TECHNOLOGIES INNOVANTES POUR L'OPTIMISATION DE LA PRODUCTIVITÉ DES PROCÉDÉS D'USINAGE PAR LASER ULTRABREF

→ Girolamo Mincuzzi | Chef du Groupe « Micro » | ALPhANOV

ALPhA NOV
Centre Technologique Optique et Lasers

CLP

e·micronora
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Localisation

Institut d'Optique d'Aquitaine - Bordeaux

ALPhANOV est implanté dans l'« **Institut d'Optique d'Aquitaine** », sur le campus universitaire de Bordeaux.

Antenne Limoges

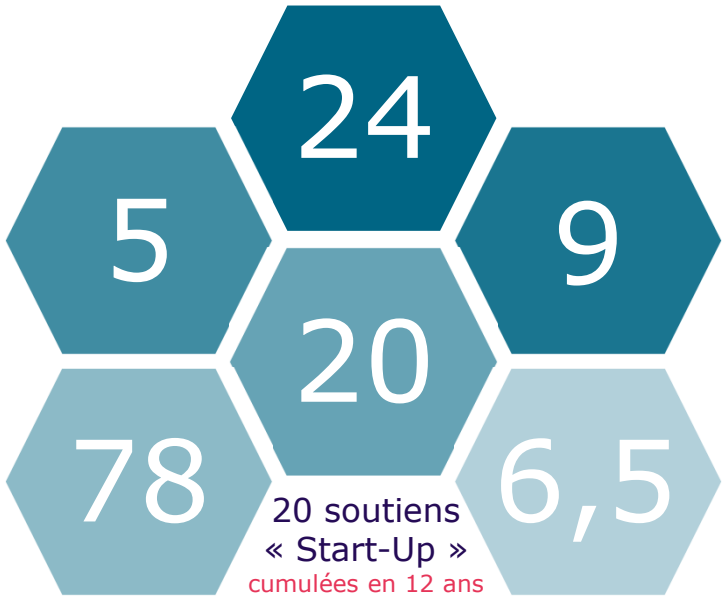
Hébergé par XLIM

Depuis Décembre 2017

ALPhANOV en quelques chiffres

Projets collaboratifs actifs

(Soutenus par l'Union Européenne, l'Etat et des organismes nationaux, la Région Nouvelle-Aquitaine)



5 entreprises hébergées en permanence

9 Brevets

Dont 6 en co-propriété, tous licenciés ou exploités

78 ETP

Association Loi 1901 créée en 2007

20 soutiens « Start-Up » cumulées en 12 ans

Chiffre d'affaires en 2019

Plus de 650 clients/partenaires cumulés, de la PME aux groupes les plus prestigieux

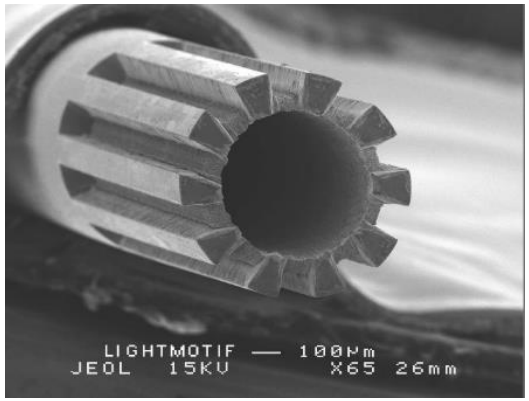
ISO 9001:2015 BUREAU VERITAS Certification

CRT

Outline

- Machining with high power high repetition rate ultrashort pulse laser
- Two key parameters:Scan Speed and Accuracy
- High Scan Speed Scanner
  Case of Study: cutting of a micro-gear
- Highly Accurate pulse triggering
  Case of Study: precise engraving
- Conclusion and outlook

Motivation

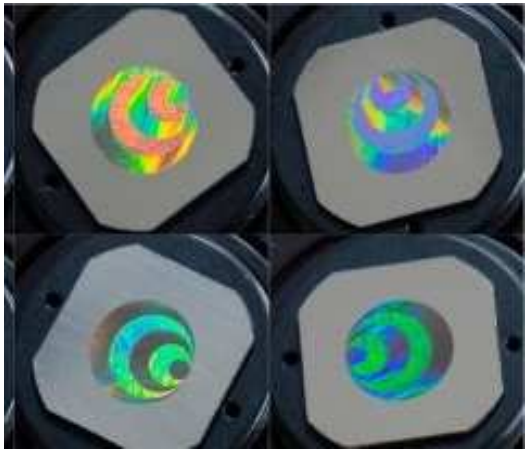


Femtosecond lasers enable the best machining quality and precision

Increase the throughput
by increasing the average power P
and keep good machining quality

Unwanted Thermal Effects prevent full exploitation of available power

Femtosecond lasers make possible process you can't do with longer pulses



Fast…

kW, MHz Class USP laser

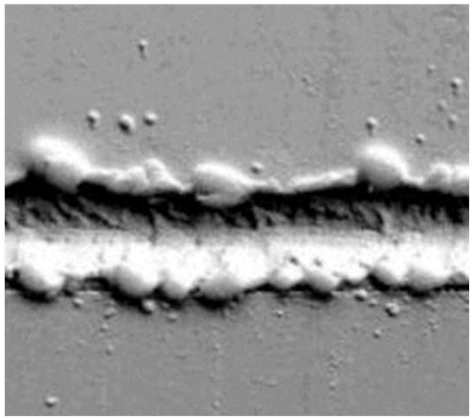
Increasing the repetition rate

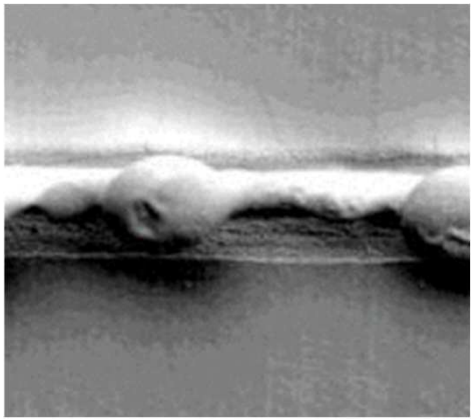
Few tens of MHz are available

→ Increase the scan speed

2D Fast Galvo

Up to 30 m/s

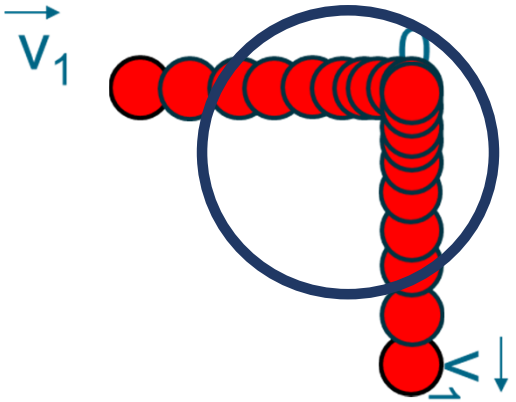




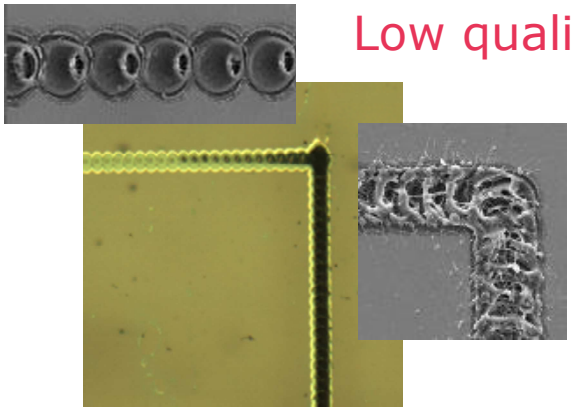
1D Polygon Scanner

Few hundreds m/s

… and Accurate



over processing!!



Low quality

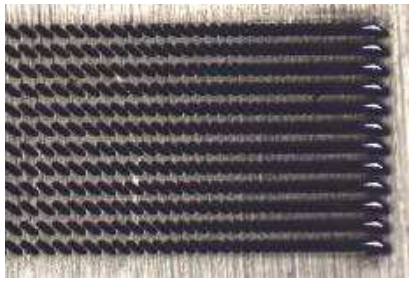
Due to Galvo Mirrors inertia

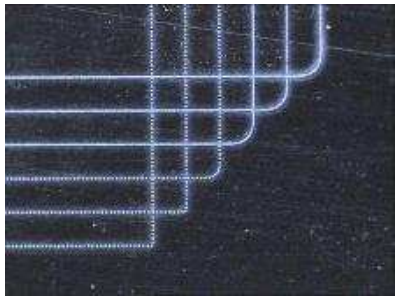
$\vec{v}_1 \rightarrow 0$

$0 \rightarrow \vec{v}_1$

It takes $\Delta t \neq 0$

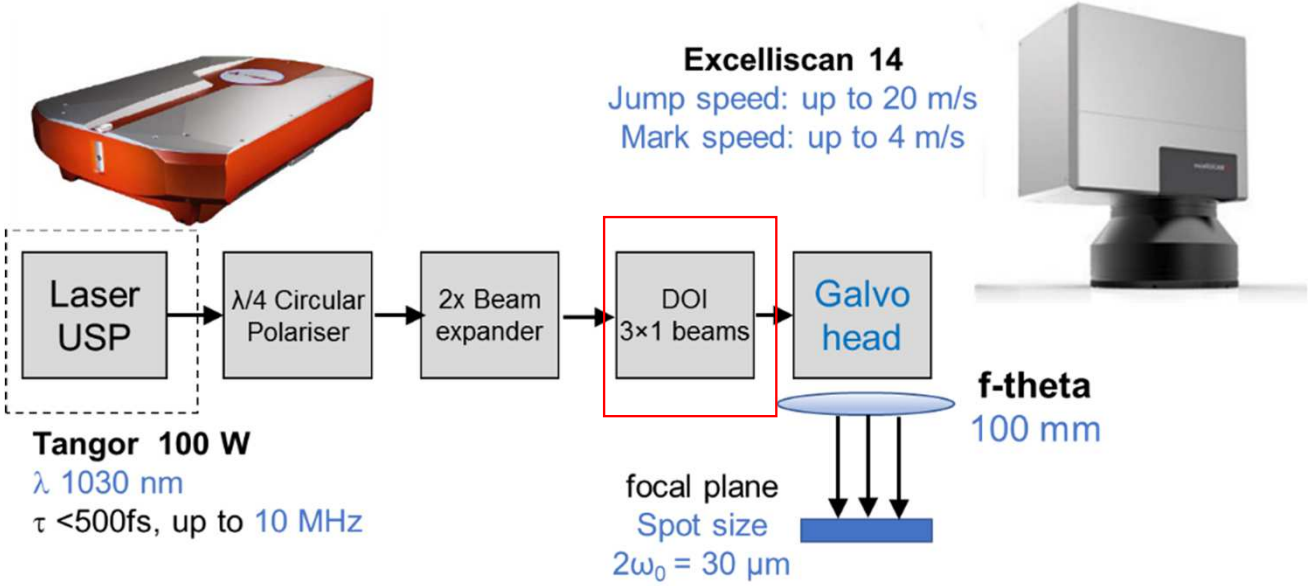
Low precision



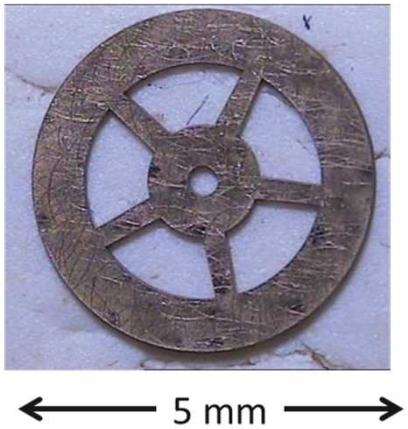


Lack of reliability

High Scan Speed Galvo-Scanner



200 µm thick brass

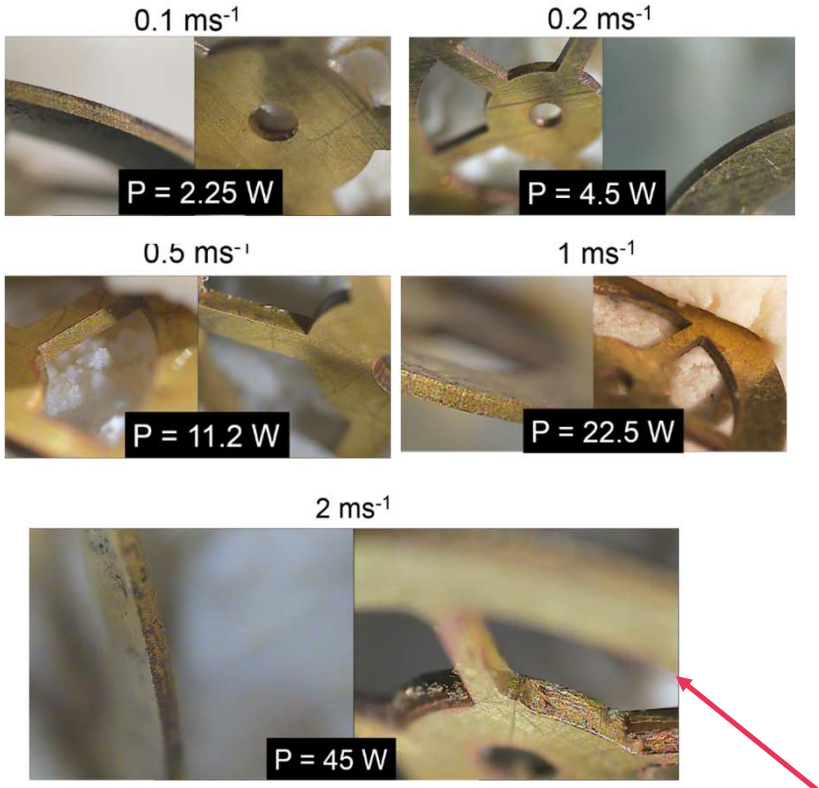


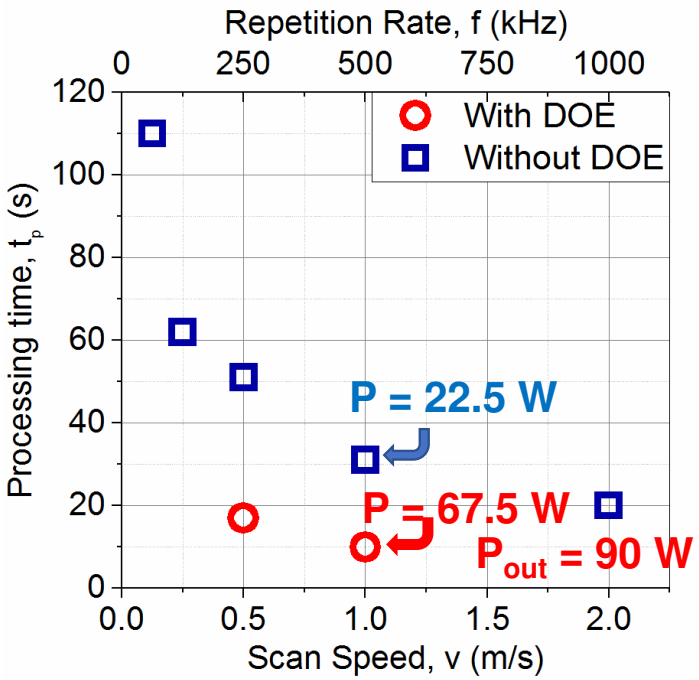
200 µm thick Brass

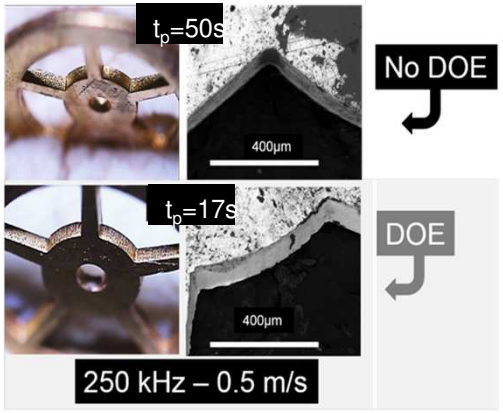
1) Serial up-scale of laser cutting on complex shapes (very High Accuracy) without DOI
2) Parallel up-scale with a DOI

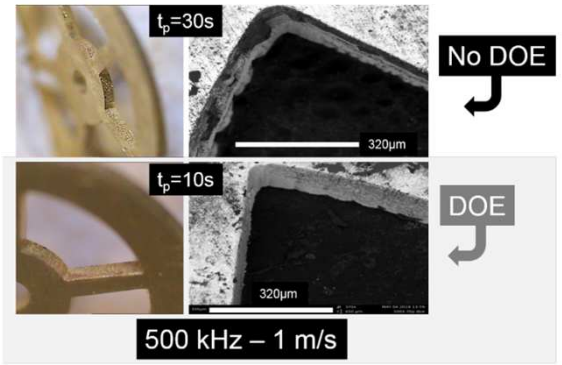
Pulse Energy E = 45 µJ
Fixed Overlapping ≈ 90%

Cutting: up-Scaling (no DOI)



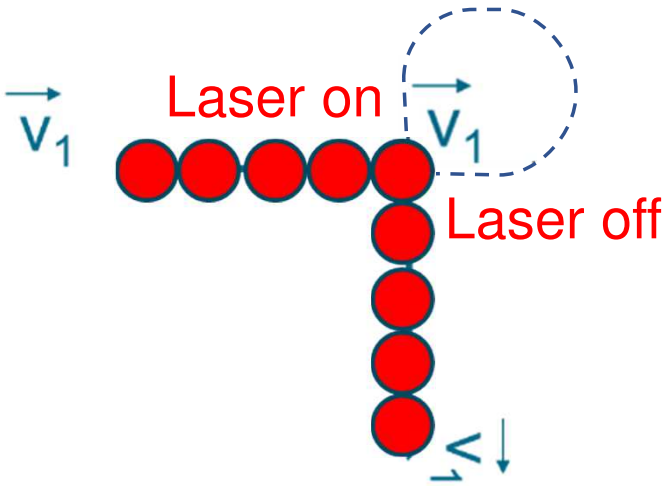






Pulse synchronization feature required

Precise Pulses Triggering: State of the Art



SuperSync:

Pulses are triggered by a clock synchronized with the seed cavity (30-80 MHz)

- Low jitter, High accuracy
- Limited to Polygon scanners
- (not easy implementation in Galvo Scanner)

Pulse on Demand:

Pulses are triggered by an external board

- Limited to ns
- Accuracy depends on the board performances

Skywriting (SW):

- Highly accurate
- Time consuming

Two innovative key technologies for a novel approach

Excelliscan 14 + RTC6 Board
(Scanlab)

Specific Feature

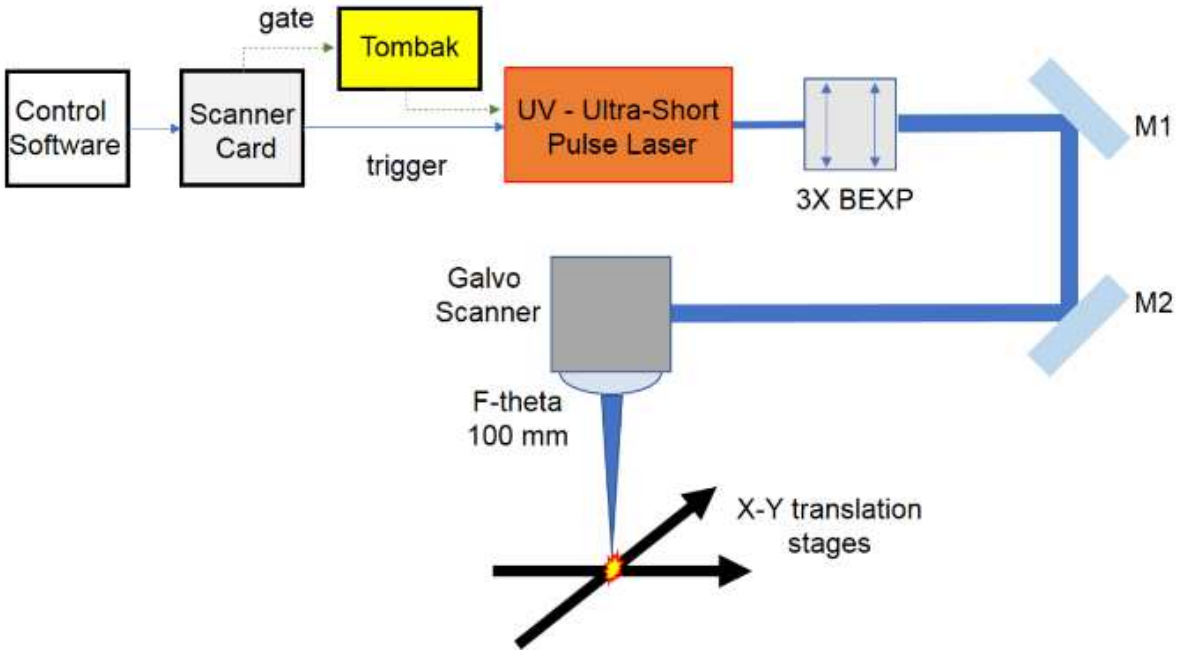
Calculate and predict the instant
to trigger every single pulse
taking into account galvo mirror inertia

Tangor UV @343 nm
(P_{max}= 35 W)
CPA, τ < 350 fs
(Amplitude)

Equipped with specific POD technology – Femtotrig ® (FT)

- High pulse energy stability
- (achieved by precise control of the laser gain through the amplifier chain)
- Possible intra-pulse delay: $\infty \rightarrow 1/f_{osc}$ (12.5 ns)

POD-FT Experimental Set-up

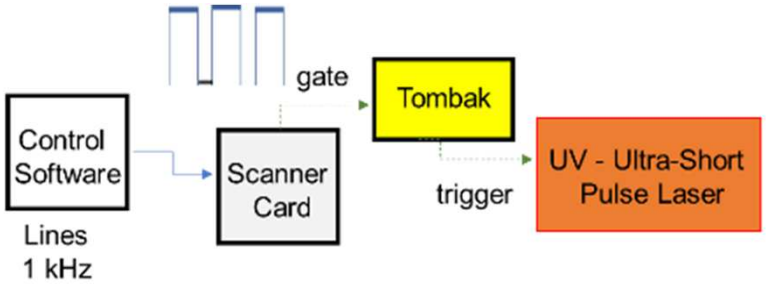


Objectif:

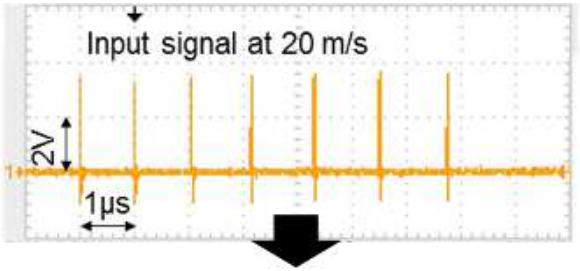
Explore the possibilities of this set-up (POD-FT) in laser machining in 2 steps:

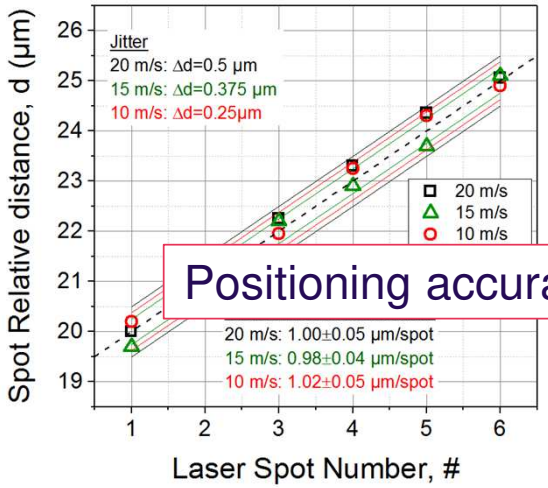
- Reliability Evaluation
- Comparative Study between POD-FT standard scanning and SW

Accuracy in Pulse positioning

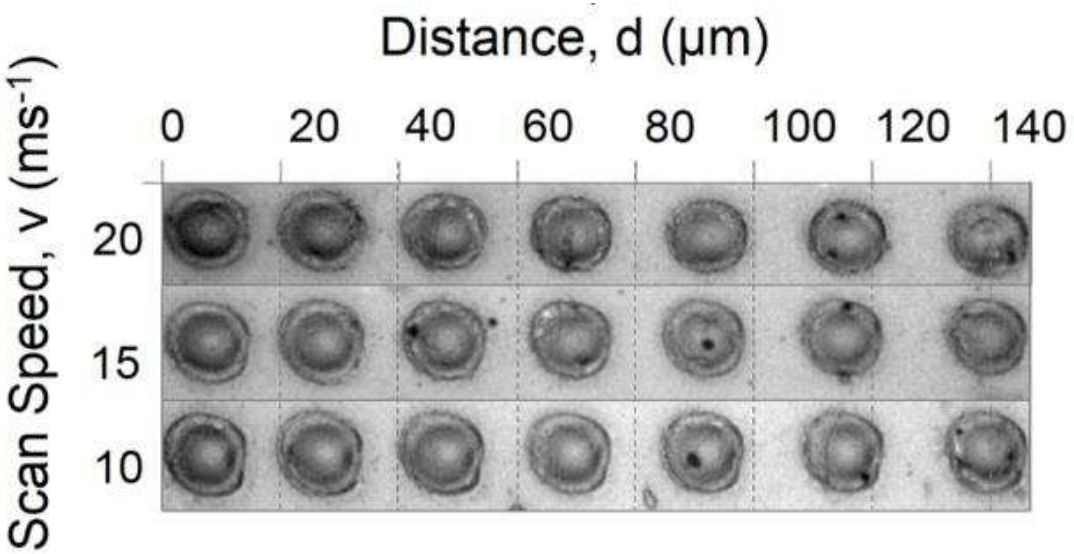


v = 10 m/s, 15 m/s, 20 m/s
d = 20 µm, 21 µm, 22 µm, 23 µm, 24 µm, 25 µm

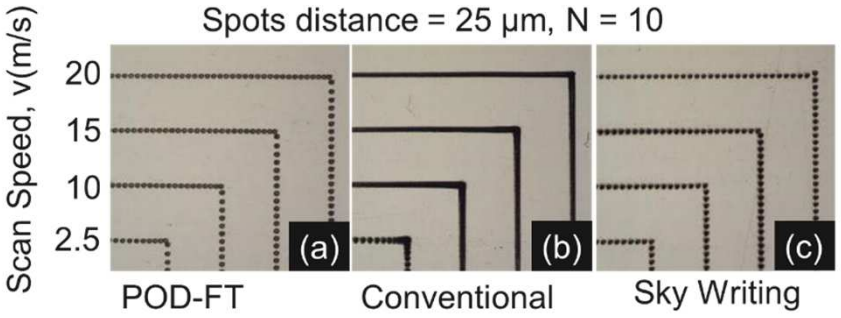


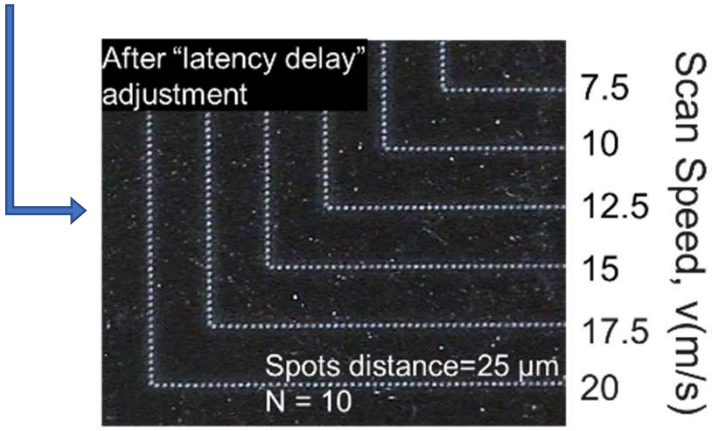


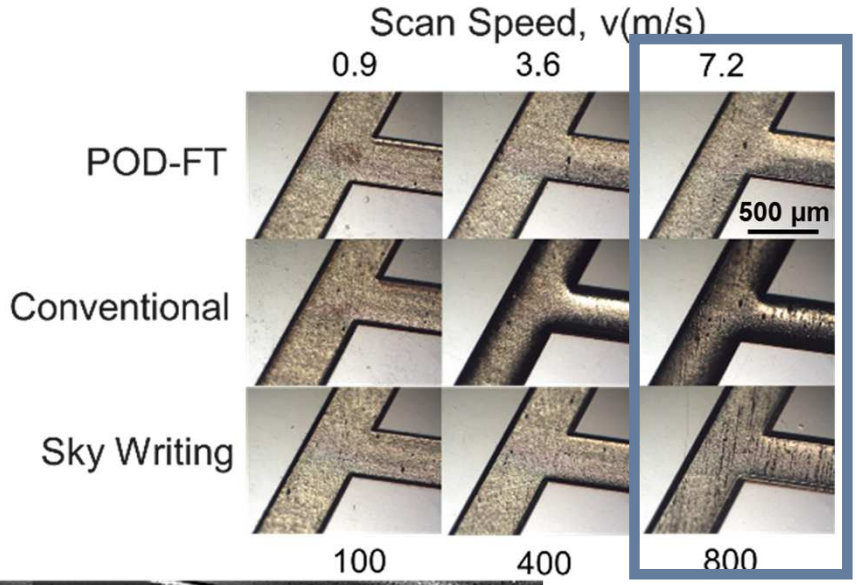
Positioning accuracy = 1µm

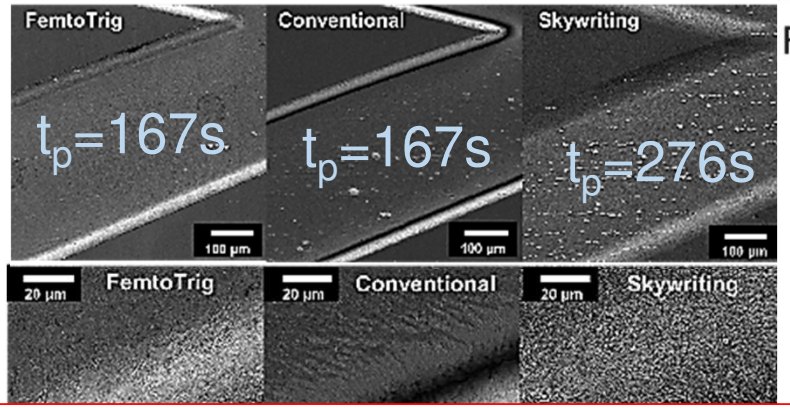


Comparative Study









SUS 316L,
Pulse Energy E = 4 µJ

- Remarkable Reduction of "Over-Engraving"
- Processing Time reduction by ≈ 40%

Conclusion

- The key role of both high scan speed and high accuracy in micromachining has been highlighted.
- Two innovative technologies have been evaluated: a fast galvo scanner and POD for fs laser.
- We have shown the advantages in term of throughput for cutting and engraving with high power, femtosecond laser.
- A remarkable reduction of the processing time has been reported for both processes: tenfold for cutting, 40% for engraving.

Acknowledgment

RÉGION Nouvelle-Aquitaine

Project « *TrulyFast* »

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MINISTÈRE DE L'ENSEIGNEMENT SUPÉRIEUR, DE LA RECHERCHE ET DE L'INNOVATION

Thank for your attention!

References:

- ***Mincuzzi et al.*** **«** Beam engineering strategies for high throughput, precise, micro-cutting by 100 W, femtosecond lasers » Journal of Laser Applications 32, 042003 (2020); https://doi.org/10.2351/7.0000174
- ***Mincuzzi et al.*** "Pulse to pulse control for highly precise and efficient micromachining with femtosecond lasers" Optics Express, Vol. 28,Issue 12, pp. 17209-17218 (2020) https://doi.org/10.1364/OE.391107

ALPhA NOV

Centre Technologique Optique et Lasers

Rue F. Mitterrand
33400 - Talence

+33 (0)5 24545274
girolamo.mincuzzi@alphanov.com

https://www.alphanov.com

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