posalux
SWISS MADE

ASTT
Association Suisse de Traitement Thermique des Matériaux

DOUZIEME RENCONTRE ROMANDE INTERASSOCIATIONS

SURF – THERM

17.11.2016

« Usinage Laser à impulsions ultra-brèves »

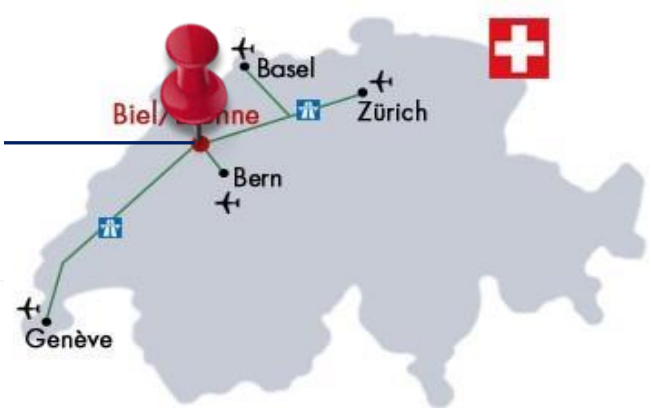
Marco Nadalin

Posalux

Thèmes de la présentation

- Présentation Posalux
- Usinages **Femto Laser** : intérêts et avantages
- Stratégies de process Laser
- Challenges pour Posalux réalisés
- Tête optique
- Machine de production et de prototypage
- Conclusion : Usinage Femto Laser

Posalux SA - Switzerland



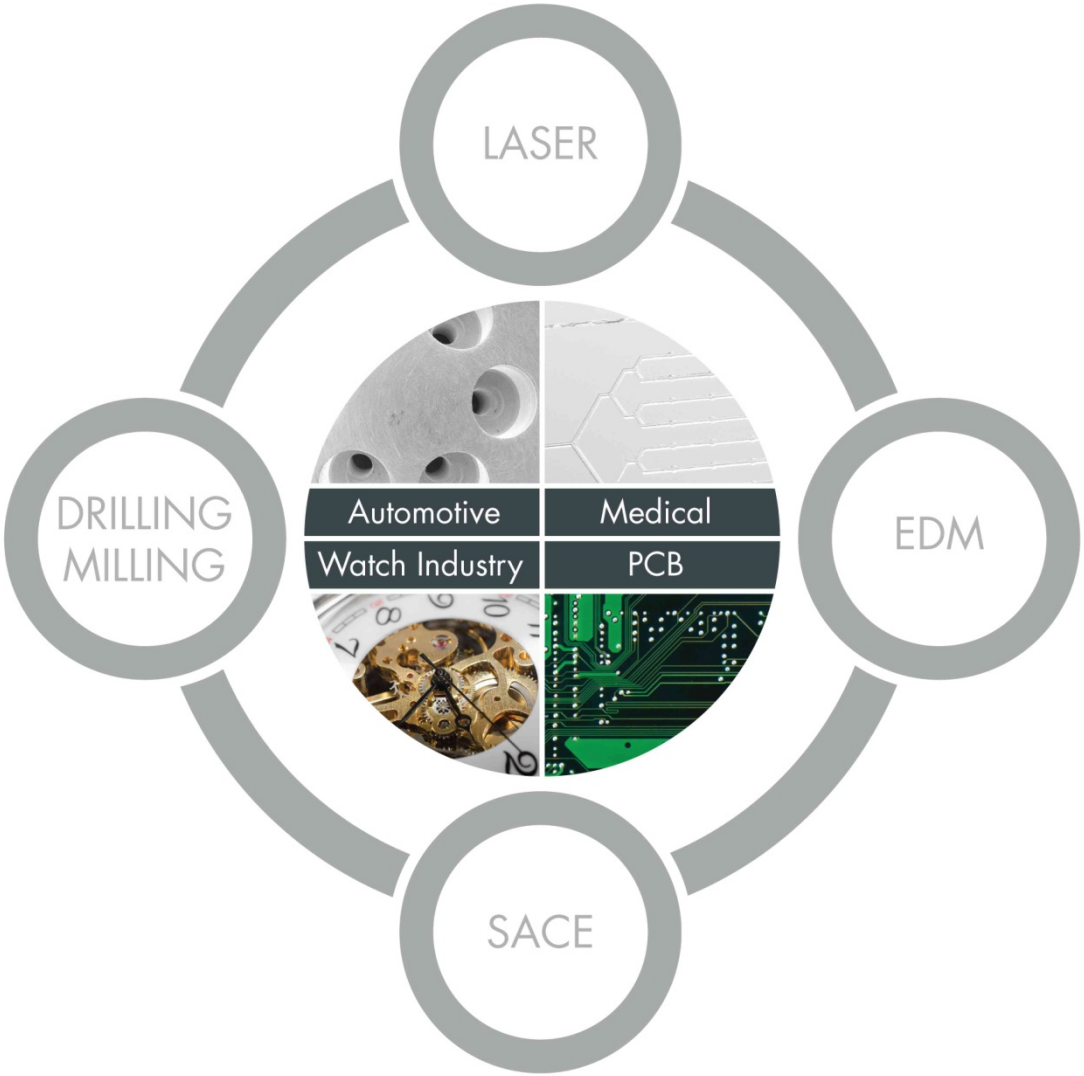
Founded in 1943, Posalux is a leading Suisse manufacturer for micro technologies for mass production.

Posalux is headquartered in Biel-Bienne, one of the most important cities of Switzerland, which is famous not only as a watch metropolis, but also as one of the most important centers for advanced technologies.

Global presence:

- Subsidiaries of Posalux in Germany, Korea and Taiwan
- Worldwide network of sales and service agents in major countries

Four technology families for four markets



Posalux Femto Laser: History

After a long and successful history on EDM and µ-Machining technologies for robust industrial applications targeting:

- Micro machining of special and stressed parts
- Stable and repeatable Quality
- Accuracy for mass productions
- Mass-production with flexible and versatile possibilities

Posalux focus on **Femto Laser Technology** for high precision **µ-Machining** since 2011

First serial Femto Laser machines are in production since end of 2014 and work 24/7

Posalux Femto Laser: History

Posalux made the choice to:

- **develop niches applications** which require a high level of skills
- build **long term industrial partnership** with our customers

Posalux **is not an integrator** of Laser equipments, we **develop industrial processes** to meet **Customer Quality requirements**. For this, measurement equipment as **Gauges, SEM, Flow-bench** are available @ Posalux to document the manufacturing processes

Posalux build and continues to build **partnership with key actors in Industrial Femto Laser applications**

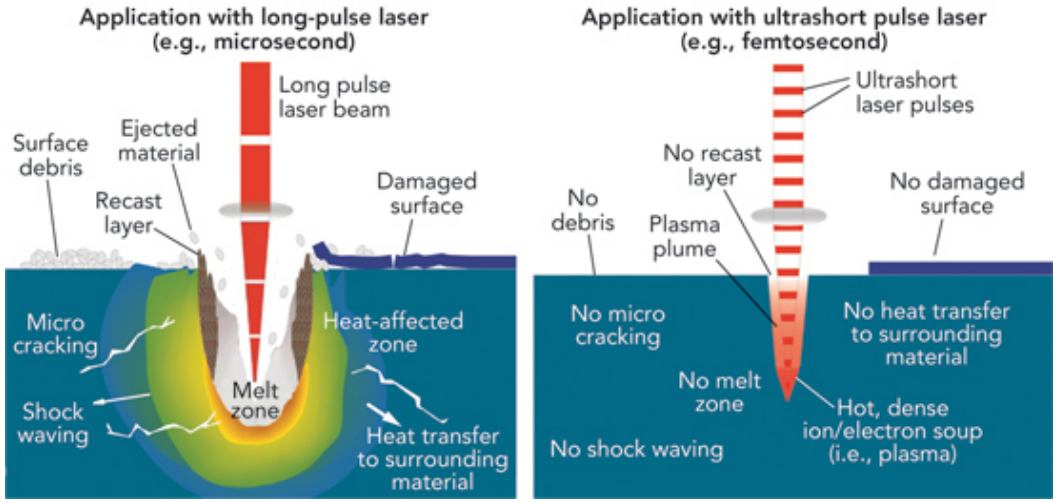
- 2 suppliers/partners for the sources (less than 300 fs)
- 2 suppliers/partners for Precession heads

Usinages Femto Laser : intérêts et avantages

Les critères influents en ce qui concerne la source Laser Femto sont :

Intégrité matière

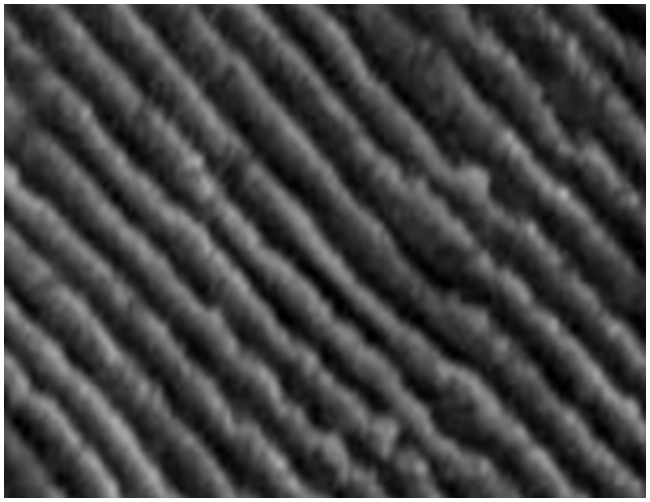
- Ablation sans échauffement sur toute matière.
- Micro-cracking inexistant.
- Precision de l'ablation < 1 µm de largeur avec Laser Femto 200-300 fs.
- Pas/peu de transformation structurelle de la matière.
- Sans dépôt et redéposition de matériau.



Usinages Femto Laser : intérêts et avantages

Etat de surface : fonctionnel et cosmétique

- Reproductibilité de la structuration
- Texturation de la surface usinée.
- Ra < 50 nm
- Applications très fines en terme d'état de surface
  ➔ Rendu de polissage
- Absence de bavure



Usinages Femto Laser : intérêts et avantages

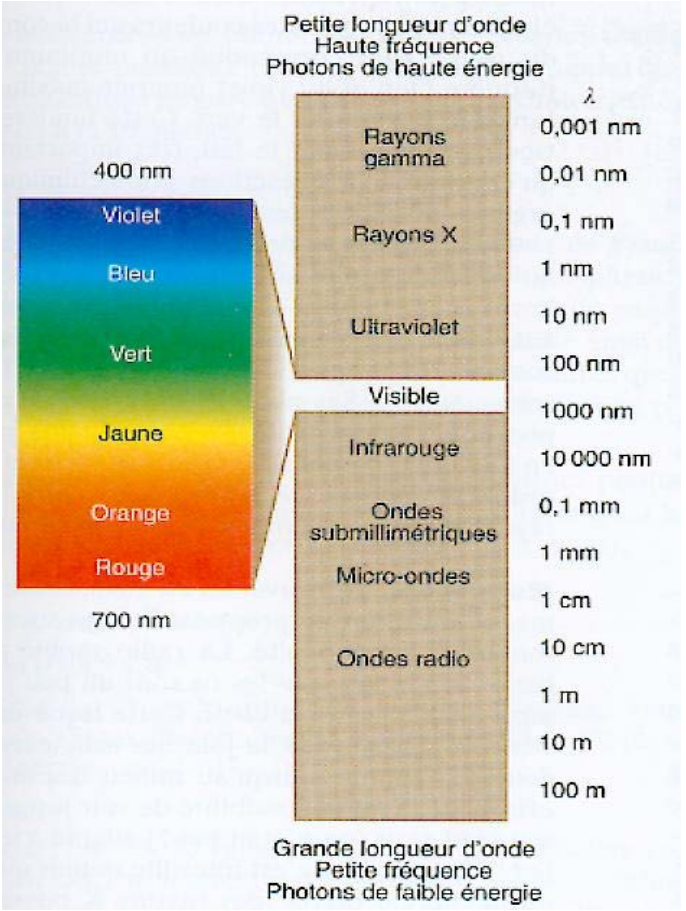
Productivité

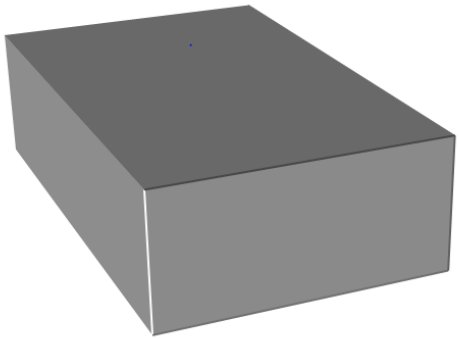
- Consommable faible (gaz assist N_2), voir nul (air)
- Flexible sur un même moyen : perçage, découpe, lamage, contourage, gravage positif et négatif etc…
- Usinage rapide sans nécessité de reprises ➔ ébauche, finition, polissage, en une seule opération

Process Laser : caractéristiques et stratégies d'usinage

Caractéristiques source Femto

- Femto source < 300 fs
- Différentes possibilités d'harmonique (longueur d'onde): nIR, Green, UV
- Energie des impulsions jusqu'à 200 µJ (20W)
- Fréquence des impulsions de 1 Hz à 2 MHz



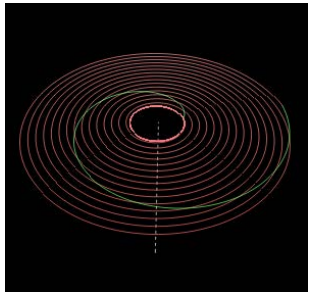


- 600x 350 x200 mm

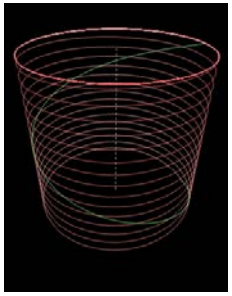
Stratégies de process Laser

Pour atteindre une haute qualité d'usinage par Laser en fonction des matériaux à usiner, la stratégie d'ablation est déterminante :

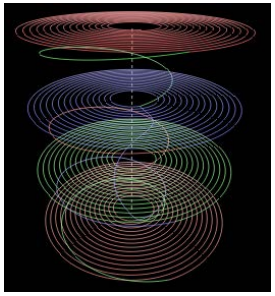
- Spirographie et précession



spiraling

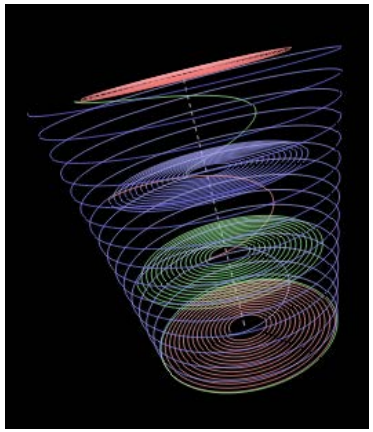


helical



spiraling by pocket

- Peck hole vs. travail par poches
- Passe de finition (géométrie et état de surface)



Peckhole :

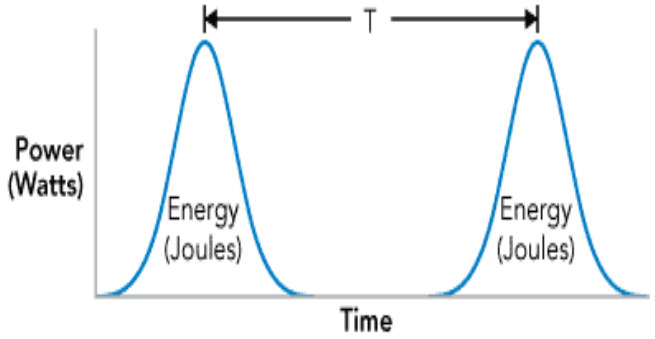
↳ spiraling pocket

Precession hole :

↳ Conical helical spiraling

Stratégies de process Laser

- Variation énergie et vitesse (fréquence)
- Choix longueur d'onde nIR/Green/UV
- Gaz assist N2/Ar
- L'interaction Laser/matière influence les paramètres process



$$P_{moyenne} = E_{pulsation} \times T$$

LASER FEMTO Applications





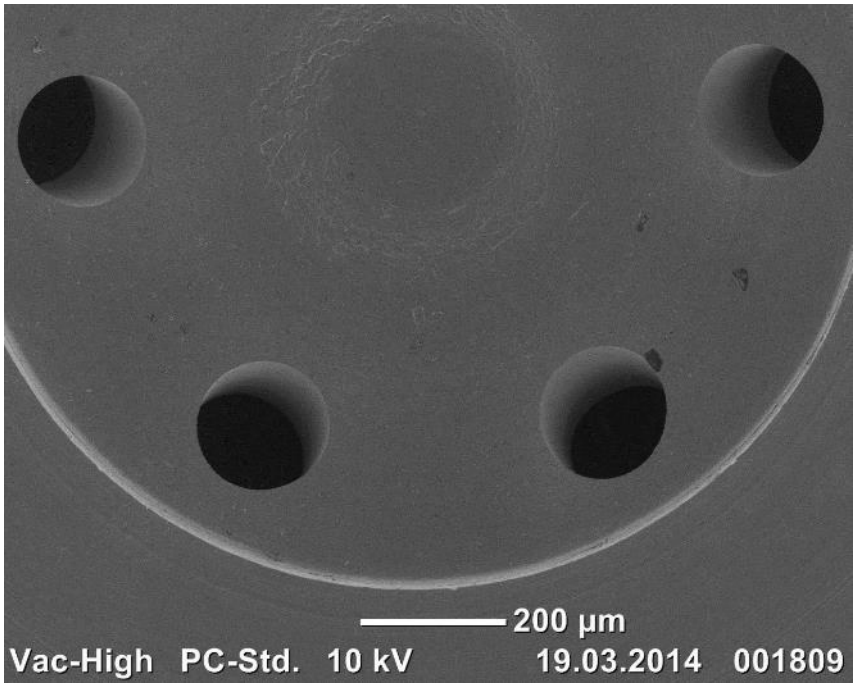

Dedicated team of 5 Engineers for process development and support of customer ramp-up phase

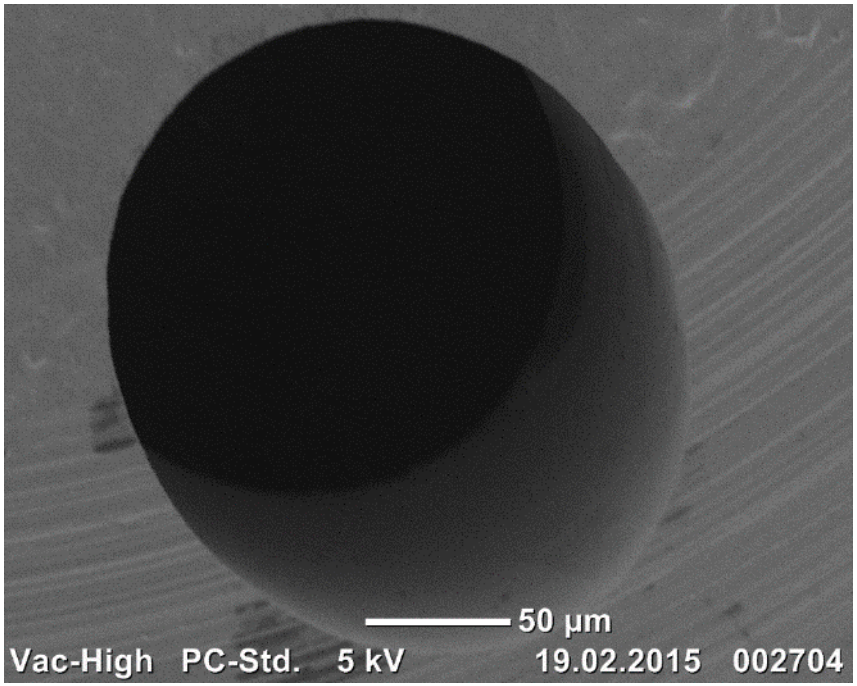
Available equipments for these activities:

- ⇨ 2 demonstrator machines
- ⇨ 1 “mono” **serial machine**
- ⇨ 1 bench on active table
- ⇨ 4 precessions heads, 4 Femto Laser sources

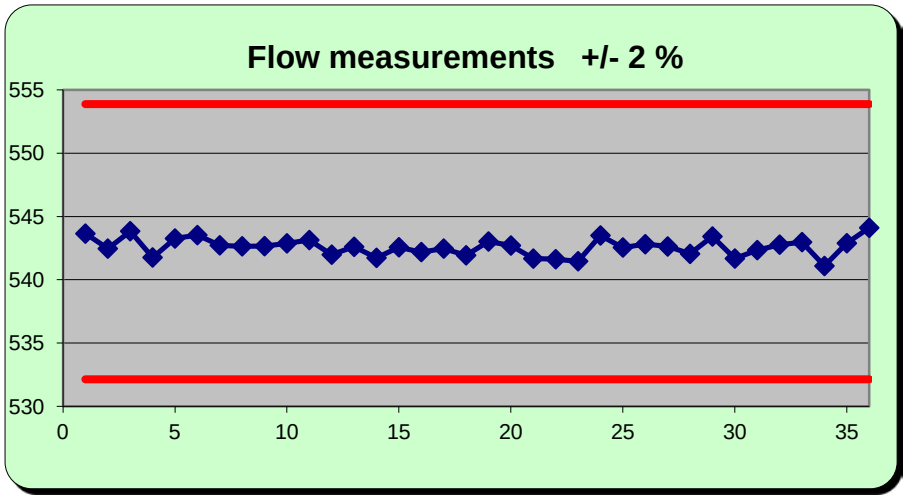
Werth Fiber probe measurement equipment, **SEM**, accurate **microscopes**, Hydraulic **flow bench** (to 200 bars, R&R = 10%), **Confocal Laser** surface finish measurement equipment (end 2016)

Industrialized processes: Gasoline Injections orifices



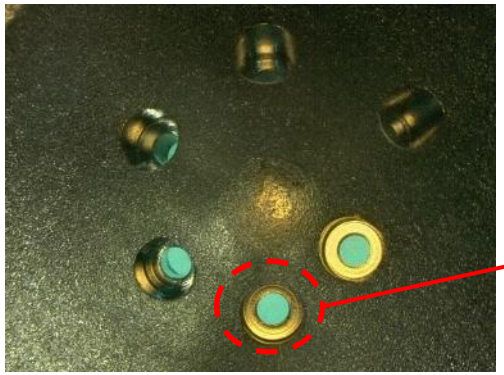


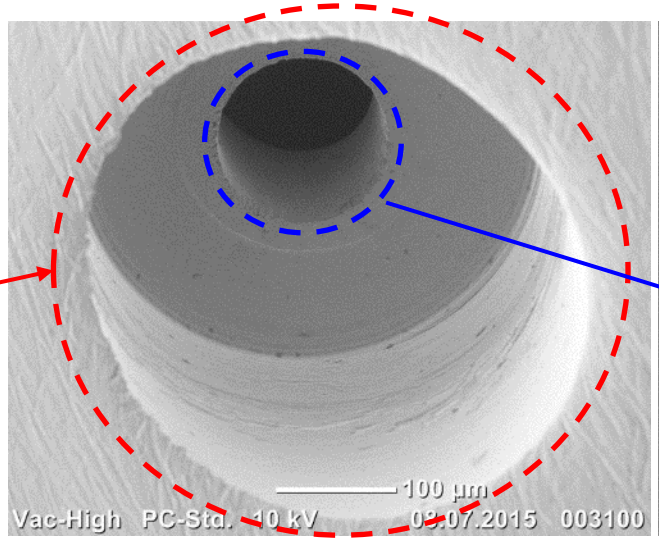
Industrialized processes: Gasoline Injections orifices

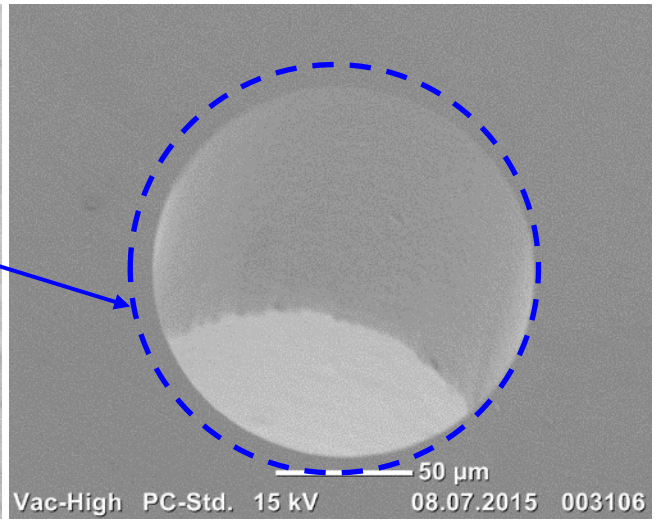


Orifice diameter = 140 µm

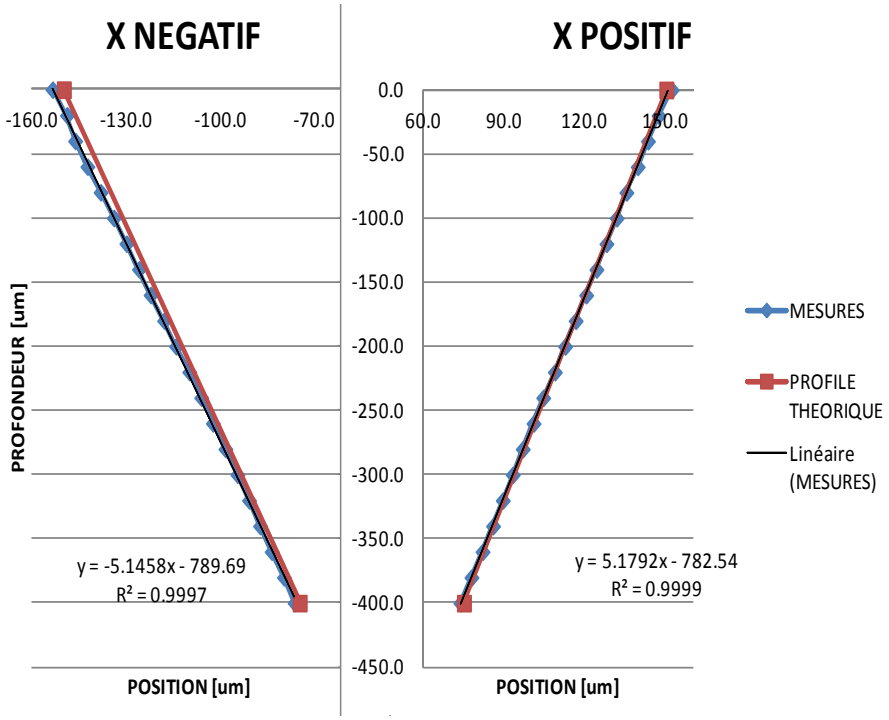
Cp	**5.10**
Cpk	**4.91**

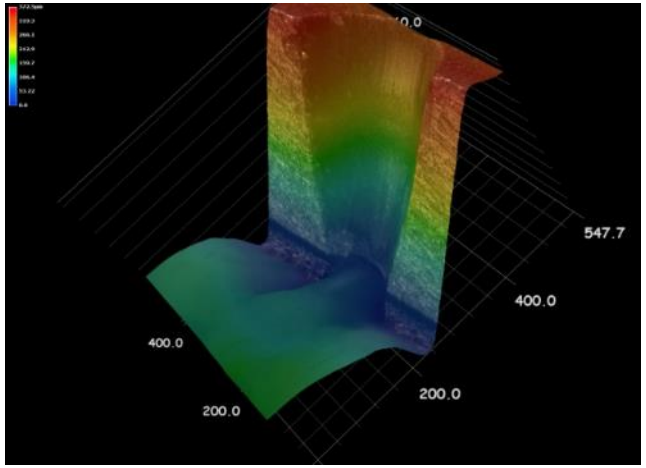


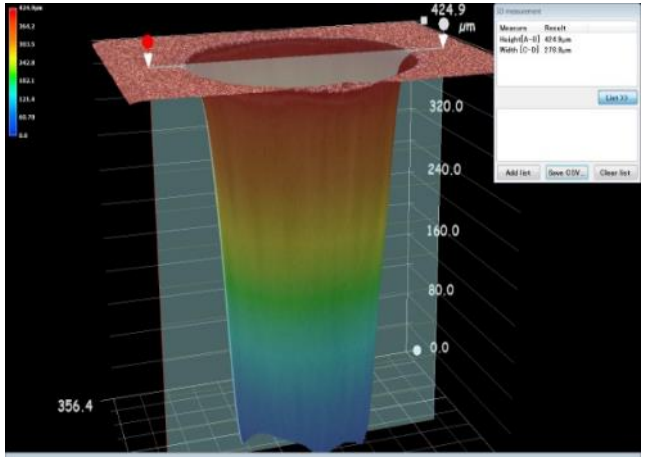




Tapered hole drilling: -15° to +23° in Steel

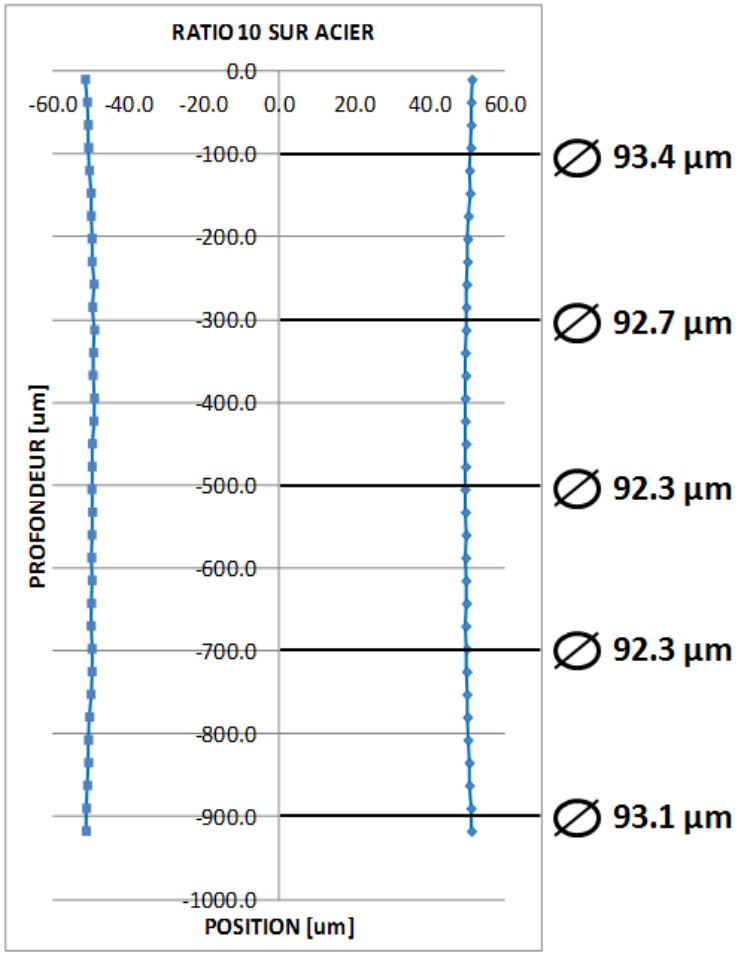


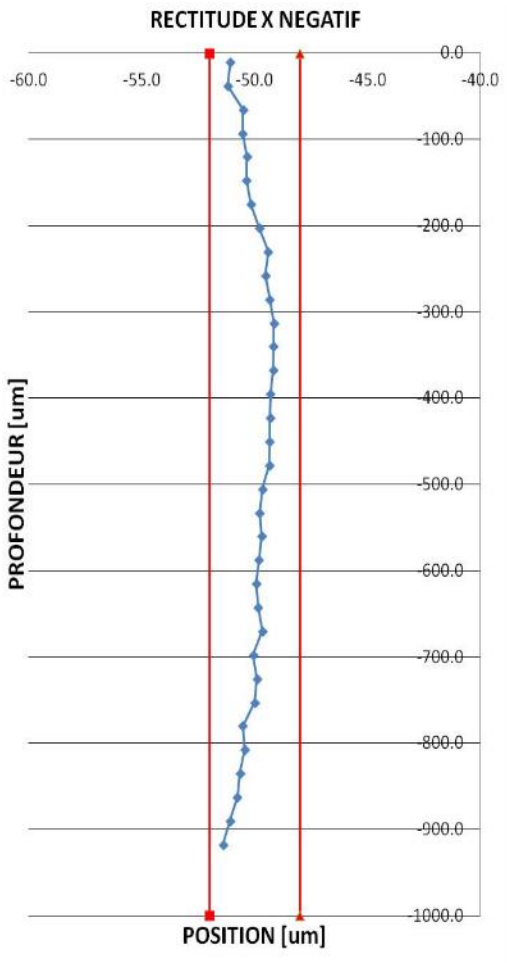


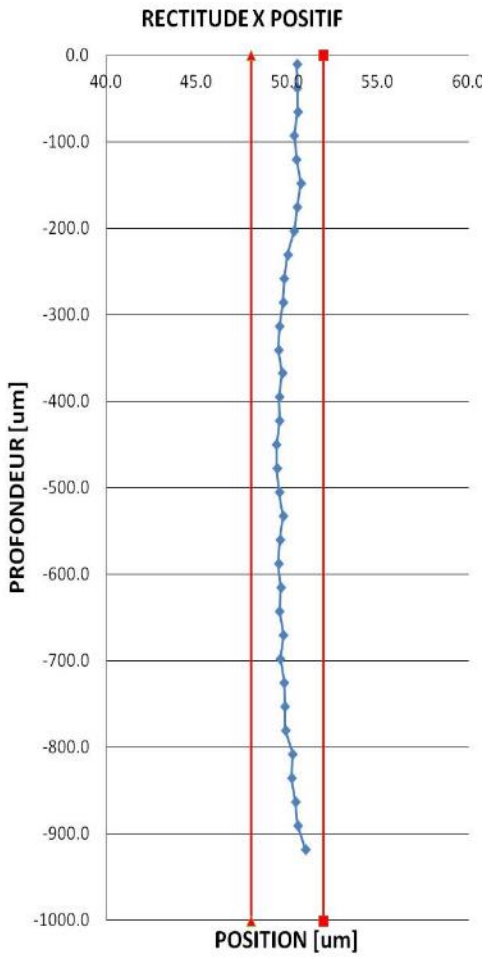


Hole drilling :

Steel Ratio 1:10

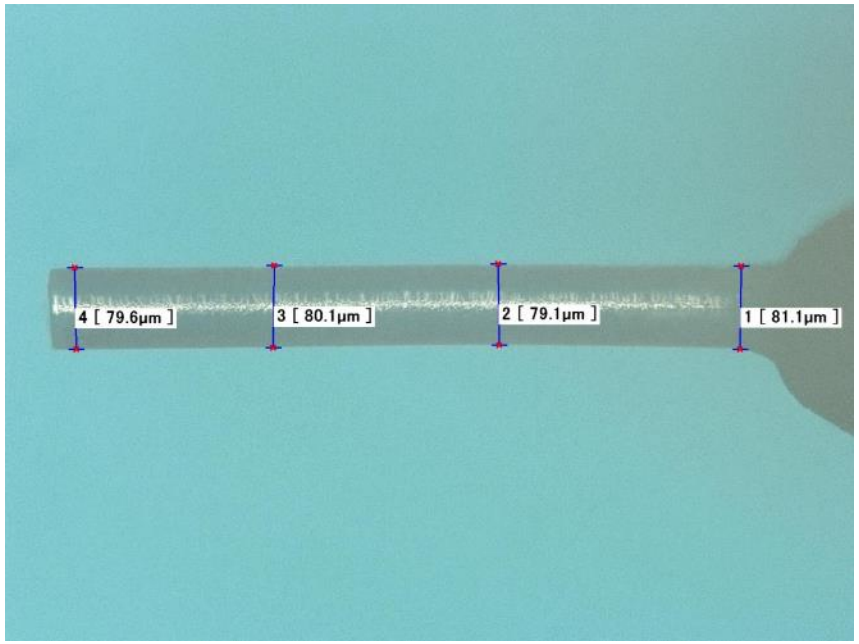






Deep hole drilling :

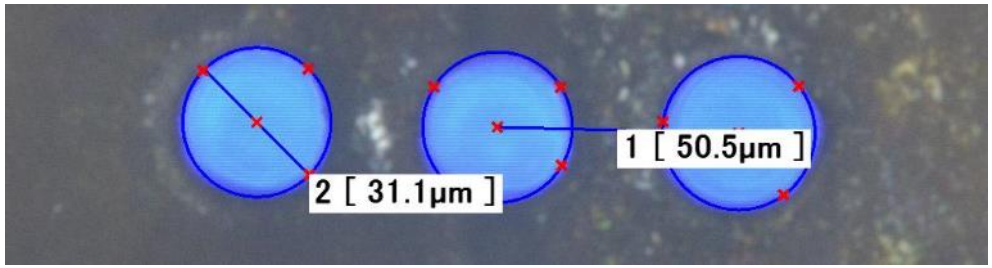
Peek & Steel

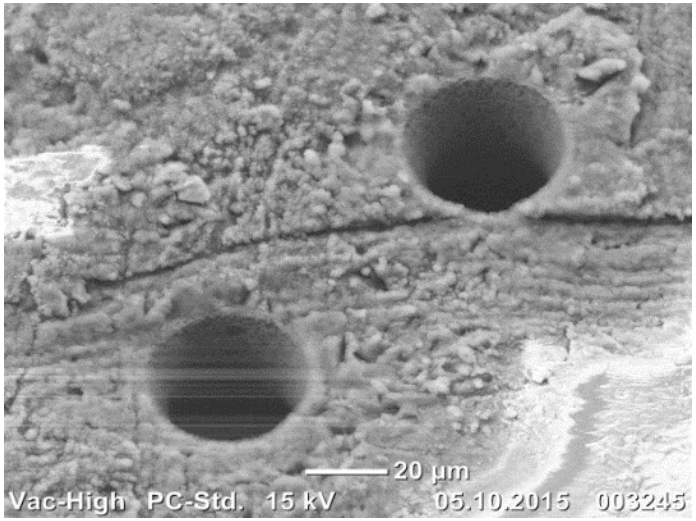


Steel: Ratio 1:10

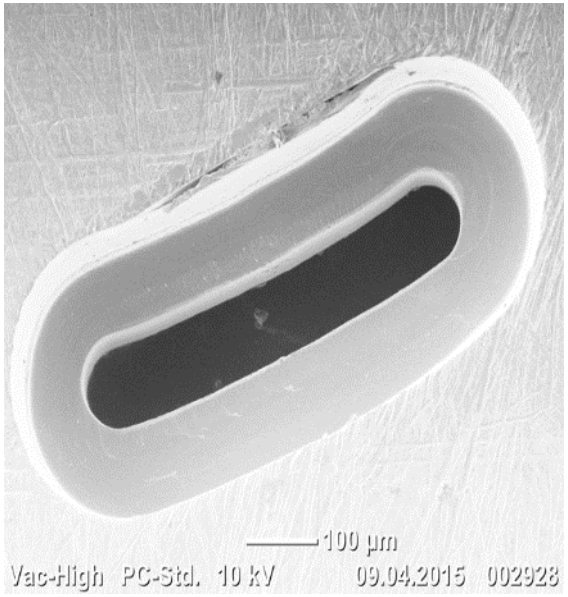
∅ 80 µm, depth = 800 µm

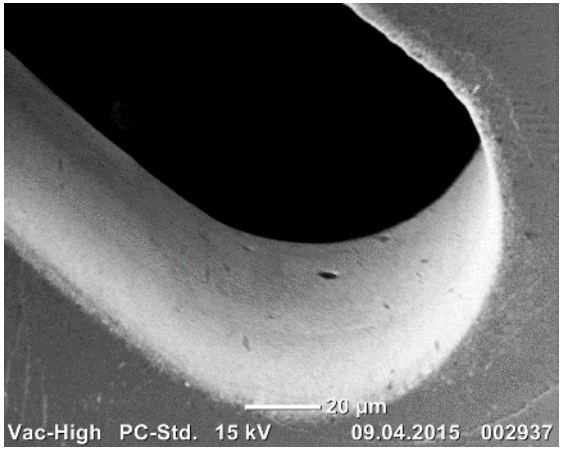
Peek Ratio 1:15

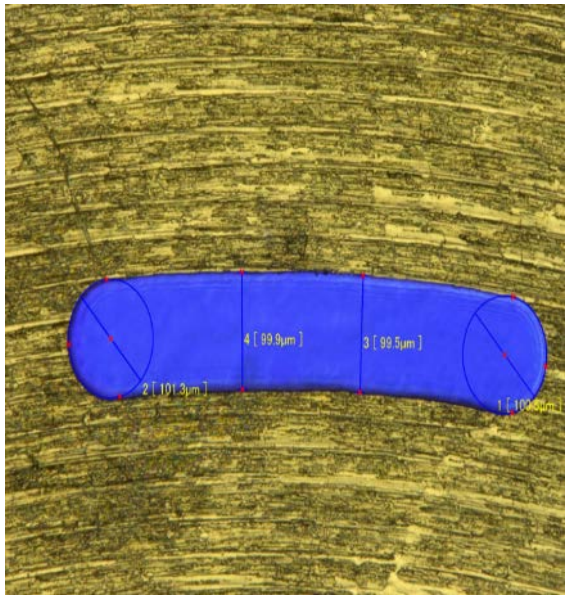




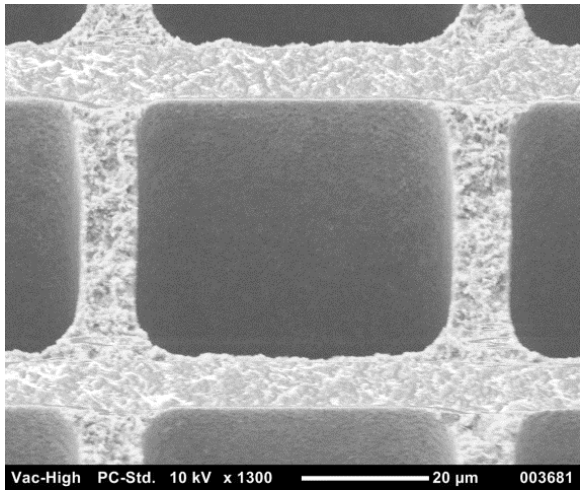
Machining and cutting “oblong shape” : Steel







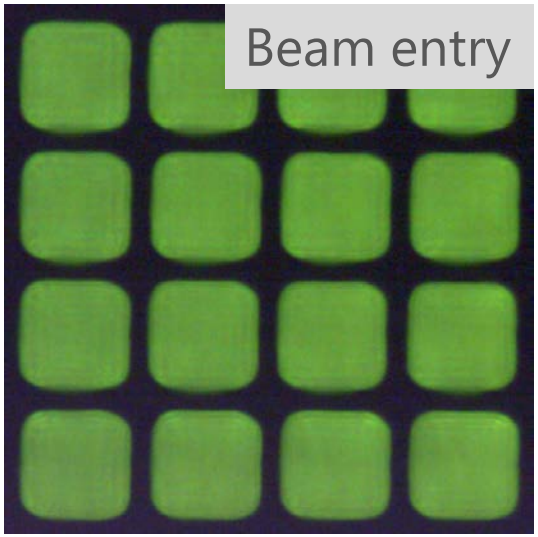
Machining of square holes : Ceramic

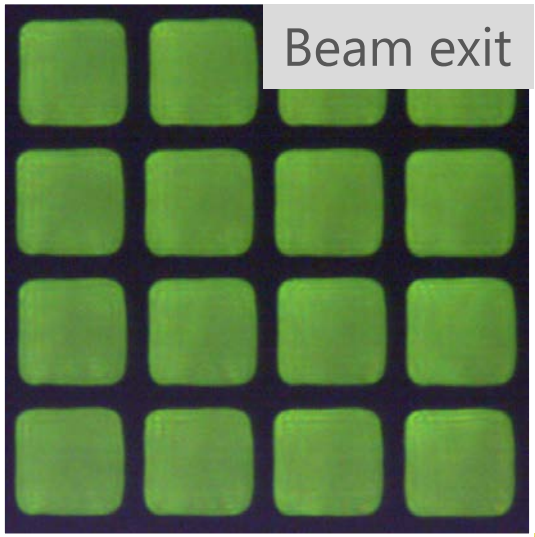


Square holes 50 µm x 50 µm x 500 µm, pitch 60 µm

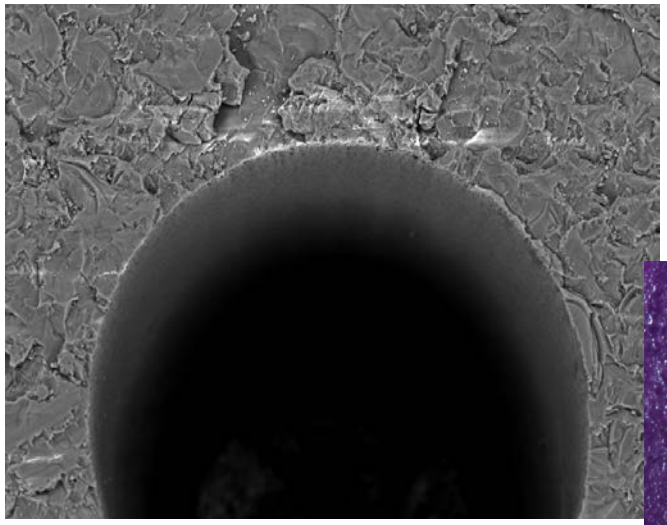
Radius ≈13 µm (radius of the beam at focal point)

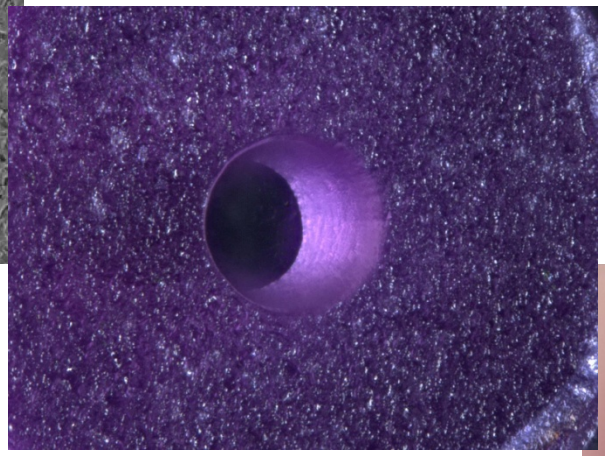
Process cycle time per hole: 15 s (can be optimized)

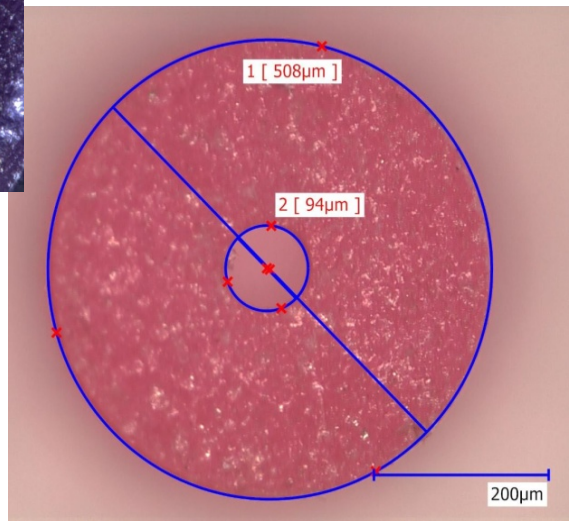




Cutting & hole drilling : Rubies

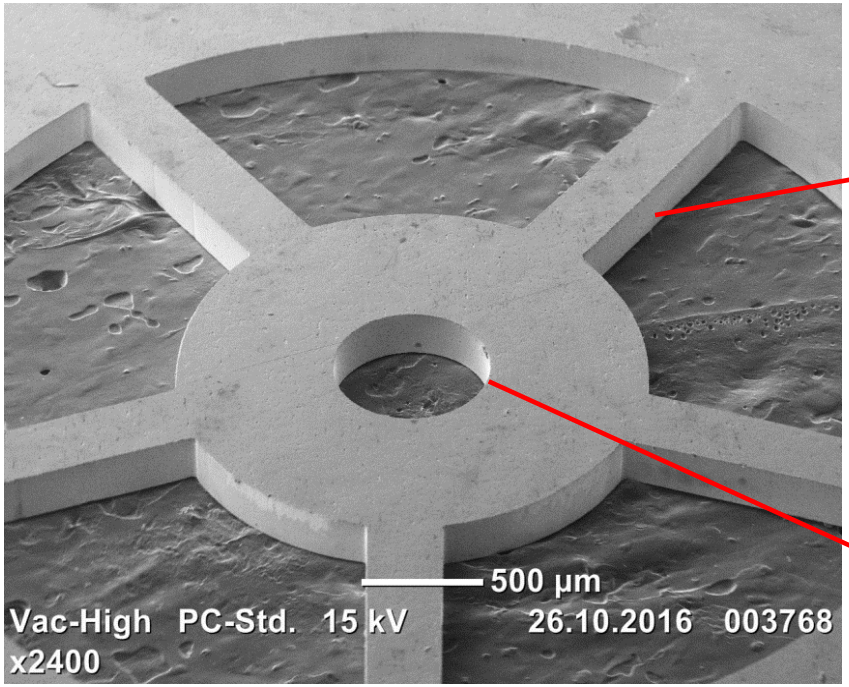


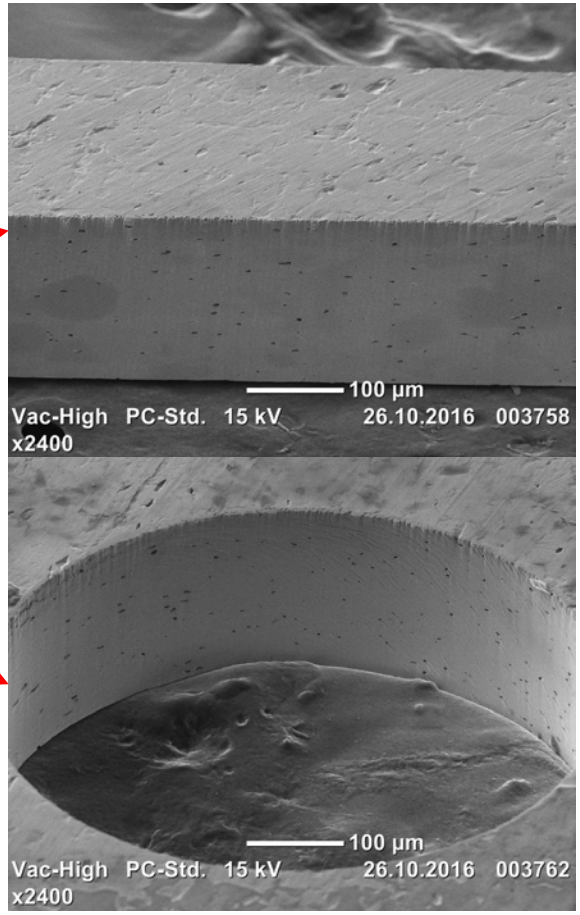




Cutting :

Brass and Maillechort





Material: Maillechort, Brass

	Tolerance	Cylindricity	Circularity	Roughness	Concentricity	Orth. clearance
Drlling hole Ø 700 µm:	± 2 µm	1.5 µm	2 µm	0.1µm	< 2 µm	<0.25°
OD cutting Ø 6000 µm:	± 2 µm	2 µm	2 µm	0.1µm	< 2 µm	<0.5°

Ruby machining by Posalux FEMTO LASER

Conventional Ruby machining: manuf. sequences

1

Raw stone sawing

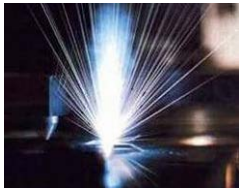
2

Half moon wafer sawing with calibrated thickness

3

Small pads sawing

4



Pre-hole drilling with fiber laser

5

I.D. enlarging

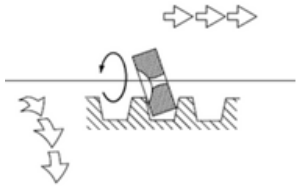
6

O.D. centerless grinding

7

Recess machining

8



Olive cut machining

9

Final faces polishing

Posalux Ruby machining: manuf. sequences

1

Raw stone sawing

2

Half moon wafer sawing with calibrated thickness

3

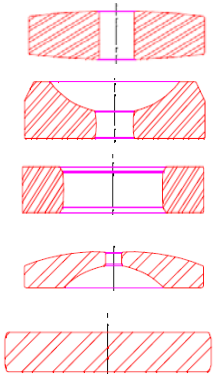
I.D machining

Recess machining

Olive cut machining

Dome shape machining

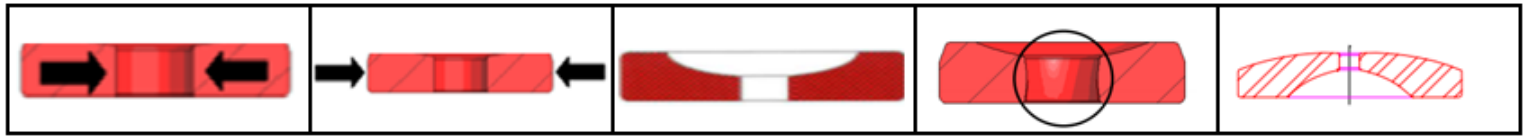
O.D. machining



4

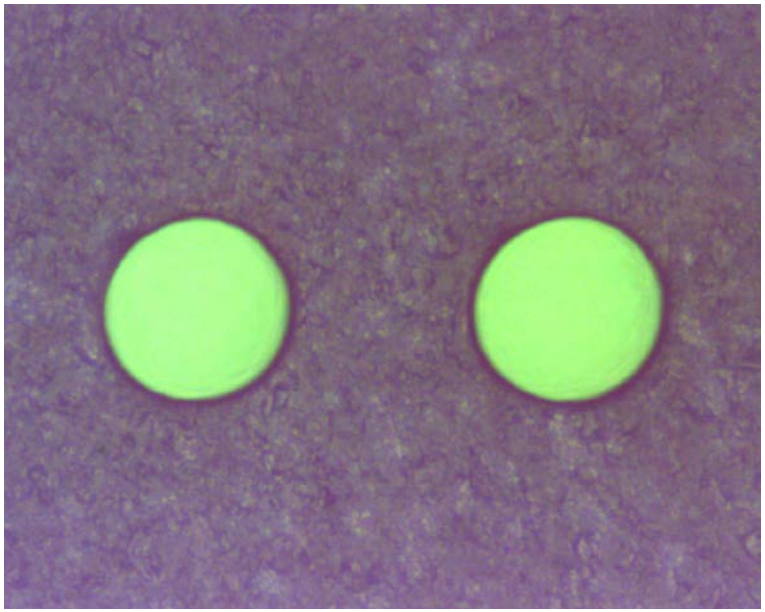
Final faces polishing

Feasibility

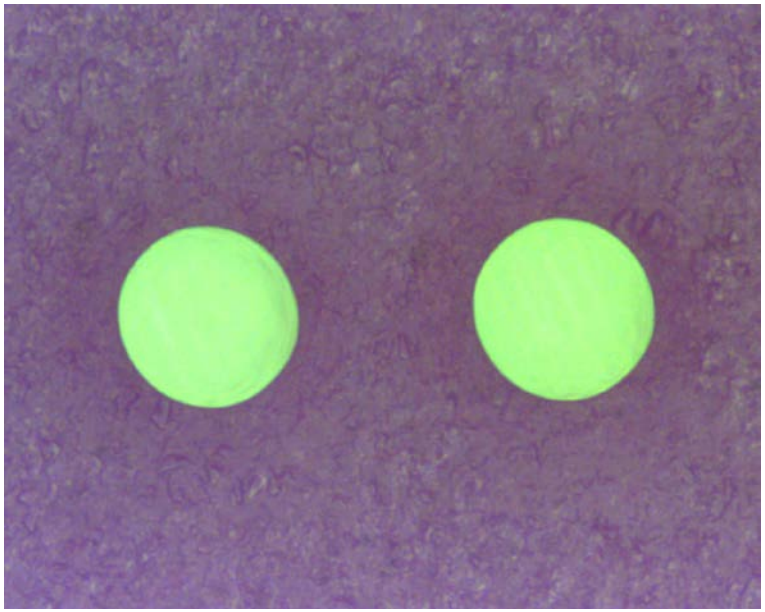


	Internal drilling	External cutting	Recess	Olive cut	Dome shape
	①	②	③	④	⑤
SMALL	100 µm	800 µm	450 / 90 µm (D x h)	110 / 100 / 110 µm	30 µm (h)
	⑥	⑦			
MEDIUM	300 µm	1000 µm			
wafer thickness	*230 µm*				

Trou central 100 µm

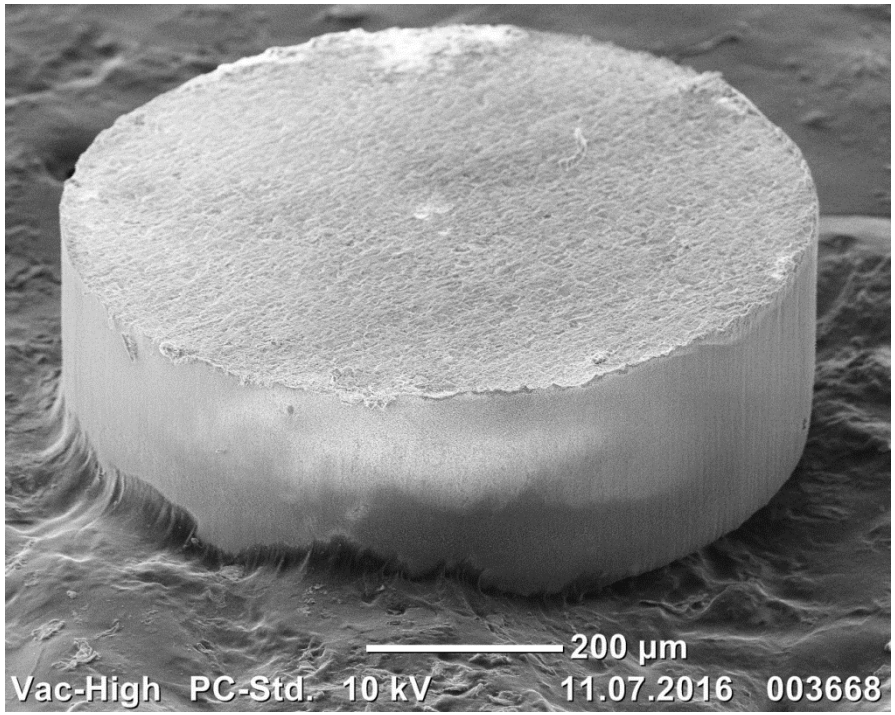


Diamètre à l'entrée
Diam 100 µm
Circularité inférieure à 2 µm

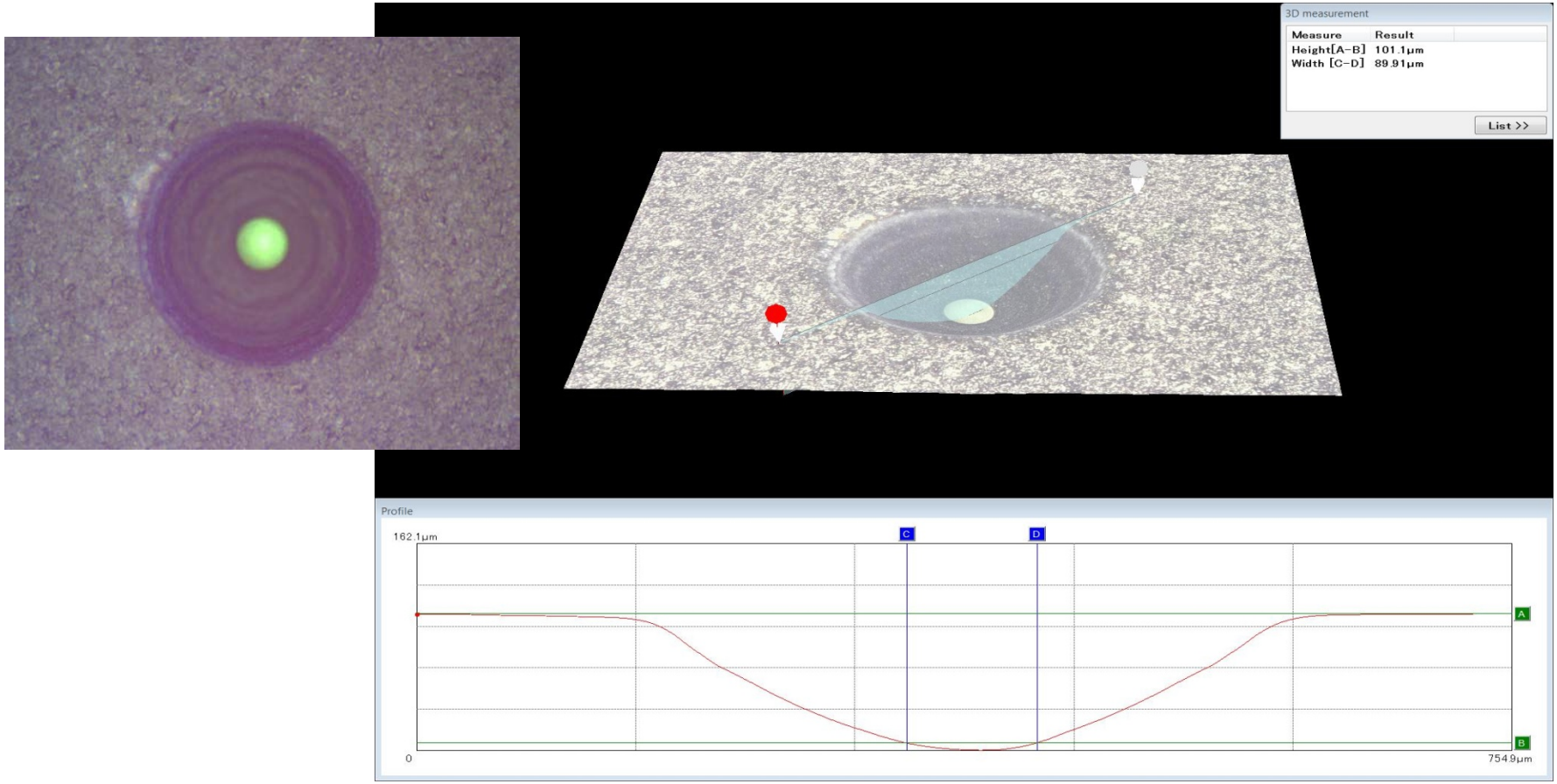


Diamètre à la sortie
Diam 100 µm
Circularité inférieure à 2 µm

Découpe extérieure ∅ 800 µm



Creusure 450 µm x 90 µm (D x h)



Olivage (Mesure empreinte)

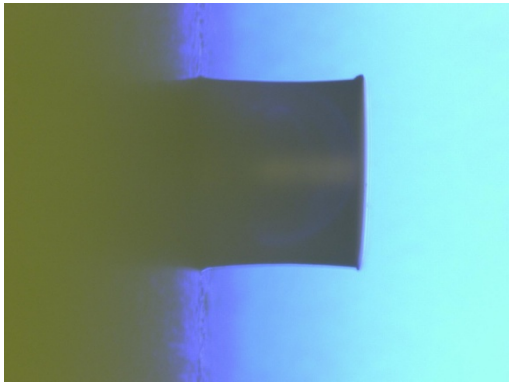
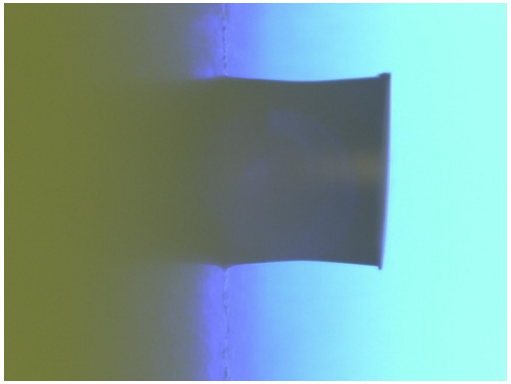


Figure 1: molded prints of shape 1) and 2) of a 300µm hole



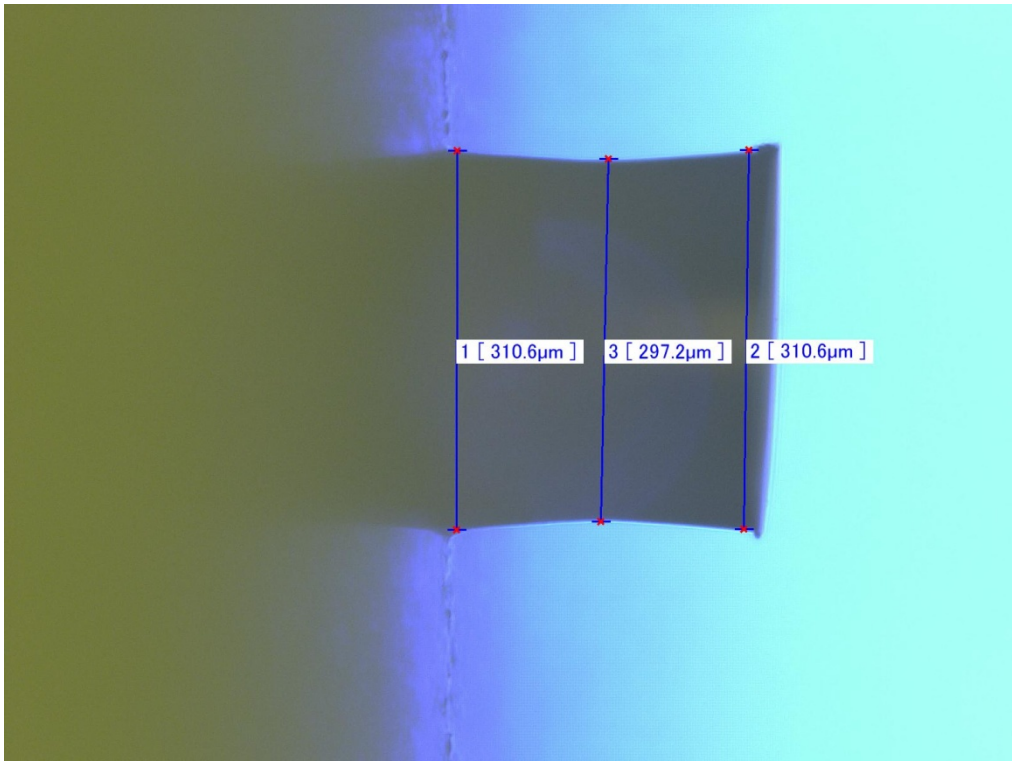
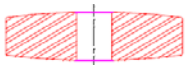
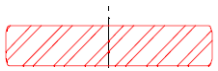
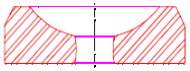
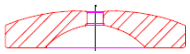


Figure 1: measurement of the molded prints 2)

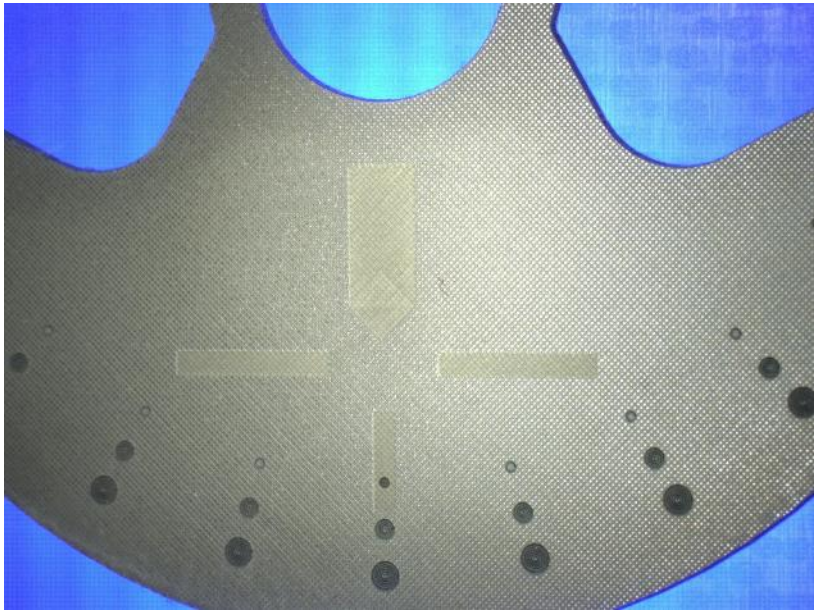
Ruby Machining Achievement

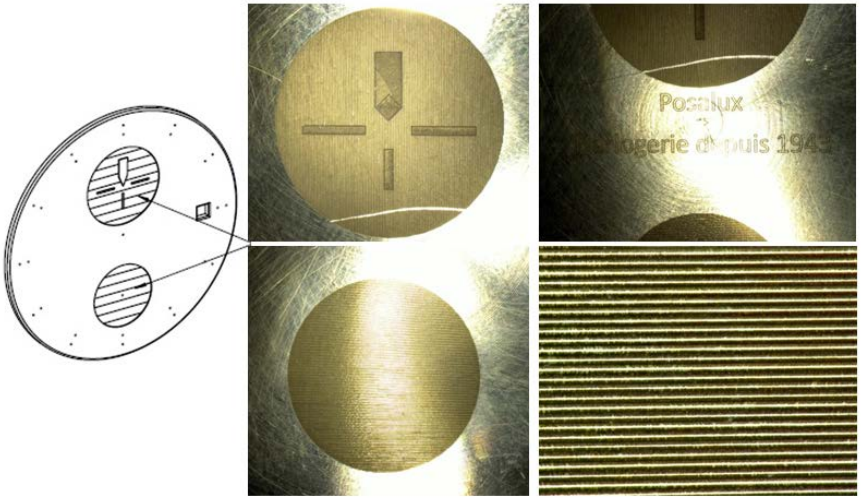
	Operation	Tolerance	Cylindricity	Circularity	Roughness Ra	Concentricity
	I.D. Ø 100µm	± 2 µm	1.5 µm	2 µm	Not measurable	3 µm
	O.D. Ø 800µm	± 2 µm	2 µm	2 µm	0.1µm axial 0.2µm radial	3 µm
	Recess 450 / 90 µm (D x h)	± 5 µm	n/a	5 µm	0.3 µm	3 µm
	Olive cut		n/a	n/a	0.025 µm	n/a
	Dome shape	n/a	n/a	n/a	0.3 µm	n/a

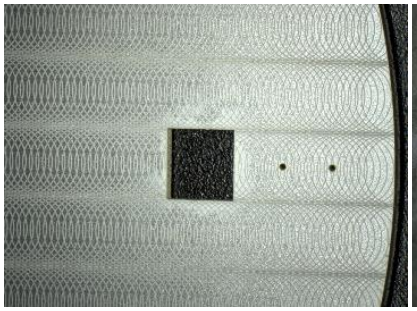
Ruby Machining Cycle Time

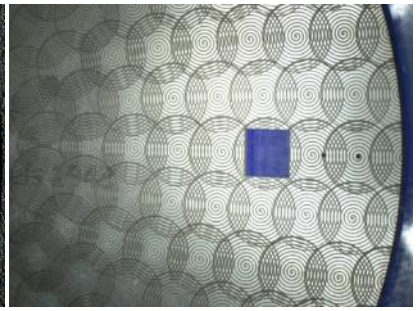
Operation	Cycle Time (sec)
I.D. Ø 100µm	2
O.D. Ø 800µm	5.4
Recess 450 / 90 µm (D x h)	2.1
Olive cut of Ø 100µm	1
Dome shape	6.5

Machining - Engraving – Texturation :









Achieved challenges for Femto technology :

Roundness	➔ < 1.5 µm	✓
Cylindricity / Straightness	➔ < 1.5 µm / for all ratio	✓
Entrance / Output shapes	➔ Sharpe Edge, Controlled radius	✓
Positive Taper	➔ up to +23°	✓
Negative Taper	➔ down to – 15 °	✓
Surface finish	➔ < 50 nm	✓
Ratio diam./depth	➔ 1:15 (e.g. 30 µm / 450 µm)	✓
Cutting squareness ⊥ clearance	➔ < 0.5°	✓

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Posalux Femto Laser: Equipment partnerships

Laser Sources

- LIGHT CONVERSION (LT based + WW) _____ *More than 3 years*
- AMPLITUDE Systèmes (FR-US based + WW) _____ *More than 2 years*

La tête optique

Le type de tête optique avec précession permet de maîtriser les caractéristiques suivantes :

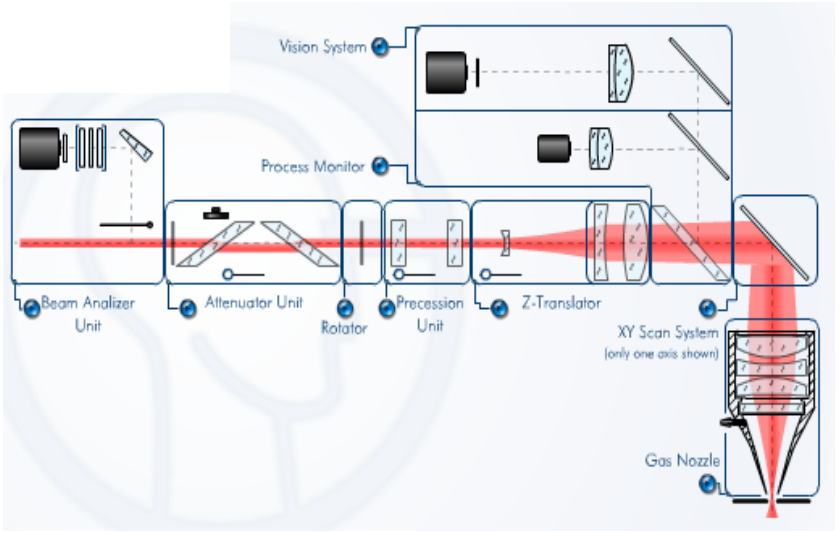
- Cylindricité
- Forme d'entrée entrée / sortie
- Rectitude
- Maîtrise des diamètres +/- 1 µm

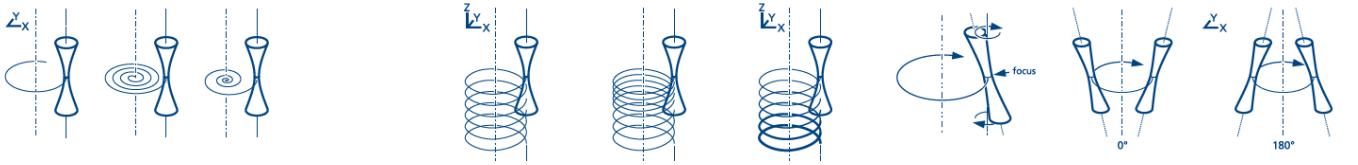
Technology: Precession Head

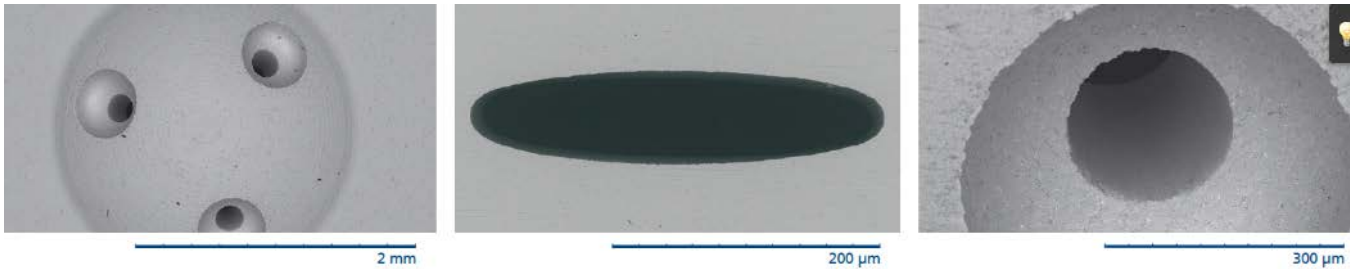
PERFORMANCE

DRILL PARAMETER	TYPICAL VALUE
Hole Diameter Ranger[1]	50 µm-500 µm
Material Thickness[1,2]	~ 1 mm
Cycle Time[3]	~ 2 seconds/hole
Taper Angle Range[1] (full angle)	Pos. & neg. to 10°
Hole Circularity	> 95 %
Surface Quality (inside wall)	R_a < 0.1 µm
Diameter Resolution	< 1 µm
Diameter Repeatability	< 0.4 %
Hole Position Accuracy[4]	± 1 µm

1) Please inquire regarding features outside this range.
2) Maximum material thickness is dependent on hole dimension.
3) Cycle time quoted for 200 µm diameter hole in 200 µm thick 440 stainless steel.
4) Hole position repeatability is dependent on overall workstation design and quality.







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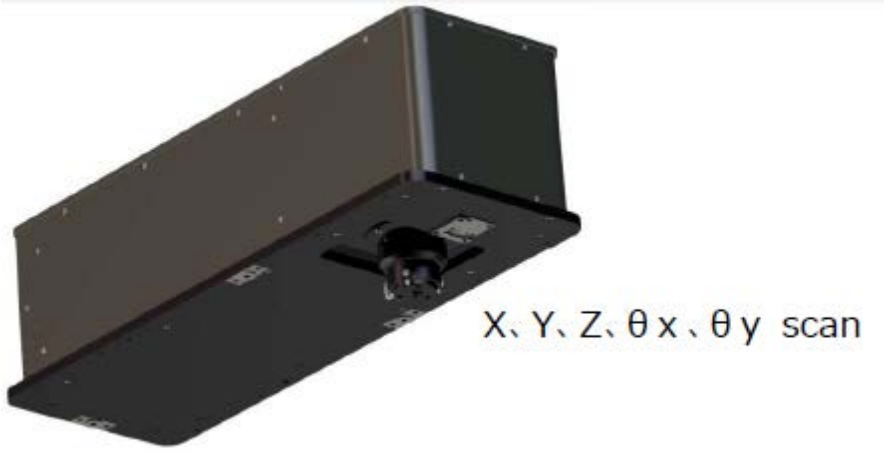
Posalux Femto Laser: Equipment partnerships

5 axes Precession Head

- SCANLAB (GE based + WW based) _____ *More than 3 years*
- CANON (WW based) _____ *More than 1 year*



Machine

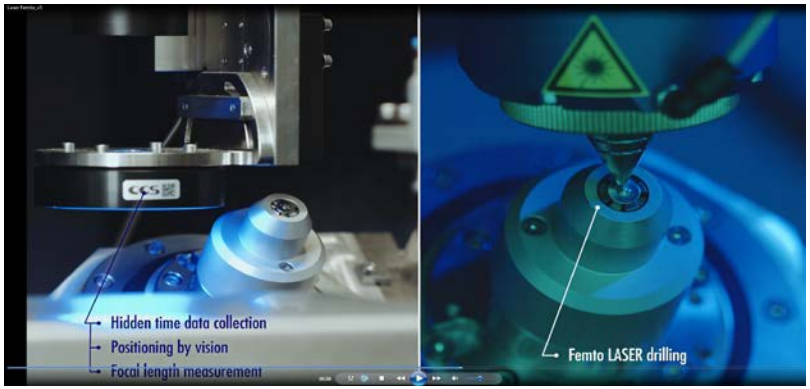
La conception de la machine est un élément déterminant pour assurer un procédé maîtrisé, elle assure les caractéristiques suivantes :

- Répétabilité
- Reproductibilité
- Flexibilité
- Productivité
- Sécurité

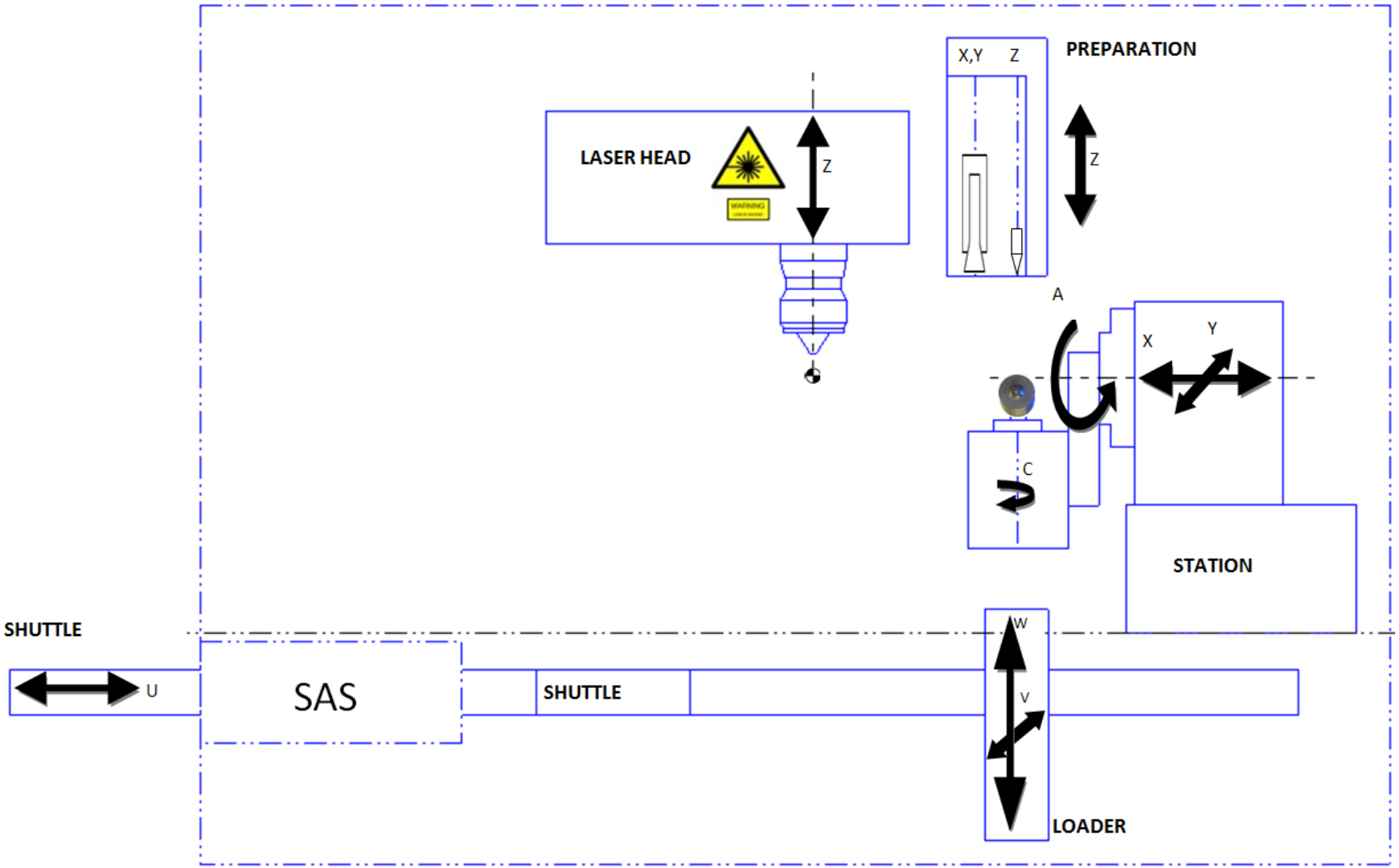
Machine

Conception en tenant compte de:

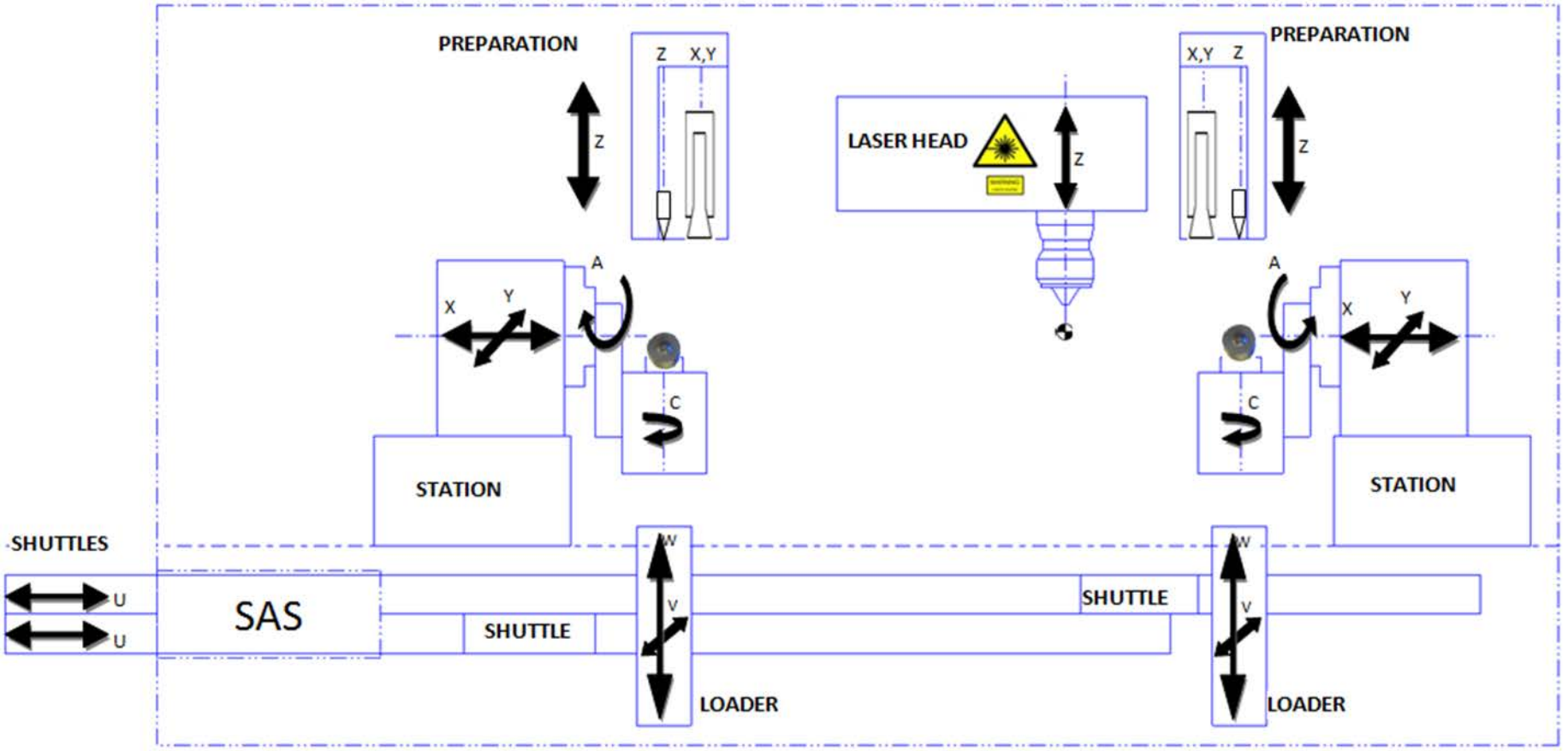
- Statique
- Cinématique
- Dynamique
- Thermique



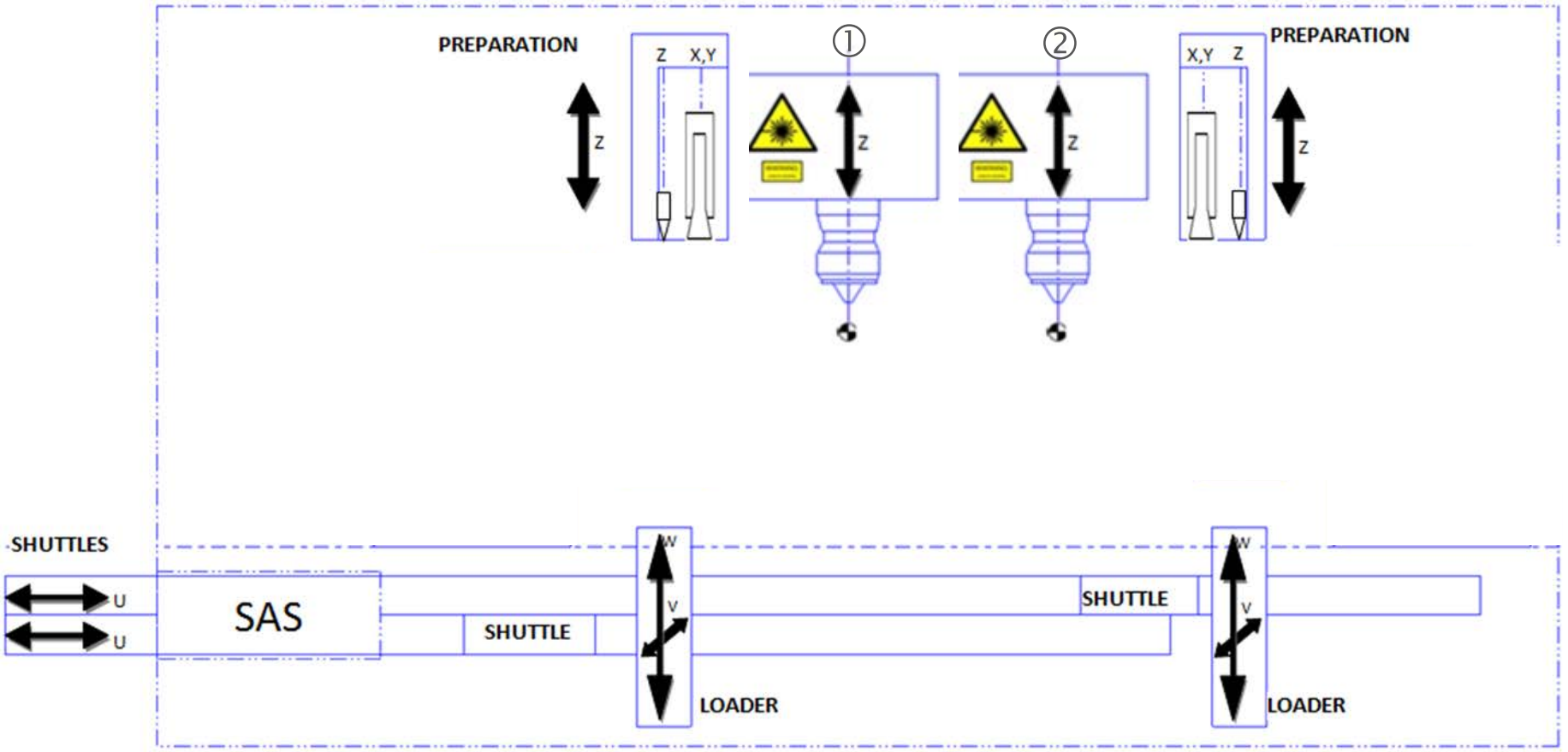
Posalux **Femto Mono**



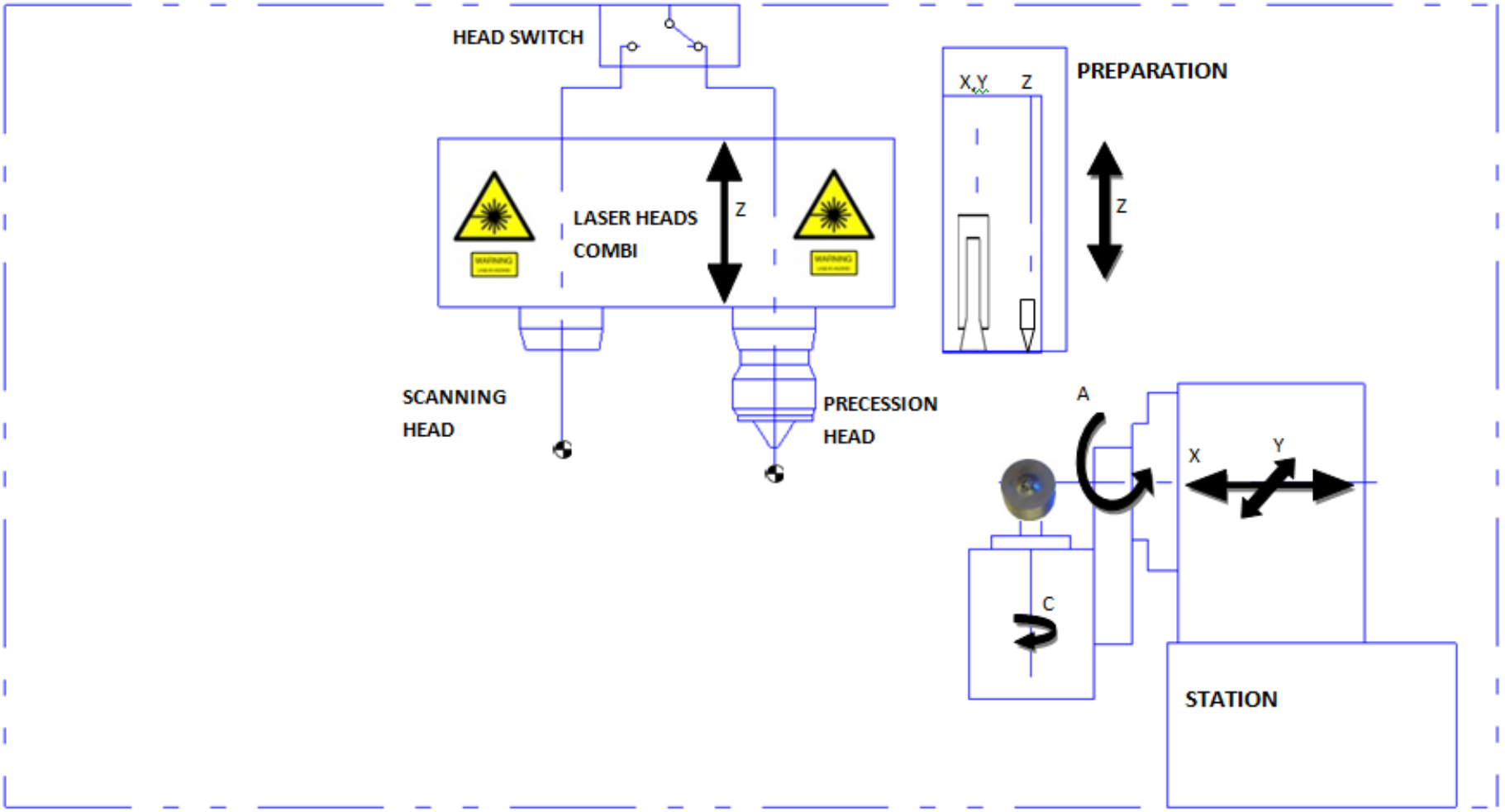
Posalux **Femto Twin**



Femto **Twin Dual**

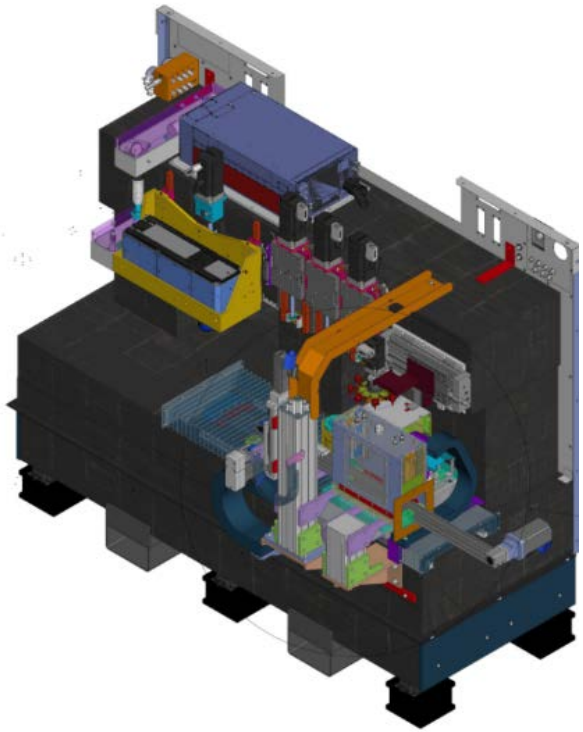


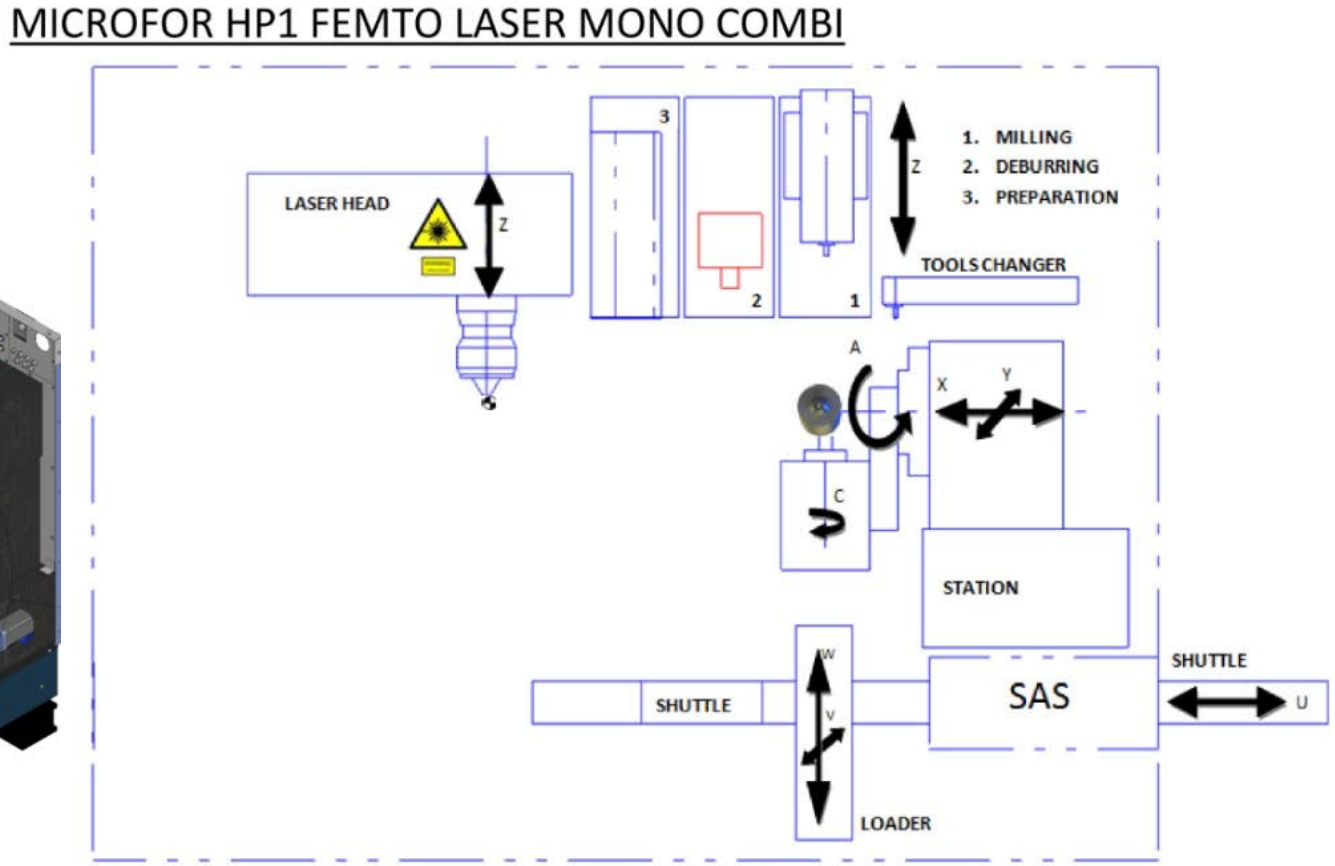
Posalux **Femto Mono Combi**



Concept **Femto Mono Combi 2**

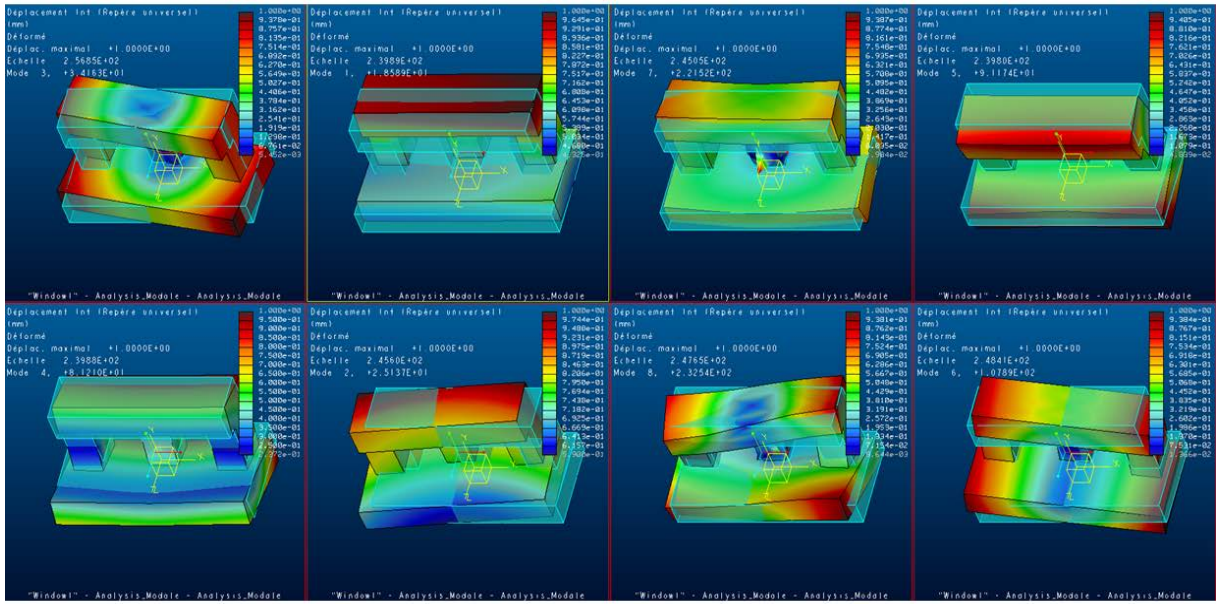
Designed for Milling, Deburring and Femto-Drilling





La machine - statique

- Comportement statique tenant compte des efforts inhérents à la machine
- Exemple: structure isostatique rigide (sur 3 points)

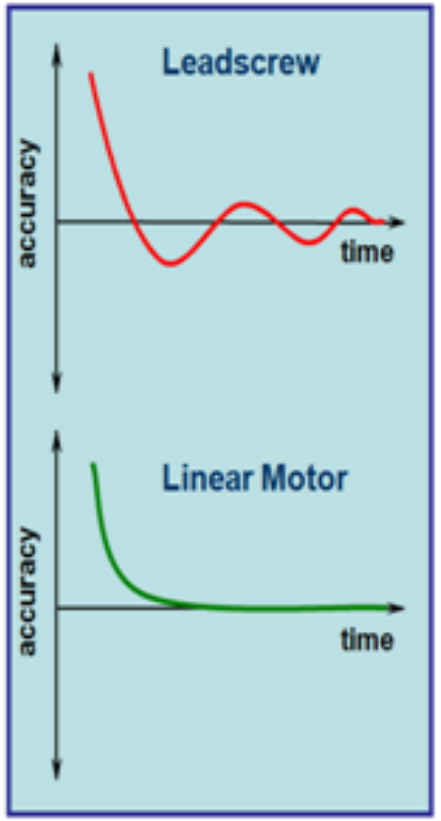


$$f = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$$

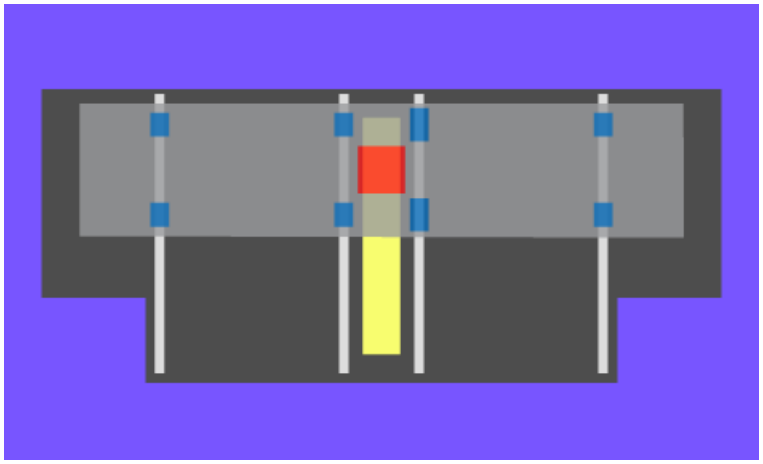
Machine- dynamique

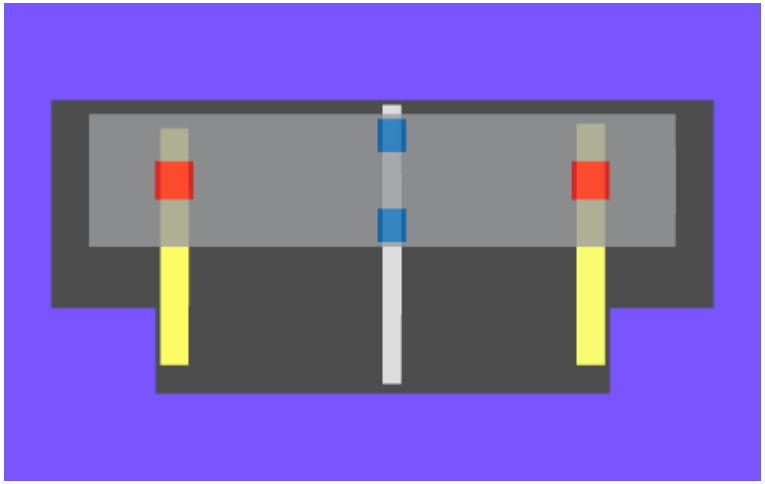
- Une machine dynamique garantie une stabilité et précision d'usinage

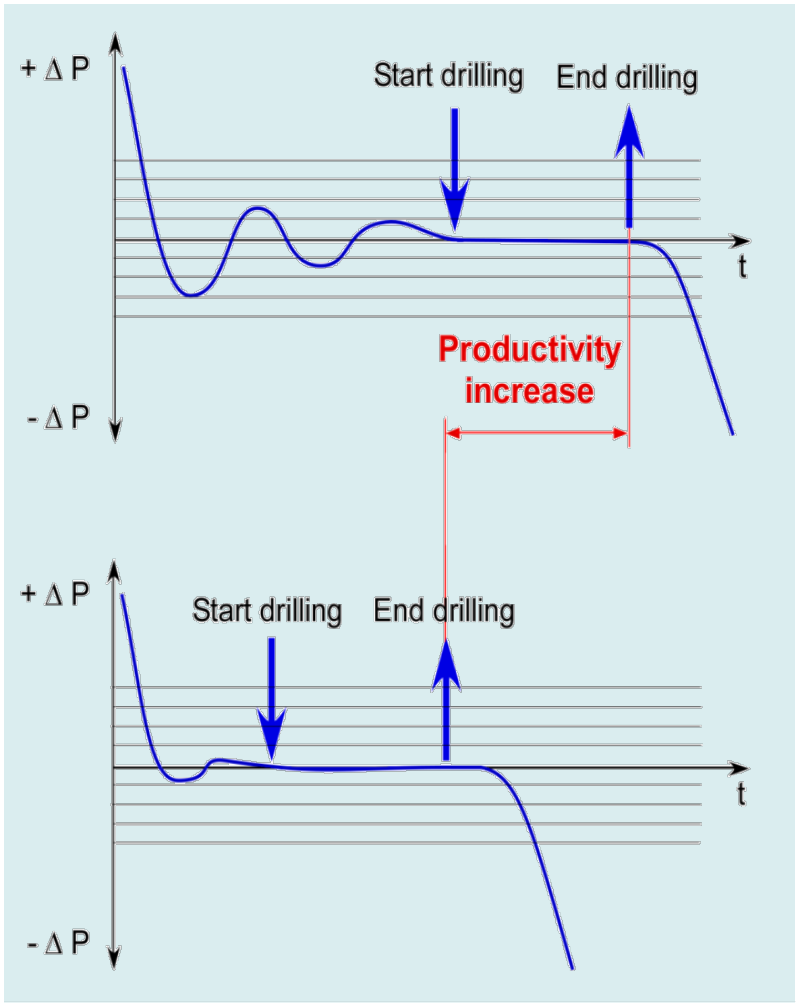
- Éviter les hyper statismes ➔imprévisibilité du comportement dynamique et précision machine



Machine - Dynamique







Conclusion Laser

Laser Femto

- Intégrité matière
- État de surface
- Productivité

Tête optique

- Géométrie
- Répétabilité
- Reproductibilité
- Flexibilité
- Productivité

Machine

- Répétabilité
- Reproductibilité
- Flexibilité
- Productivité
- IHM, évolutions
- Sécurité

Merci de votre attention

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