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Efficient high-quality white engraving of steel using picosecond-lasers with flexible burst-mode

Dr. Andreas Oehler

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EPHJ LE MONDE DE LA HAUTE PRÉCISION

SWISS PHOTONICS

Motivation

Demand for efficient high-quality white engraving in stainless steel from watch- and jewelery-industry

Process usually split

- Engraving to depth
- Generating surface-texture to give white appearance
- Sometimes this is done with two different techniques/laser-sources

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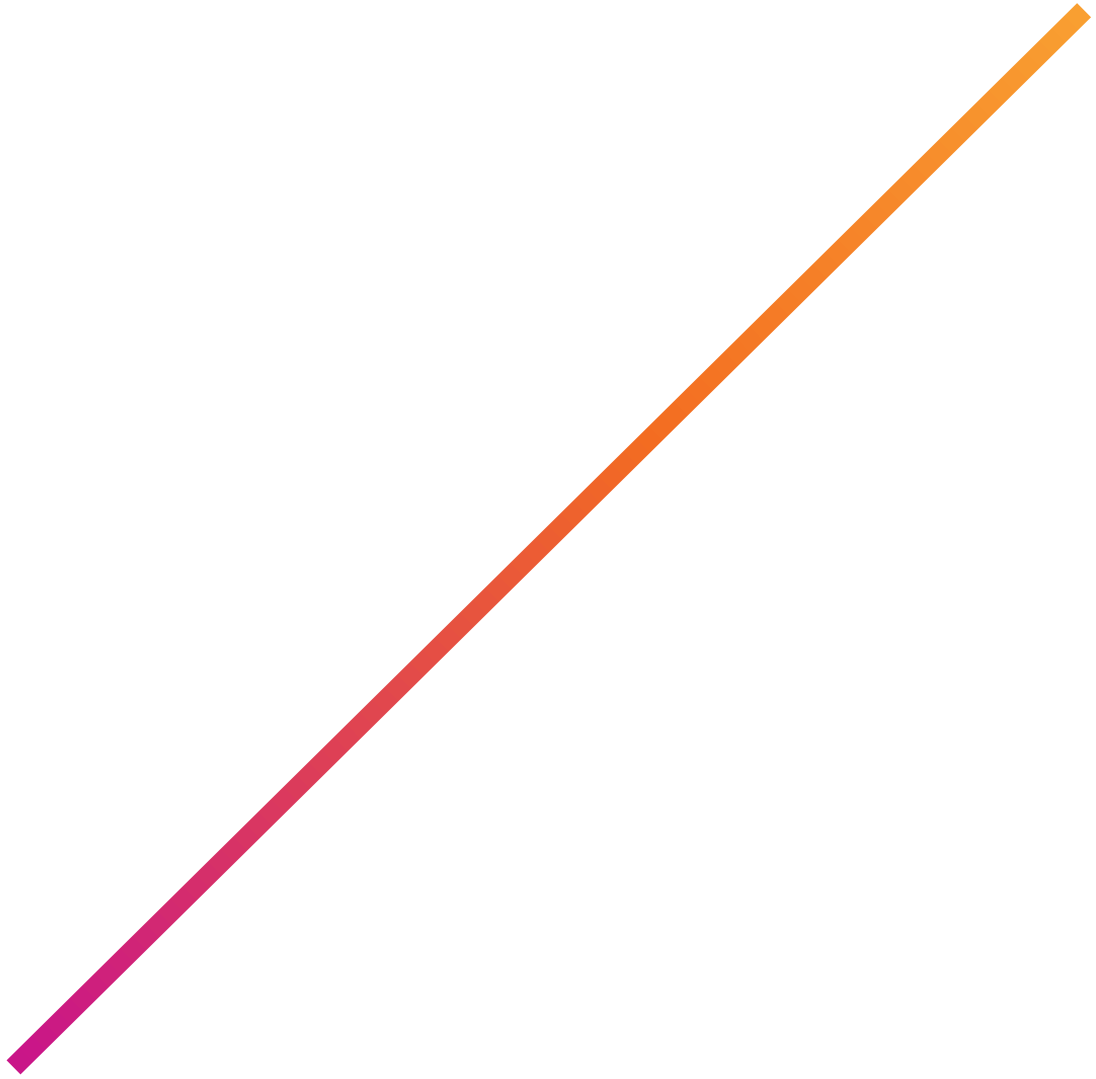
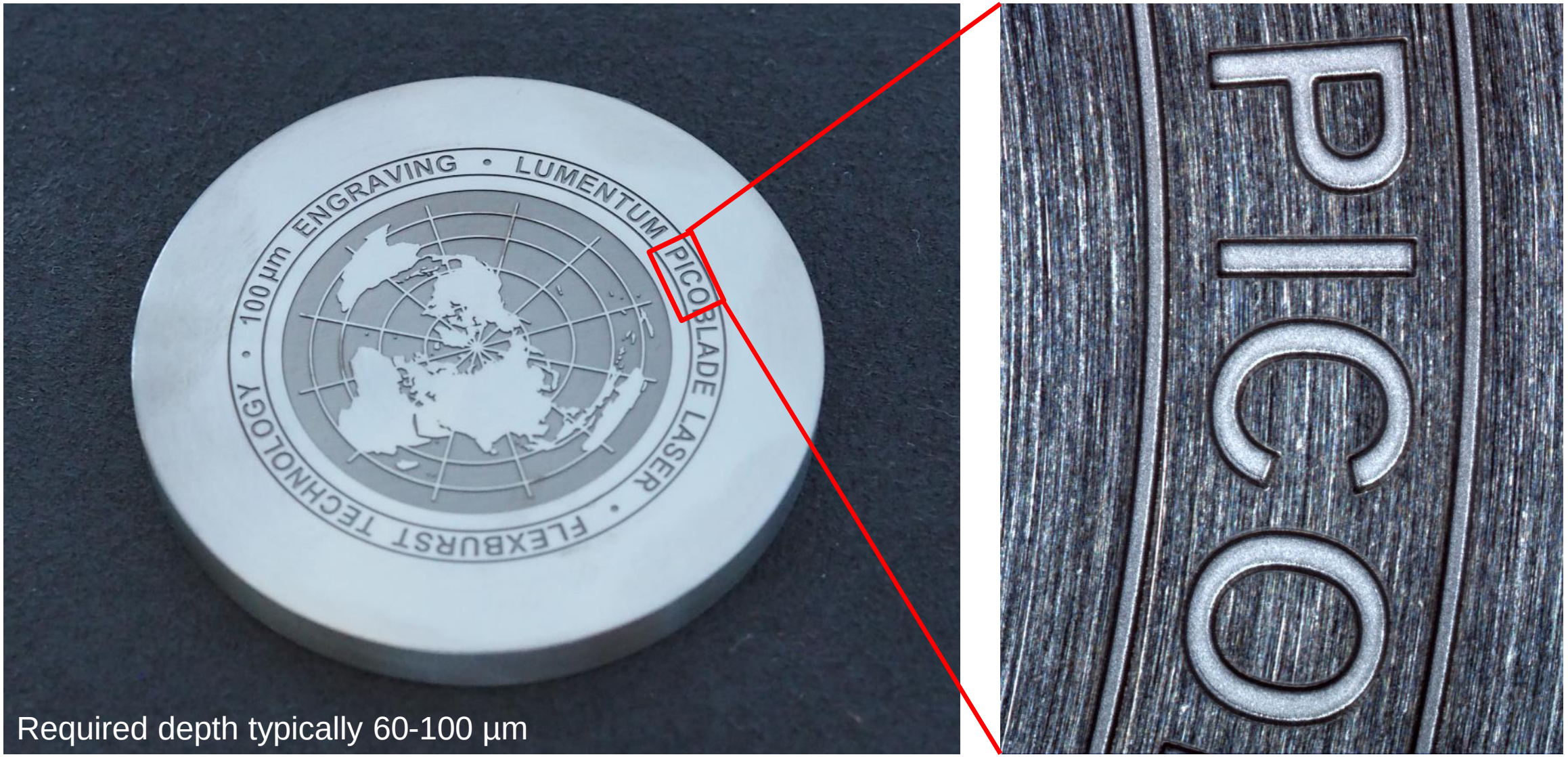
Engraving to depth



Engraving of stainless steel with picosecond laser



Why is the obtained quality comparably good?

- **Most traditional laser processes are thermal processes**
  → create a melt-phase → eject molten material

  \+ Rather efficient process
  - Quality: for many materials unwanted side-effects (burr, dross, splashing, rough surfaces etc.)
  - Often post-processing required (polishing down some 10µm)

- **For picosecond-processes we try to stay athermal**
  → material is sublimated (solid → gaseous)

  \+ With right process minimal side effects (like burr, splashing, etc.)
  \+ Excellent quality, smooth surfaces
  \+ Minimal to no post-processing required
  - Process not as efficient

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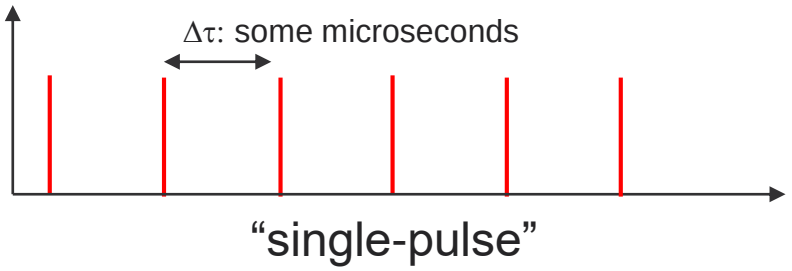
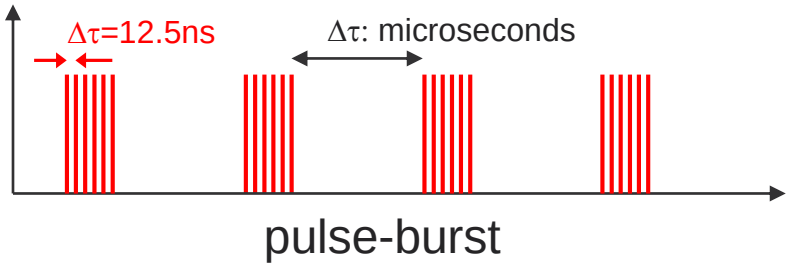
What has this to do with pulse-bursts?

What is a pulse-burst?

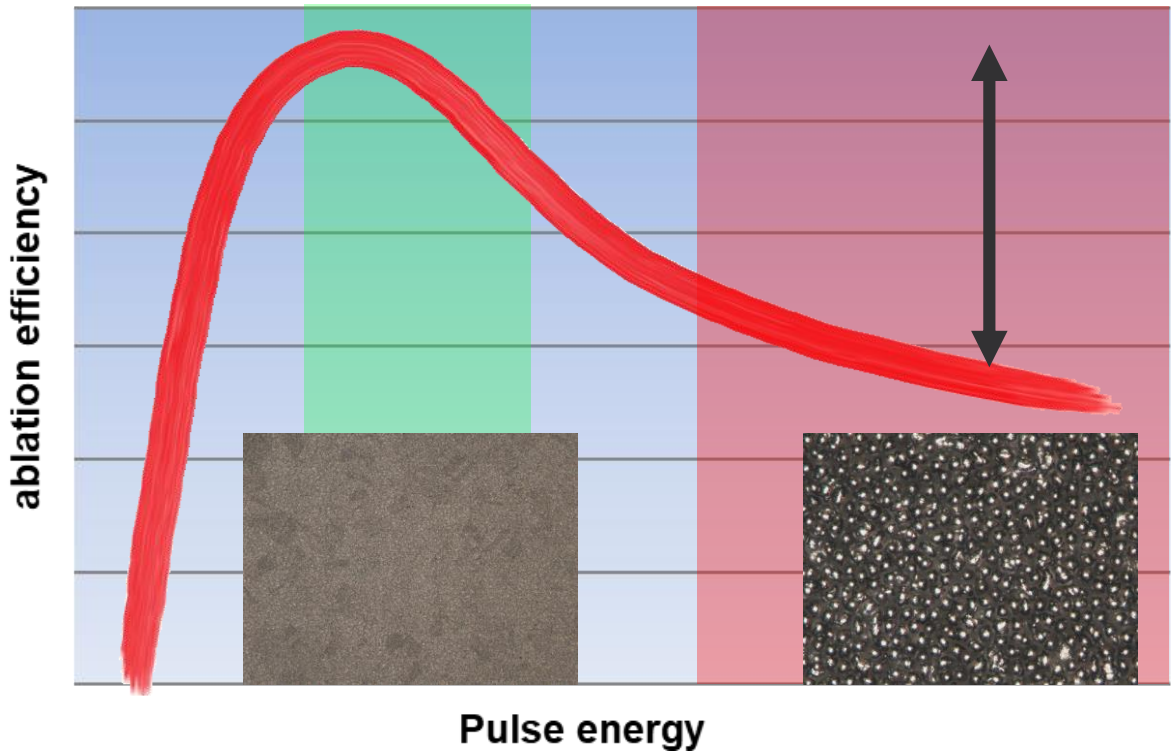




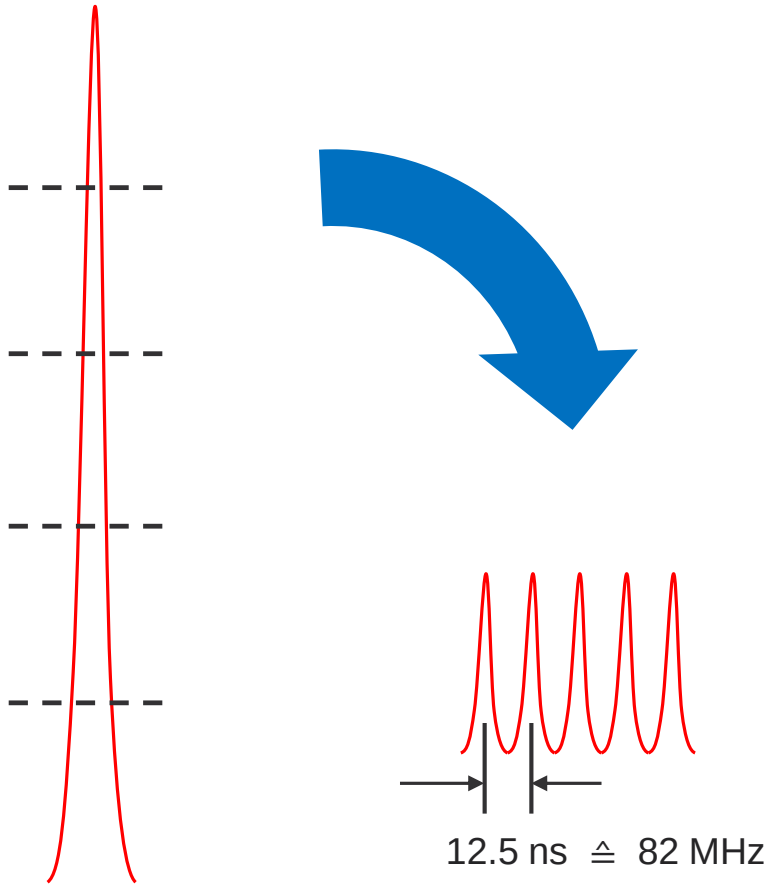
What is it used for?

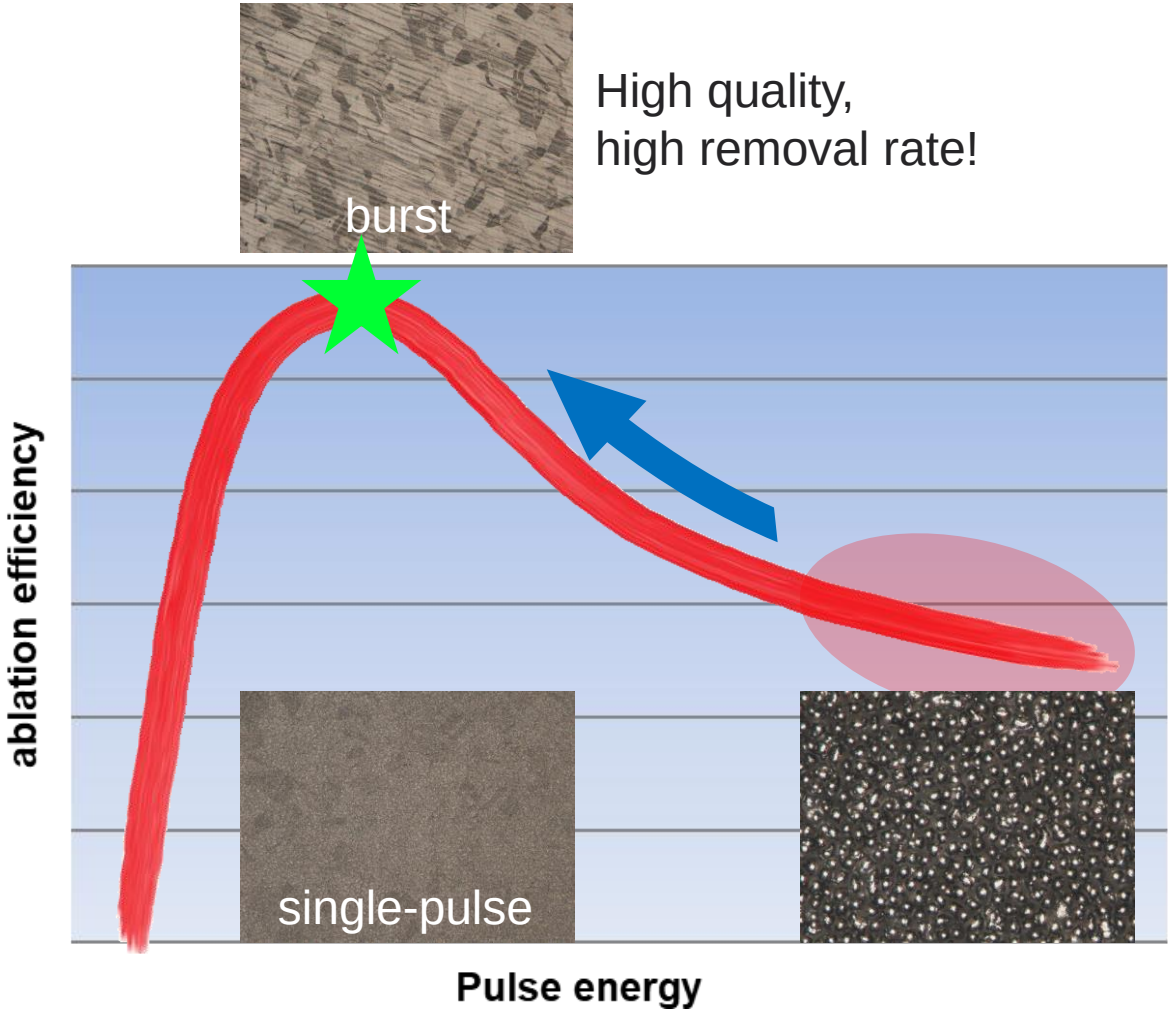
- For power-scaling
  - To increase the volume removal rate (by increasing the power) **while maintaining quality**

Process efficiency for picosecond-lasers

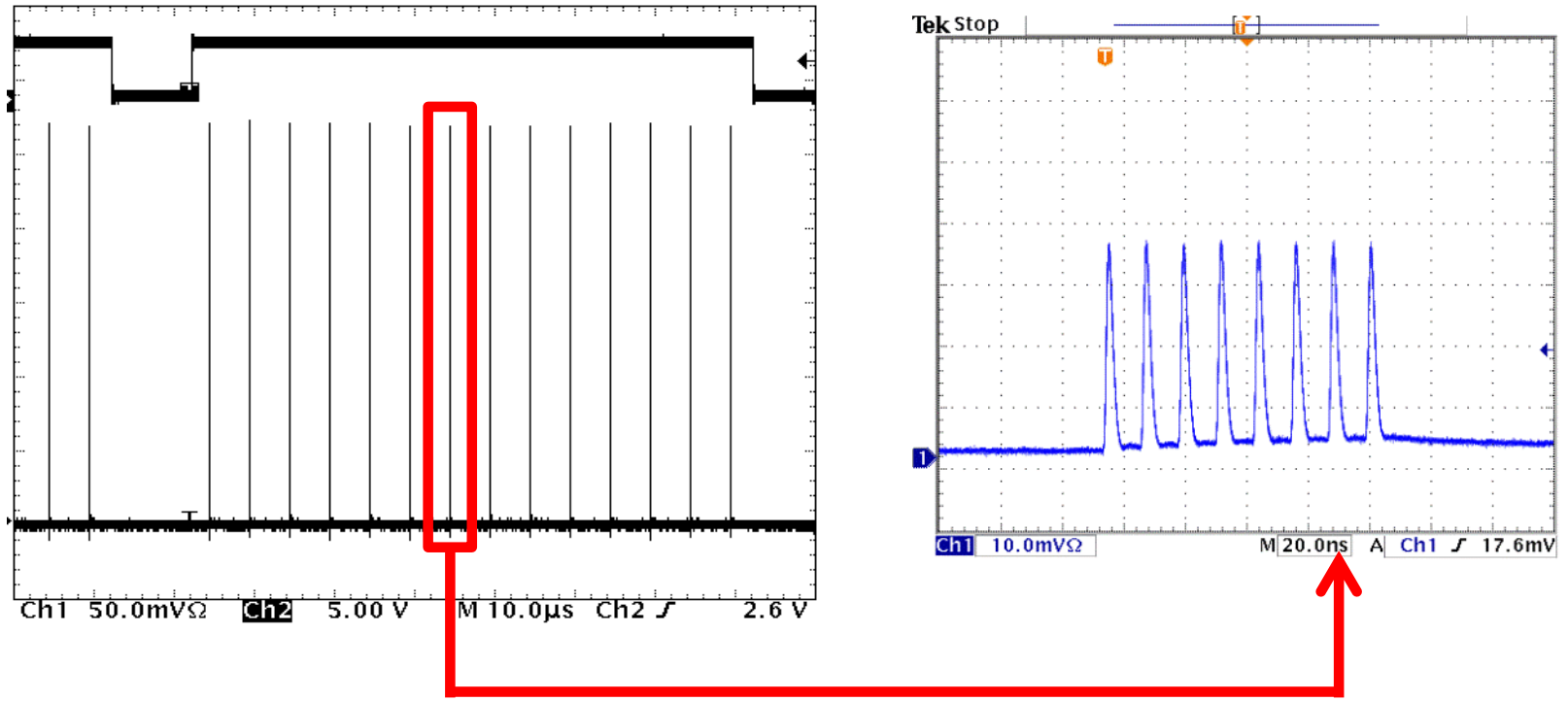


Process efficiency for picosecond-lasers



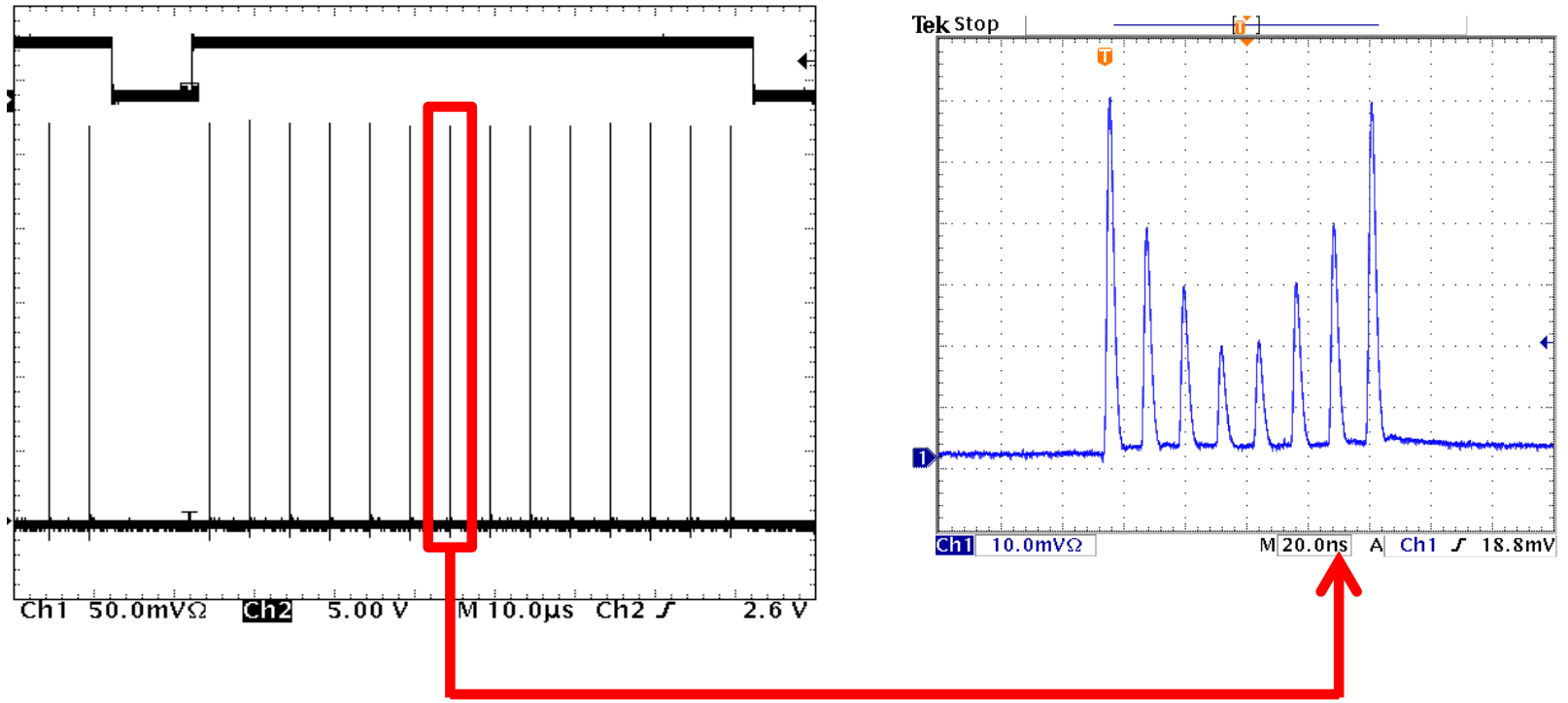


FlexBurst™ technology



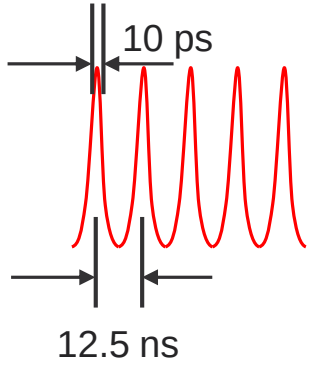
FlexBurst™ technology

- Maximum 40 pulses per burst
- Minimum spacing between individual pulses ~12.5 ns (1/82 MHz)

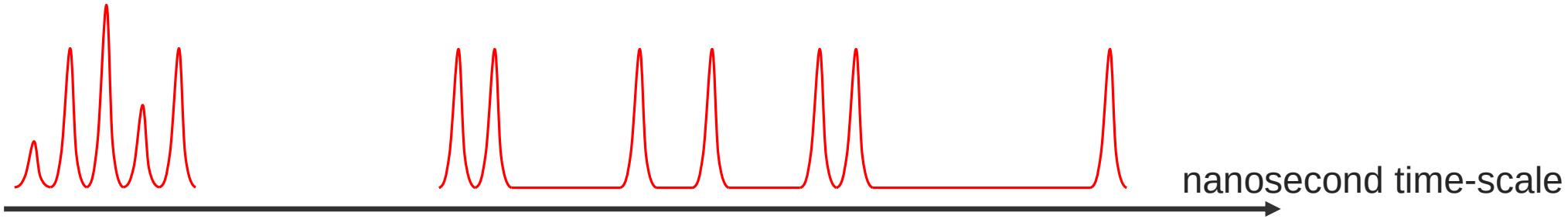


FlexBurst™ technology

- USP-bursts not equivalent to ns-pulses!!
  → duty-cycle is <0.1%!!



- Single pulses at high rep-rate do not work similar to bursts!



– Being able to change the amplitude of individual pulses in the burst as well as the pulse-spacing gives much better control over induced thermal load!

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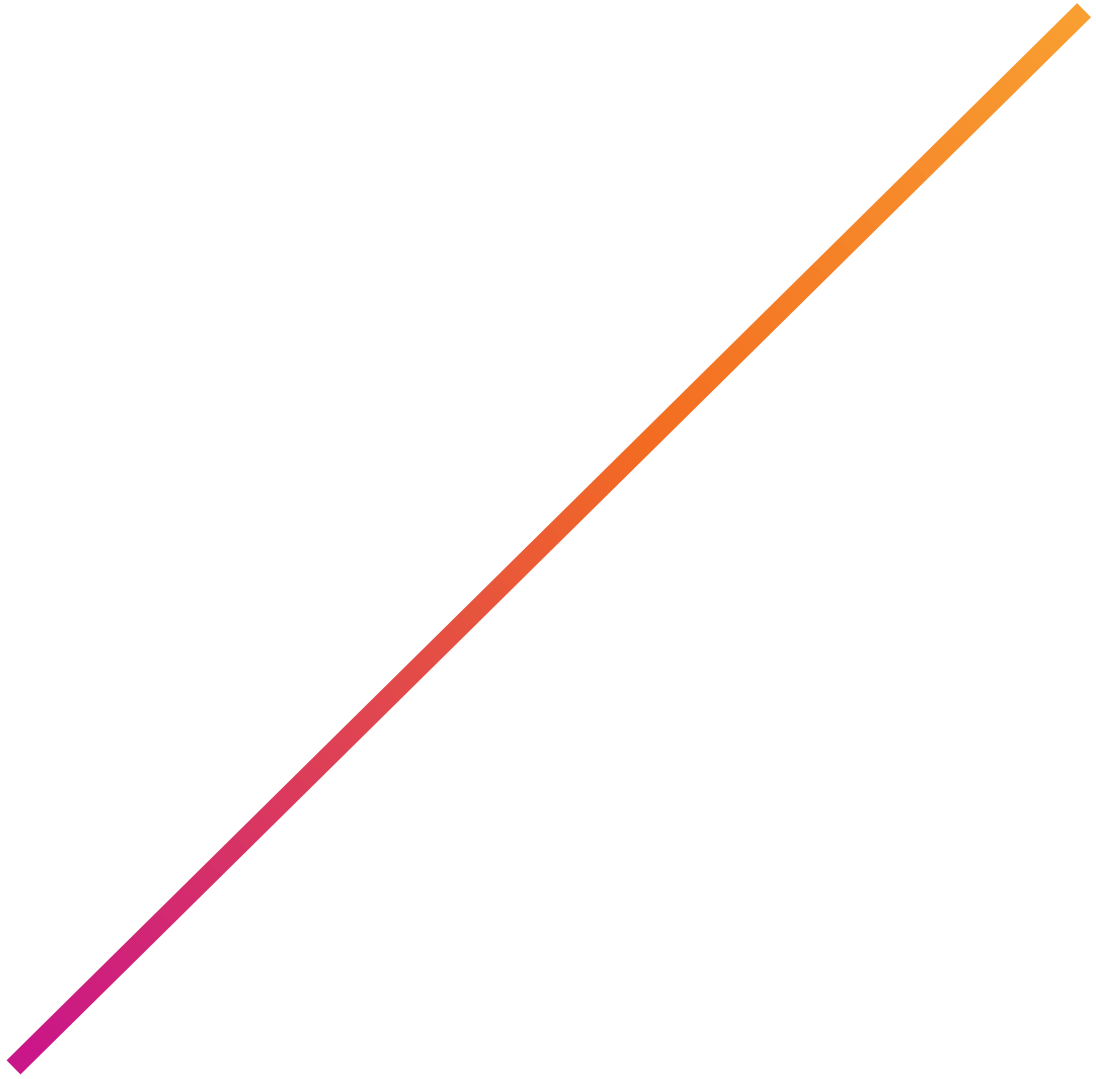
White-marking



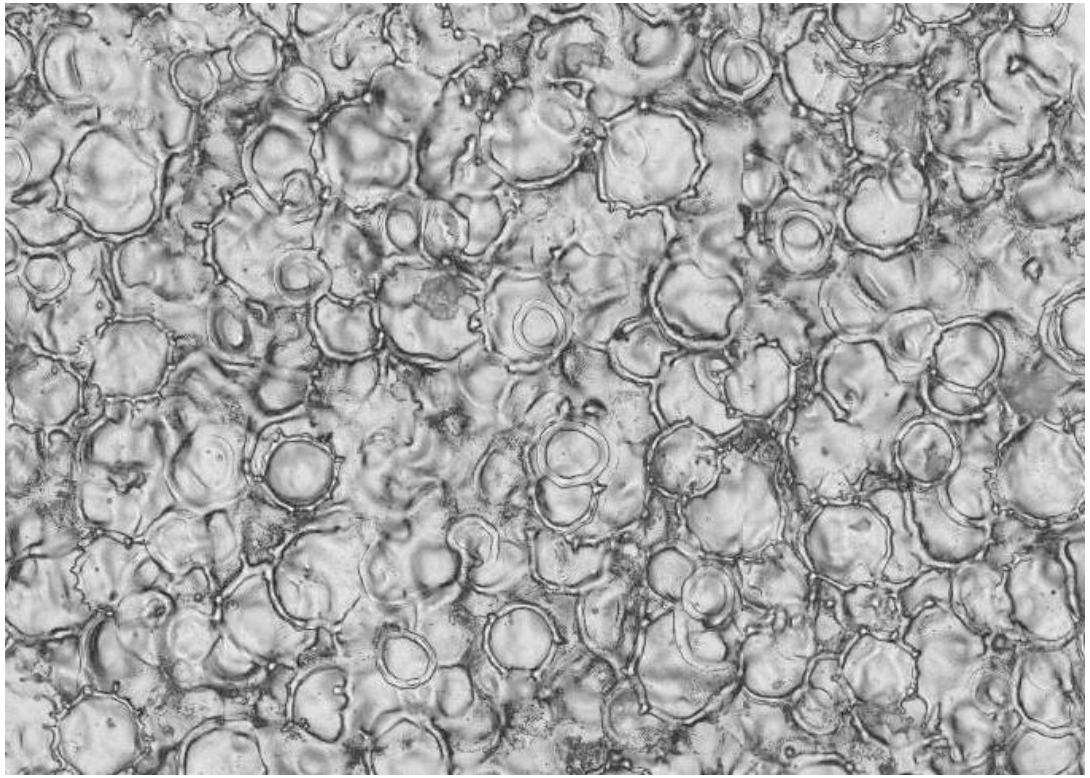
What is “white marking”?

For an aesthetic surface, there is no absolute measure, no right or wrong

- White-mark with angle-dependent sparkle
- Angle-independent mark with homogeneous appearance

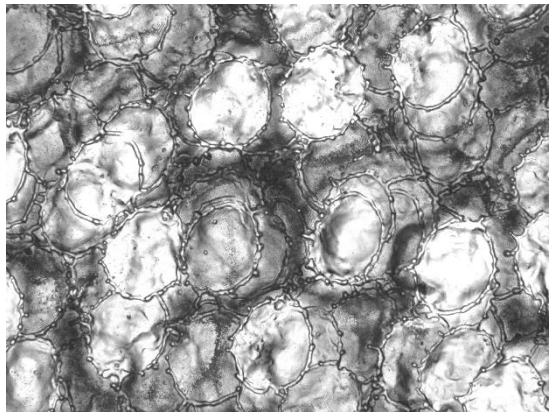
Commonality:

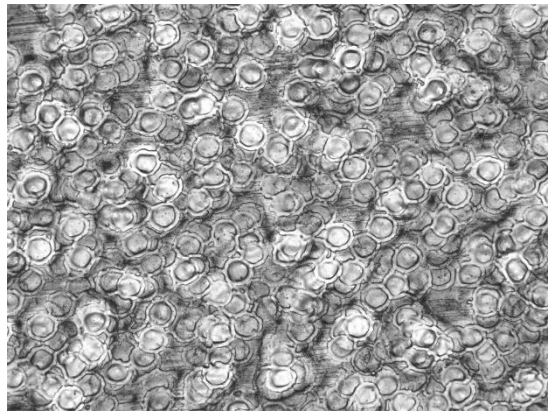
- Surface-structure with reflecting dimples to scatter light



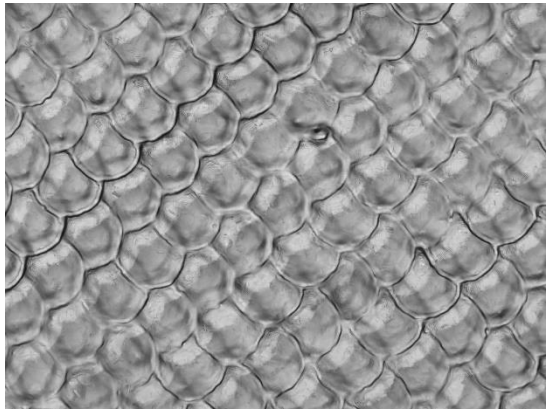
Influencing properties

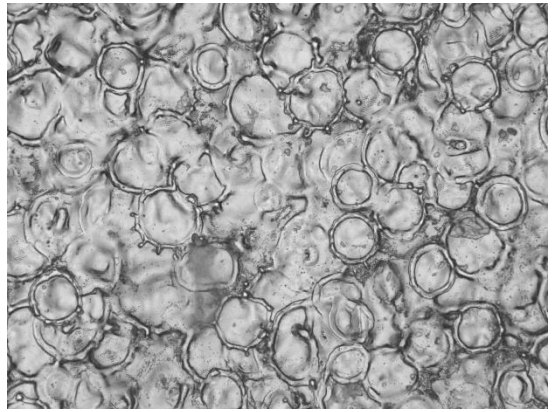
- Size of dimples
  – Large, small or mixed



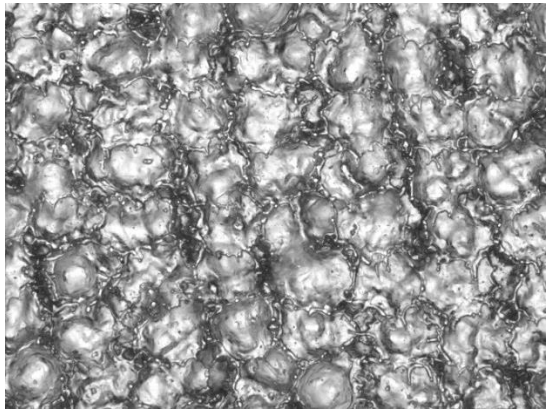


- Positioning of dimples
  – Highly ordered or random



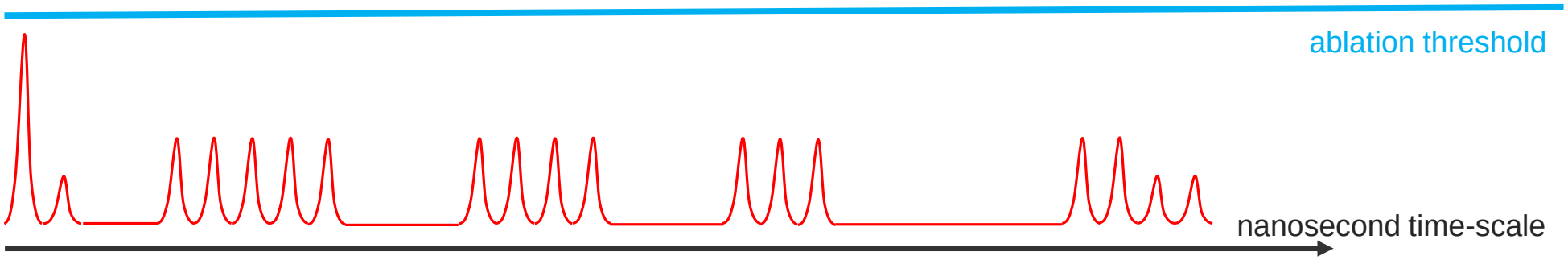


- Structure of dimple-edge
  – Well-defined or “splattered”



Powerful tool: picosecond-laser with flexible burst-mode

- With a flexible burst-mode, we can precisely control the heat coupled into the material to locally melt it and create dimples
- Pulses inside burst typically below the ablation threshold
- Typically >20 pulses in the burst (to provide enough energy)



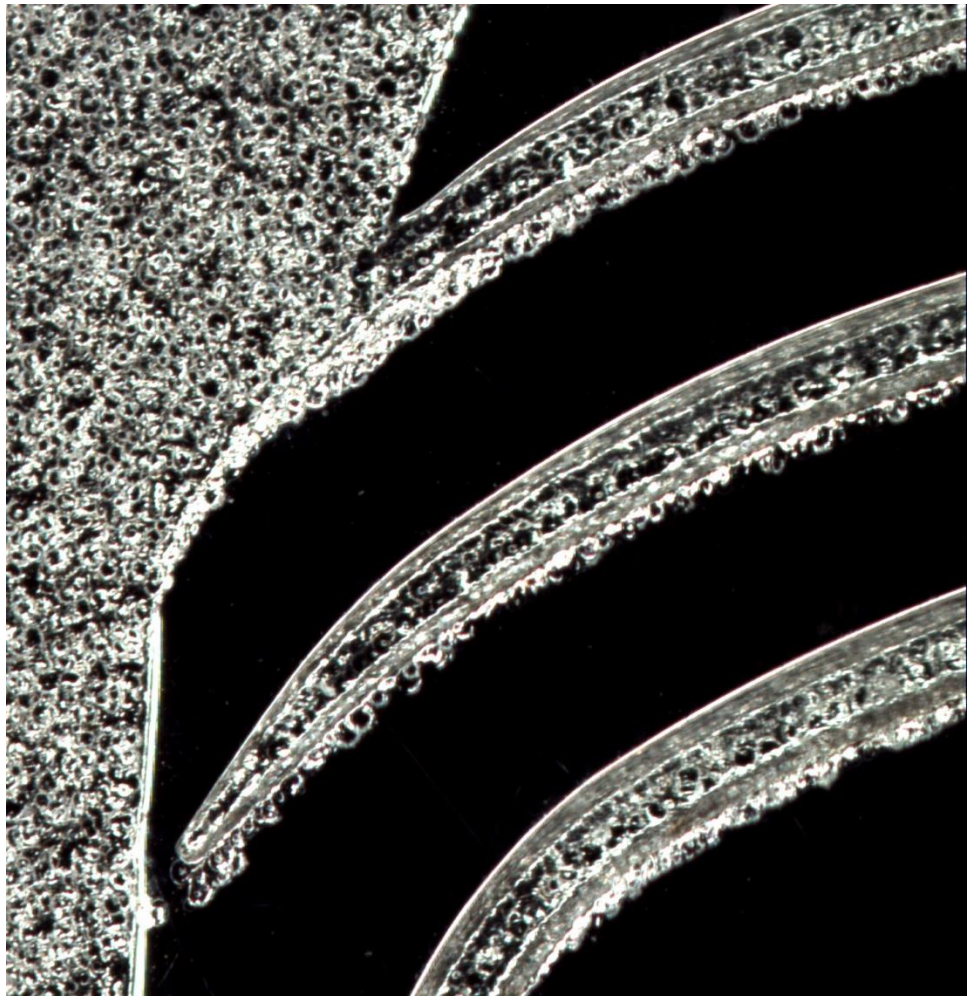
– Control the diameter of each dimple (for up to 2 Mio. dimples/second)

– Control edge-definition of dimples

White engraving – two processing steps, one laser source!

Common issue for two step-process using two different techniques:

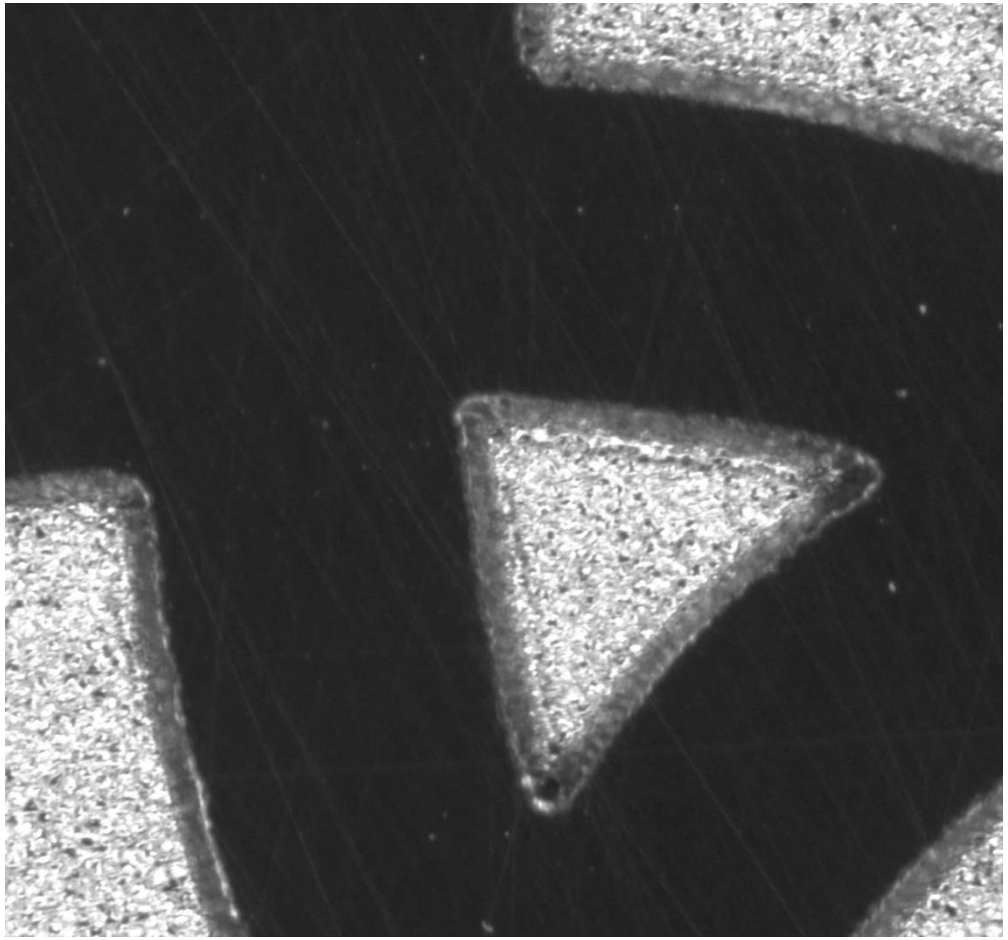
- Overlap-errors between engraved structure and white surface-texture
- Reduced visual quality



White engraving – two processing steps, one laser source!

Picosecond-solution:

- Both steps are performed with same laser through same beam-line
- Perfect overlap between engraving and surface-texture
- Switching between engraving and texturing within a second
- Full control over micro-structure of surface-texture to realize different appearances



Summary

- Picosecond-lasers provide excellent quality when engraving stainless steel
- With pulse-bursts high throughput can be realized while maintaining process quality
- Flexible burst-programming and high modulation bandwidth gives full control over micro-structure of white surface-texture
- Excellent overlap between engraving and surface-texture gives highest quality result in appearance
- Operation-mode can be switched within a second
- Minimal to no post-processing required

Lumentum product offering

PicoBlade® 2

Parameter	Specification
Output Power	≥ 45 W at 1064 nm ≥ 25 W at 532 nm ≥ 10 W at 355 nm
Energy	Single pulse energy up to 200 µJ High energy bursts up to 600 µJ
Wavelengths	1064 nm or 532 nm or 355 nm
Pulse Repetition Rates, after POD	Single shot – 8.2 MHz
Pulse Duration	10 ps
Beam Quality Parameter (M^2x & M^2y)	< 1.3
Dimensions	989 x 276 x 178 mm (l,w,h)

PicoBlade® 3

Parameter	Specification
Output Power	≥ 170 W at 1064 nm ≥ 100 W at 532 nm ≥ 50 W at 355 nm
Energy	Single pulse energy up to 400 µJ High energy bursts up to 1 mJ
Wavelengths	1064 nm or 532 nm or 355 nm
Pulse Repetition Rates, after POD	Single shot – 8.2 MHz
Pulse Duration	10 ps
Beam Quality Parameter (M^2x & M^2y)	< 1.3
Dimensions	740 x 573 x 212 mm (l,w,h)

Features

- Flexible Bursts (FlexBurst)
- Advanced PoD technology (full and highly dynamic pulse control)
- AccuTrig
- SYNC option for line scanners
- High energy burst (MegaBurst™)

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Thank you

Dr. Andreas Oehler
Head of Laser Micro Applications
andreas.Oehler@lumentum.com

Lumentum Switzerland
www.lumentum.com

Sales-contact:
christian.ritzenthaler@lumentum.com