SYNOVA

Innovative Laser Systems

Laser MicroJet®

…a technology for

- prototyping
- design innovation
- mass customization
- small / mid-sized manufacturing runs

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EPMT – EPHJ
Swissphotonics seminar

June 2015, 4th

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technology

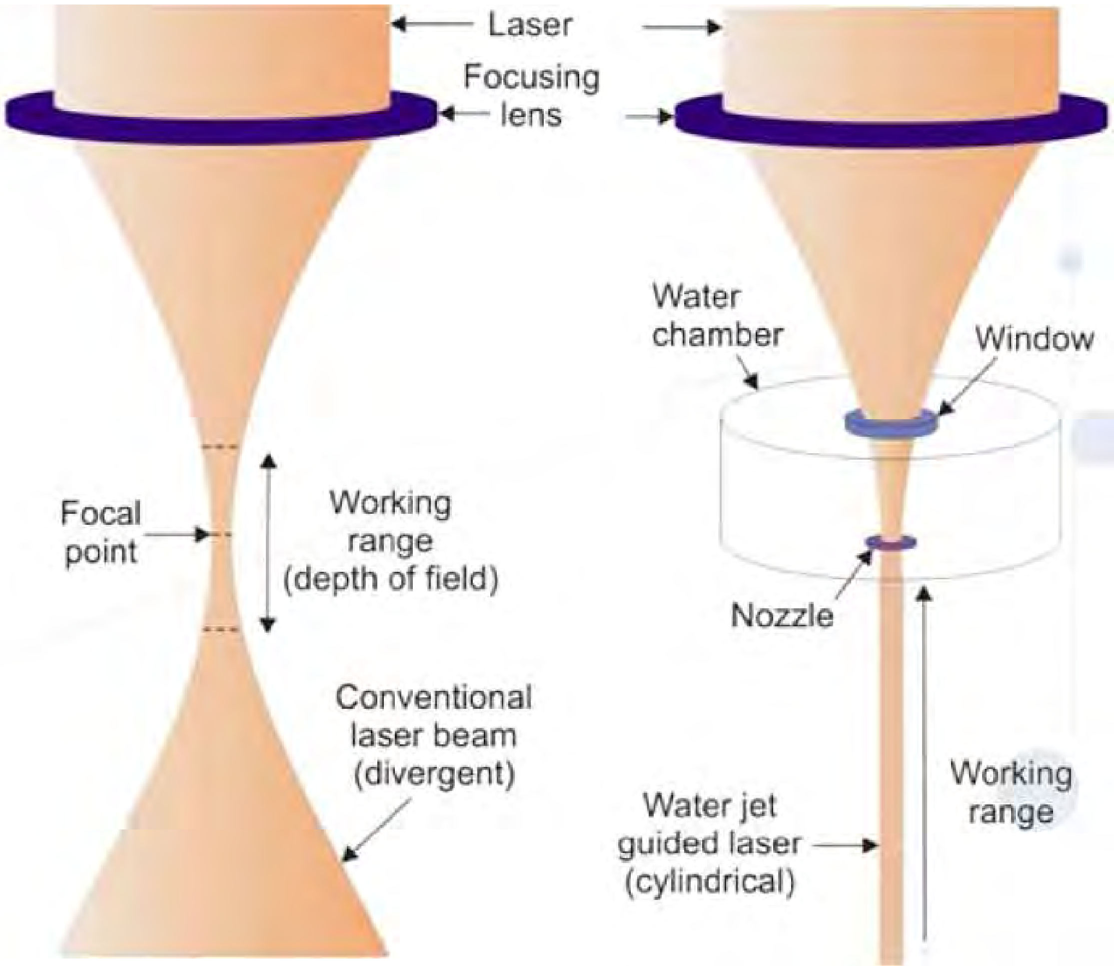
Laser Microjet ® Technology – a perfect tool

The perfect shape

- The conventional focused laser beam has a limited working distance of just a few of a mm, due to beam divergence, making precise focussing and distance control necessary, so limiting the ratio of kerf width to depth.
- The Laser MicroJet® technology employs a laser beam which is completely reflected at the air-water interface, where the beam can be guided over a distance of up to 10 cm, permitting production of parallel high aspect ratio cut kerfs. No focussing or distance control is required.

Conventional laser beam

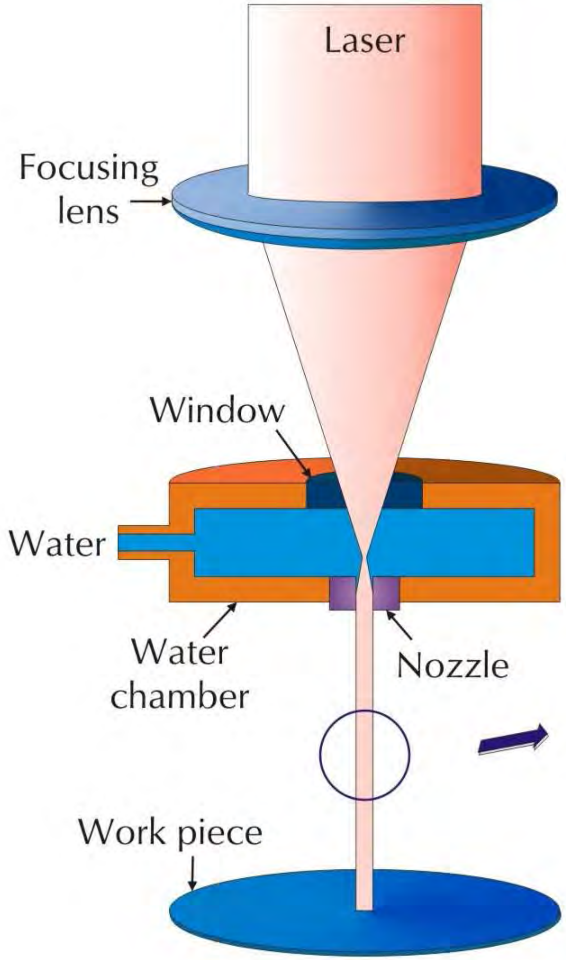
MicroJet laser beam

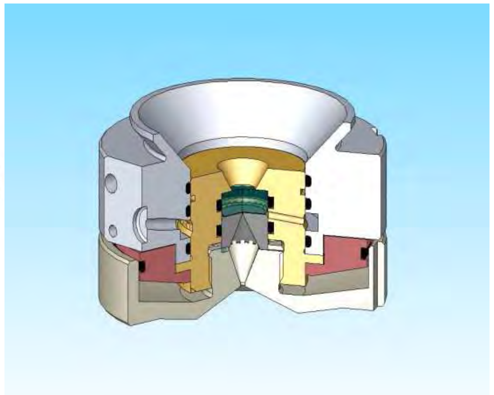


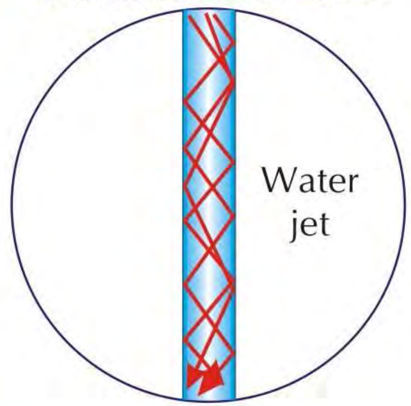
Laser Microjet ® Technology – a simple principle

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.
- Using 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.

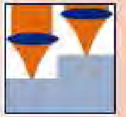
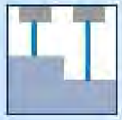
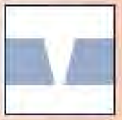
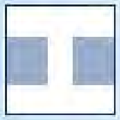
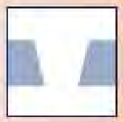
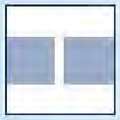
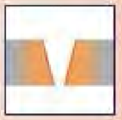
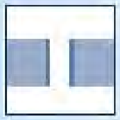
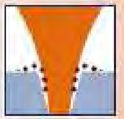
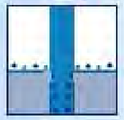
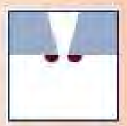
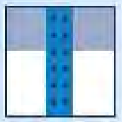






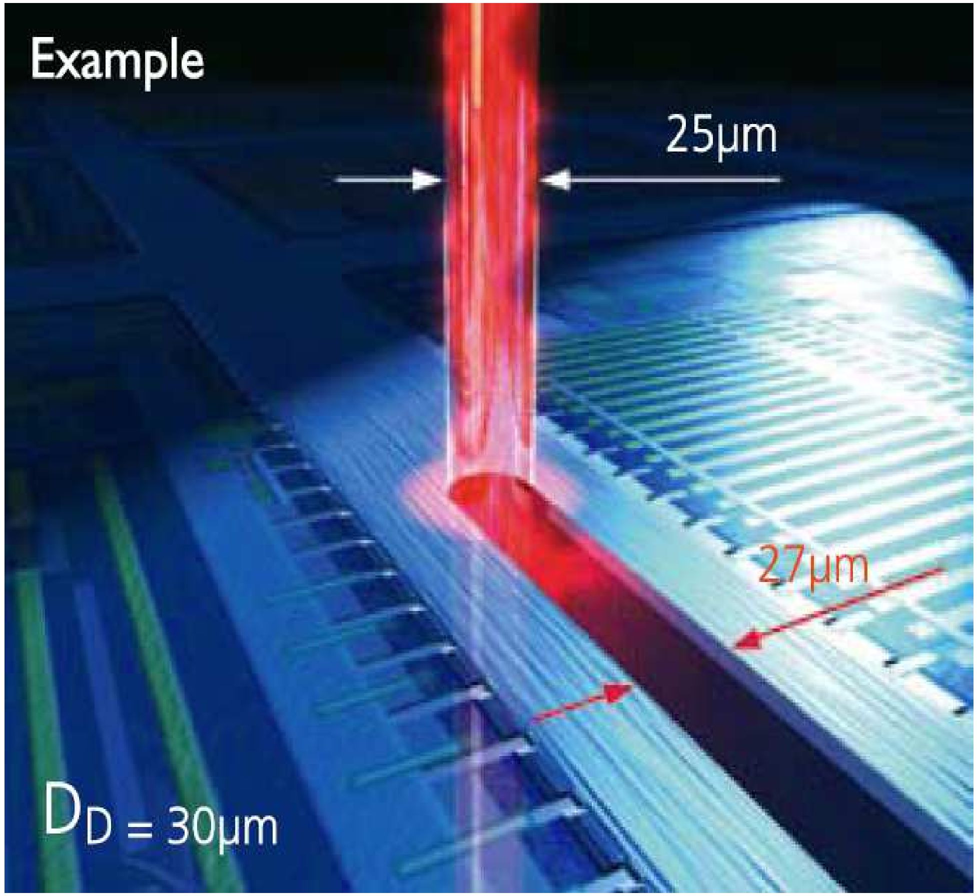
Technology advantages

LMJ solves all drawbacks of conventional lasers

Conventional Laser			Laser MicroJet®
Requires precise focus adjustment			No focus adjustment required, non-flat surfaces are not an issue, 3D cutting possible, variable cutting depth of up to several cm
Conical laser beam leaves non-parallel kerf walls			Cylindrical beam results in parallel kerf walls, consistent high quality cutting
Limitations in cutting aspect ratio			High aspect ratio, very small kerf widths (< 30 µm possible), minimising material loss, with simultaneous deep cuts possible
Heat affected zone			Water-cooling process avoids thermal damage and material change, high fracture strength is maintained
Particle deposition			A thin water film eliminates particle deposition and contamination, no surface protection layer required
Inefficient material removal leaves burrs			The high kinetic energy of the water jet expels molten material, no burrs form

as precise as EDM + as fast as laser

Laser Microjet ® Technology – thinner than a hair



Lasers
Lasers used are diode pumped solid state Nd:YAG lasers with pulse durations in the µs or ns range, operating at 1064 nm, 532 nm, or 355 nm. Average laser power ranges from 10 W to 300 W.

Water
Pure deionised and filtered water, at low pressure, is used. Because the jet is "hair thin," the level of water consumption is extremely low—in the order of 1 litre per hour at 300 bar pressure and the resulting forces exerted are negligible (<0.1 N).

Nozzle
The nozzles range in diameter from 20 to 150 µm and are made of sapphire or diamond, as these materials' hardness enables generation of a long, stable water jet over a long period of time without requiring replacement.

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markets

main Laser-Microjet® markets and applications

Watch Making :
Watch hands, precision metal parts

Hard Tooling :
Super hard material such as cubic boron nitride (CBN), polycrystalline diamond (PCD), silicon nitride (SiN)

Diamond Industrie :
Cutting of raw diamonds

Medical :
Stents, needles, implants, scalpels

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machines

LCS series: LCS 50, LCS150, LCS 300

LCS 50, 3- & 5-axis machines

Process Station

- 3/5-Axis table with CNC controller and servos.
- Work piece fixation and optional loading/unloading
- Interconnection for laser, pump optical head & vision

Utilities Cabinet

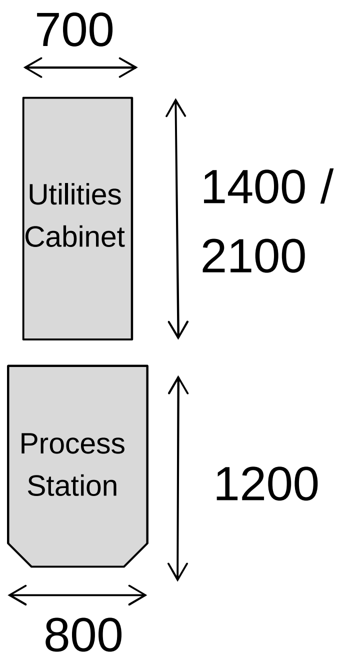
- Laser source
- Water pump
- Water treatment

Precision

+/- 1 µm

Floor Space

(mm)



Products

General purpose

Laser Cutting System (LCS)

Loading system

Dicing / trimming / scribing of wafers

Laser Dicing System (LDS)

Laser Edge-Grinding System (LGS) with DIT

Cutting of diamonds

Diamond Cutting System (DCS)

Machines with Manufacturing Partners

Tool Cutting / Turbine Drilling System (TCS / TDS 250) with Willemin-Macodel

Laser Cutting System (MCS) with Makino

Laser Drilling System with Posalux

Hybrid Laser Saw (HLS) with Disco

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watch applications

laser sources / thicknesses / Ra / speed

- **specialized sources for thin metals (short pulse lasers)**
  - power: up to 20 W
  - pulse duration: 7 to 20 ns
  - metal thickness: up to 300 µm
  - **typical Ra: 0,15 to 0,35 µm (down to 0,12 µm (Alicona))**
  - typical speed: 0,05 to 0,5 mm/s

- **polyvalent sources (long pulse lasers)**
  - power: 50 W, 100 W, 200 W, 300 W
  - tunable pulse duration: 80 to 400 ns
  - typical thickness: 0 - 4 mm (up to 10 mm)
  - **typical Ra : 0,35 - 0,7 µm**
  - typical speed: several mm/s

watch parts cut with Laser MicroJet®

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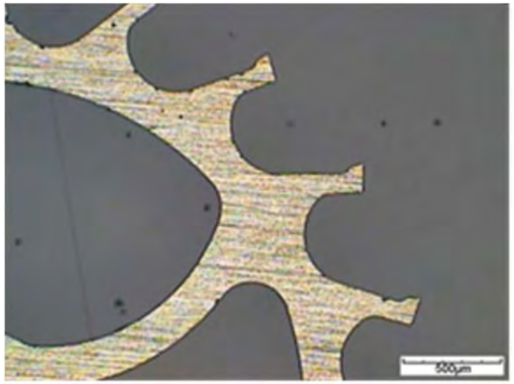
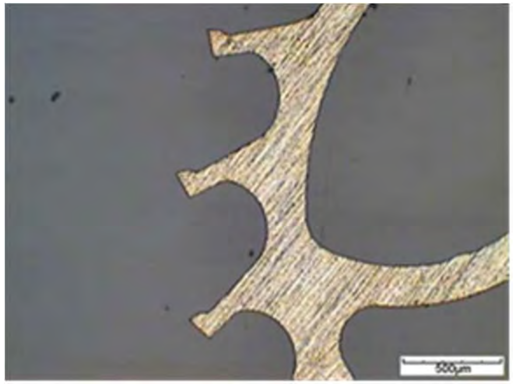
* short pulse laser
* single pass cut
* without finishing pass
* process time not optimized !

roue d'échappement Durnico 100 μm / production high speed; Ra = 0,35 μm (short pulse laser)

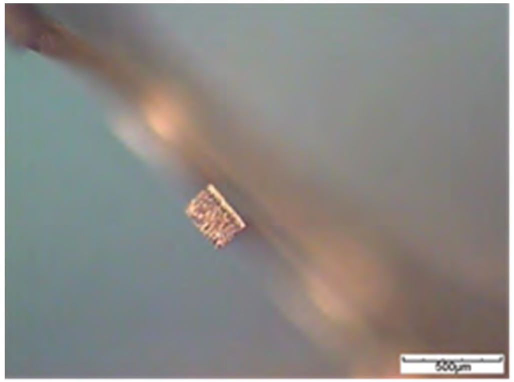
process time
1mn 20 s

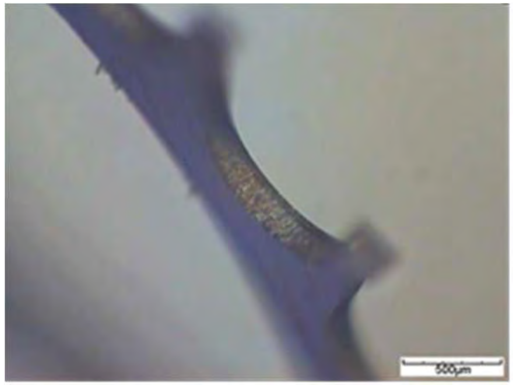


front side

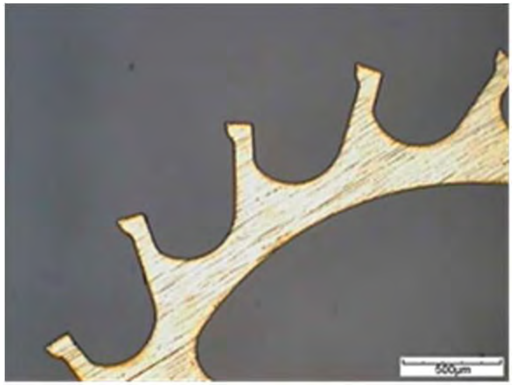


back side

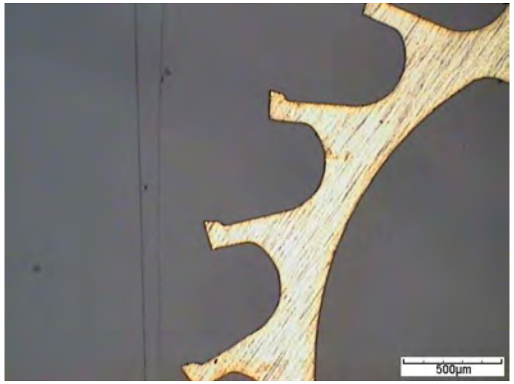




Roue d'échappement Durnico 100 μm (short pulse laser) medium speed, Ra = 0,29 μm

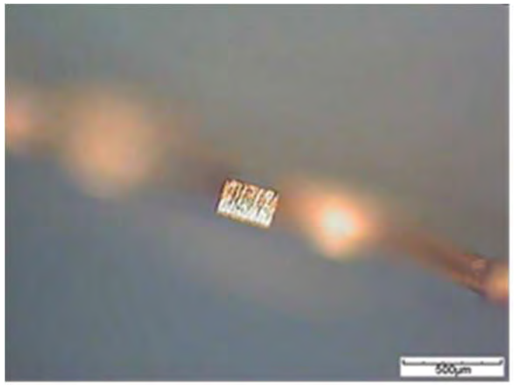


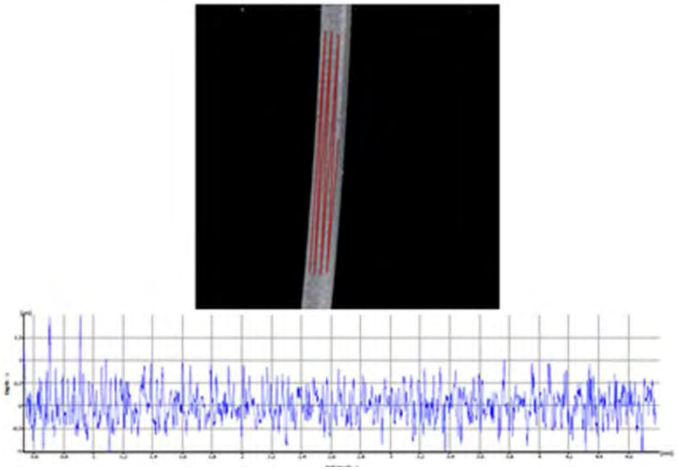
front side



back side

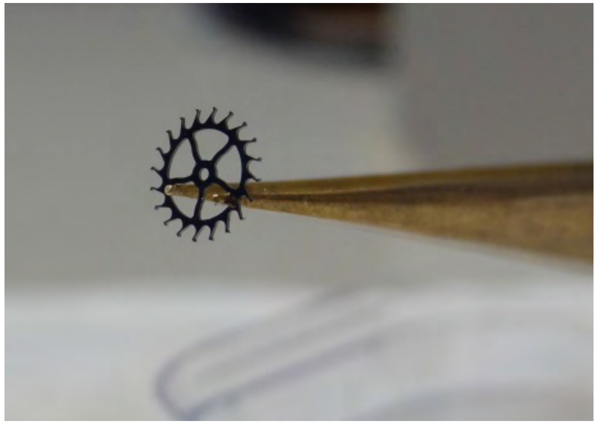
process time
2 mn 40 s

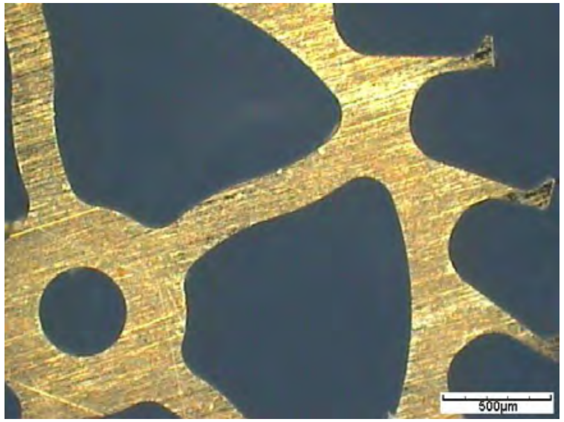


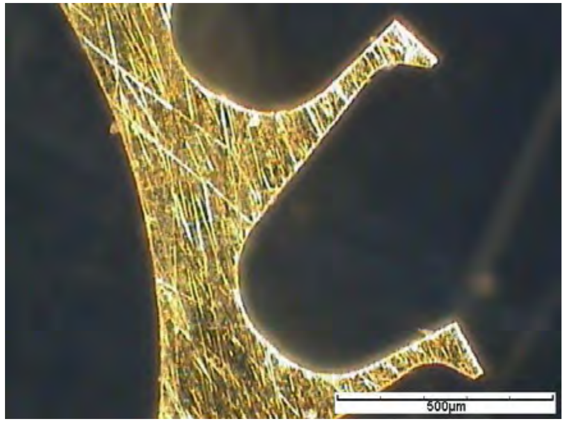


Ra = 0,29 μm

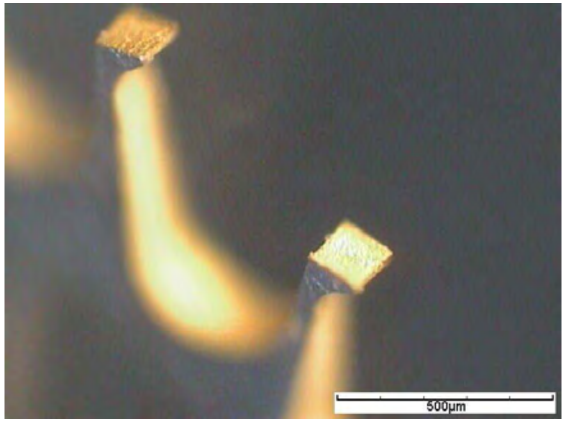
roue d’échappement, Durnico 150µm (short pulse laser) low speed, Ra = 0,2 µm

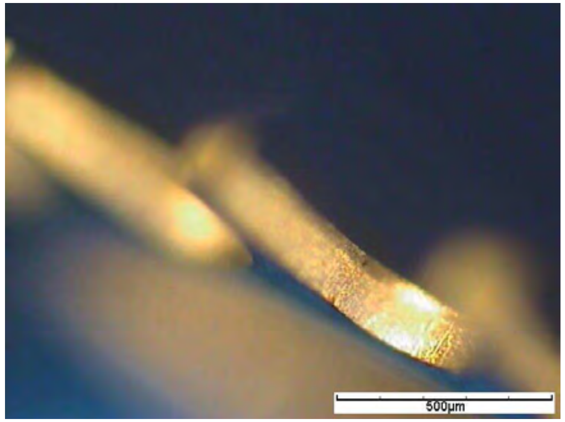




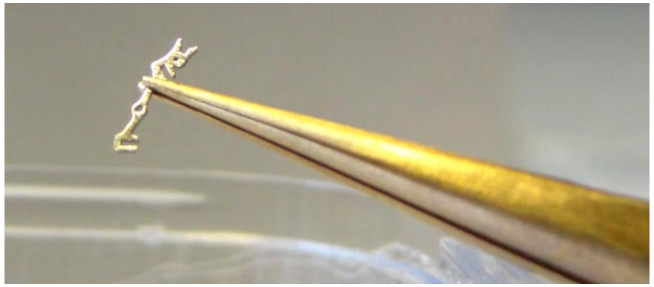


speed [mm/s]	Process time [min-sec]
0.2	5 min 29 s

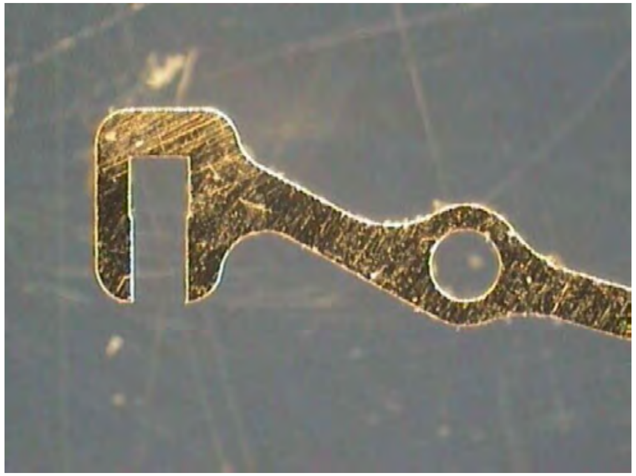


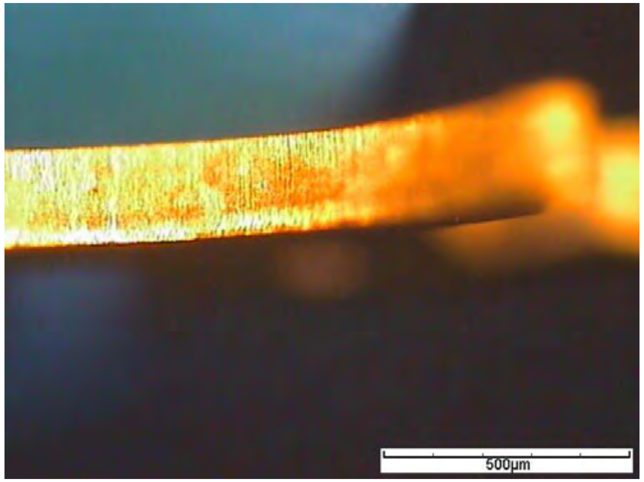


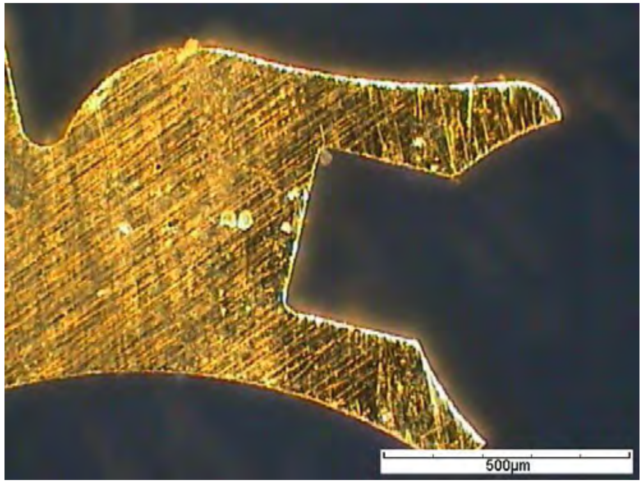
ancre en Durnico 200 µm (short pulse laser) very low speed, no taper



speed [mm/s]	process time
0.1	3 min 20 s







watch parts cut with laser microjet®

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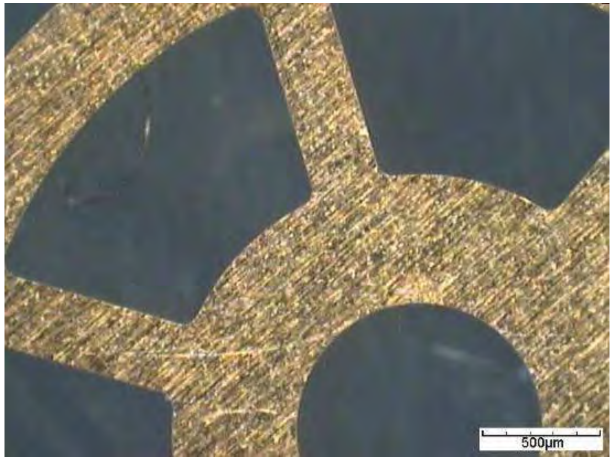
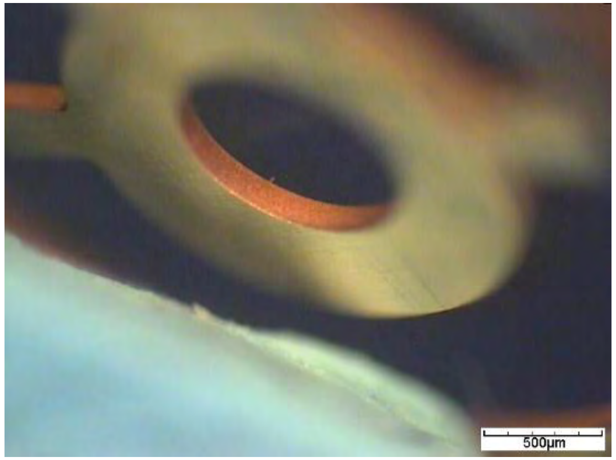
* short pulse laser
* single pass cut + finishing pass
* time not optimized !

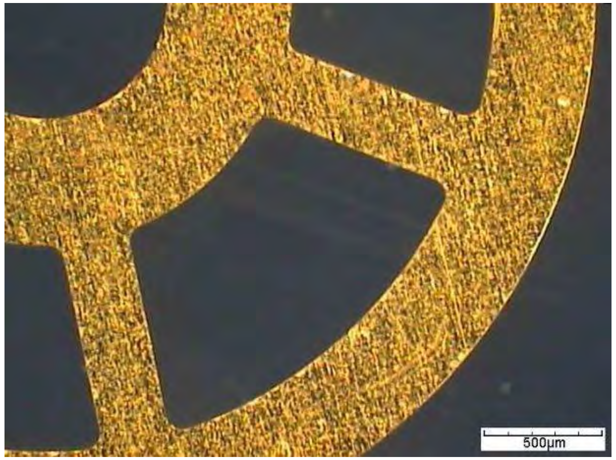
planche de réserve de marche en CuBe 150µm with finishing pass (short pulse laser)

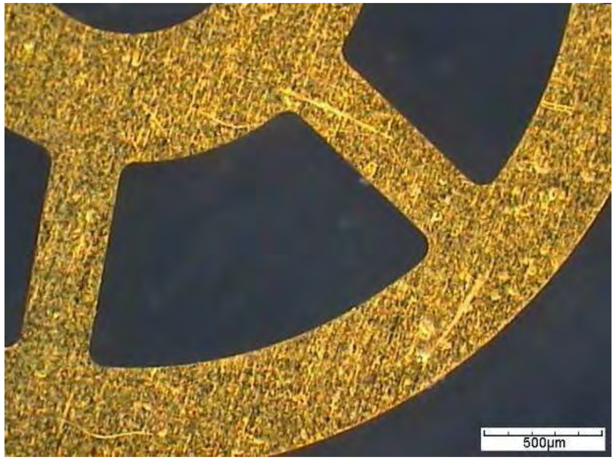




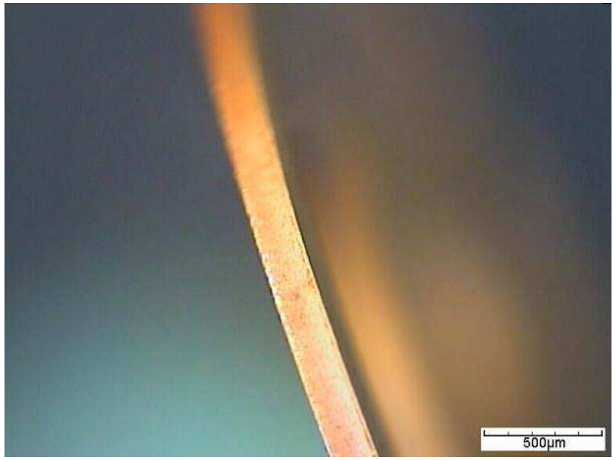
speed (ébauche) [mm/s]	speed (finishing pass) [mm/s]	process time
0.4	0.3	4 mn 54s

planche de réserve de marche en laiton 200 µm …with finishing pass (short pulse laser), no taper

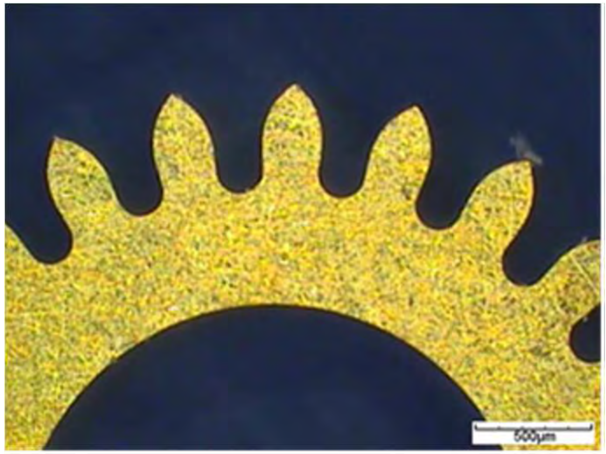


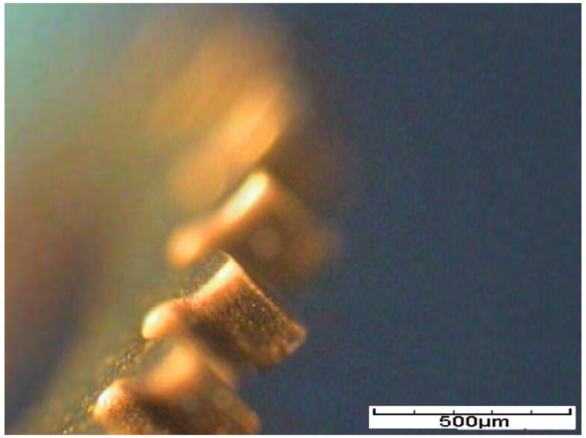


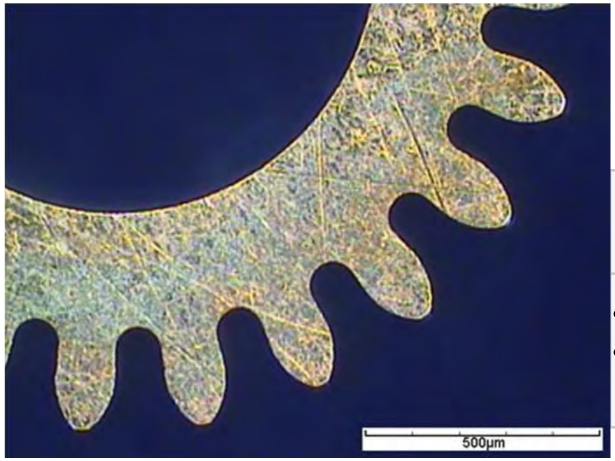
speed (ébauche) [mm/s]	speed (finishing pass) [mm/s]	process time
0.3	0.3	4 mn 54 s

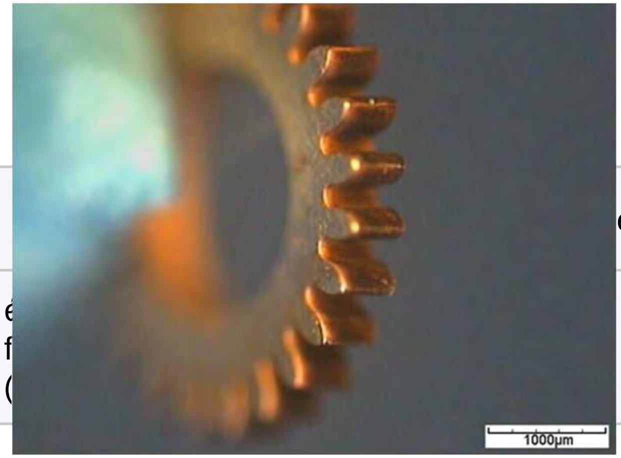


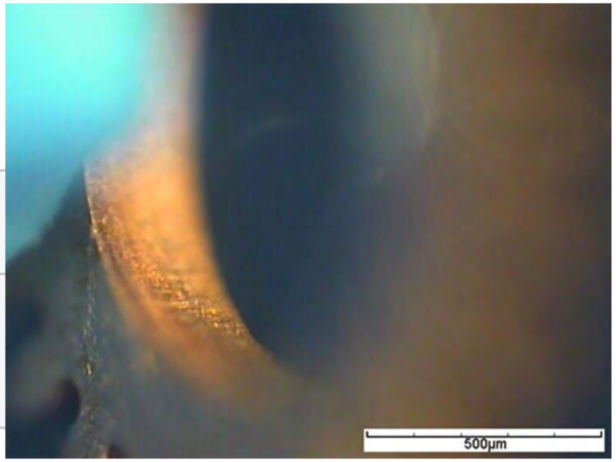
280 µm, no taper, time: 2mn 18 s ⇑ brass ⇓ CuBe



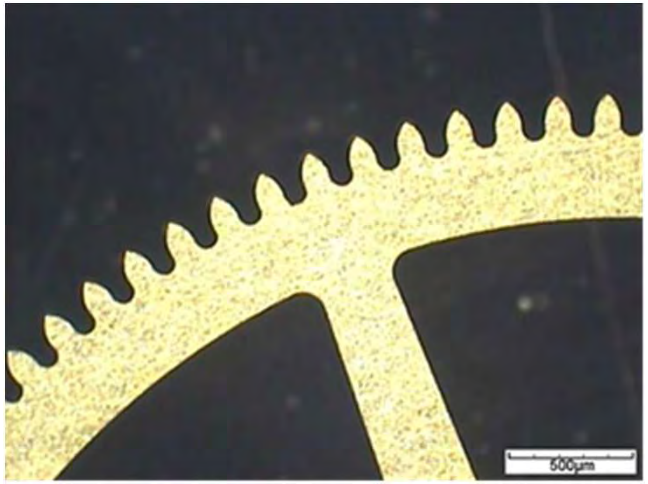




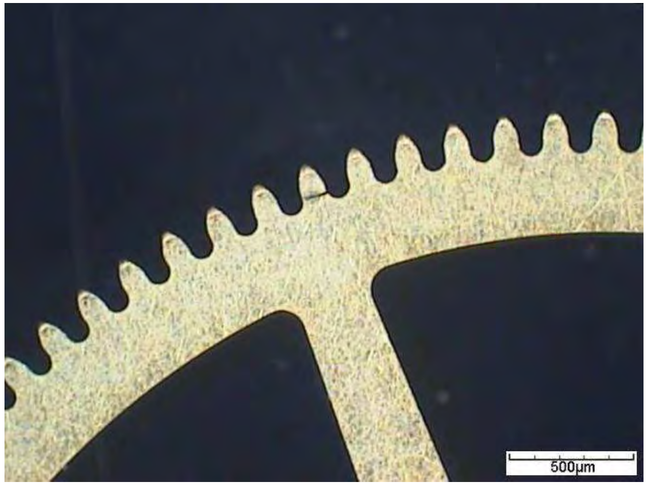




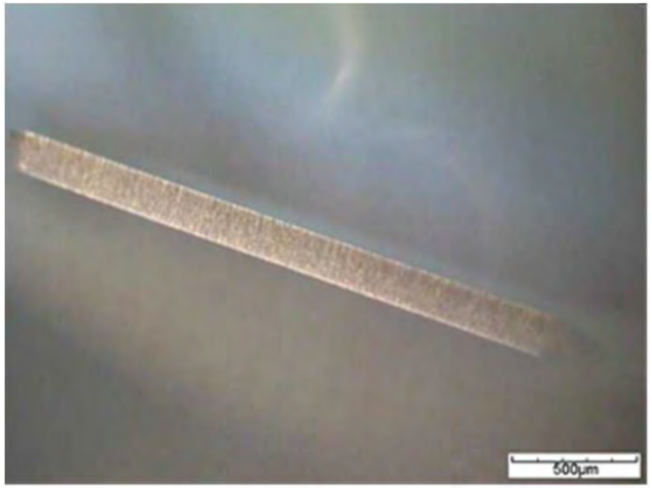
maillechort 200 µm, Ra = 0,15µm (short pulses)



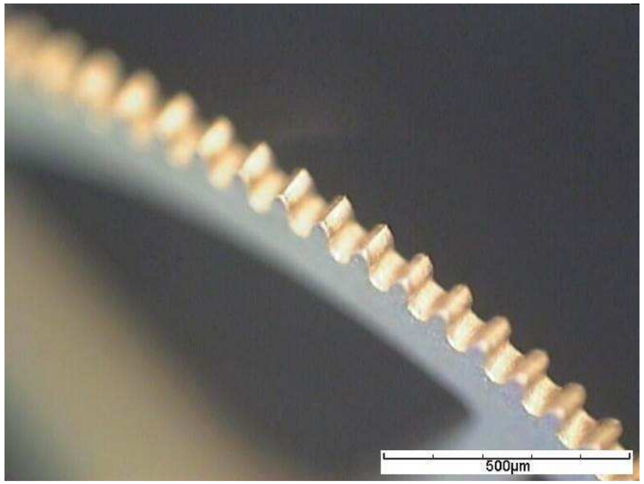
front side



back side



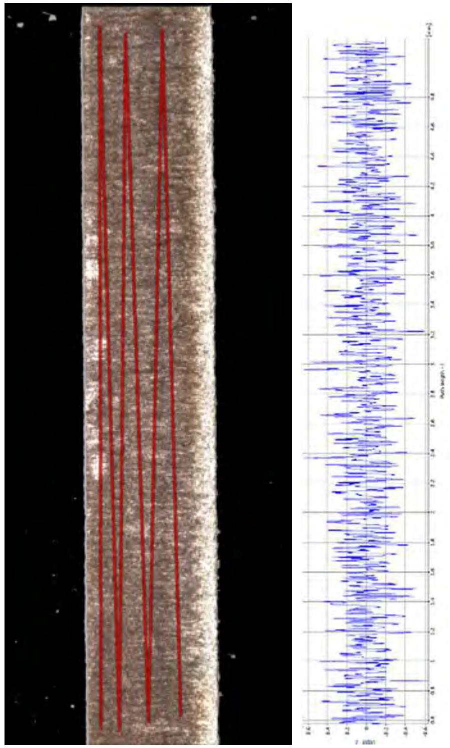
inner cut (with finishing pass)



outer cut (without finishing pass)

maillechort 200 µm, Ra = 0,15 µm (short pulses)

speed [mm/s]	process time
• ébauche: 0,1 mm/s • finishing pass: 0,1 mm/s (interior only)	18 mn 09 s



Ra=153.2 nm
Rq=190.1 nm
Rz=109.0 nm
(étude sur 3 mm, Lc=250.000 µm)

watch parts cut with Laser MicroJet®

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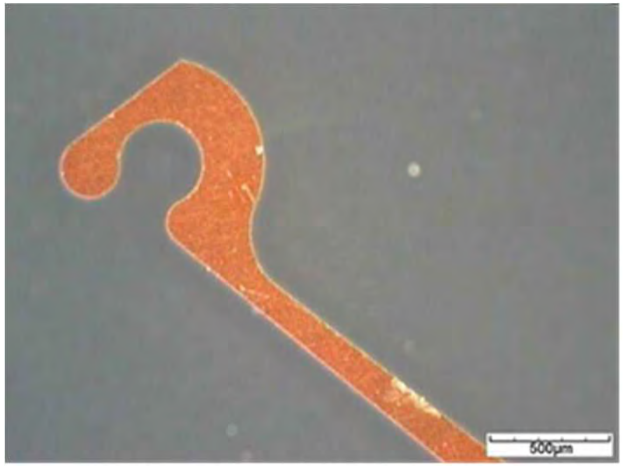
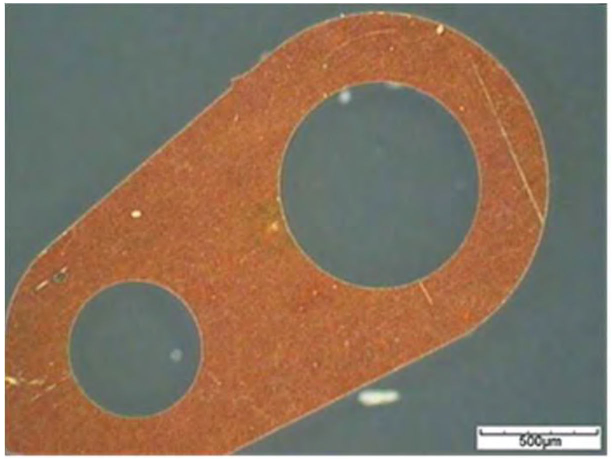
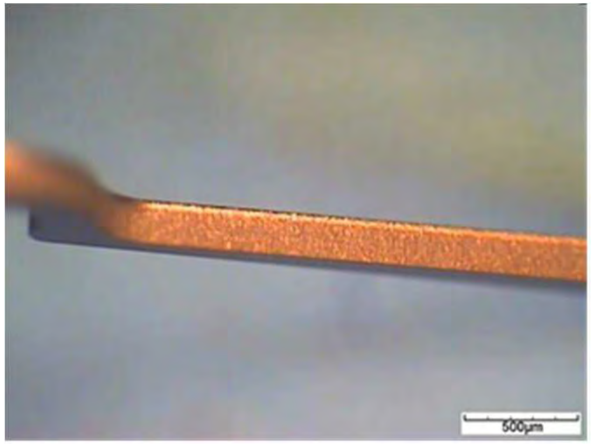
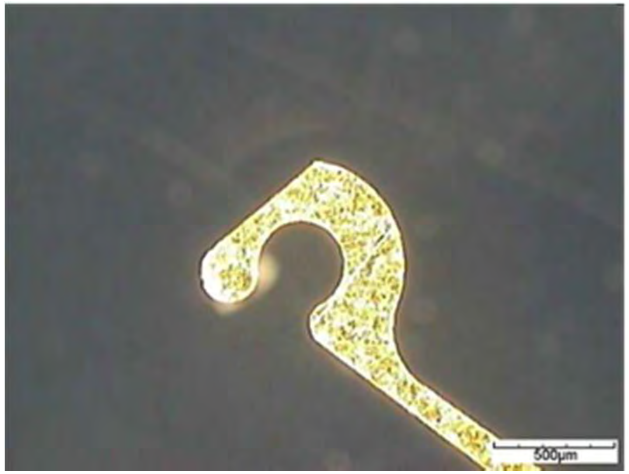
* long pulse lasers
* time not optimized !

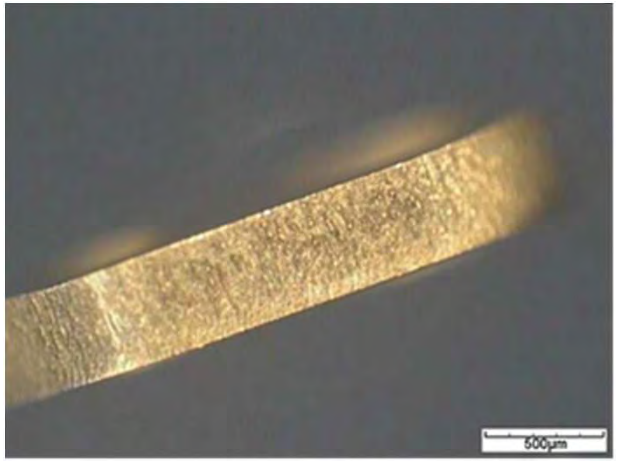
⇧ spring durnico 200 µm (short pulses) (5 mn 15 s)
⇩ 450 µm durnico (1,2) brass (3) (long pulses) (2 mn 29 s)

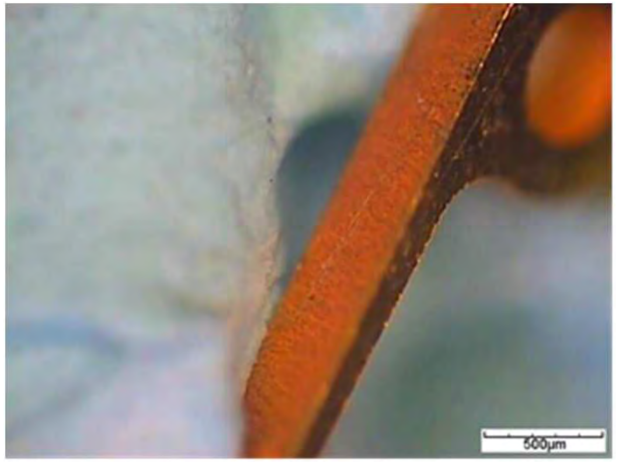




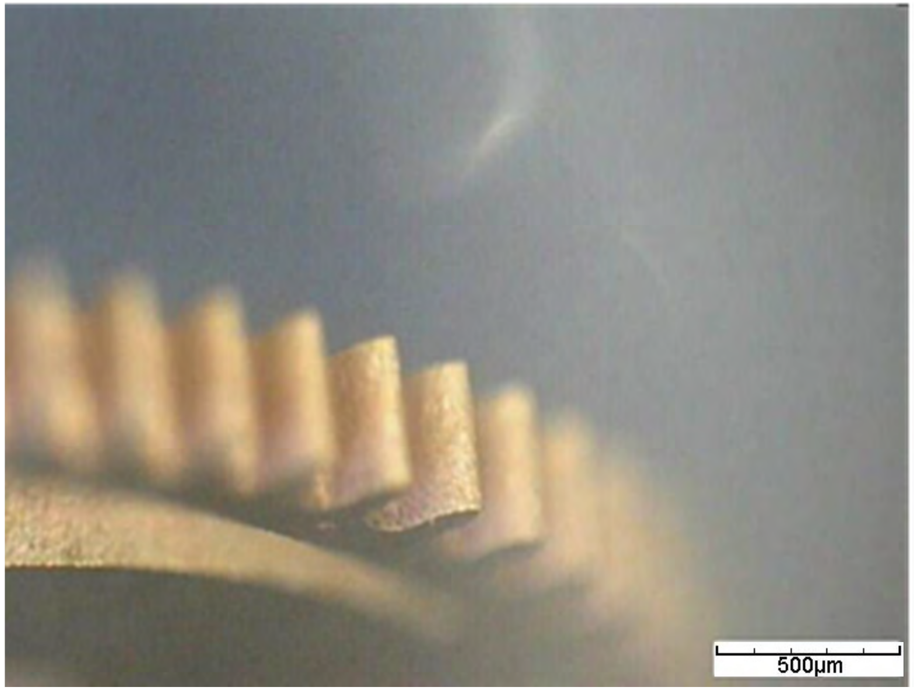




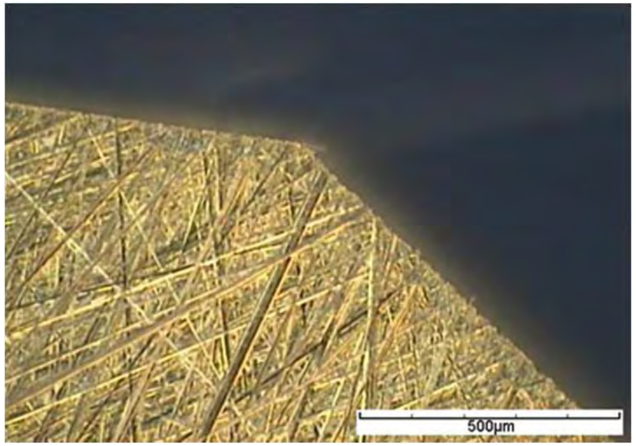




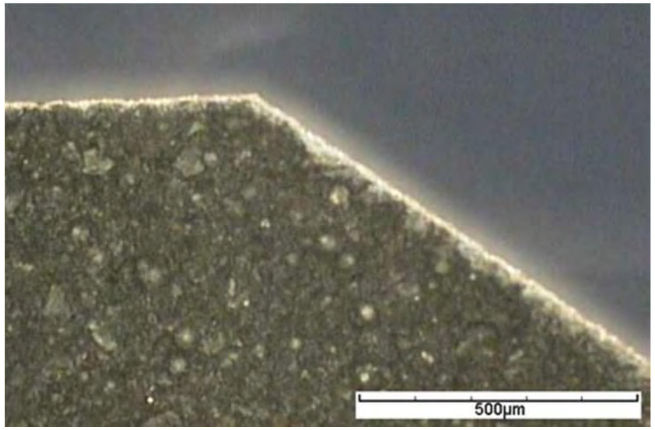
450 μm brass (long pulses), single pass, no taper



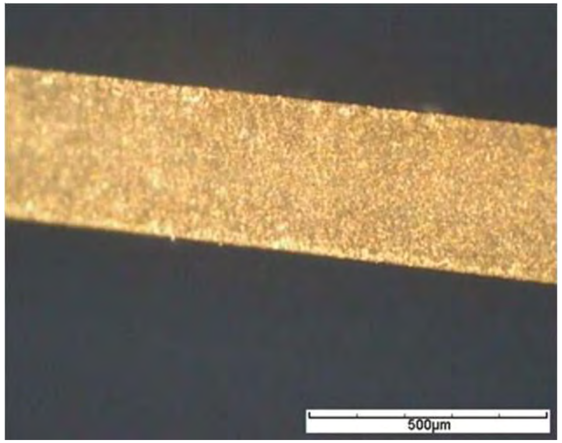
ceramic watch hands 280 μm (0,2 to 0,3 mm/s), single pass, no taper, no chipping



back side



front side (polished) side

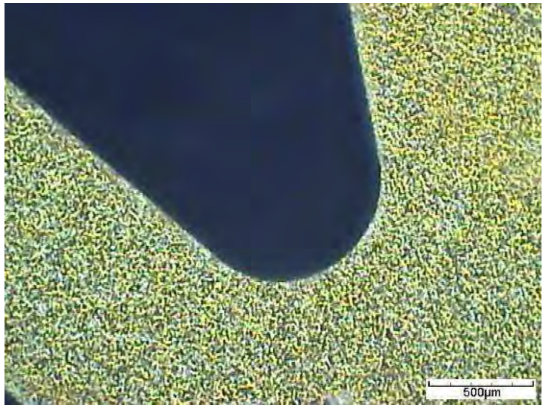


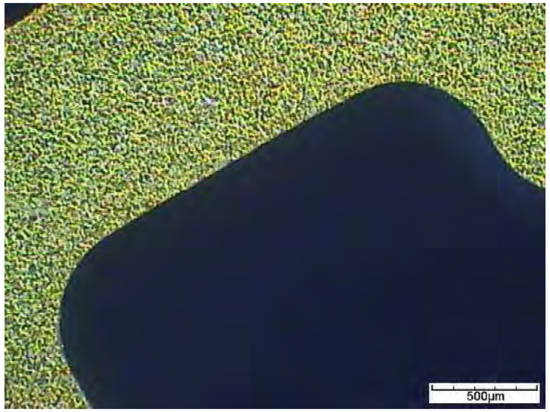
cutting across variable thickness 250 to 2170 µm, one-time process (time: 23-36 mn) (multiple pass + finishing pass) (long pulses)

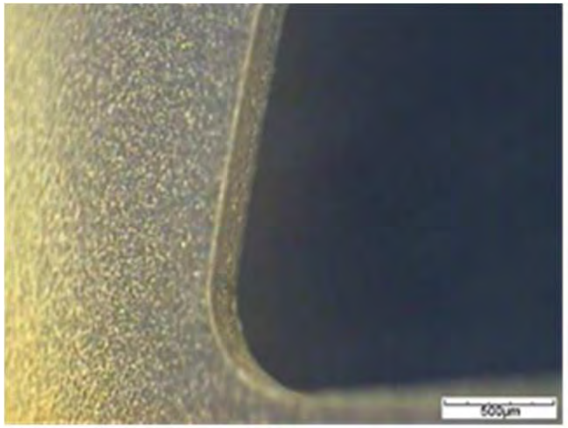
platine
(ébauche)

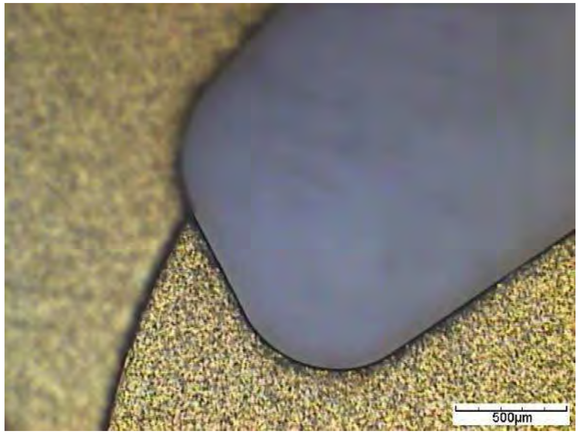
⇓

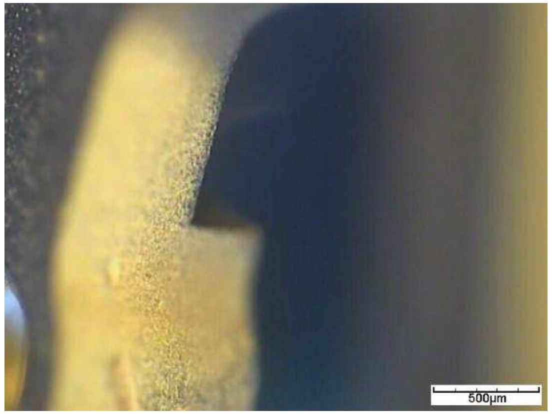
platine
(après ouverture
de poches)











SYNOVA

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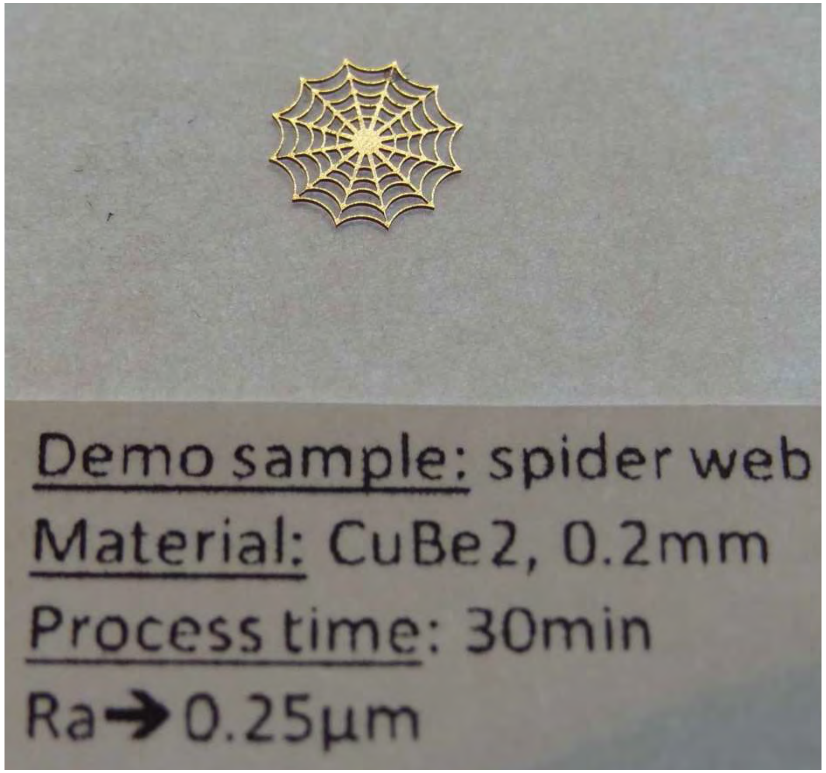
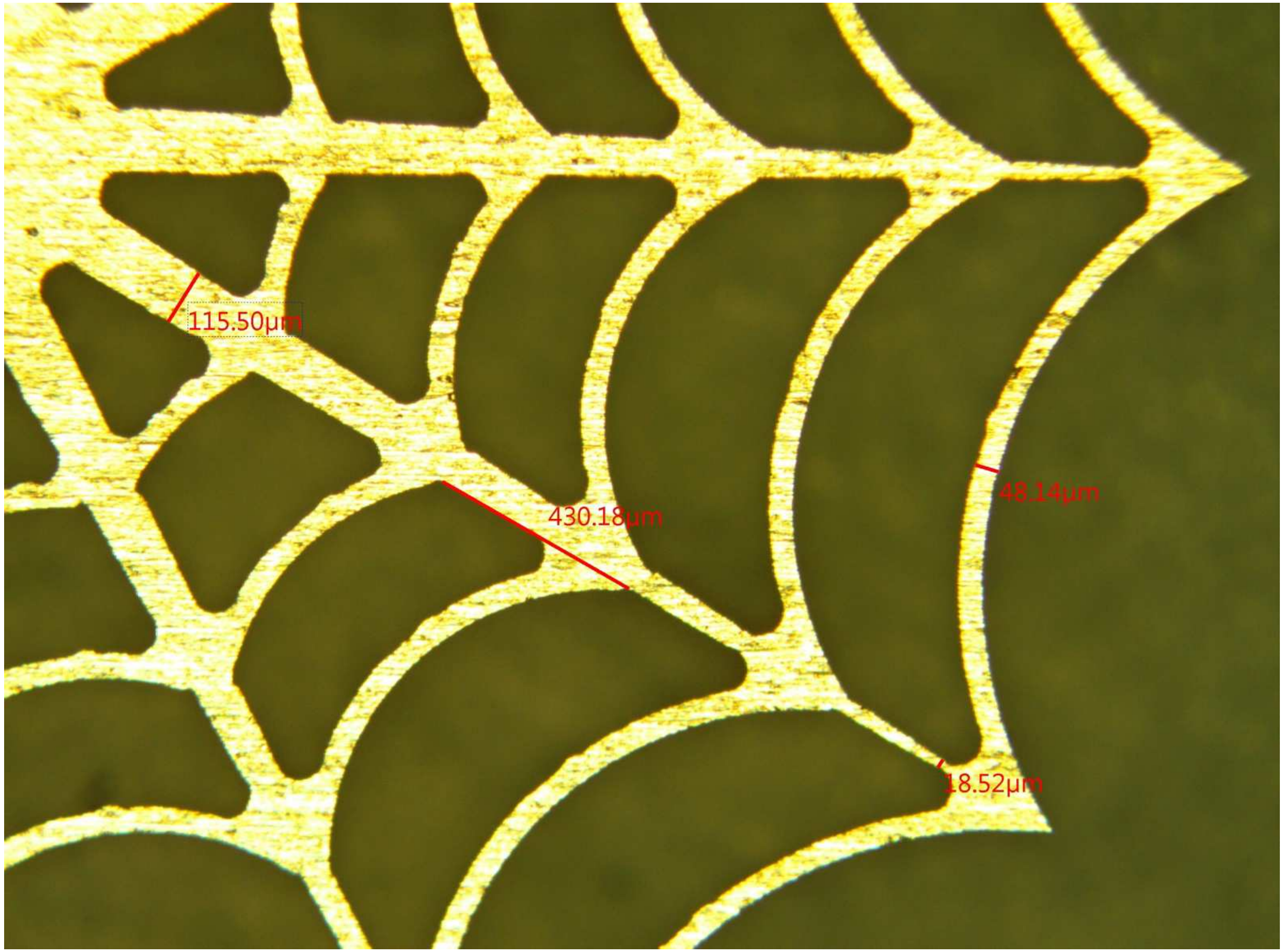
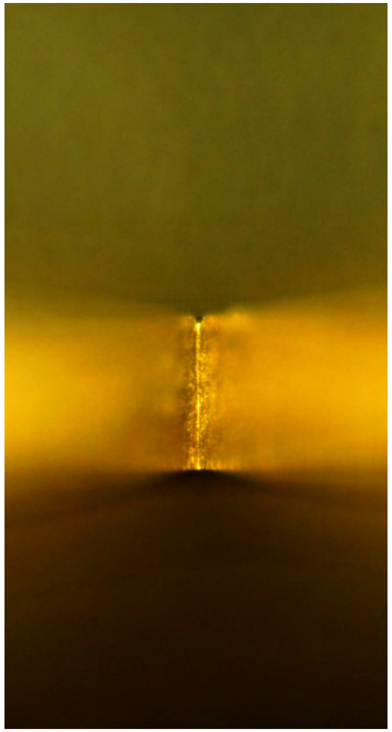
fancy designs implementation

CuBe 2 spider web, Ø = 5mm



CuBe 2 spider web, Ø = 5mm





SYNOVA

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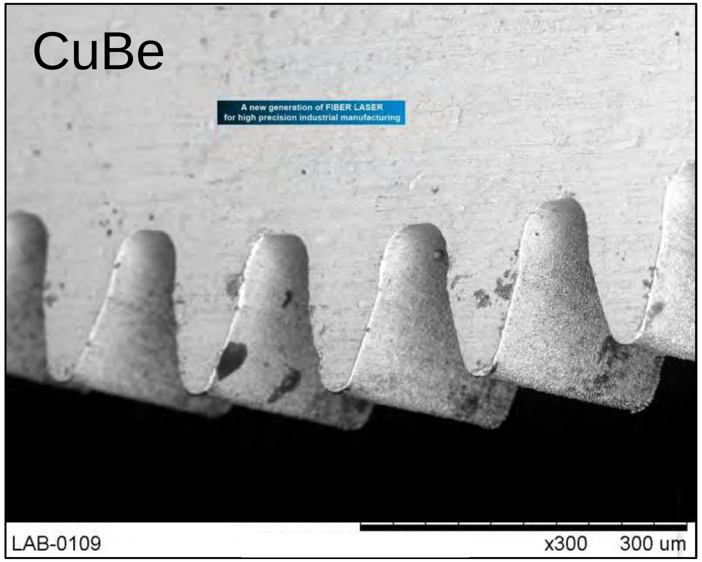
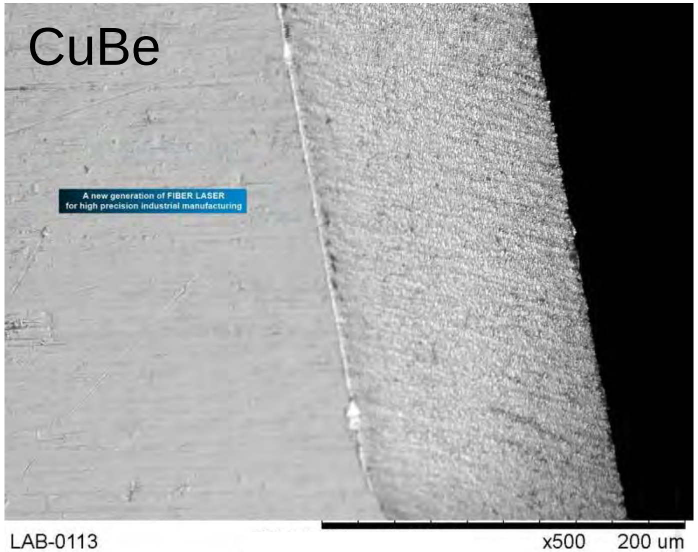
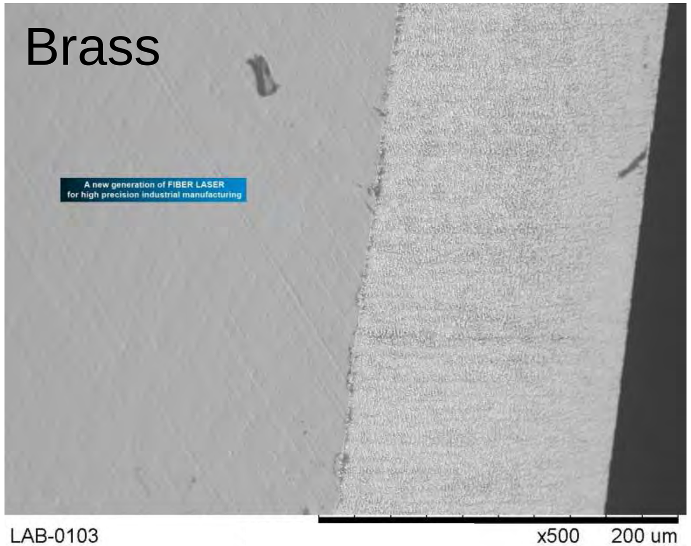
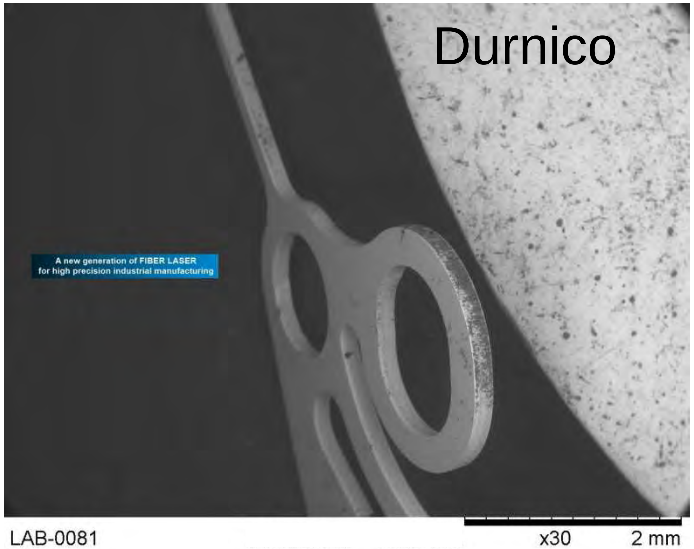
microstructures

microstructures





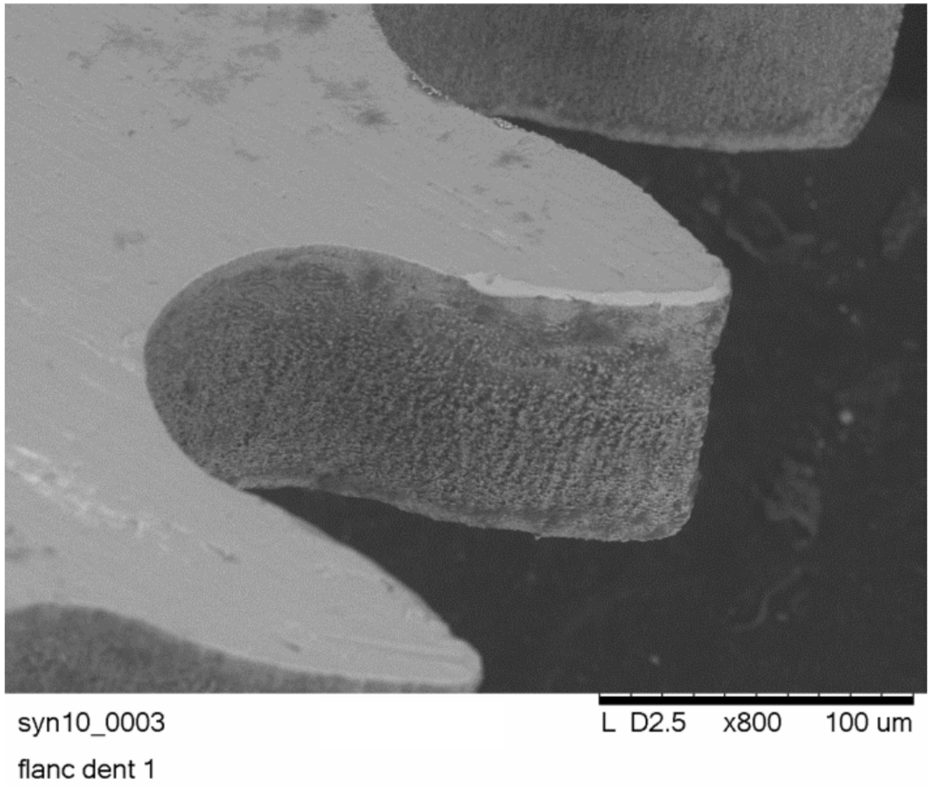


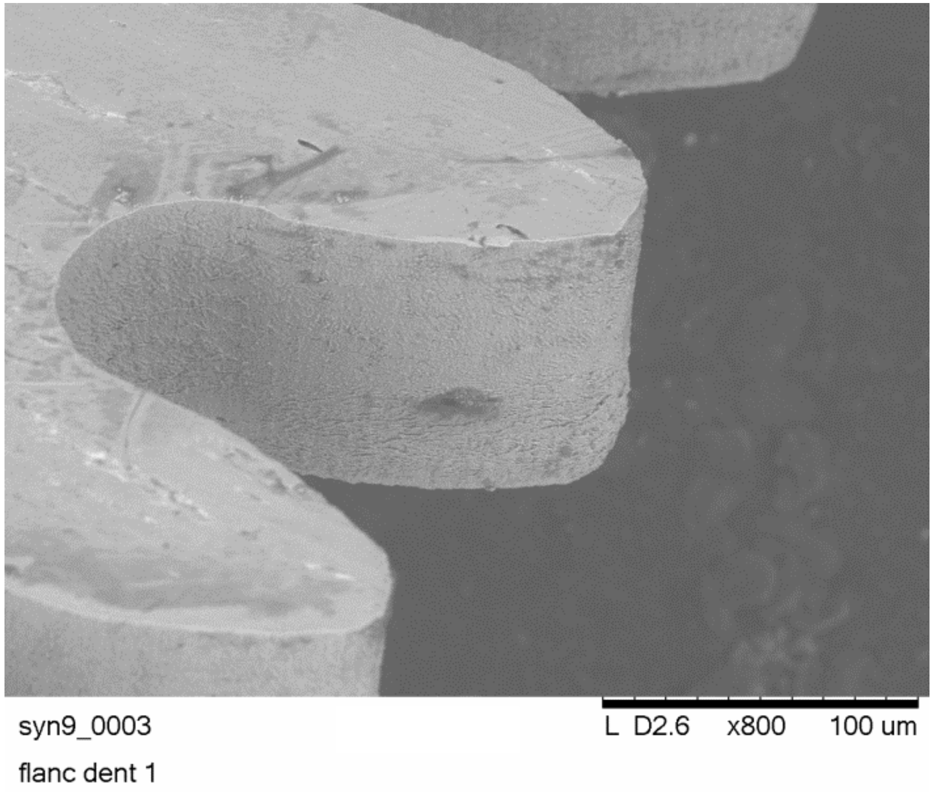


microstructures on brass 150 µm

⇓ Ra = 0,4 µm (typical of long pulses)

⇓ Ra = 0,2 µm (typical of short pulses)





SYNOVA

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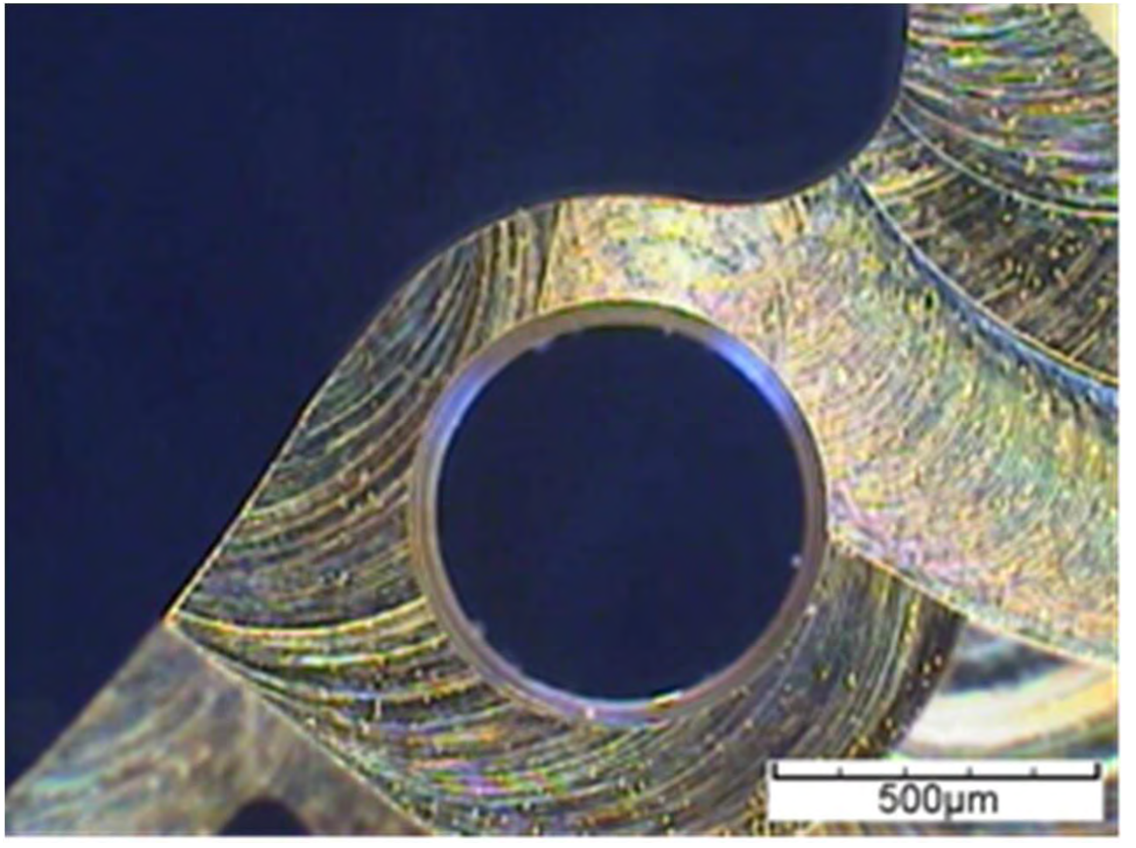
visual realignment

visual realignment capacity +/- 2 μm



summary / benefits for watch making (1)

- QUALITY
  - superior surface quality in terms of roughness, tolerance, chipping & burrs, absence of taper & thermal stress
  - no thermal stress $\Rightarrow$ outstanding results even for copper alloys

- SPEED & COST EFFICIENCY IN PROTOTYPING
  - prototypes realized very fast (up to > 30 times quicker & with superior quality vs alternatives)
  - no post-treatment required
  - no waiting time and cost for a stamping tool
  - no waiting time and cost for a batch based manufacturing processes

- UNRIVALED SOLUTION FOR IMPLEMENTATION OF INNOVATIVE DESIGNS
  - possibility to realize in a record time, designs not feasable with any other substractive technology

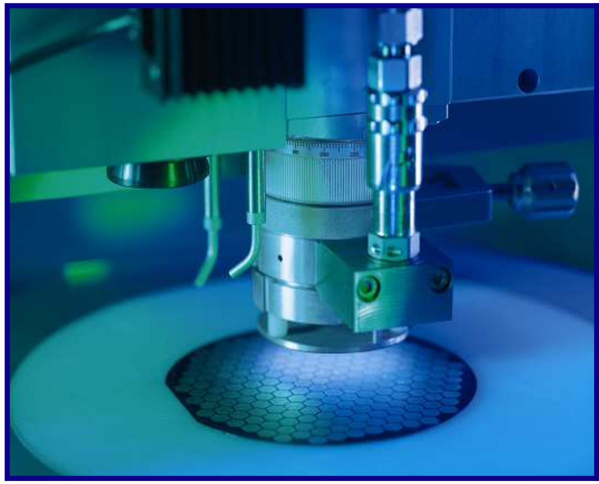
summary / benefits for watch making (2)

- ECONOMICAL ALTERNATIVE FOR SMALL TO MEDIUM SERIES PRODUCTION VS.

  - stamping
    - no stamping tool required
    - no minimum batch size
    - no excessive inventory

  - profile turning + wheel cutting + thickness calibration
    - no minimum batch size
    - no multiple operations
    - no excessive inventory

Contact



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