SWTEST

PROBE TODAY, FOR TOMORROW

2022 CONFERENCE

Does Femto Laser micro machining match with guide plates and probes requirements?

posalux®

SWISS MADE

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Posalux SA

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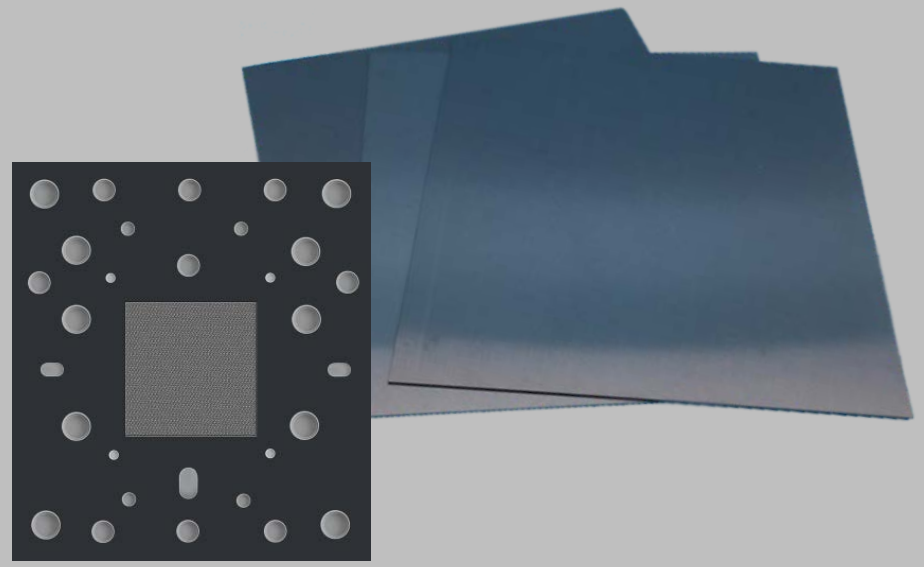
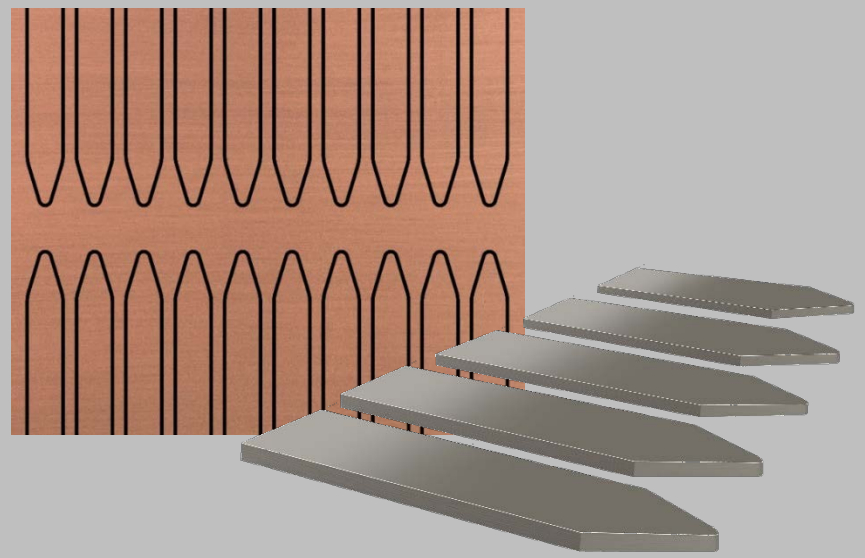
The world of Laser micro-machining



Ceramic Guide Plates



Vertical and MEMS Probes

Overview

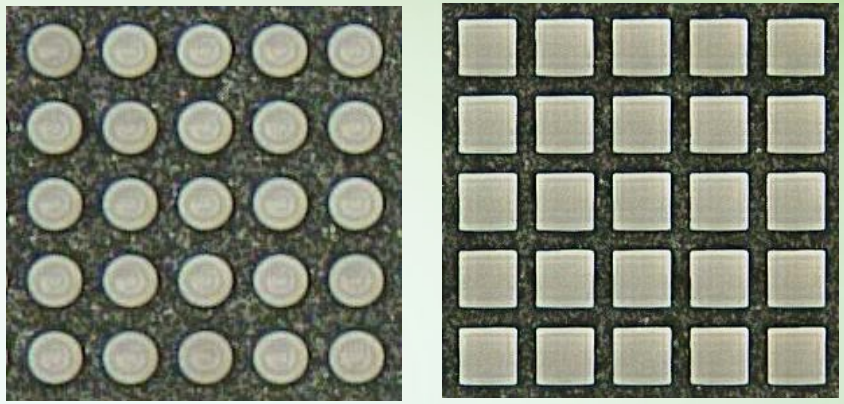
- Introduction
- Technical specifications / State-of-the-art
- Femto Laser technology
- Increasing challenges
- Femto Laser, YES but…
- Conclusion

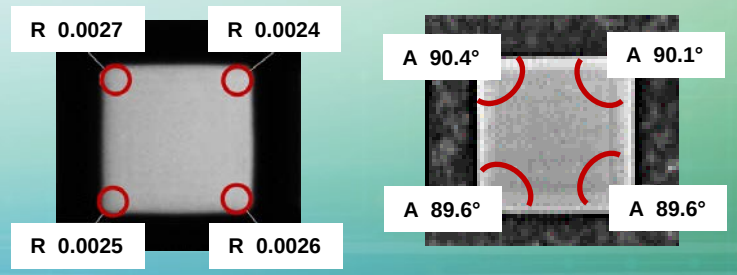
Introduction

- Ceramic guide plates processing by Laser is well known in the industry, wafer probes as well
- Why Femto Laser helps to achieve increasing challenges?
- Is the Femto Laser enough to cover all technical (new) requirements?

Technical specifications / State-of-the-art (1/2)

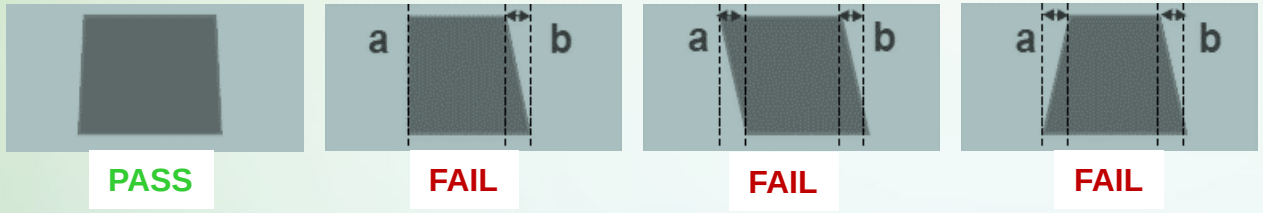
- **Guide plates**
  - Round, square and rectangle holes
  - Diameter / Dimensions down to 20 µm or less
  - Size tolerances < ±1.5 µm
  - Straight holes (no taper)
  - Wall thickness < 8 µm or less
  - Corner radius < 3 µm (square holes)
  - "Orthogonality" 89° < … < 91° (square holes)
  - Surface quality / Homogeneity of the hole
  - No damages, no micro cracks

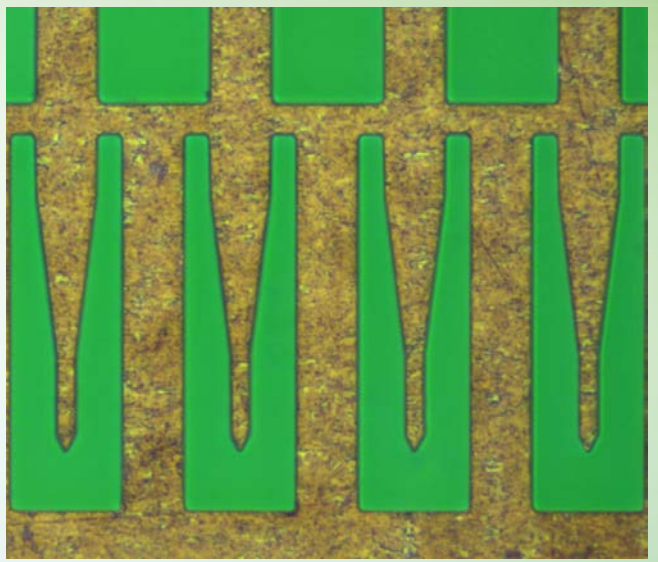




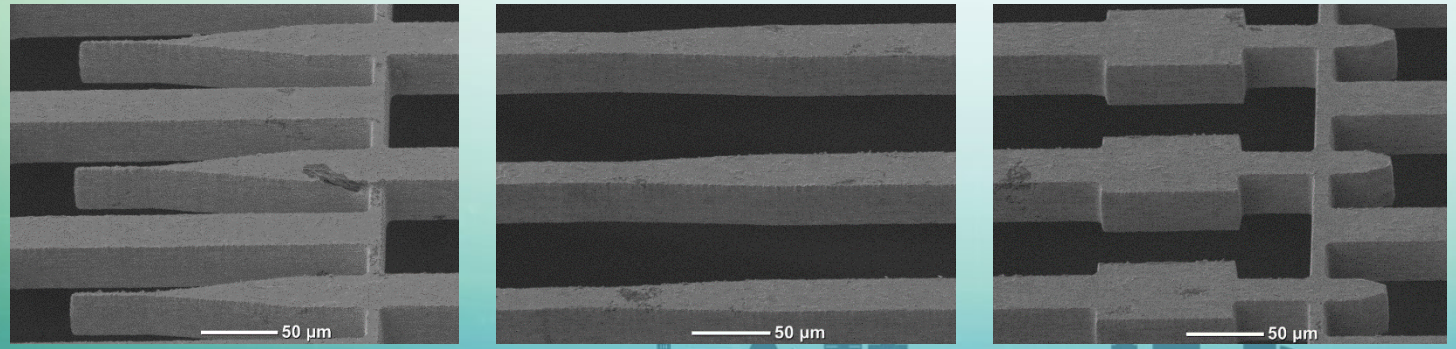
Technical specifications / State-of-the-art (2/2)

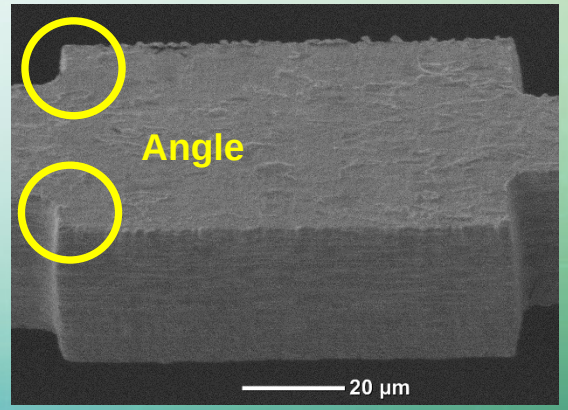
- **Vertical and MEMS probes**
  - Size tolerances < ±1.5 µm / Min. width down to 15 µm
  - Cross section of the probe (taper size and symmetry)





  - Angle
  - Outlook (cutting uniformity, smooth)

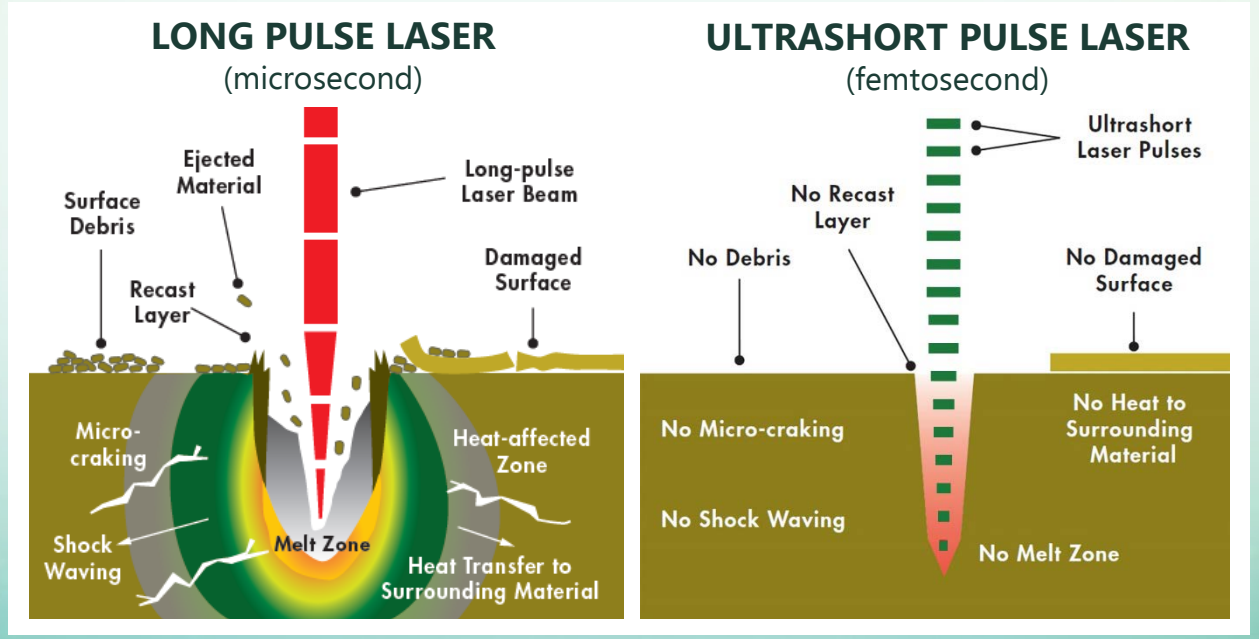




Femto Laser technology (1/2)

What means Femto Laser?

A FEMTO-LASER is a Laser which emits optical pulses with a duration well below 1 ps, i.e., in the domain of femtoseconds (1 fs = 10^{-15} s = One quadrillionth of one second). It thus also belongs to the category of ULTRAFAST LASERS or ULTRASHORT PULSE LASERS

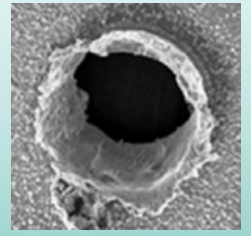


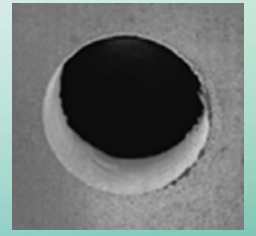
Femto Laser technology (2/2)

Pulse duration (fs-ps) and mechanism

Key parameter to achieve non-thermal process. The maximum pulse duration to avoid thermal effects is dependent on material (< 500 fs is convenient for most of the materials)

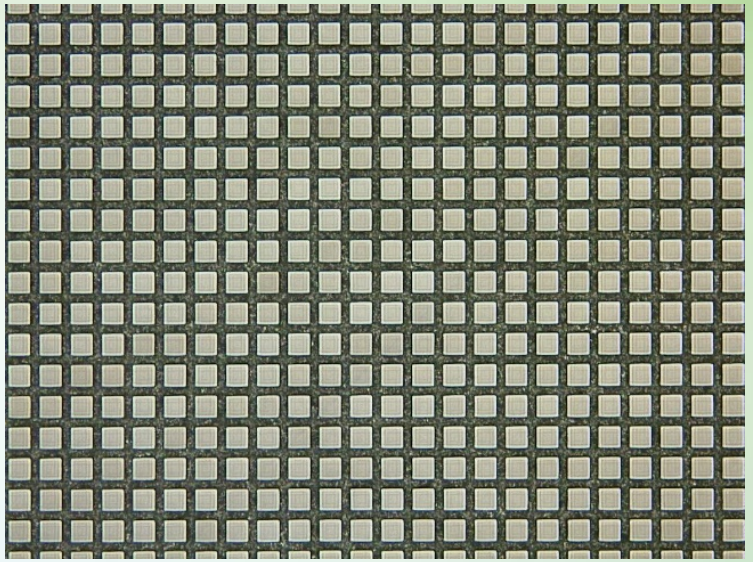
Theoretical value (or limit) for heat diffusion time 0.5 ps / 500 fs	"Long" pulse (> 0.5 ps)	"Ultrashort" pulse (< 0.5 ps)
Ablation rate	☺	☺
Side effects	☹	☺
HAZ	☹	☺

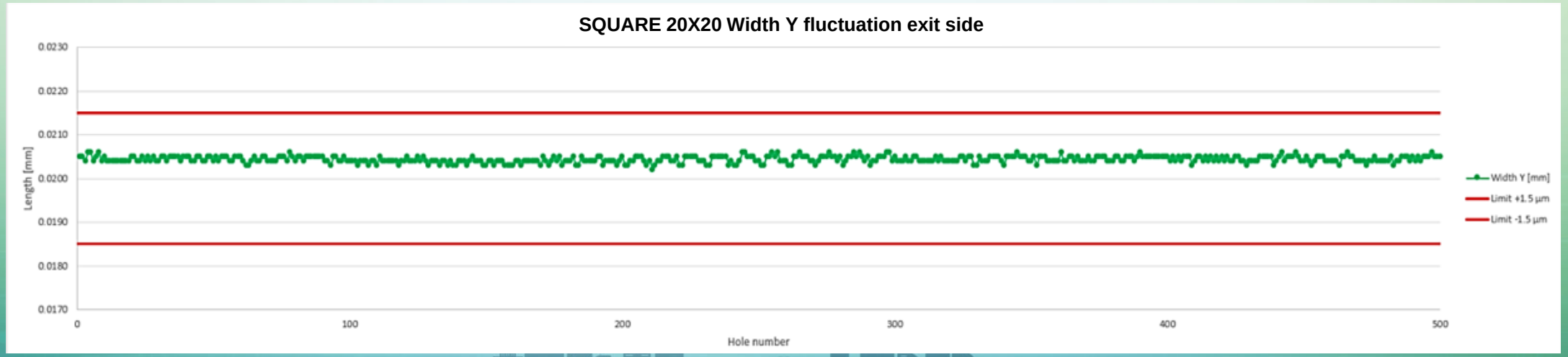




Increasing challenges (1/2)

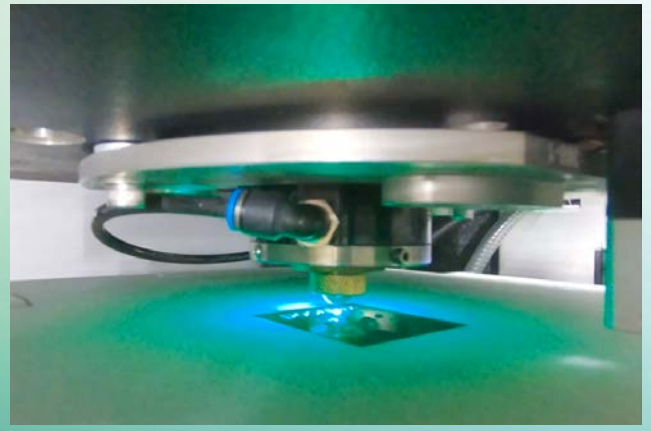
- **Increased number of holes per guide plate (> 100K) with reduced pitch**
- **Productivity (square holes 20 x 20 µm < 1.2 sec/hole)**
- **Repeatability, reproducibility, consistency (several days of production in a row)**

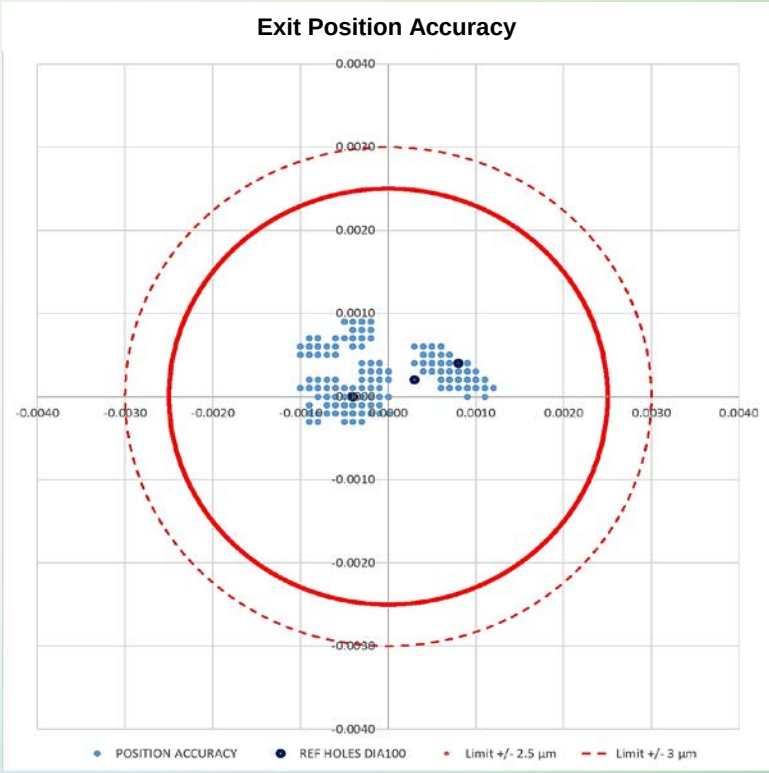




Increasing challenges (2/2)

- **High positioning accuracy**
  (process accuracy within ± 2 µm)
- **Stability + reliability (running 24/7)**
- **R&D vs. mass production**





Femto Laser, YES but… (1/7)

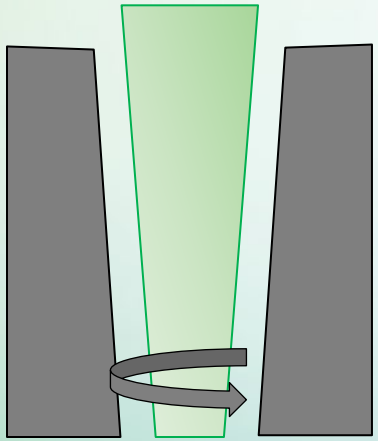
- **Femto Laser is a key part but not completely sufficient to cover the latest and future challenges**
- **Some other components are essential to reach a higher level in applications**
- **Flexibility of the system (drilling, routing/milling, cutting), several operations in the same process are achieved using additional elements**

Femto Laser, YES but… (2/7)

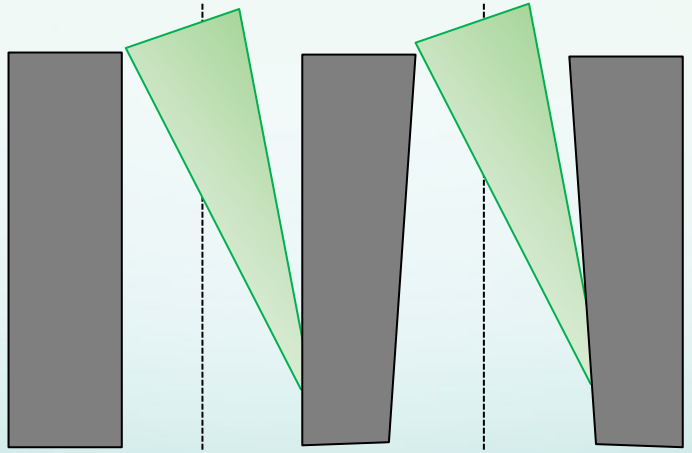
… A precession head (5-axis scanner) is needed

High precision manufacturing with high aspect ratios and perpendicular shaped wall angles, i.e. drilling of cylindrical or even negative tapered walls

Technology: Conventional laser drilling

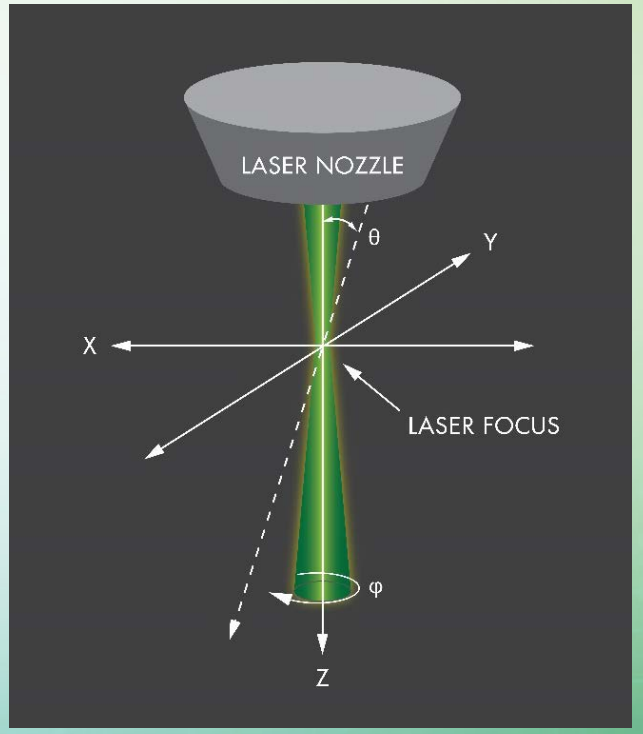


5-Axis drilling



Result: Positive tapered wall angle

Demand:
Zero or negative tapered wall angles

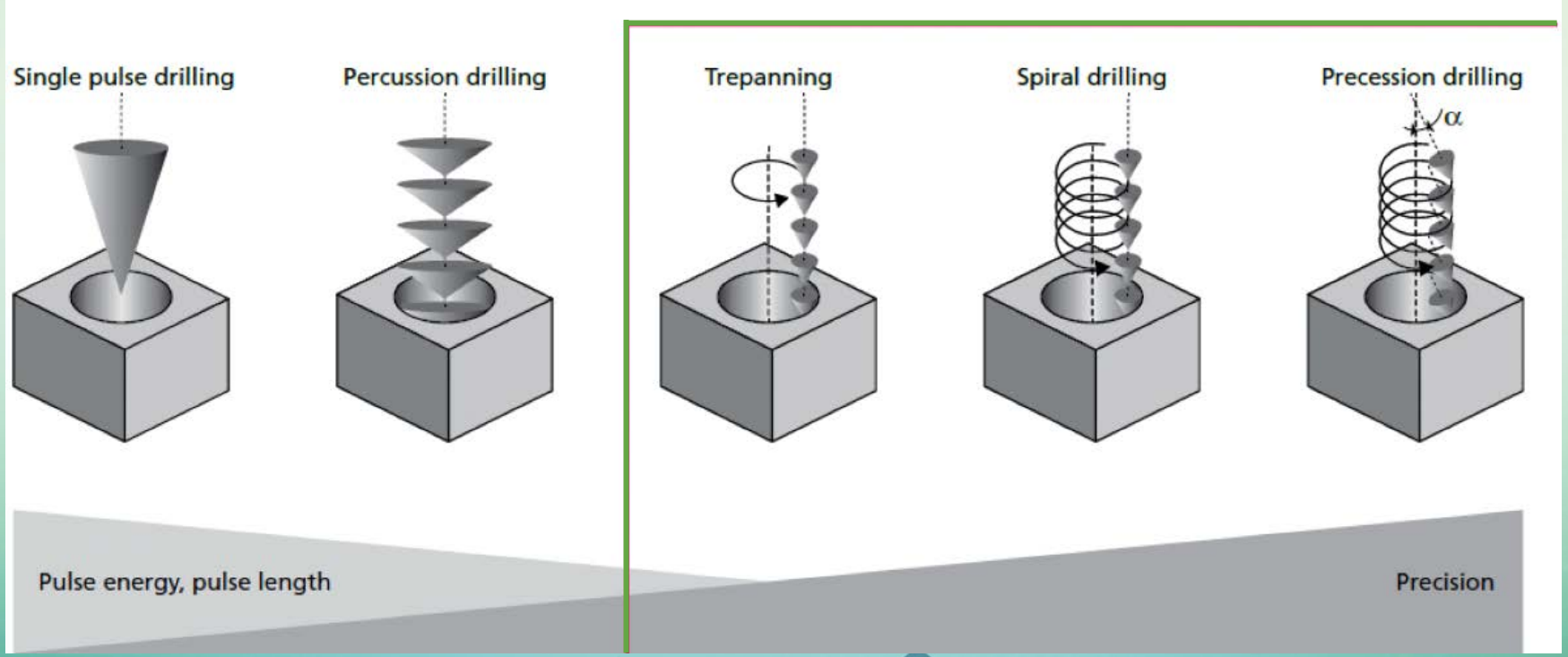


x, y, z, incidence angles θ and ɣ

Femto Laser, YES but... (3/7)

... A precession head (5-axis scanner) is needed

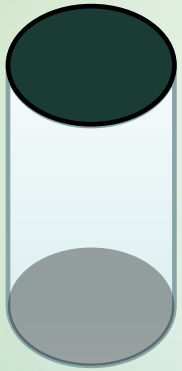
- The Laser is moved helically with tilted laser beam e.g. while trepanning and spiral drilling
- Precession drilling means the laser is tilted and moved helically



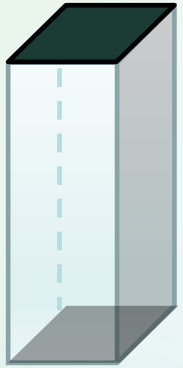
Femto Laser, YES but… (4/7)

… A precession head (5-axis scanner) is needed

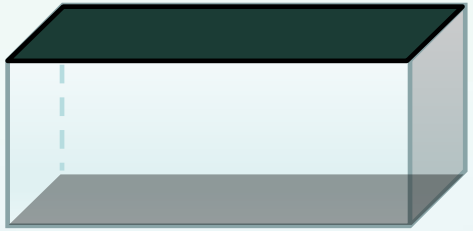
- Free selectable geometries, no damage of the hole shape



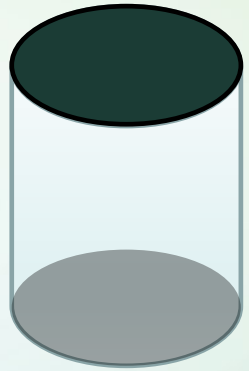
Round holes



Square holes



Rectangular holes



Elliptical holes

Step holes

Straight

Chamfer

Tilt

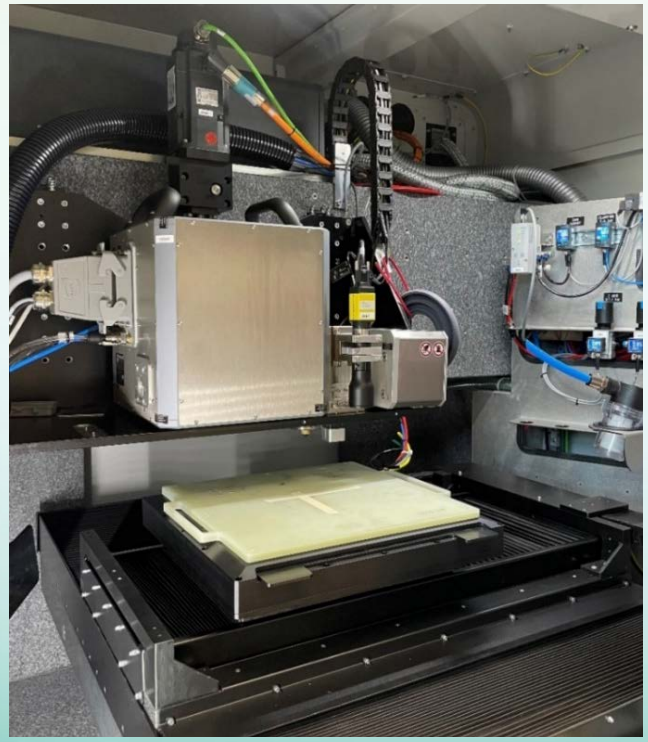
Negative taper

Positive taper

Femto Laser, YES but… (5/7)

… A machine concept following fundamental design rules is needed

- Statics, kinematics, dynamics and thermal

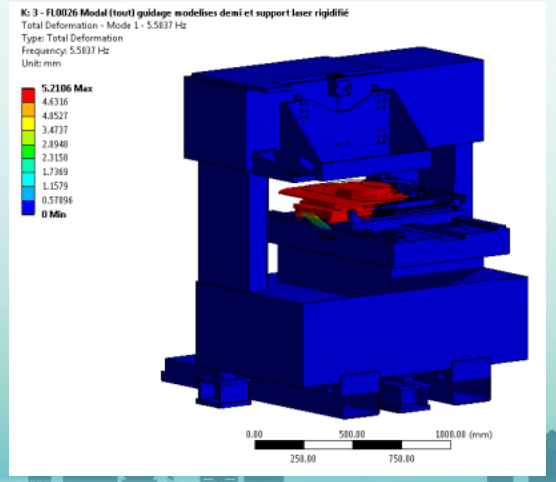


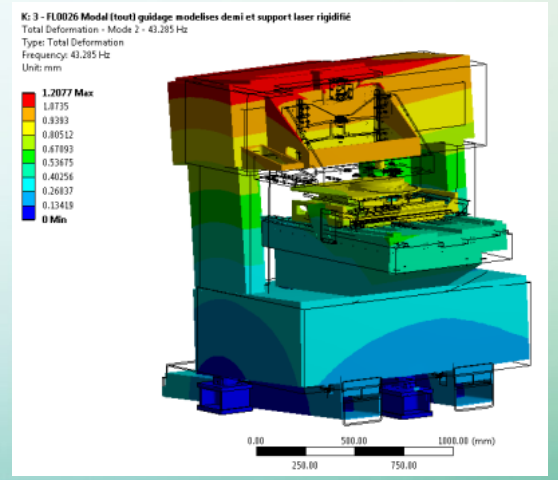
Femto Laser, YES but… (6/7)

… A machine concept following fundamental design rules is needed

- Statics, kinematics and dynamics
- Static behavior taking into account the efforts of the machine
- Stiffness and isostatic structure (on 3 feet)
- High natural frequency = Stability of the system
- Acceleration / Deceleration

$$f = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$$





Femto Laser, YES but… (7/7)

… A machine concept following fundamental design rules is needed

- Tolerances are getting tighter
- “Long runners” require long-term thermal stability
- Isostatic construction
- Choice of materials (structure, XY table in granite)
- Environmental regulation by PID, active air conditioning
- Compensation matrix (drilling room at 23°C / machine calibrated at 20°C)
- Target is to keep everything at ambient temperature, without high variations per day and during production

Conclusion

FEMTO-LASER (very low heat diffusion time < 300 fs)	PRECESSION HEAD (5-optical-axis beam management)	MACHINE CONSTRUCTION	PROCESS ENGINEERING
No thermal effects	**Free selectable geometries**	**Reproducibility**	**Know-how & Experience**
High quality (no recast debris on surface, good roughness)	**High quality** (no damage of the hole shape)	**Stability**	
High productivity (high repetition rate)	**High productivity** (optical axes with high dynamic)	**High productivity**	
Repeatability	**Repeatability**	**Positioning accuracy**	
Accuracy (dimensions)	**Accuracy** (fine adjustments)	**Flexibility** (drilling, routing, cutting)	