Laser micromachining with fs-lasers: demands and trends

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lasea
PRECISION LASER SOLUTIONS

Lasea at a glance

Lasea at a glance

Lasea SA (60 people)

Liege Science Park
BELGIUM

Lasea Switzerland SA (2 p.)

Biel/Bienne
SWITZERLAND

Lasea France SAS (8 p.)

Cité de la Photonique
FRANCE

- Belgium: Headquarter, R&D, integration, software, sales and applications lab
- Switzerland: Sales and applications lab
- France: Development of the modules, sales and applications lab
- USA: Sales and applications lab

Lasea US Inc (2 p.)

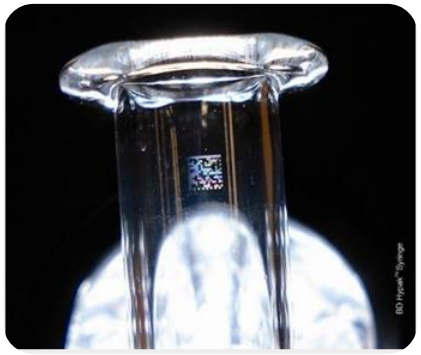
San Diego, California
USA

Workstations

- From small table top solutions (LS2) to full automated 24/7 production machines (LS5)
  - Based on granite tables (except LS2)
  - Modular design
  - Combination with robot possible (LS4,LS5)
  - Vision systems (shape recognition)
  - Axes systems (linear and rotary drives)
  - Fume extraction
  - Metrology options

Applications

Applications: Life Science (Pharmaceutical, Hospitals, Medical Devices)



Anti mix-up marking

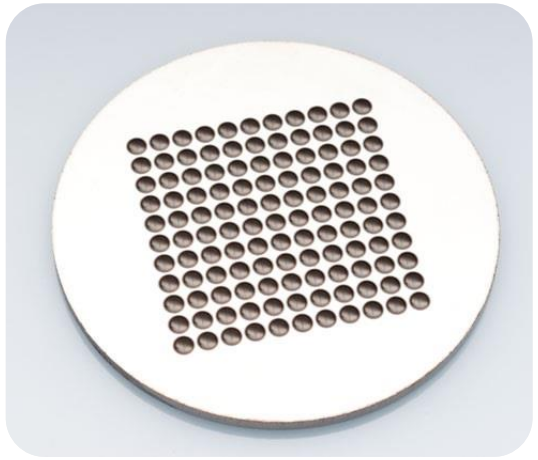
Track&Trace marking

Laser Drilling and Cutting

Plastic welding

Applications: Luxury (Watches)

- Laser engraving



Micro cavities in stainless steel

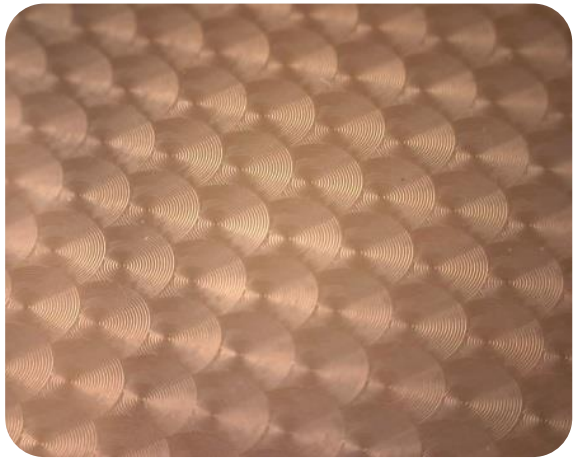
Poinçon in steel

Bezel in zirconia

Applications: Luxury (Watches)

- Laser engraving
- Laser texturing

“Côtes de Genève”
(stainless steel)

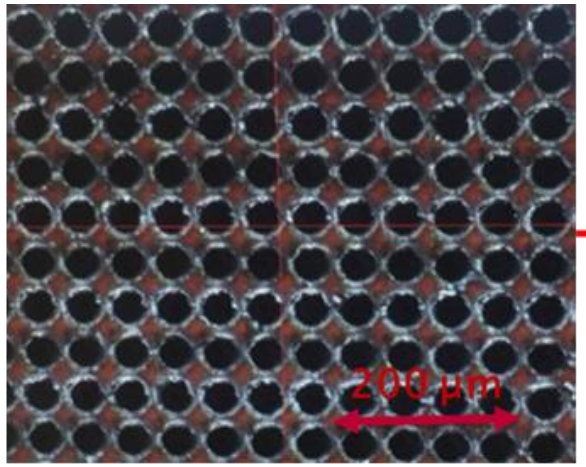


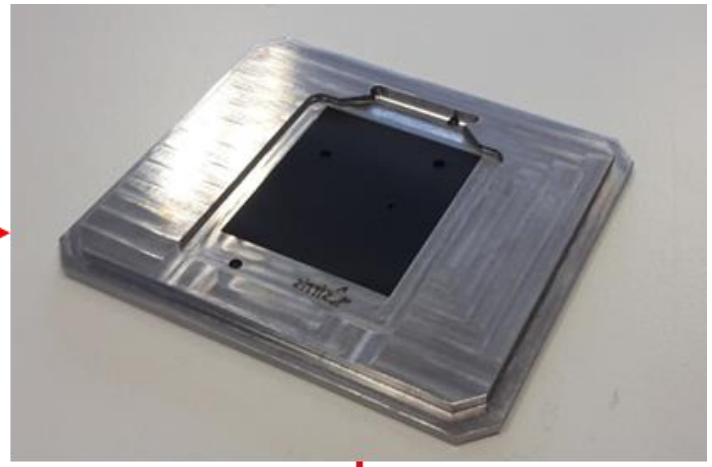
”Perlage”
(copper)

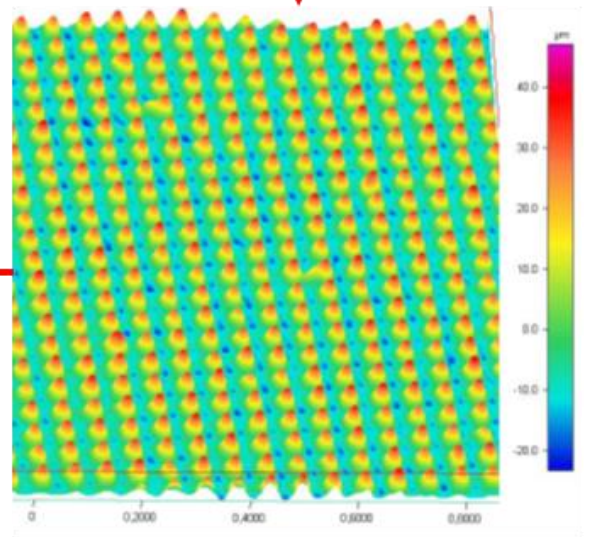
“Colimaçonnage”
(brass)

Applications

- Laser engraving
- Laser texturing







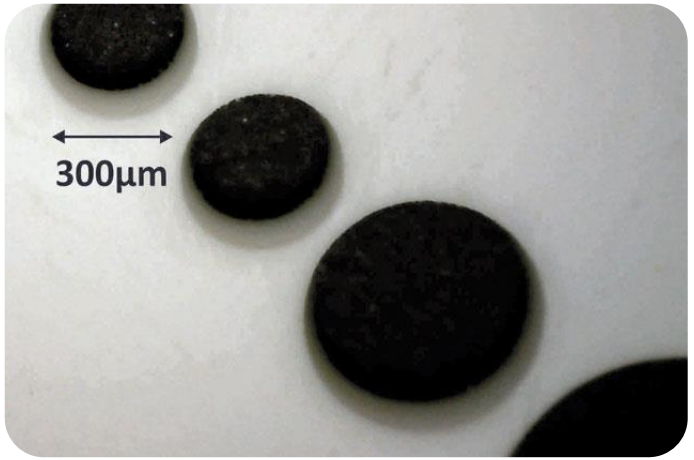
Source: Sirris, sirris.be

Applications

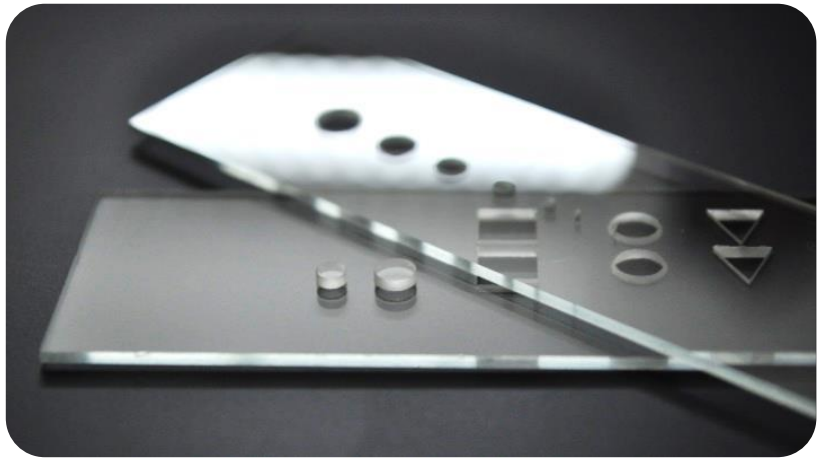
Source: youtube.com, Sirris, KU Leuven

Applications: Luxury (Watches)

- Laser engraving
- Laser texturing
- Laser drilling



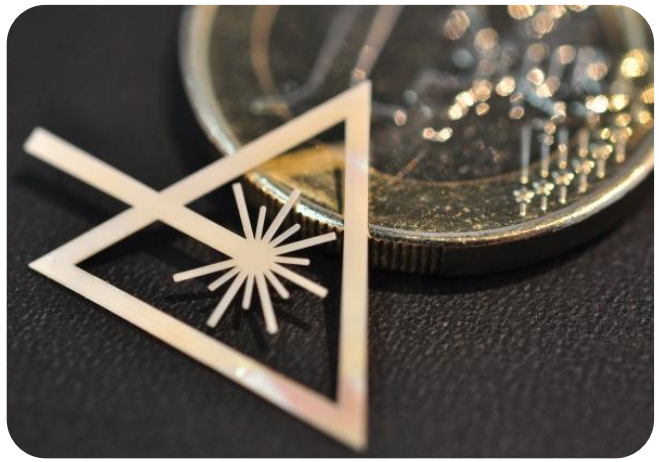
Holes in ceramic



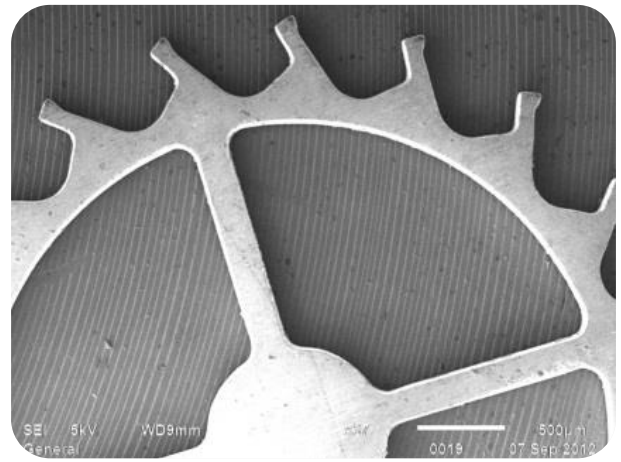
Holes in glass

Applications: Luxury (Watches)

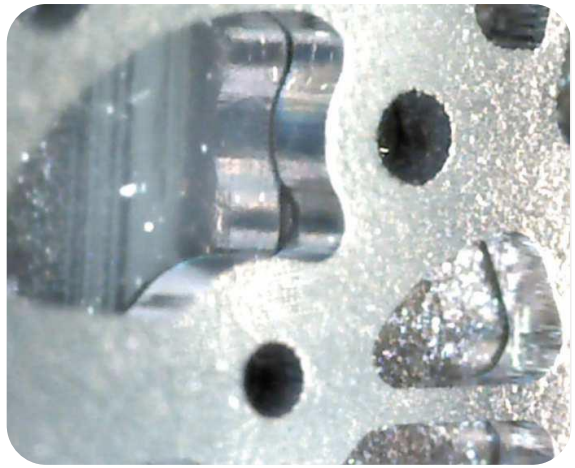
- Laser engraving
- Laser texturing
- Laser drilling
- Laser cutting



“Applique” (mother of pearl)



“Escapement wheel” (metal)



“Movement component”
(phynox 500 µm)

Throughput

Throughput

- Increasing throughput is key for industrial applications:
  - Today's high power USP laser systems:
    - 100 W regime (industrial) [1]
    - kW regime (scientific) [2,3]
    - Pulse energy of several 100 µJ
  - Moderate fluences to treat metals
    - Optimum peak fluence (most energy efficient point) of some J/cm^2

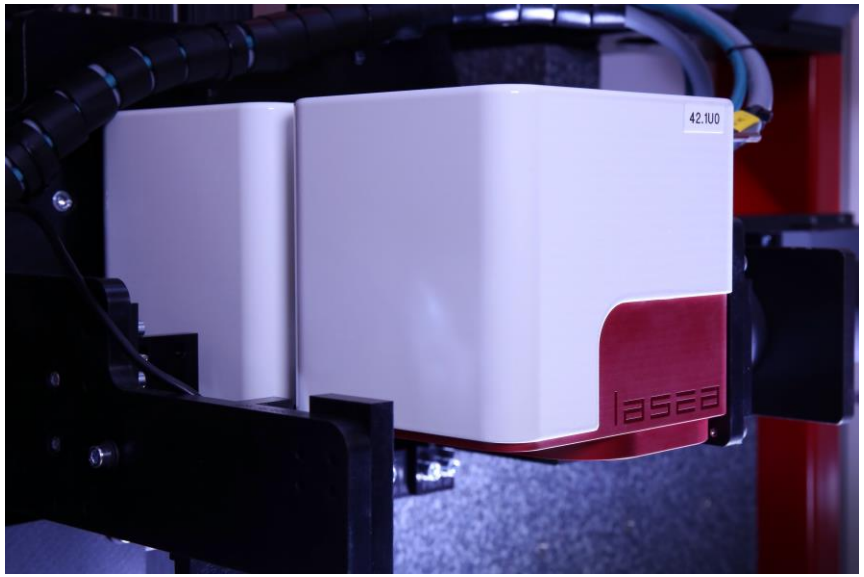
[1] C. Hoenninger, J. Akhil, Laser Technik Journal 13 (2), (2016) 56

[2]: P. Russbueldt, T. Mans, J. Weitenberg, H. D. Hoffmann, R. Proprawe, Opt. Letters 35 (24), (2010) 4169

[3]: J.-P. Negel, A. Voss, M. Abdou Ahmed, D. Bauer, D. Sutter, A. Killi, T. Graf, Opt. Letters 38 (24), (2013) 5442

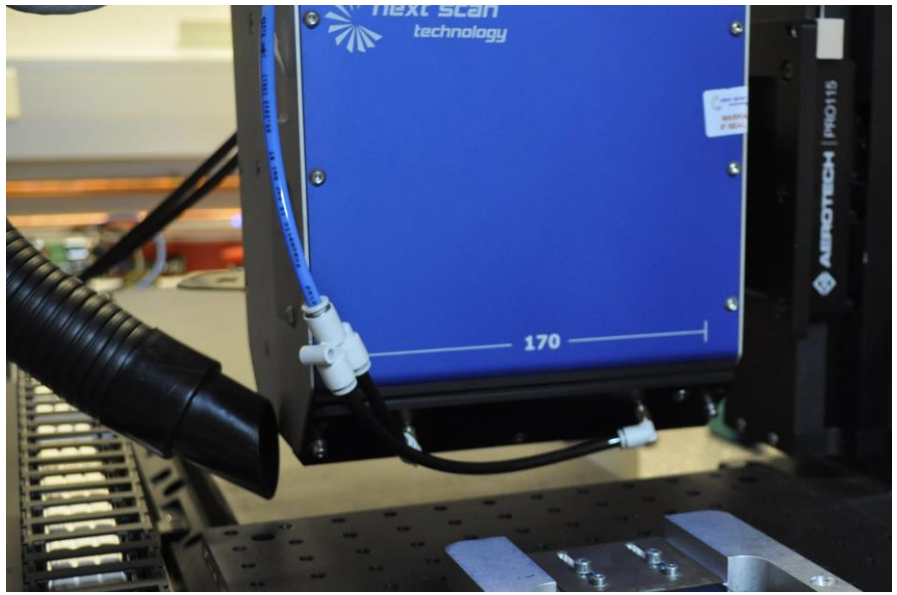
Throughput, Lasea's solutions

- Increasing throughput is key for industrial applications:
  - Increasing E_p (increasing P_{av} at constant f_{rep})
    - Beam splitting using the LS-Split
      - dividing the high energy beam into two beams
      - 2 galvo scanners simultaneously



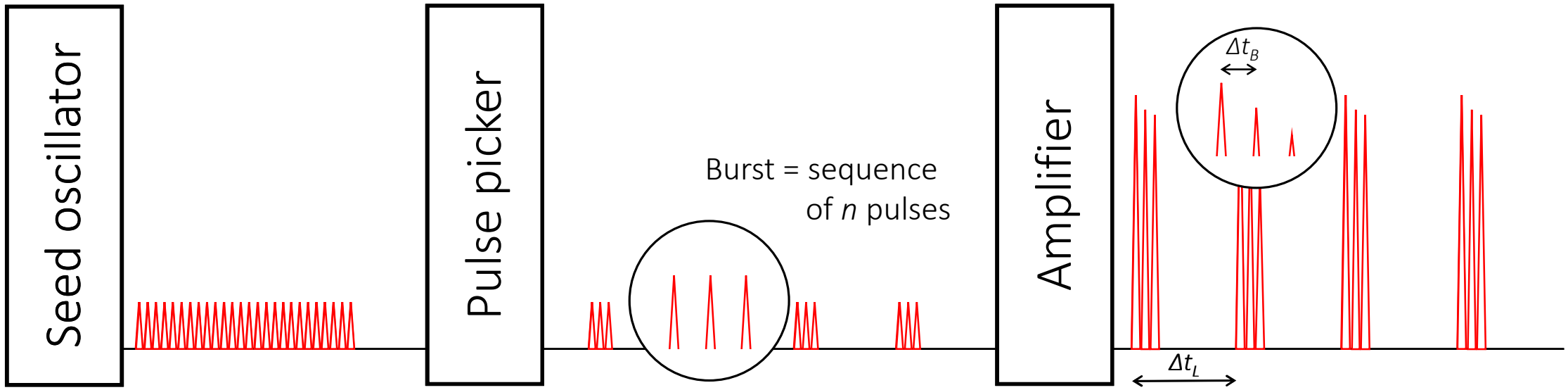
Throughput, Lasea's solutions

- Increasing throughput is key for industrial applications:
  - Increasing f_{rep} together with P_{av} (constant ϕ_0) and v_{scan} for constant pulse overlap
    - Polygon line scanners

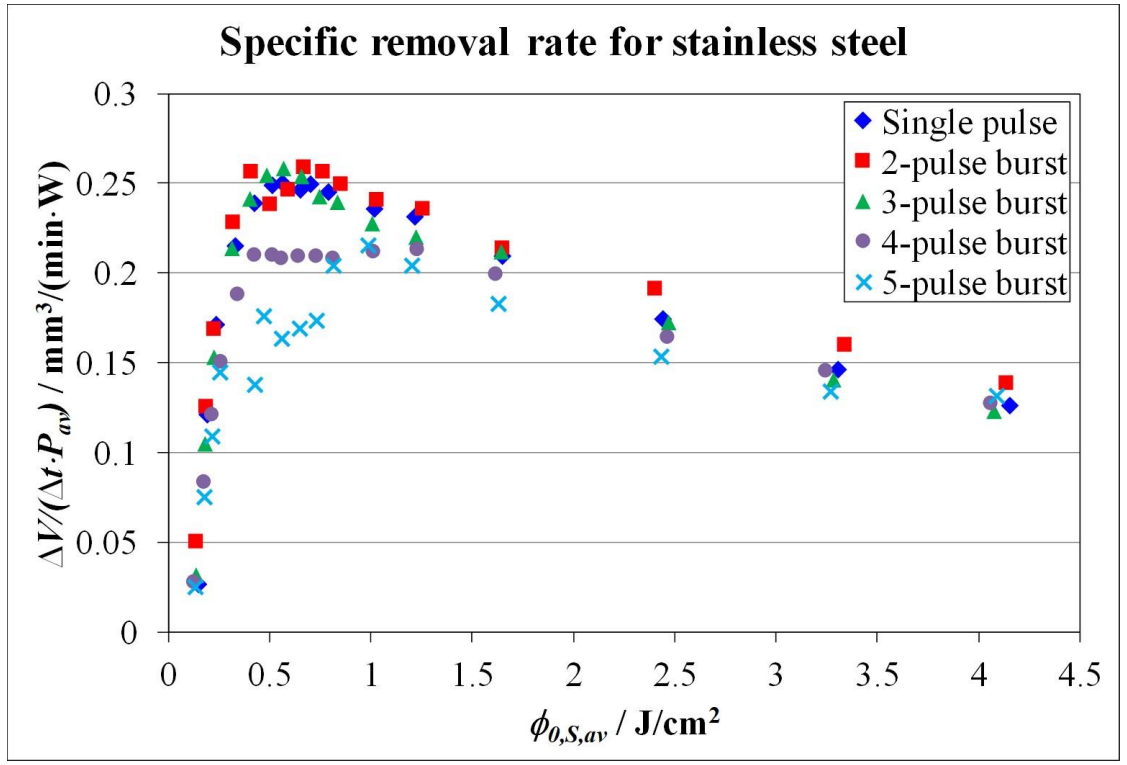


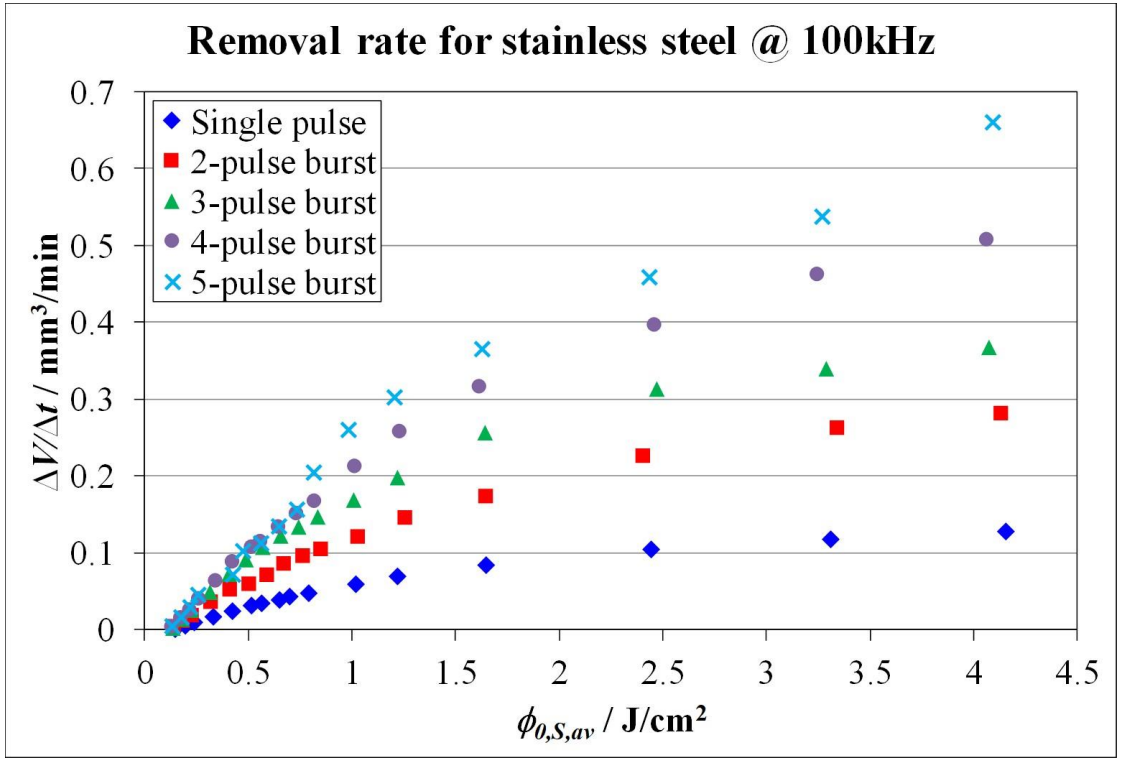
Throughput - Pulse bursts

- Increasing throughput is key for industrial applications:
  - Increasing the throughput using pulse bursts
    - $\Delta t_L = 1/f_L$ = 10 µs (100 kHz)
    - $\Delta t_B = 1/f_S$ = 25 ns (40 MHz)



Stainless steel AISI 304



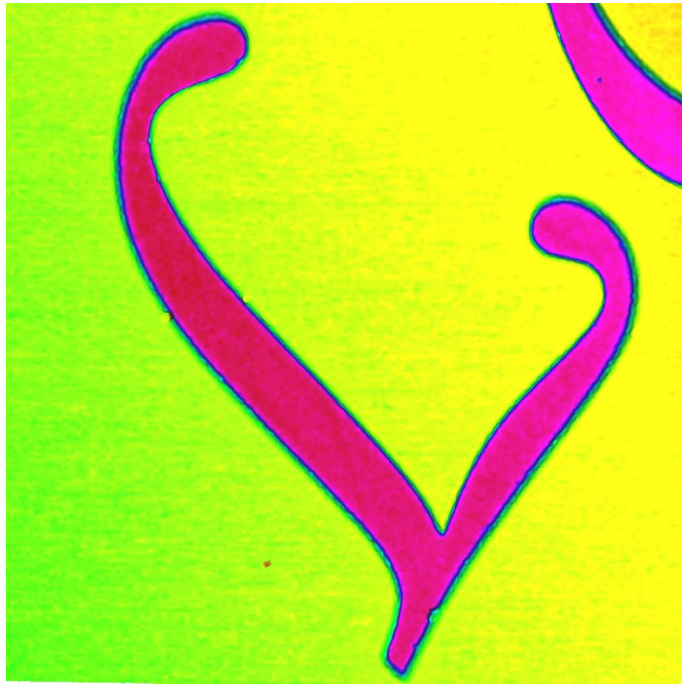


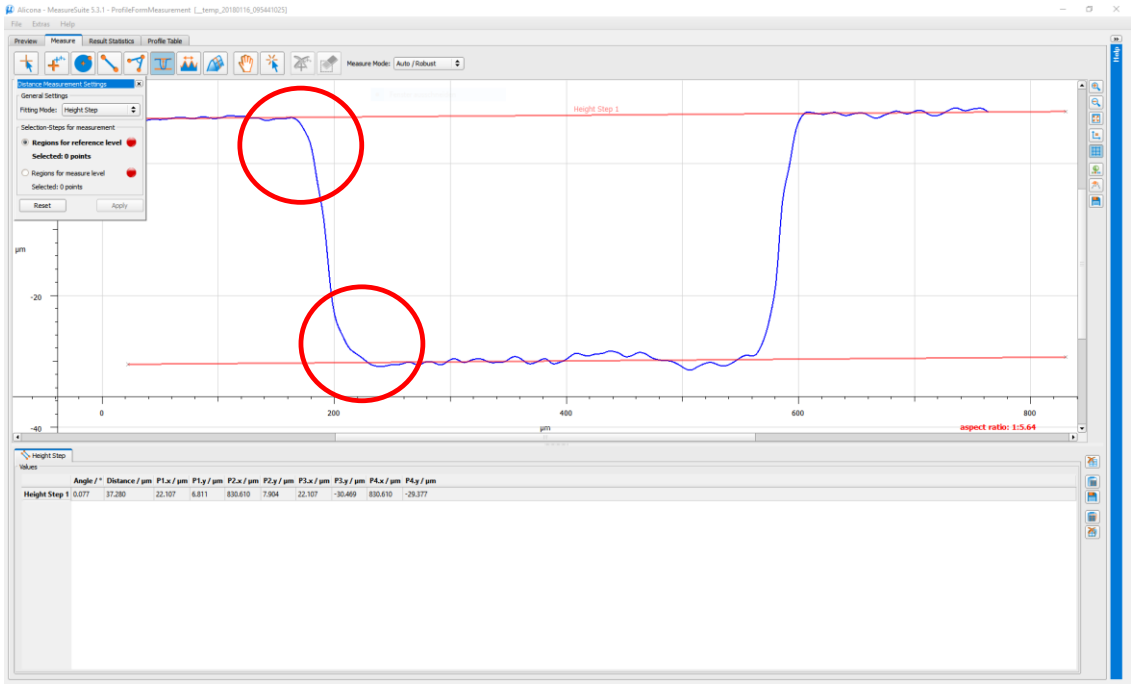
Specific removal rate rests constant up to a 3-pulse burst

If repetition rate is fixed to 100 kHz, higher ablation rate using pulse bursts

Engraving stainless steel with pulse bursts

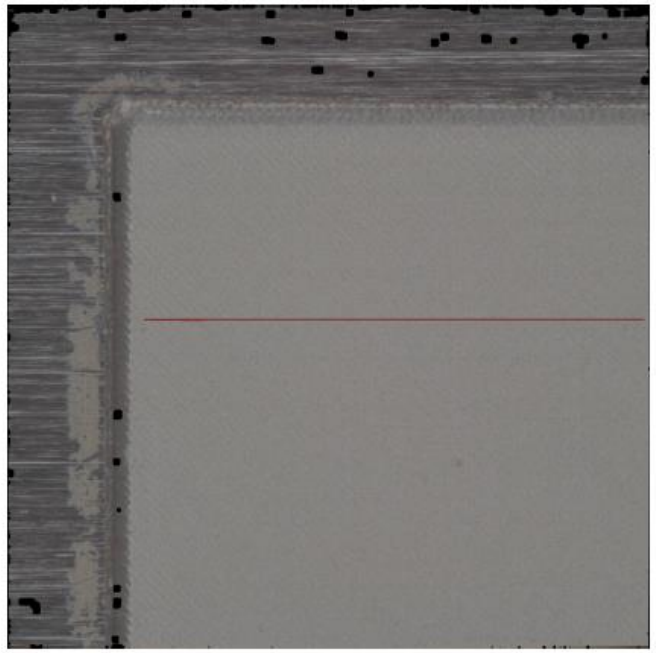
- Optimized parameter for engraving AISI 304 using pulse bursts:

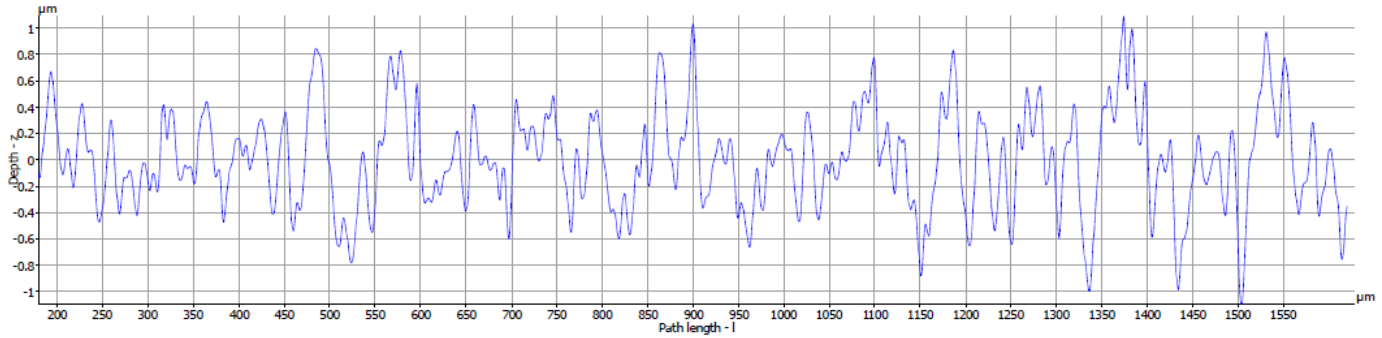




Engraving stainless steel with pulse bursts

- Optimized parameter for engraving AISI 304 using pulse bursts:
  - No over-engraving
  - No burr
  - Ra ≈ 0.3 µm, measured on a random line





Ra: 0.292µm
Rq: 0.372µm
Rz: 1.689µm

Filter: high pass - roughness profile
Lc:= 250.000µm

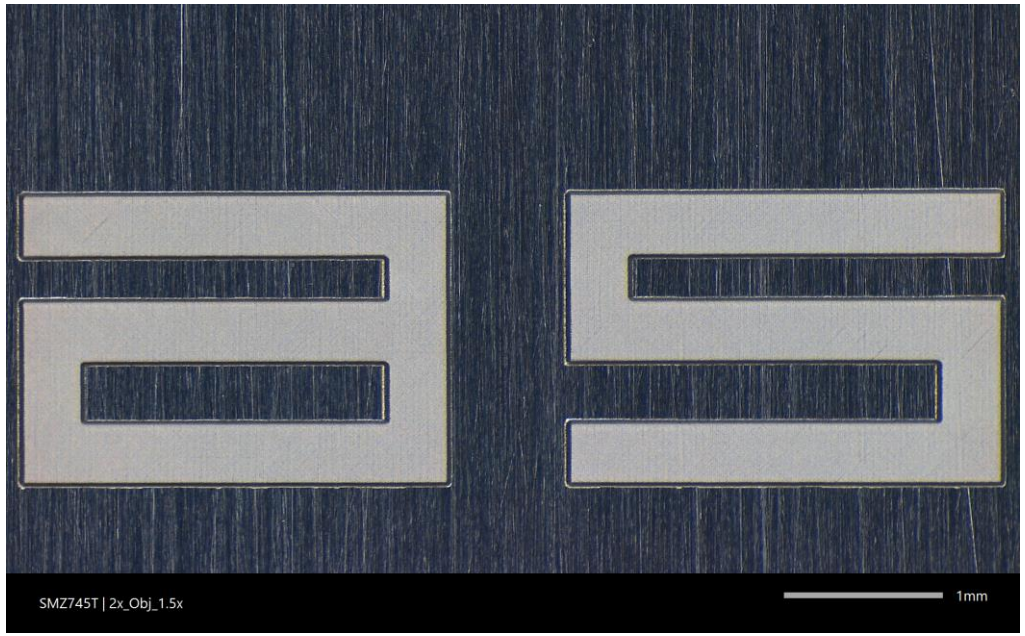
Engraving stainless steel with pulse bursts

- Engraving with no hole formation on the surface!

- Engraving with single pulses:
  - 190 layers for a depth of 40 µm

- Engraving with pulse bursts:
  - 44 layers for a depth of 40 µm

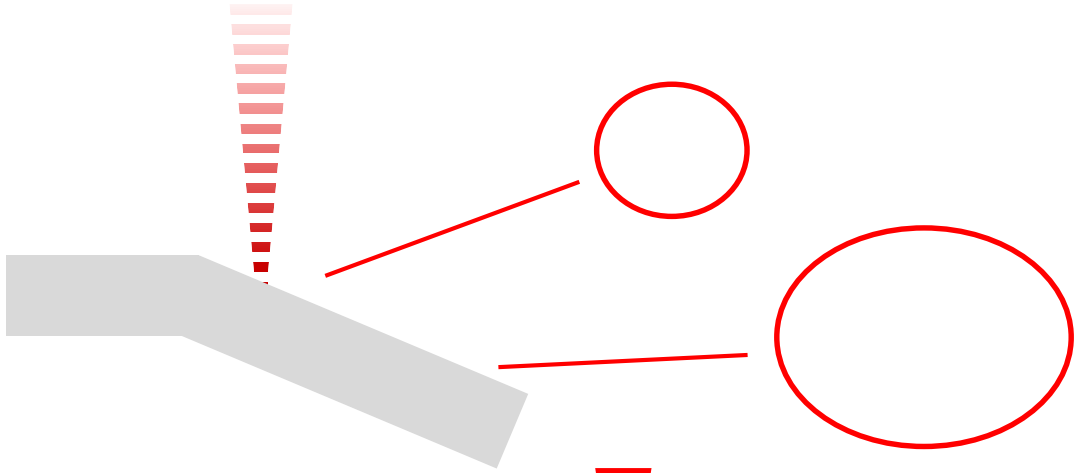
- Time reduction of a factor of 4



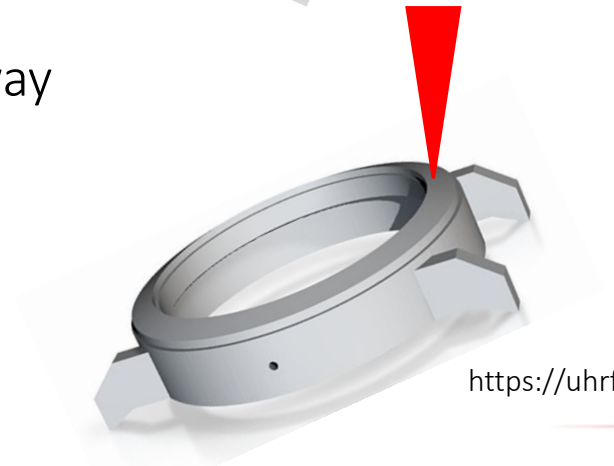
Multi-axis processing

Multi-axis processing

- 90° angle of incident and no variation in surface height
  - Constant spot diameter, i.e. constant fluence on the workpiece



  - Solution is to align the part in a proper way

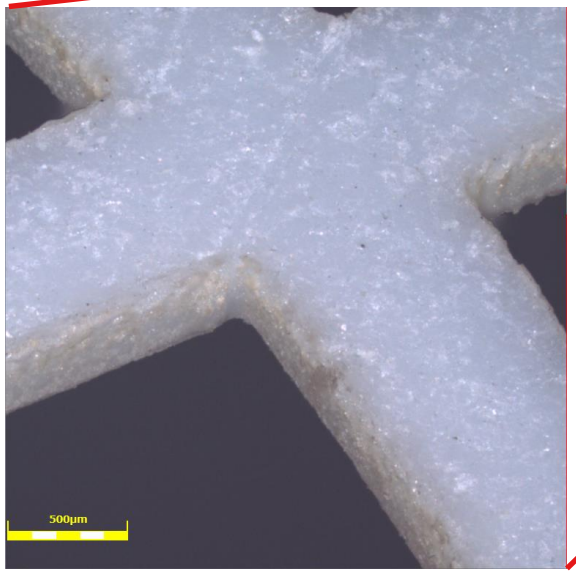


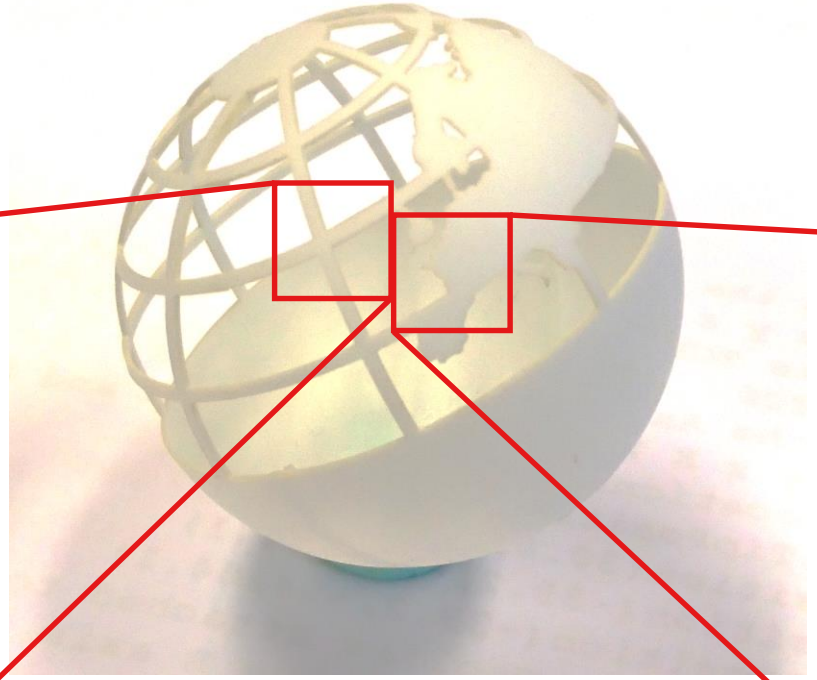
https://uhrforum.de/konstruktion-uhrengehaeuse-t93837-3c

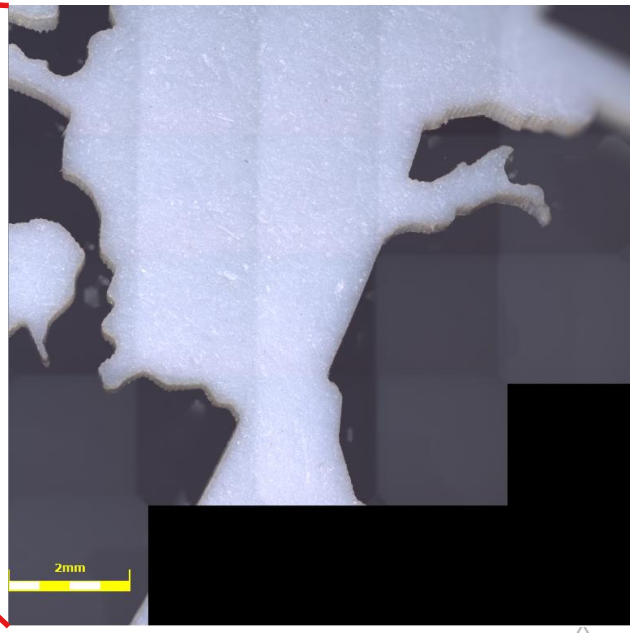
Multi-axis processing

Multi-axis processing

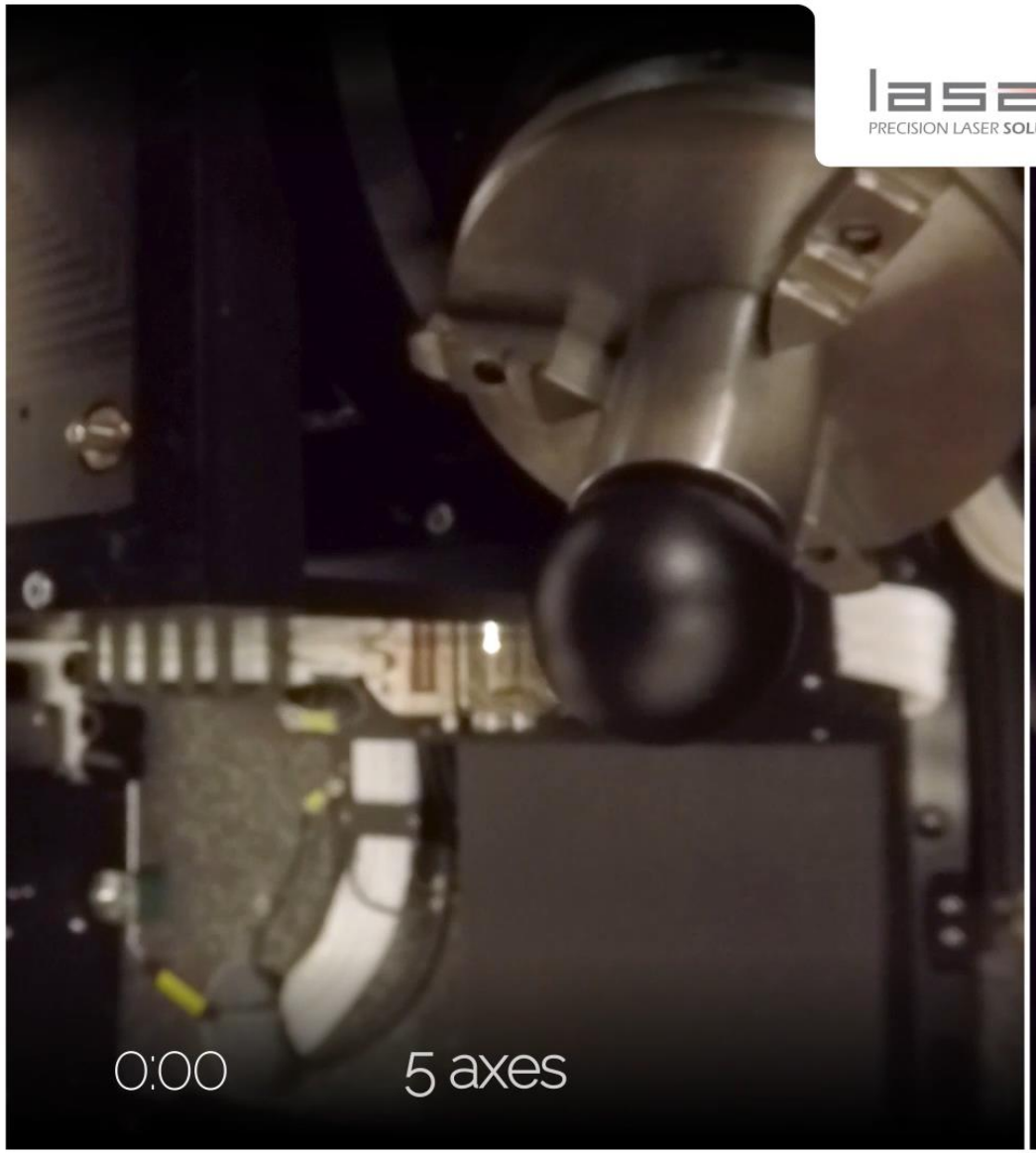
- Cut of 3D geometries
  - Nitro cellulose ball
  - Extremely flammable
  - Melting temperature : 80 °C
  - Thickness : 400 µm







Multi-axis processing



Conclusions

- Lasea is a laser solution provider

- Increasing throughput by:
  - Splitting the high energy beam
  - Fast scanning
  - Pulse bursts (reduce the machining time of a factor of 4 for stainless steel)

- Multi-axis processing is needed for 3D parts

- 7 axis simultaneously processing for seamless engraving on 3D parts

Thank you for your attention

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