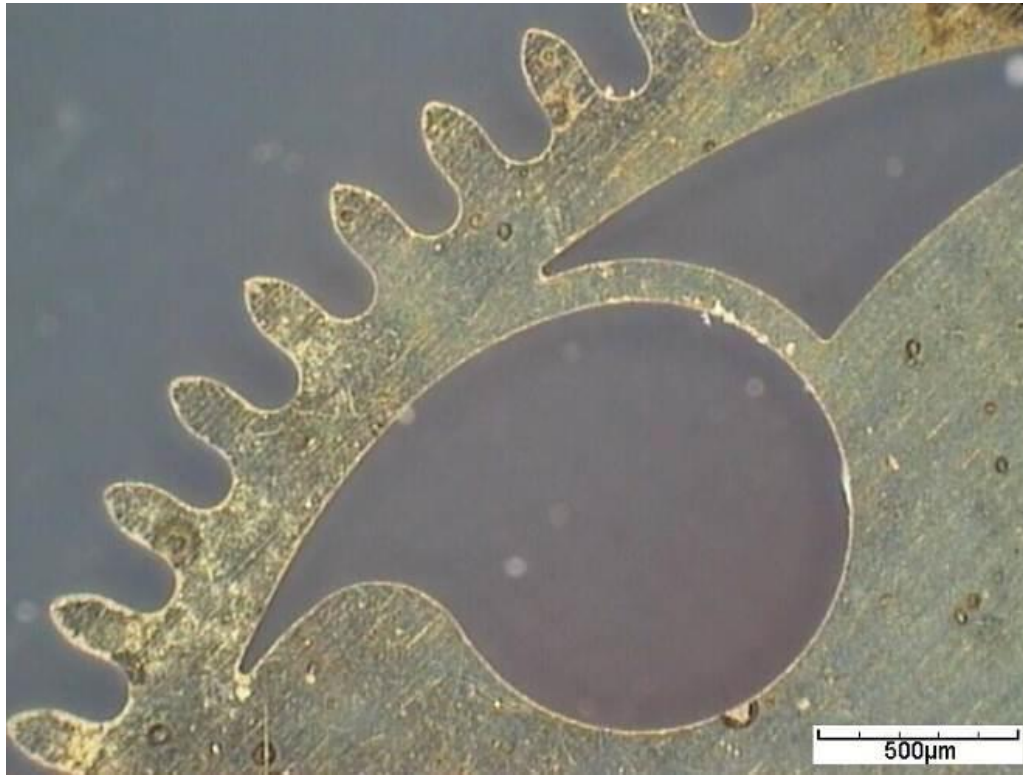


3D view

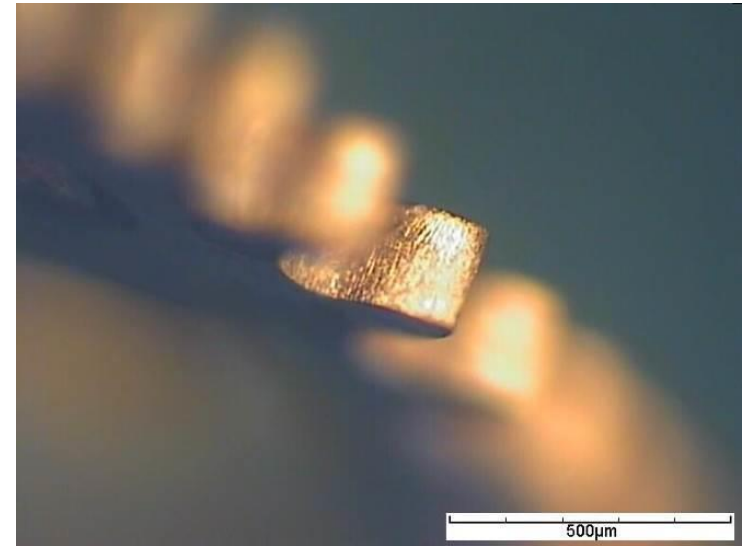


Application: Durnico (X2NiCoMo) 0.2 mm

Seconds Wheel



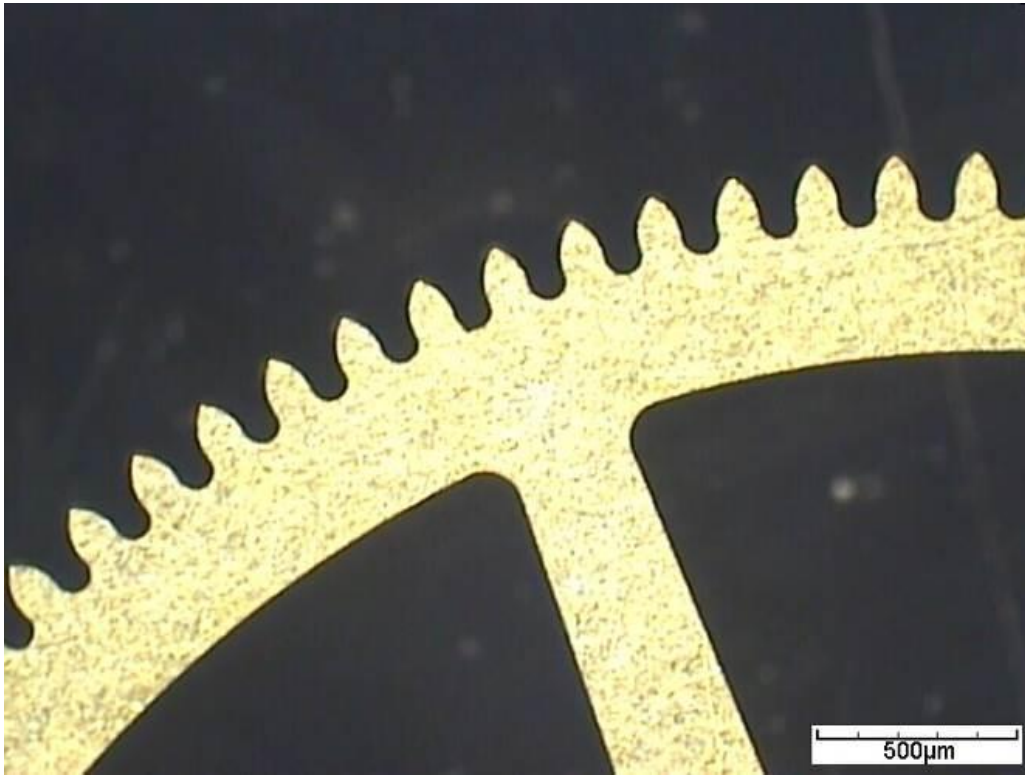
Processing strategy	Multi-pass
Roughness Ra, nm	200
Overall Speed, mm/s	0.06



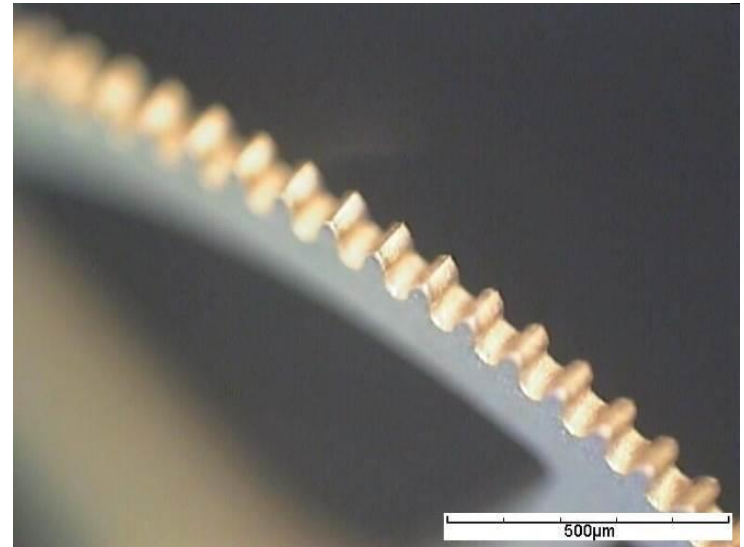
3D view

Application: CuNiZn 0.2 mm

Seconds Wheel



Processing strategy	Multi-pass
Roughness Ra, nm	150
Overall Speed, mm/s	0.05

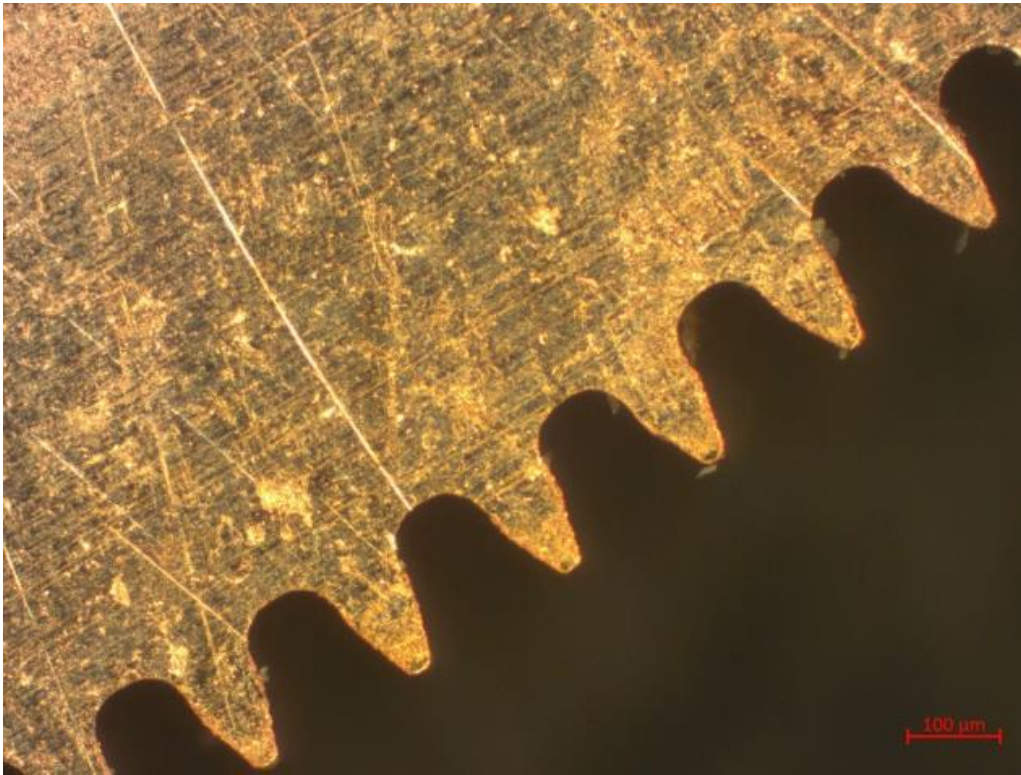


3D view

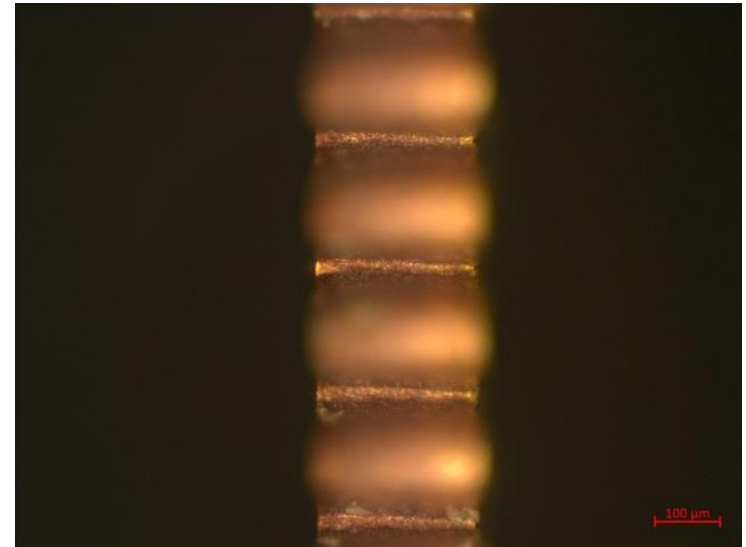


Application: CuBe 0.25 mm

Seconds Wheel



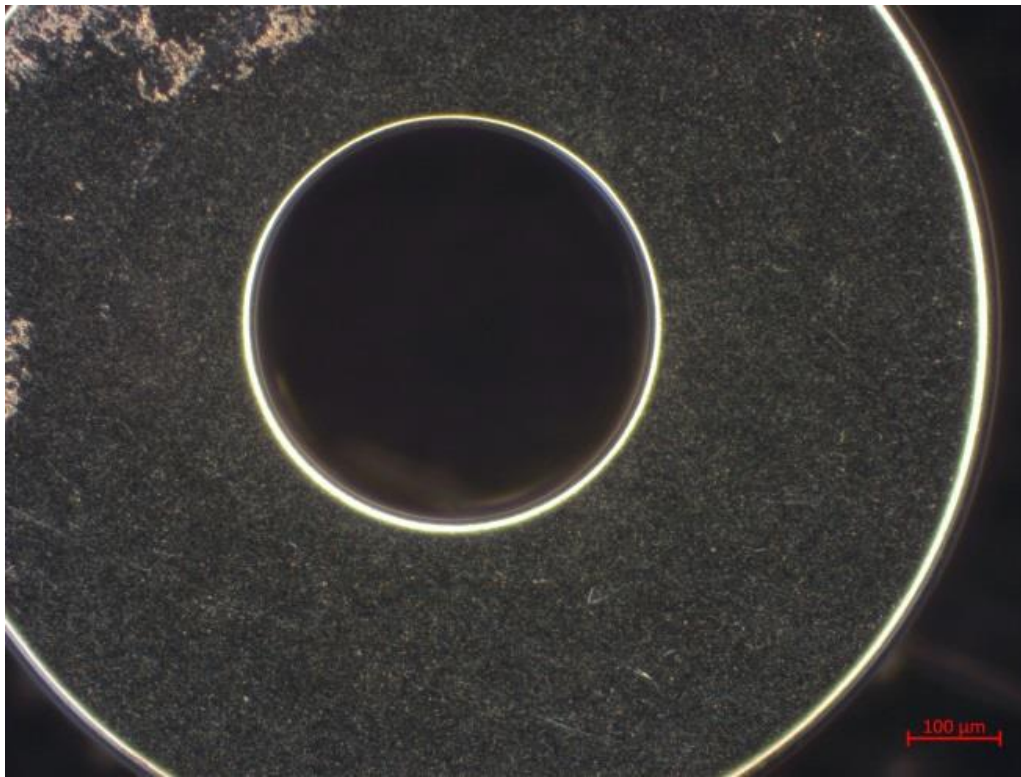
Processing strategy	One pass
Roughness Ra, nm	
Overall Speed, mm/s	0.05



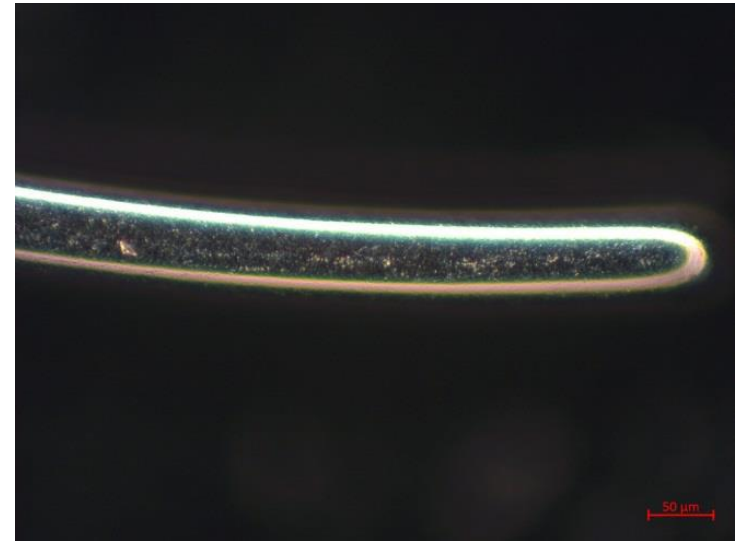
3D view: Radius = 10 μm

Application: Phynox (CoCr20Ni15Mo7) 0.1 mm

Spring (hole)



Processing strategy	One pass
Roughness Ra, nm	220
Overall Speed, mm/s	0.1

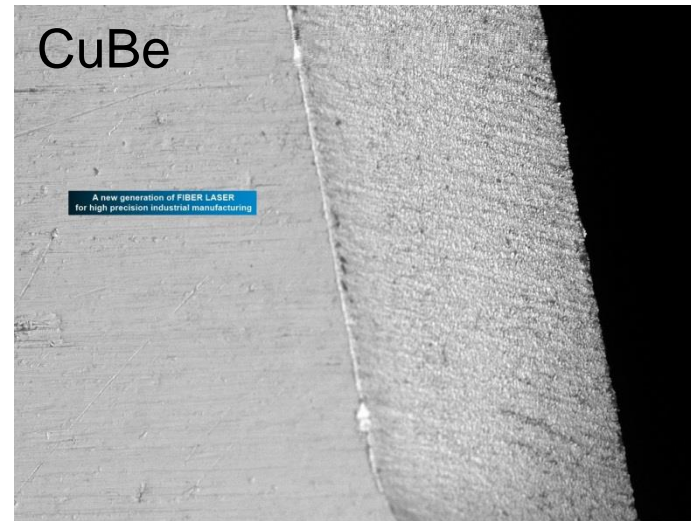


Spring: side view

Application: SEM pictures of Watch parts 0.15 mm



LAB-0109 2013/01/29 16:36 AL x300 300 um



LAB-0113 2013/01/29 16:45 AL x500 200 um



LAB-0103 2013/01/29 16:05 AL x500 200 um



LAB-0081 2013/01/29 14:35 AL x30 2 mm



Summary

- Laser MicroJet is a versatile tool for high quality microstructuring of ceramics, metals, composites and diamonds
- Usually applied DPSS lasers cannot meet the requirements of the watch and luxury good markets
- Green Fibre laser like VGEN-xx-G series from Spectra Physics is a good and reliable tool in LMJ applications for the watch industry applications
- Materials like Durnico, Phynox, CuBe, CuNiZn, Brass can be processed with roughness values down to 150 nm and overall speed up to 0.1 mm/s
- High quality cuts on materials up to 0.15 mm meet the requirements of the customers in respect to the achieved form (taper) and surface quality

