

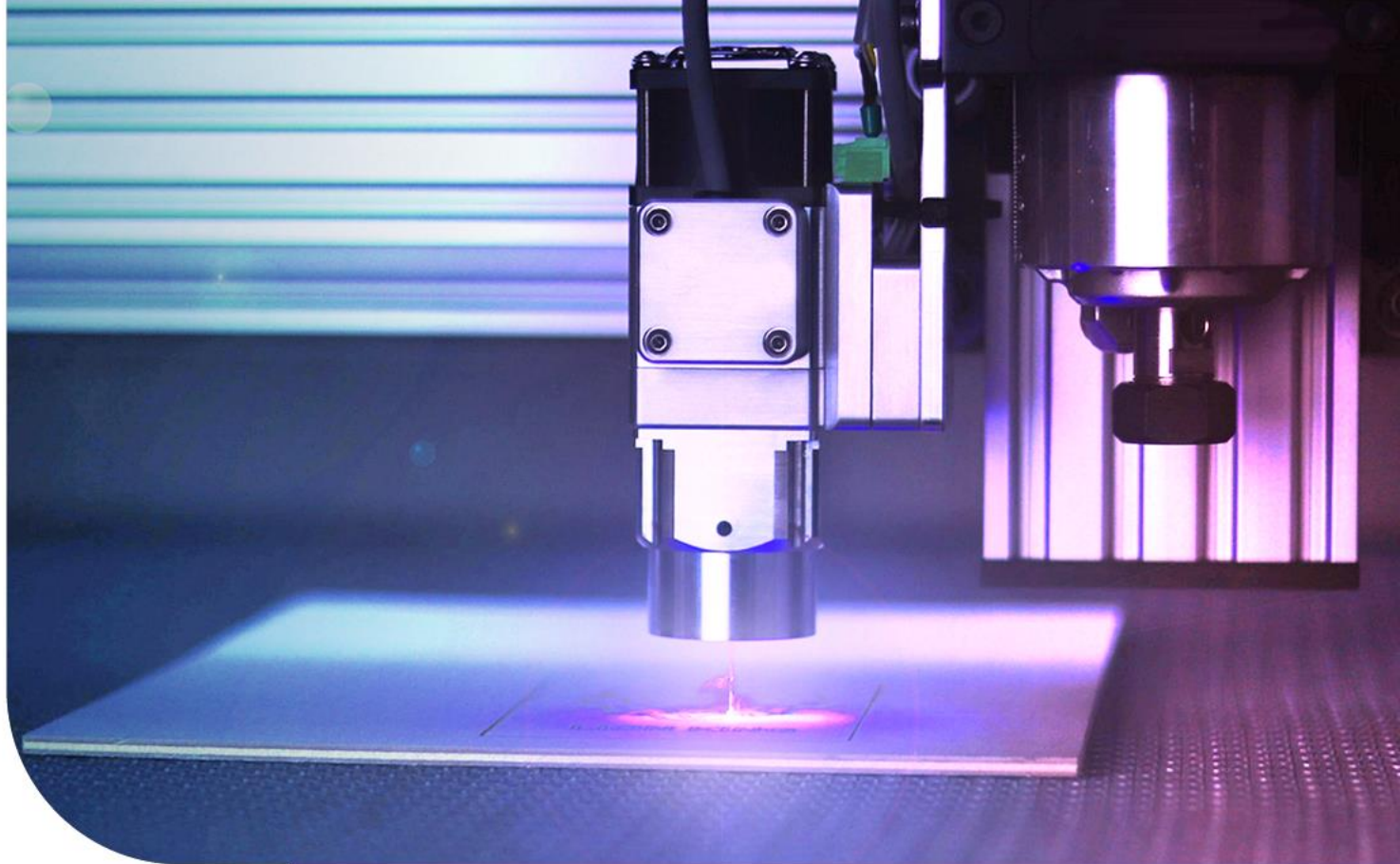
FLASH

Flexible Laser-Based Manufacturing

WP10 – Exploitation, dissemination, training & standardisation RP2

Clémentine Maurier - CAILABS

M24 Review Meeting January 28th



3drivers
QUADRANTE

aimen
CENTRO TECNOLOGICO

ATS

cailabs
SHAPING THE LIGHT

UNIVERSITÀ
DEGLI STUDI
DI PALERMO

diamoutils
PRECISION DIAMOND TOOLS

IMA AUTOMATION

DePuy Synthes
THE ORTHOPAEDIC COMPANY OF Johnson & Johnson

University of
HUDDERSFIELD
Inspiring tomorrow's professionals

COSMOS THRACE

Prima
Additive

ROBUST AO

SYNOVA

TOFAS
TUKE GROUPS (BERNARDI) S.R.L.

EWf

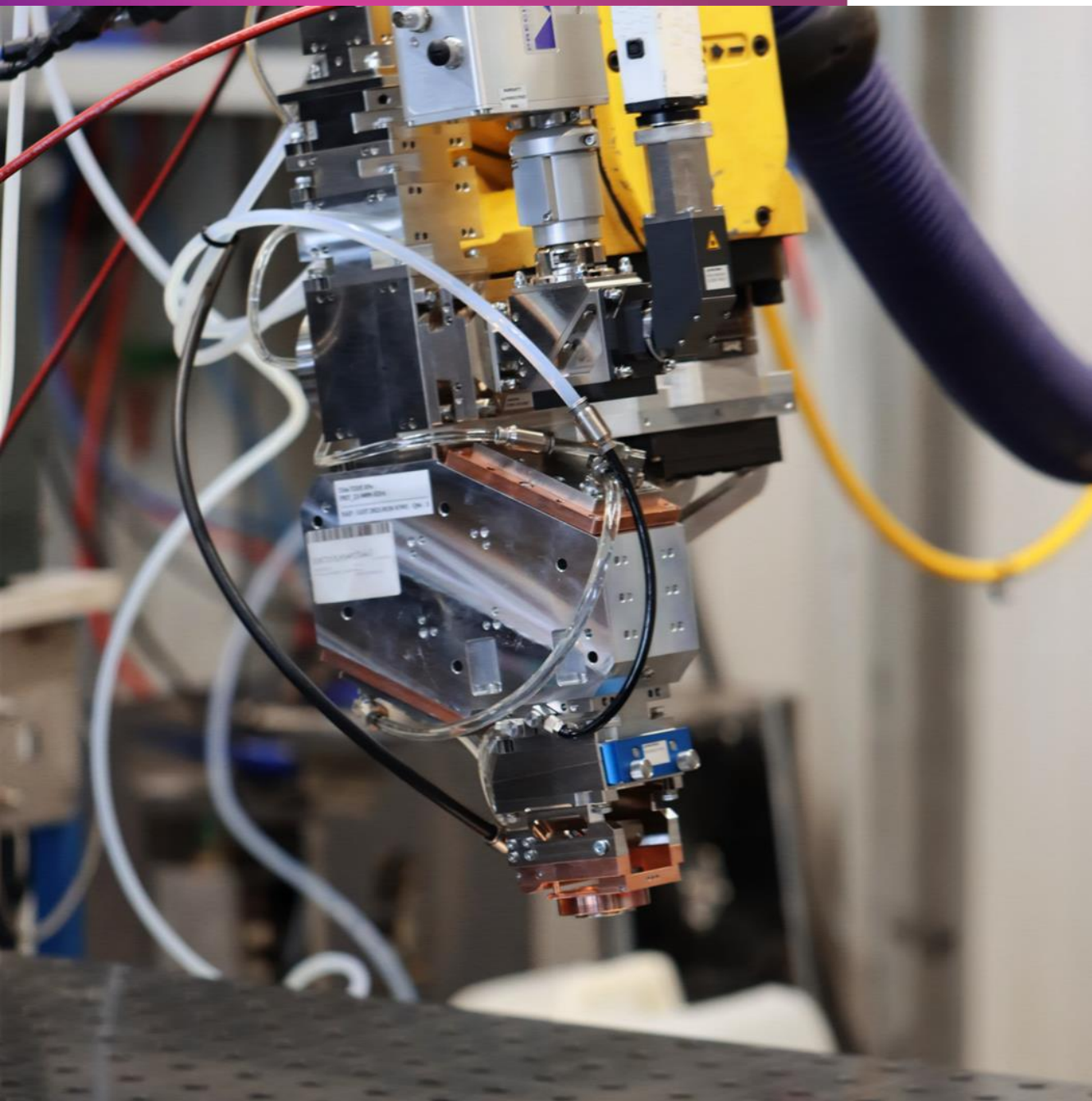
mtc+ where
progress
happens



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-  **Cailabs in a few words**
-  Beam shaping technologies
-  Upscale laser welding processes
-  Upscale micro-processing processes
-  What's next ?



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Mastering & Shaping the Future of Light since 2013



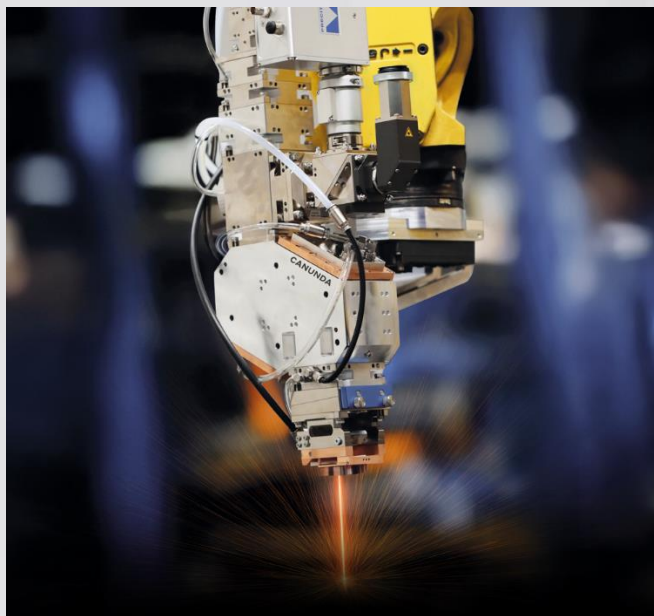
Elevating Industries with Laser Light



Aerospace & Defense

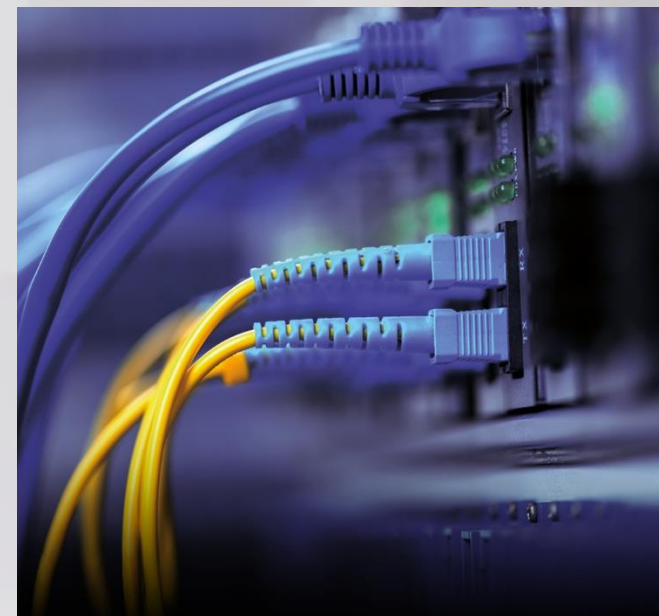
- Laser Communications
- Optronics

FLASH



Industrial Laser Processing

- Laser Welding
- Laser Additive Manufacturing
- Micro-Processing

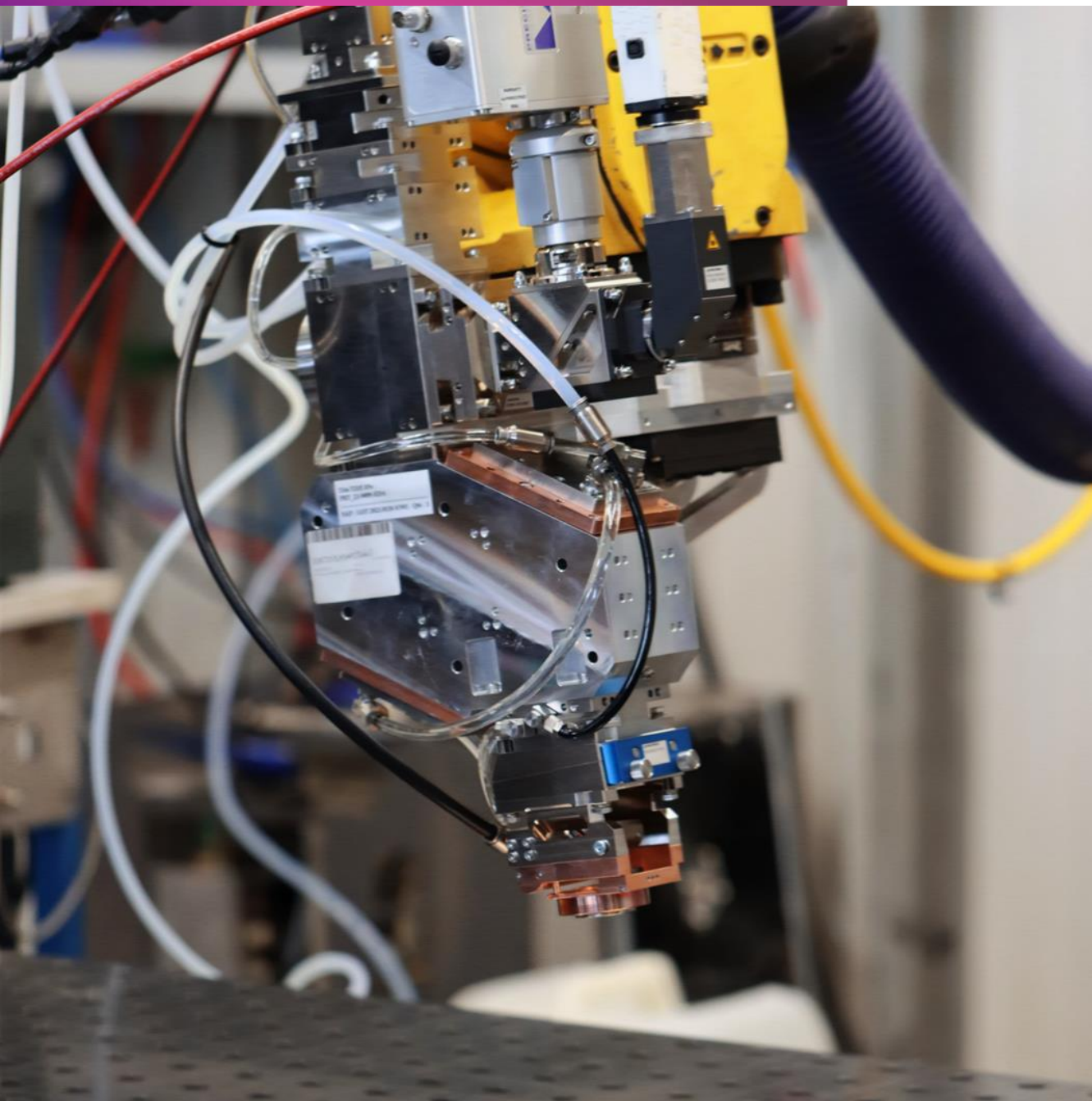


Fiber Networks

- Local Area Networks
- Optical Networks of the Future



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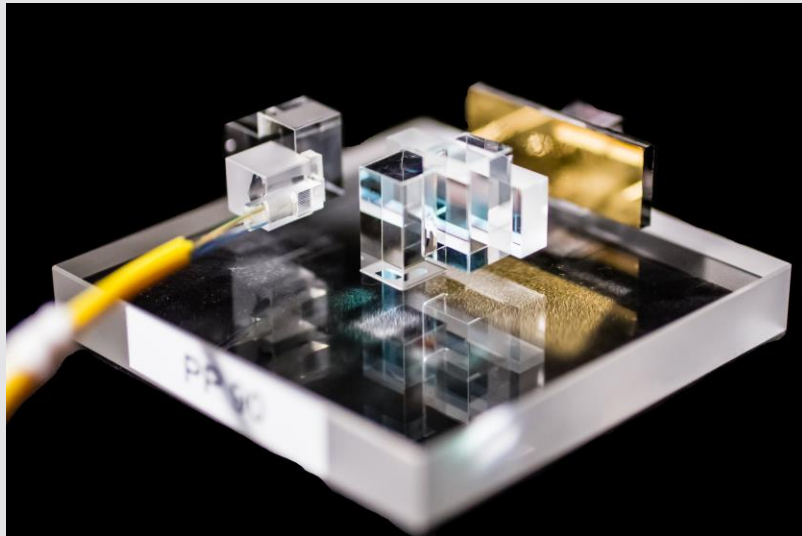


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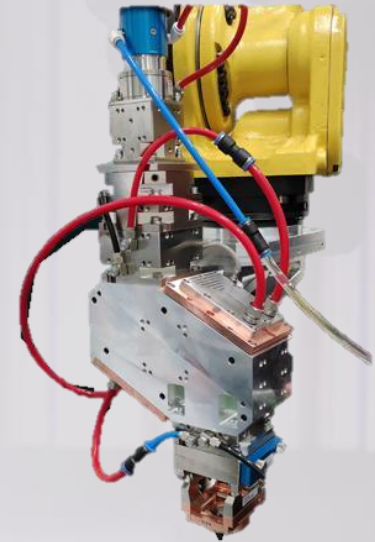
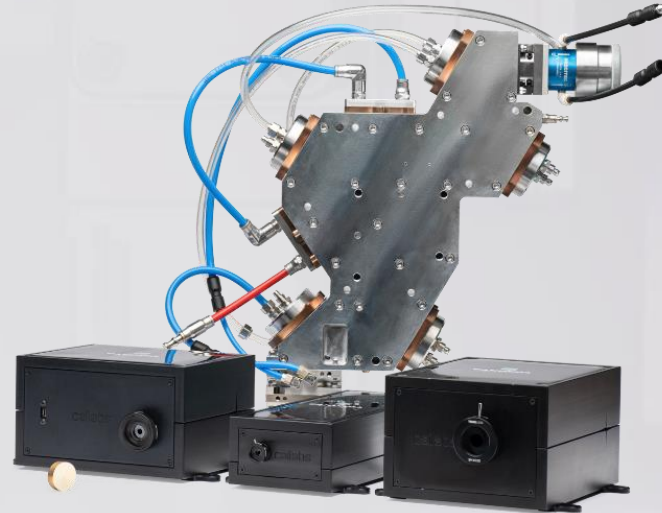
Multi-Plane Light Conversion (MPLC) to shape light

MPLC technology...



Free-form intensity + phase profiles
Mode propagation
Passive and reflective

... implemented for laser processing

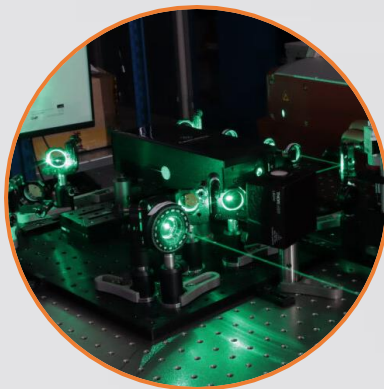


In between the laser and the process
Fibered or free-space
Compatible with all lasers

We develop turnkey & customized solutions for laser processing



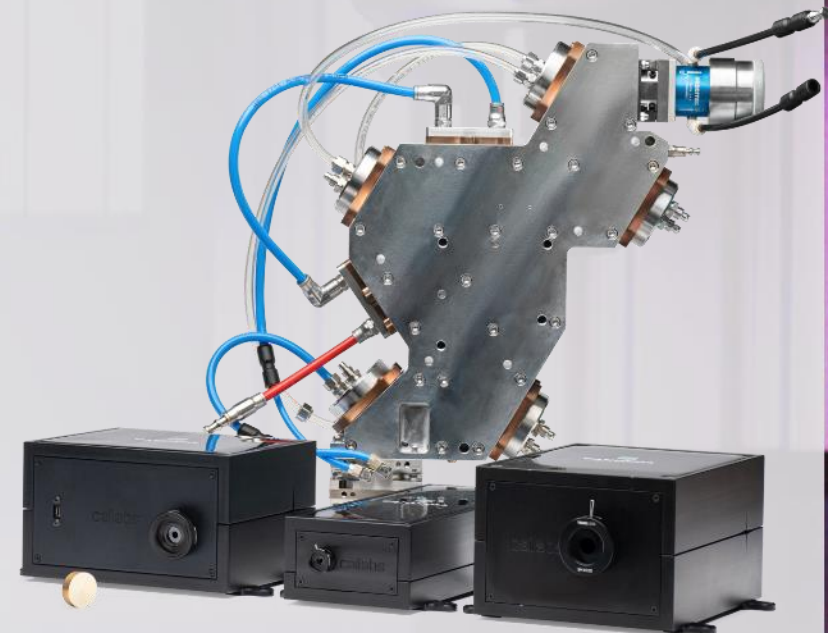
Laser Welding



**Micro-
processing**



**Additive
Manufacturing**

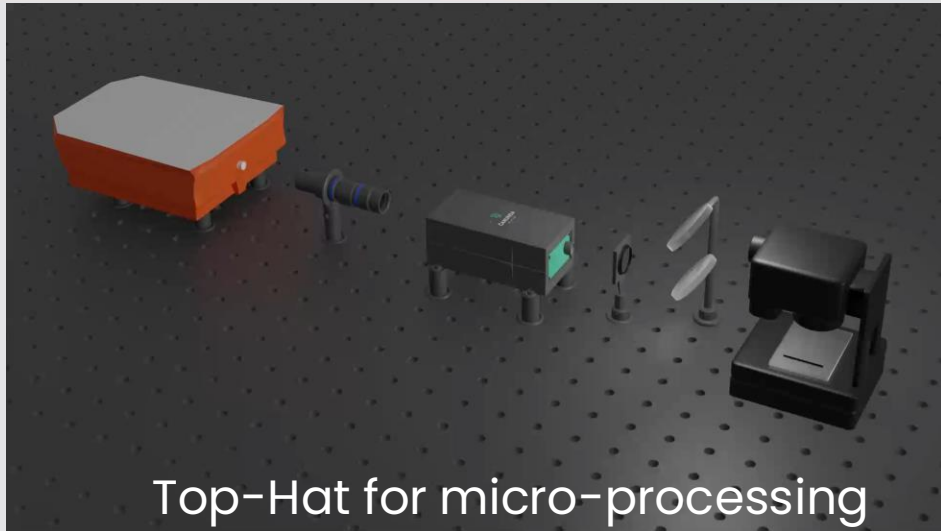


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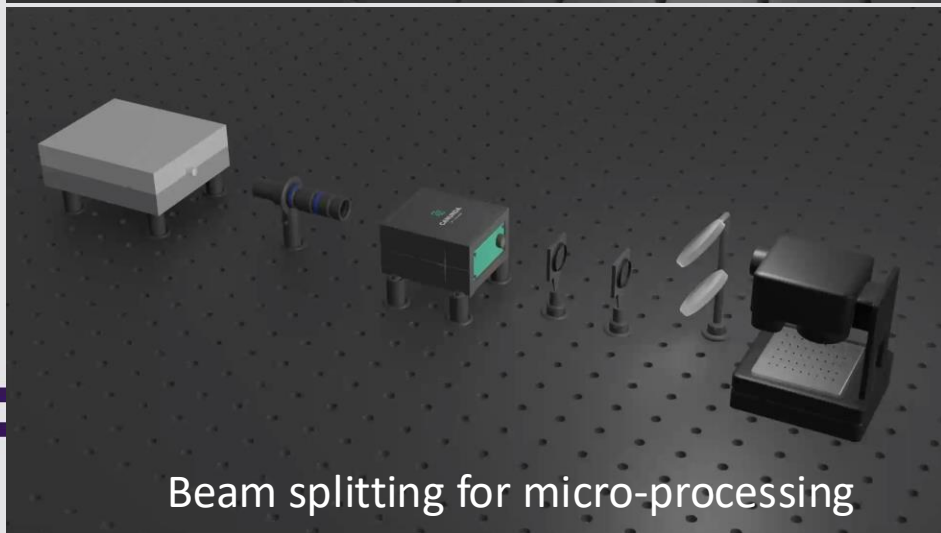


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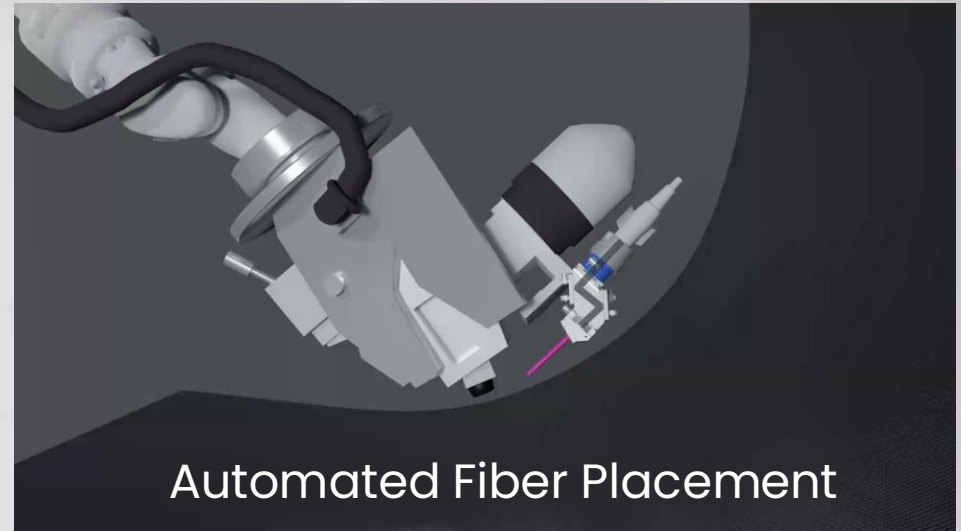
MPLC beam-shapers implemented in industrial environment



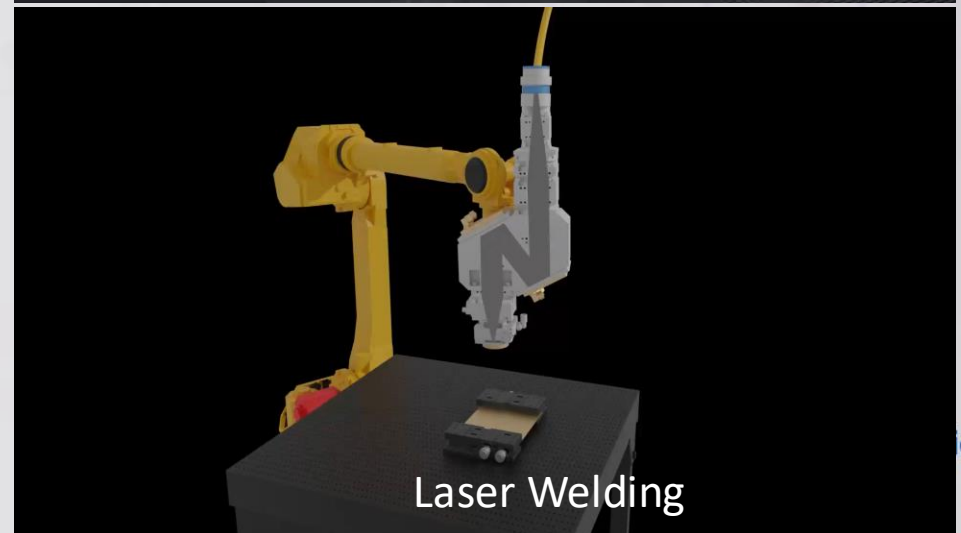
Top-Hat for micro-processing



Beam splitting for micro-processing

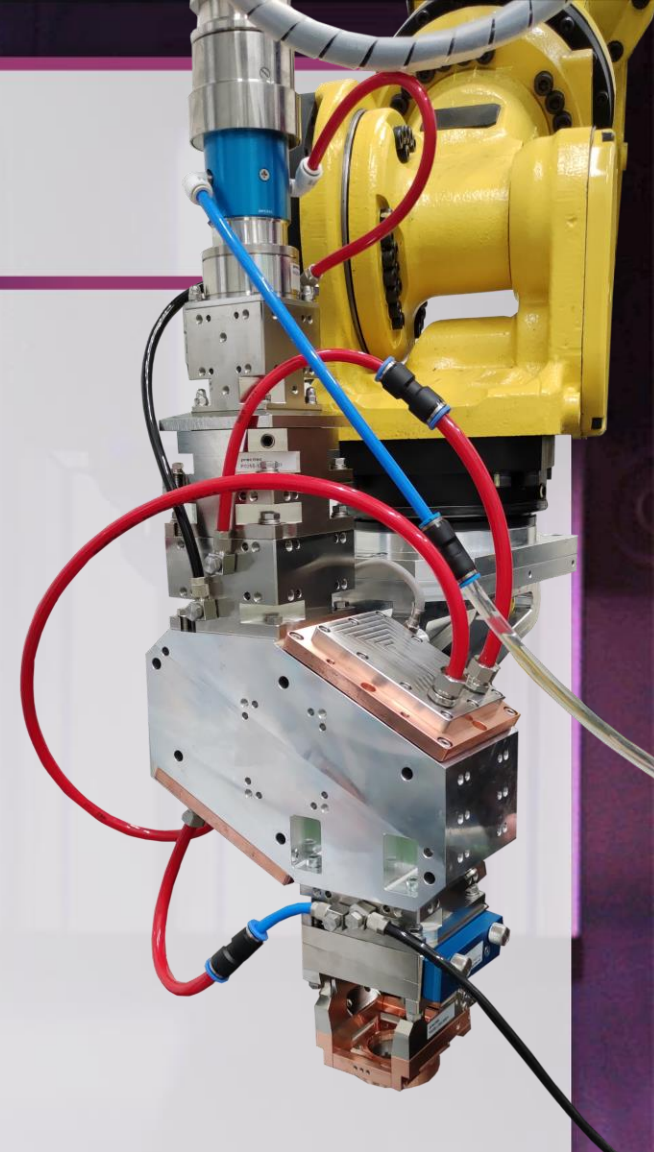


Automated Fiber Placement



Laser Welding

A fully integrated beam-shaper



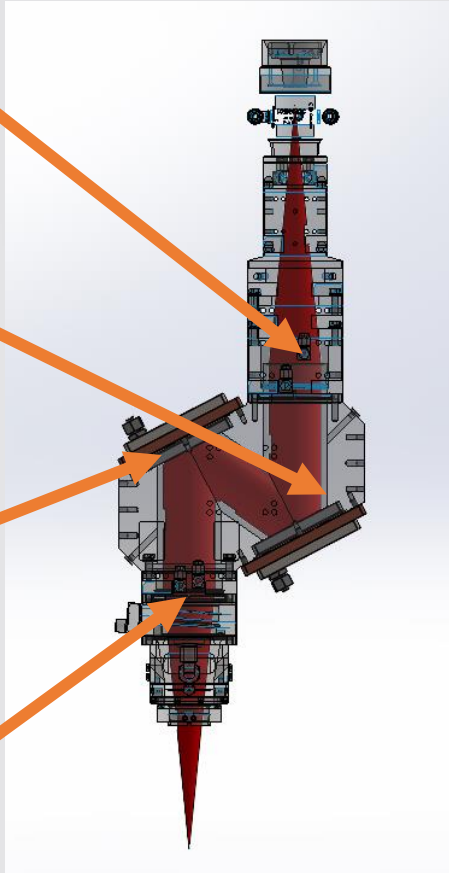
Collimation

Shaping 1

Shaping 2

Focusing

FLASH

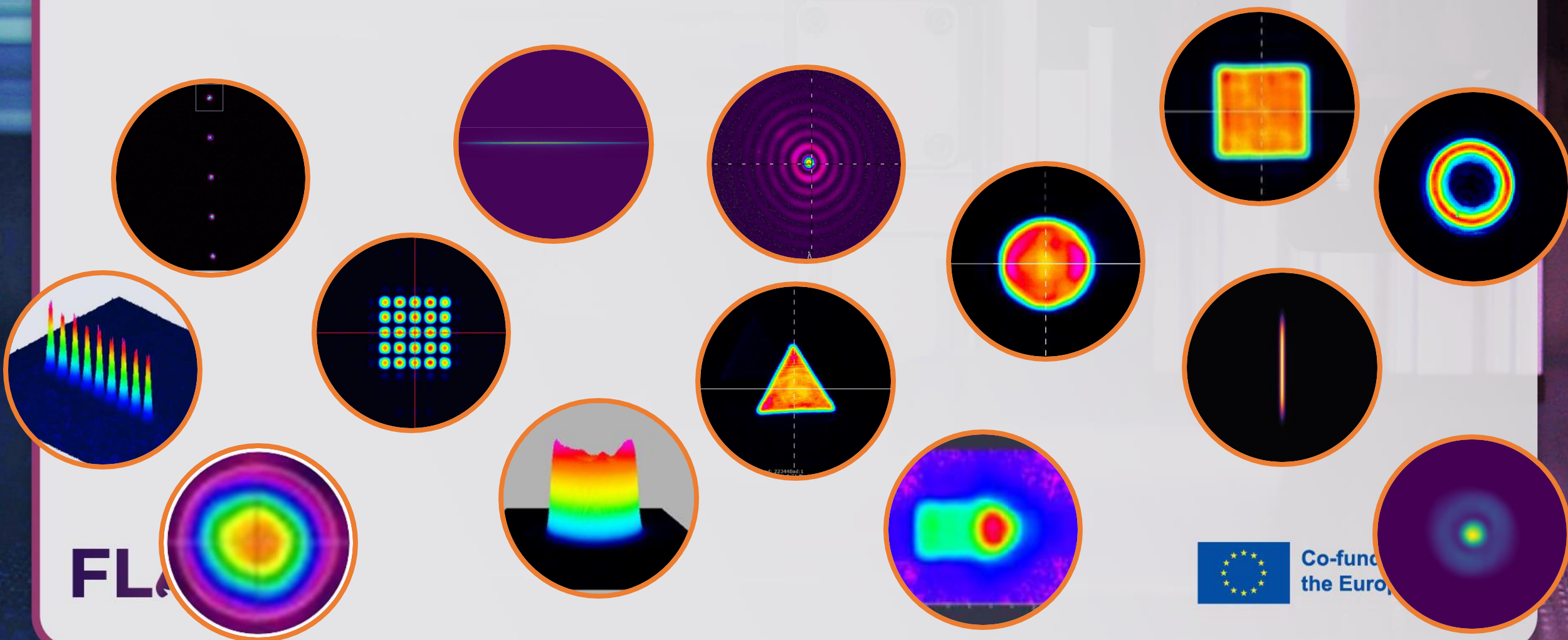


The optical chain is made of :

- Connector : LLK-D
- Collimation lens: 100mm & 200mm
- Two shaping optics
- Focusing lens : 200mm & 250mm

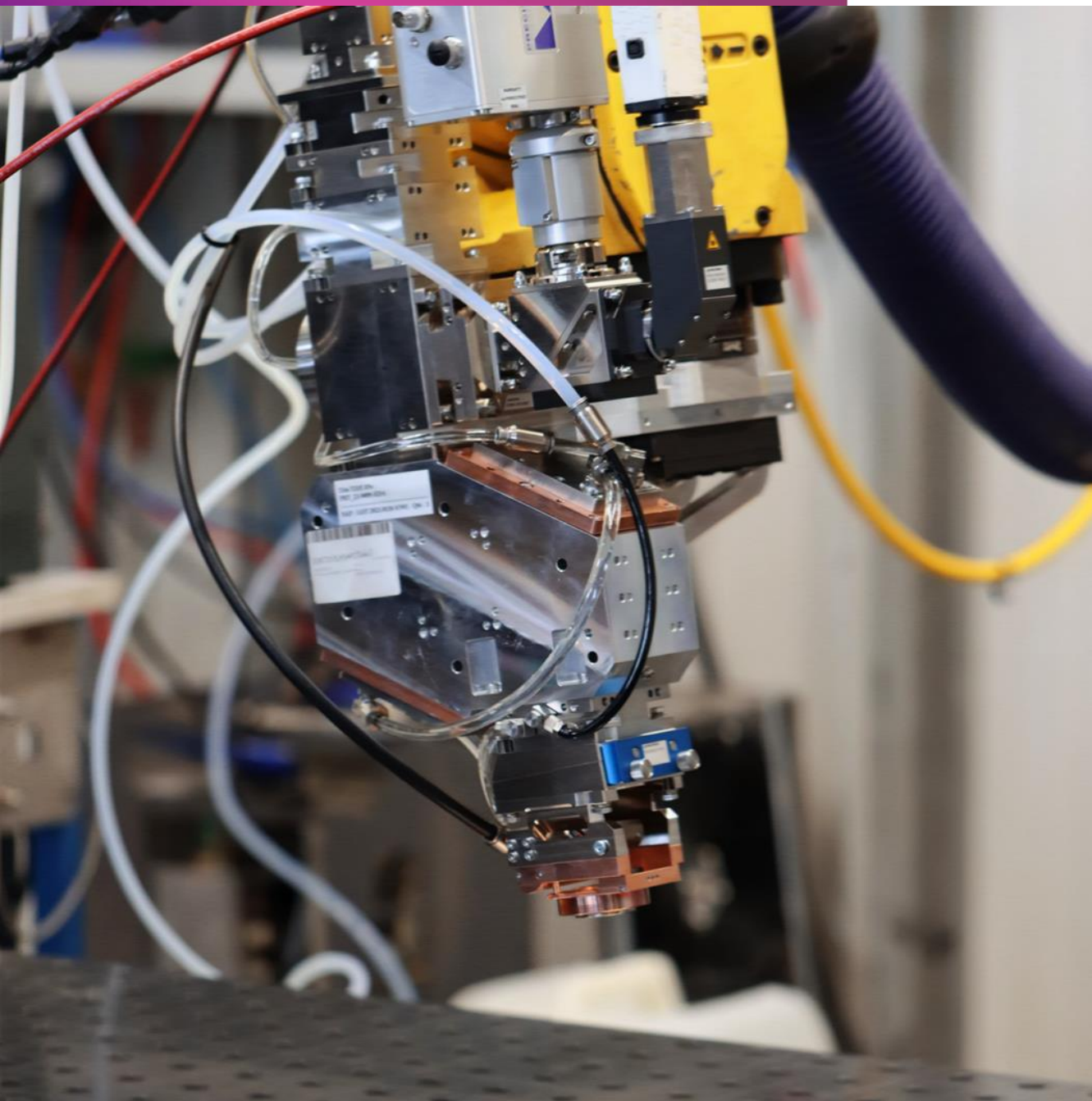


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A process using a beam-shape

Name of the process...

Image of
process

- Process parameters
- ...

... name of the shape

in the processing plane :

- Shape parameters
- ...

Actual
shape in
processing
plane

Gain
obtained

➤ What is the upscale for the industry

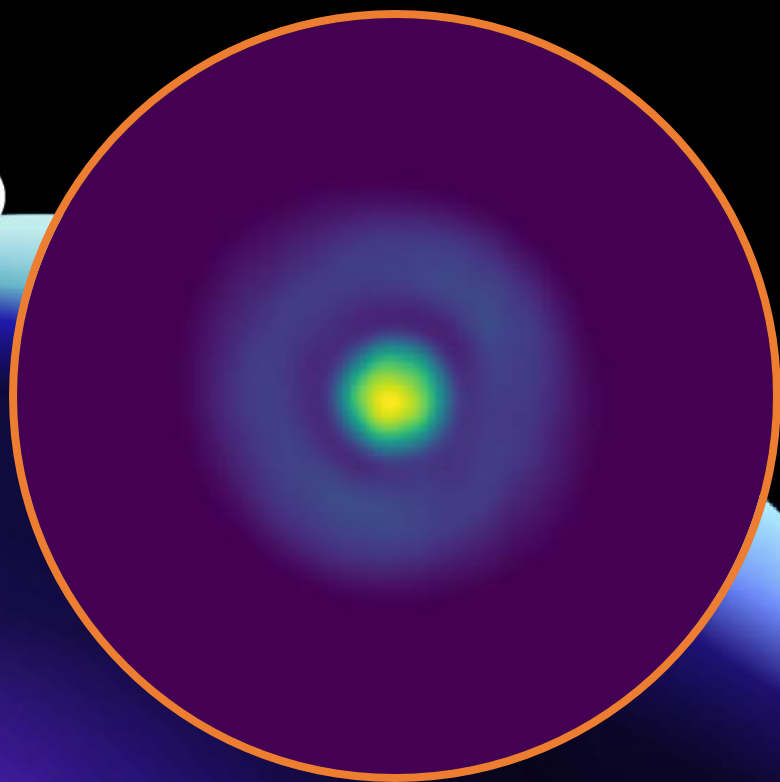
Partner logo

1st publication reference : author, title, conference (year)

FLASH

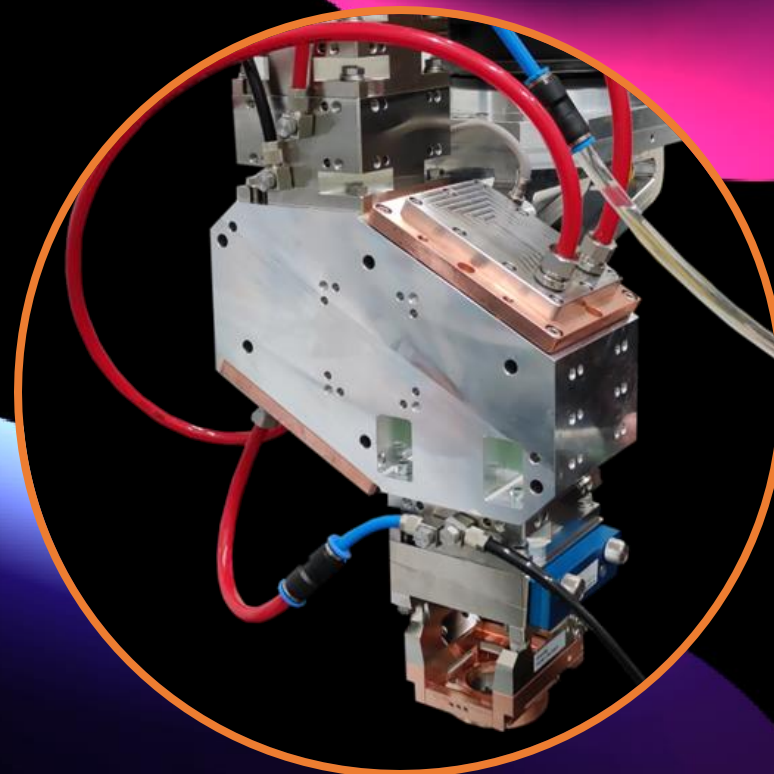


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The ring-dot shape E-mobility applications

Flexible Laser-Based Manufacturing



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Better hairpins welding with a ring-dot shape



Hairpins welding...

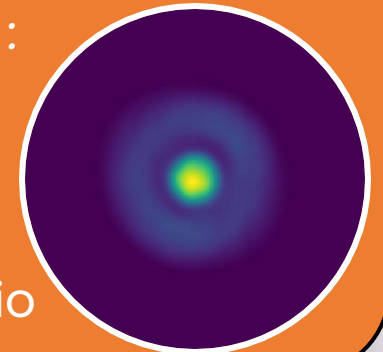


- Cu ETP
- 4mm x 1mm hairpins
- 3.5kW 175mm/sec

... with a ring-dot shape

in the processing plane :

- 520µm ring diameter
- 135µ dot diameter
- 60% / 40% energy ratio



Spatters /2

➤ Decreasing scrap rate to enable **relocation of EV manufacturing** in Europe

A. Kumar et al., Beam shaping with multi-plane light conversion to improve laser beam welding for e-mobility applications, Photonics West (2024)

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 **Fraunhofer**
ILT



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Faster cell contacting with a ring-dot shape

Cell contacting...

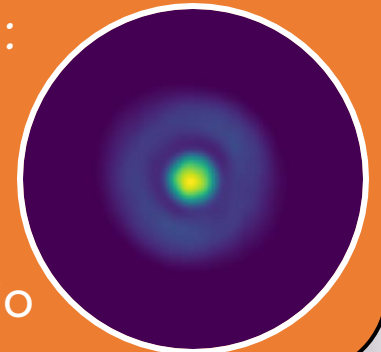


- Ncu ETP 2.5mm over DC04 4mm
- 1.5kW 400mm/sec

... with a ring-dot shape

in the processing plane :

- 520µm ring diameter
- 135µ dot diameter
- 60% / 40% energy ratio



Speed **x5**

G. Pallier et al., Process improvement through innovative beam-shaping in laser welding, AKL (2024)

- Improving manufacturing yield to enable **relocation of EV manufacturing** in Europe

FLASH

Fraunhofer
ILT

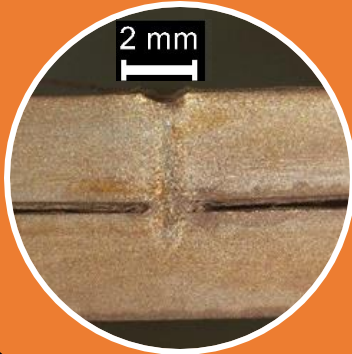


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Deeper busbars welding with a ring-dot shape

Busbars welding...

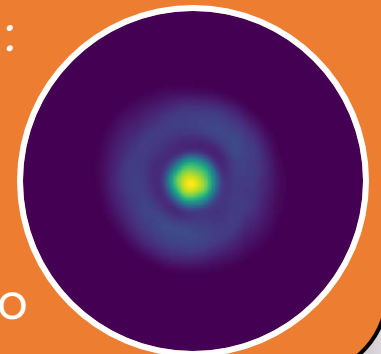


- Cu ETP
- 3mm over 3mm
- 8kW, 3m/min
- Up to 0.4mm gap

... with a ring-dot shape

in the processing plane :

- 400µm ring diameter
- 100µm dot diameter
- 70% / 30% energy ratio



x1.5 Depth

G. Pallier et al., Process improvement through innovative beam-shaping in laser welding, AKL (2024)

- Managing **deep welding with standard laser** enabling **more flexible production** and **relocation of EV manufacturing** in Europe

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Stronger busbars welding contacting with a ring-dot shape



Busbars welding...

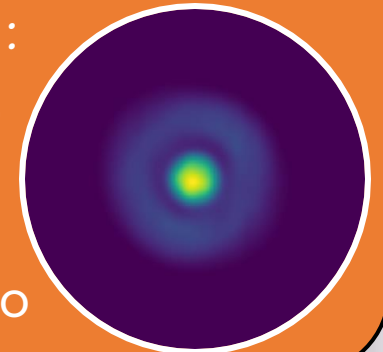


- Cu ETP
- 1mm over 1mm
- 6kW, 6m/min
- Up to 0.3mm gap

... with a ring-dot shape

in the processing plane :

- 400µm ring diameter
- 100µm dot diameter
- 70% / 30% energy ratio



x1.5 Accepted Gap

G. Pallier et al., Process improvement through innovative beam-shaping in laser welding, AKL (2024)

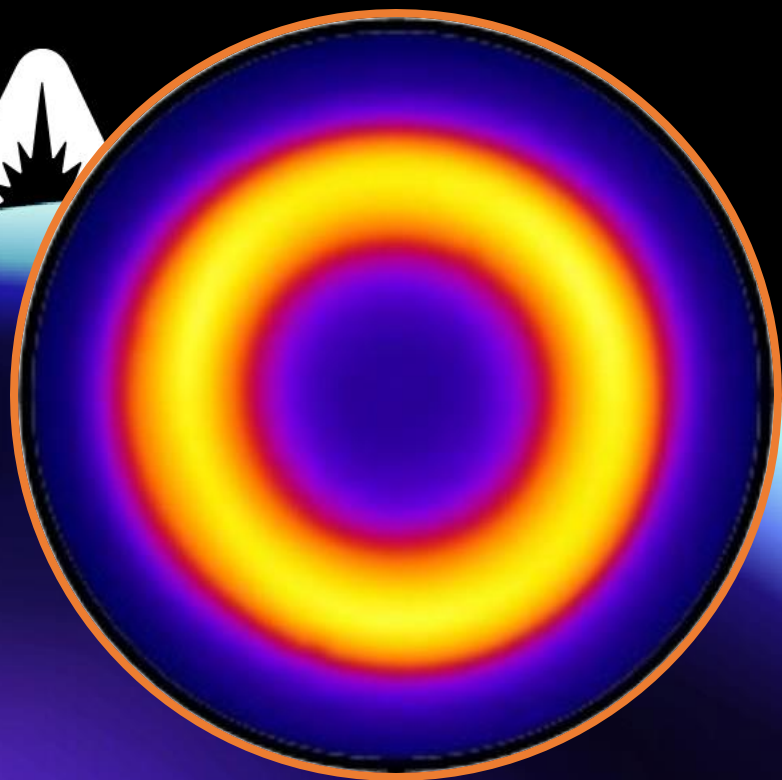
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➤ **Reducing tolerances** on parts and **simplifying fixtures** enabling **more flexible production** and **relocation of EV manufacturing** in Europe

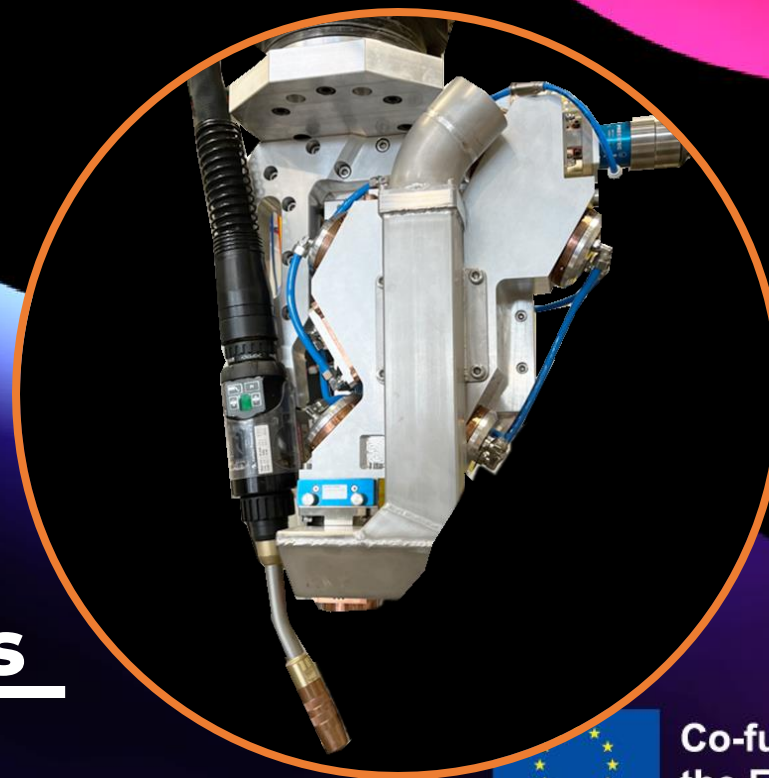
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Flexible Laser-Based Manufacturing



The ring shape Thick steel sheets applications

Flexible Laser-Based Manufacturing



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More robust steel welding with ring shape

Thick steel welding...



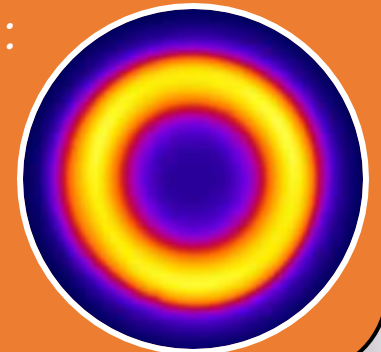
- S355 steel plates (t=28mm)
- 16kW, 0.8m/min
- Up to 0.7mm gap

A. Orioux *et al.*, Beam shaping for HLAW welding of thick stainless-steel plates with multi-plane light conversion, *Photonics West* (2024)

... with a ring shape

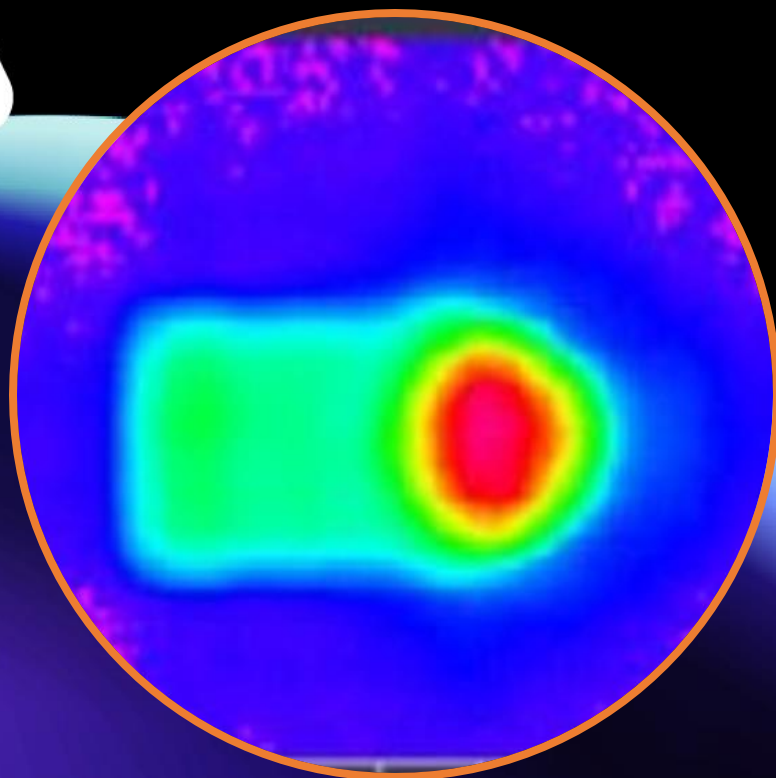
in the processing plane :

- 800µm ring diameter
- 200µm ring thickness



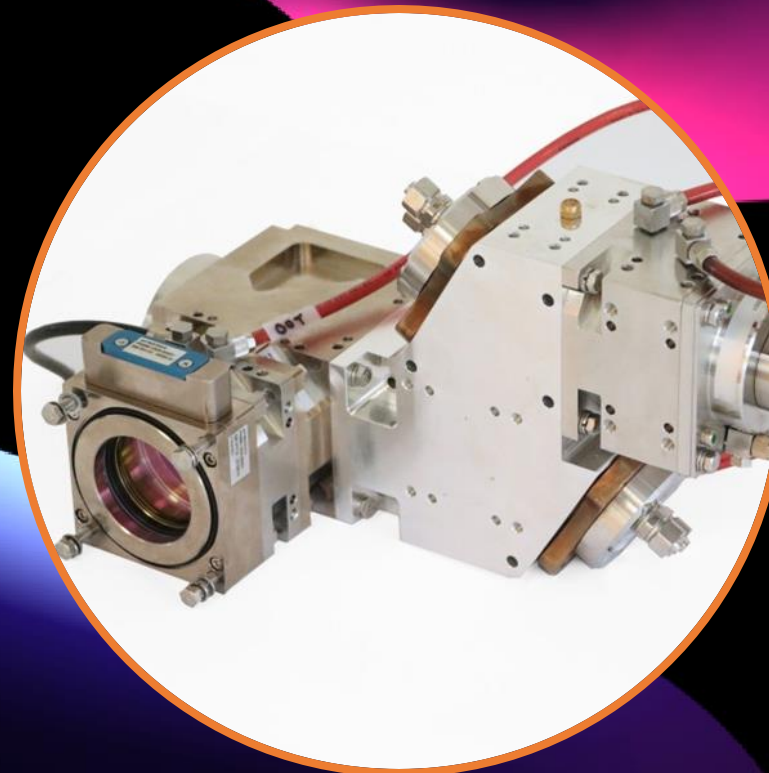
x1.5 Accepted Gap

- **Increasing acceptable gap** to meet industrial standard requirements and to enable a traditional process to switch to a laser process



Others shapes **Thick steel sheets applications**

Flexible Laser-Based Manufacturing



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Stainless steel welding using dynamic rectangle-dot shape

Stainless steel welding...

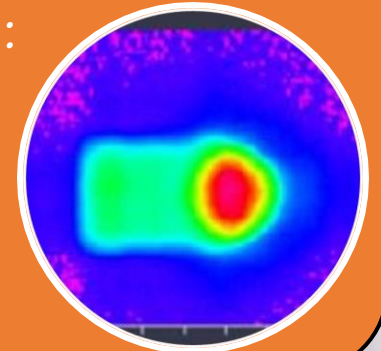


- 304L stainless steel
- 1030 nm, 8 kW
- 80 mm/s
- 0 mm to 0.4 mm gap

... with a rectangle-dot shape

in the processing plane :

- Ø Dot = 0.7 mm
- Rectangle : 1.6mm x 0.8 to 1.5mm ...



x2 gap
managed

M. Meunier et al., Stainless Steel Laser Beam Welding with a Dynamic Tailored Beam Laser-Head based on Multi-Plane Light Conversion, *ICALEO* (2022)

➤ **Reducing tolerances** on parts and **improve scrap rate** to **reduce manufacturing costs**

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Reduced hot cracking with a 4 spots shape

Battery case welding ...

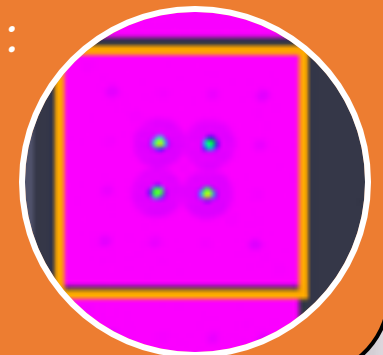


- Al 5081 (3mm) over Al 6082 (4mm)
- 8kW
- 2, 4, 8m/min

... with a 4 spots

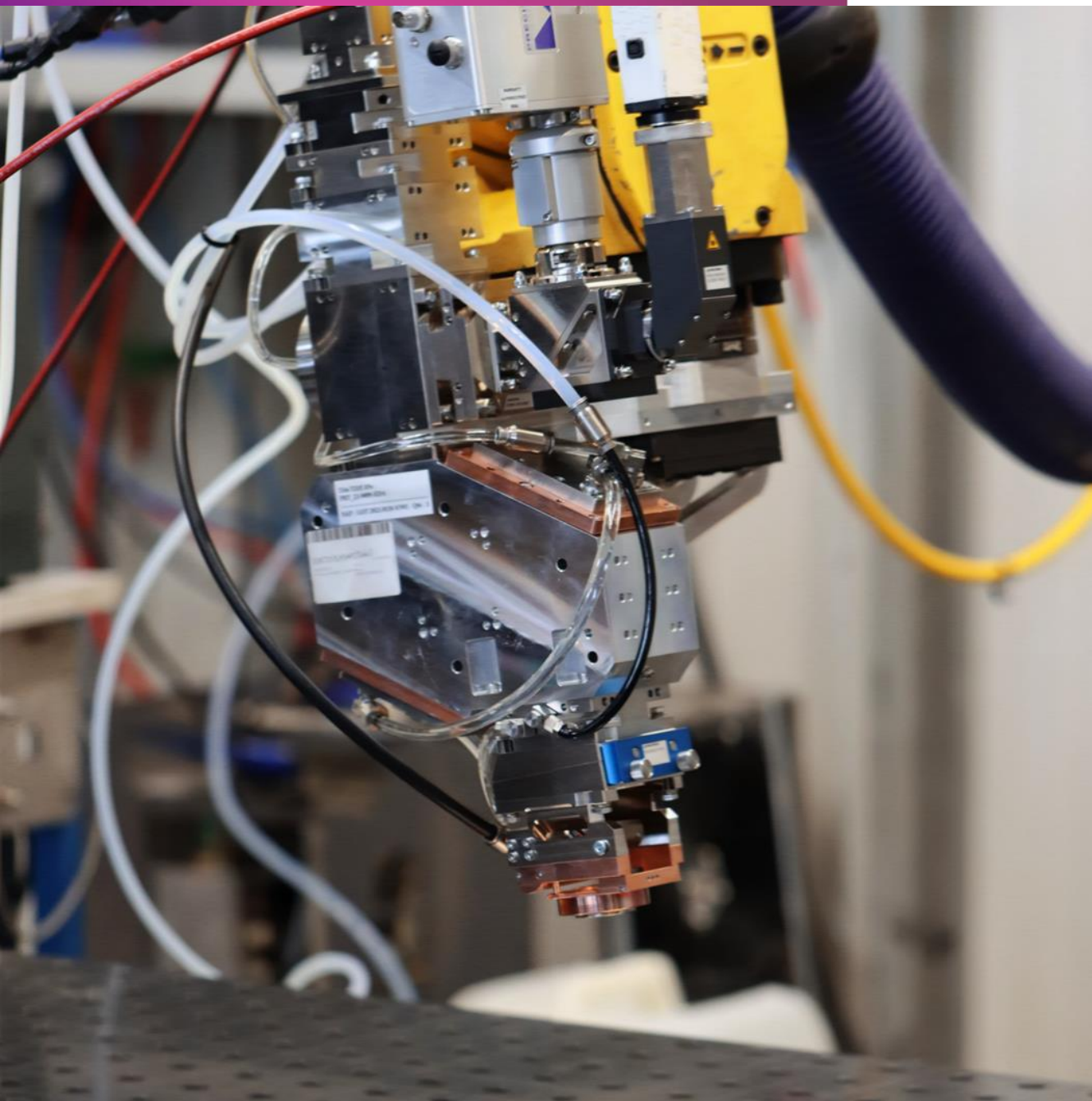
in the processing plane :

- 400 μ m pitch
- 100 μ m spot diameter



Crack free

A. Kumar et al., Aluminum battery pack laser welding with a 4-spots beam-shaper compatible with all lasers, LIM (2025)



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-  What's next ?

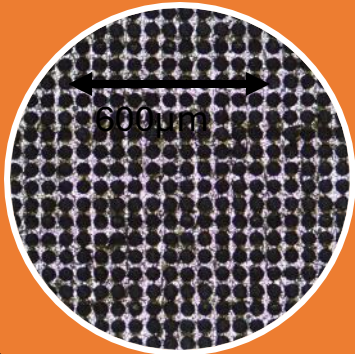


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Faster surface texturing thanks to 5 splitted beams

Surface texturing (tribological) ...

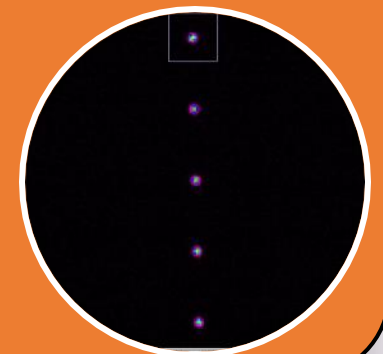


- Stainless steel
- 4mmx4mm
- 1030nm
- Scanning pitch 50µm

... with 5 splitted beams

in the processing plane :

- 40µm diameter
- 200µm pitch
- <2.5% homogeneity



Process
Speed **x2.5**

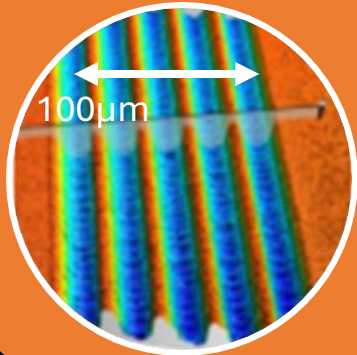
➤ **Increasing process speed and improve machine ROI**

M. Ziat et al., Tribological Properties Improvement of Stainless Steel and Nickel Samples at Large Scale thanks to Beam Splitting with a Femtosecond Laser, ICALEO (2023)



Faster riblets drilling thanks to a square top-hat

Surface texturing (riblets) ...

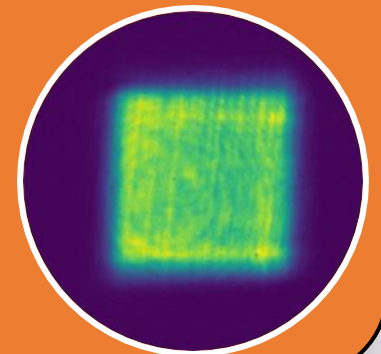


- Aluminium AU4G
- 1030nm - 0.9 J/cm² (vs 0.6) @2MHz
- 1 lateral & 21 longitudinal passes (vs 13 & 37)

... with a square top-hat

in the processing plane :

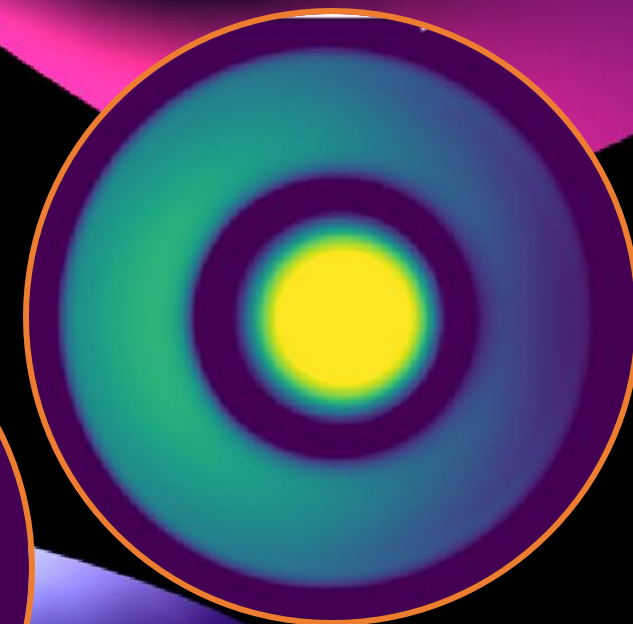
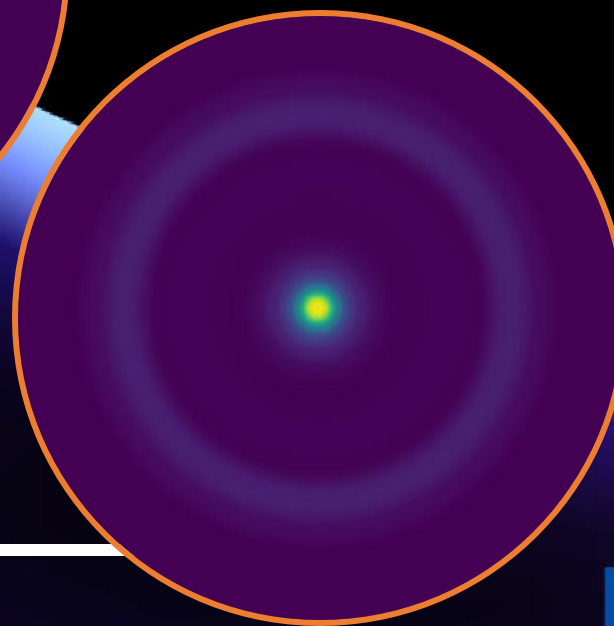
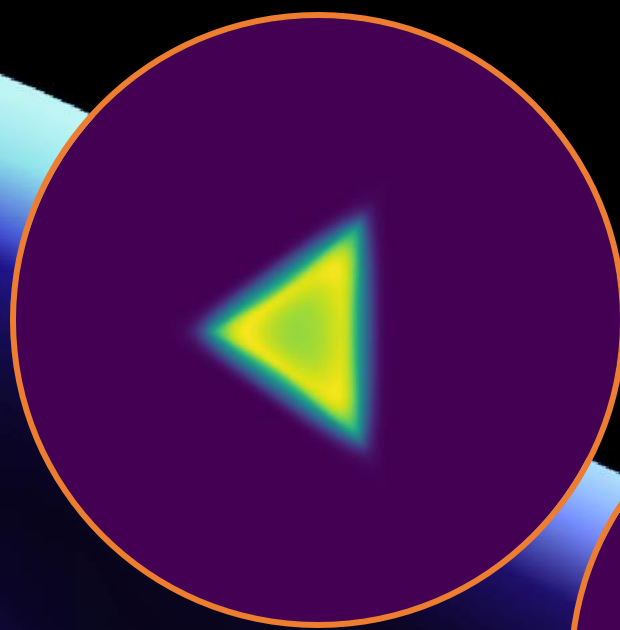
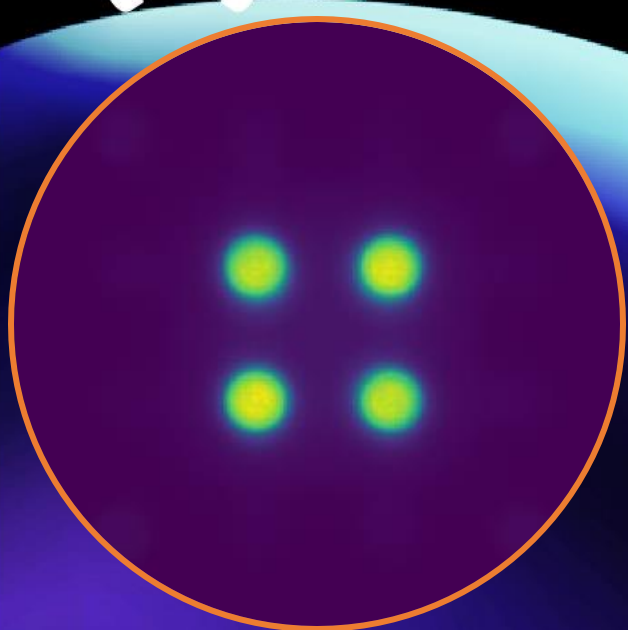
- 15µm width
- Uniformity : 0.1
- Sharpness : t/L = 0.1



Process
Speed **x17**

E. Mottay et al., High Power Shaped Femtosecond Beams for Riblets Manufacturing, SPIE Photonics West (2023)

Getting to the targeted industrial speed for surface texturing (target 100cm²/min, x100 vs current SOA)

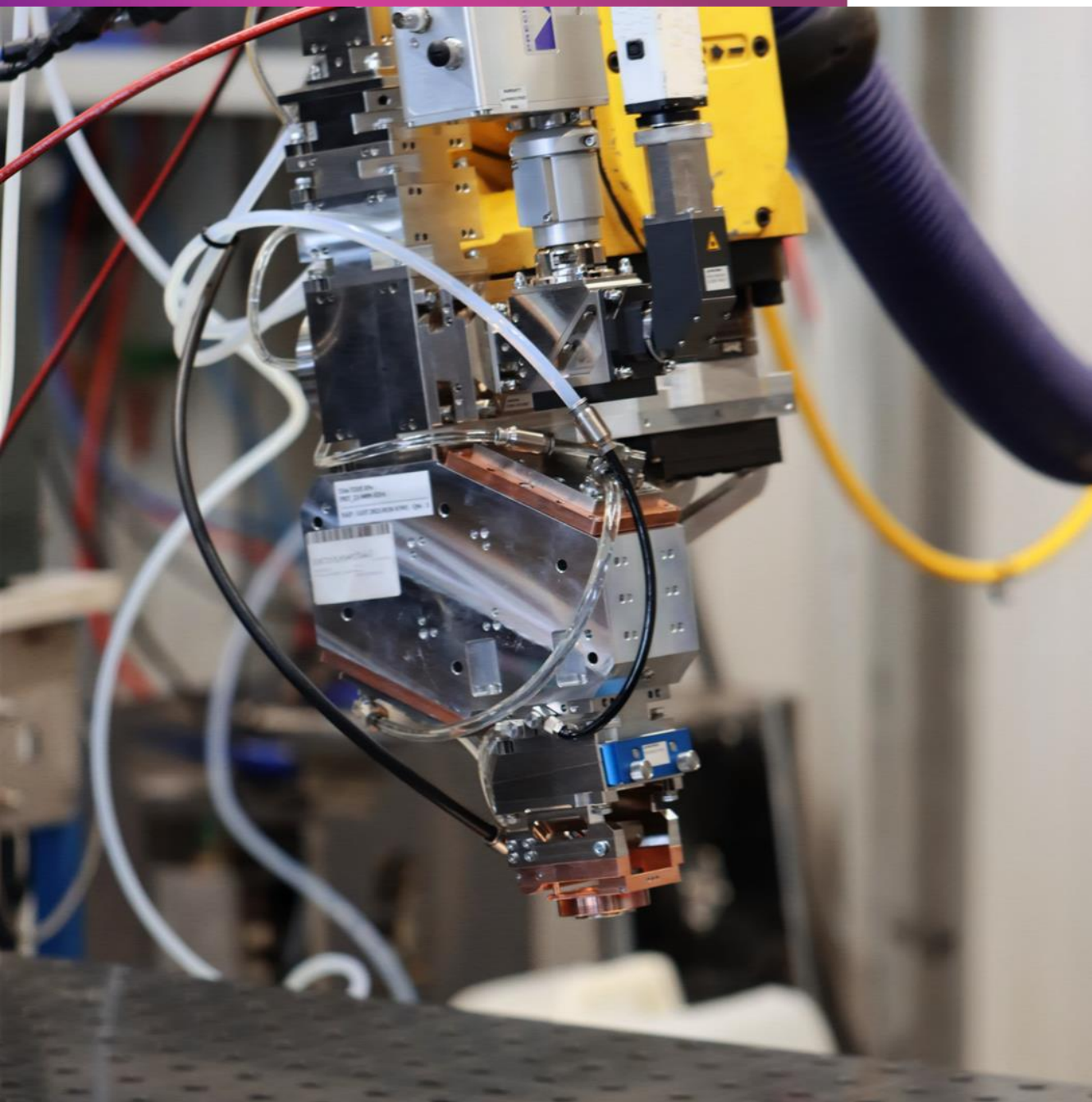


Other shapes are under investigation !

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This is just the beginning !

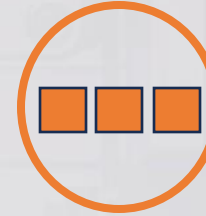


DED

New applications



Power

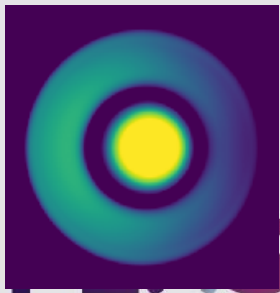


Combined functions

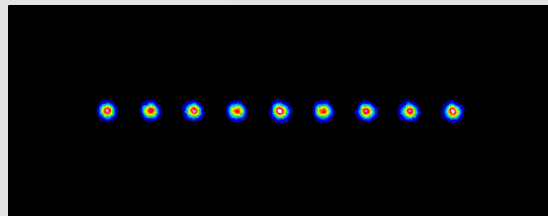
Complex shapes



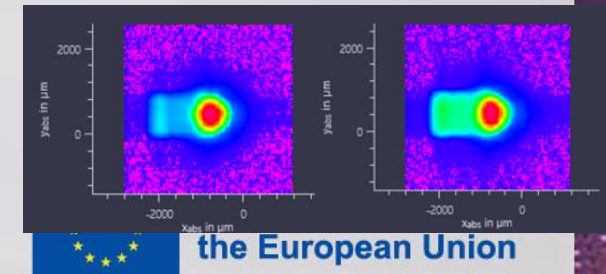
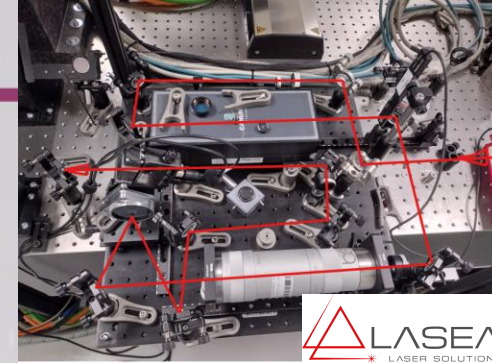
Dynamicity (&3d)



Asymmetric shape



λ
Wavelength

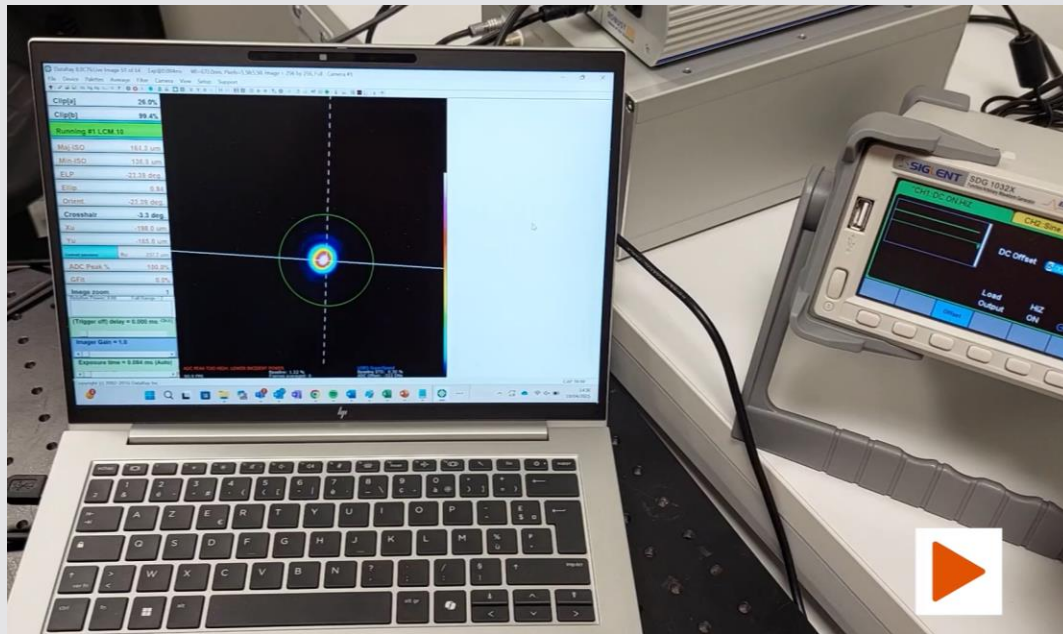


the European Union

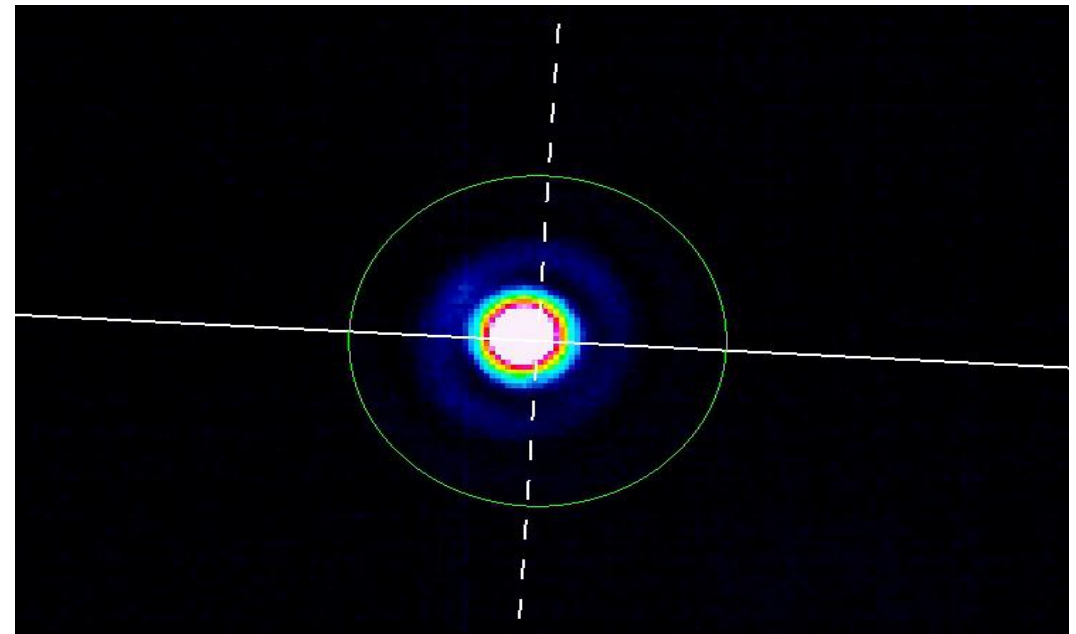
Having a Gaussian beam, another shape (larger ring), and switching fast and precisely in between is possible



Choose your shape

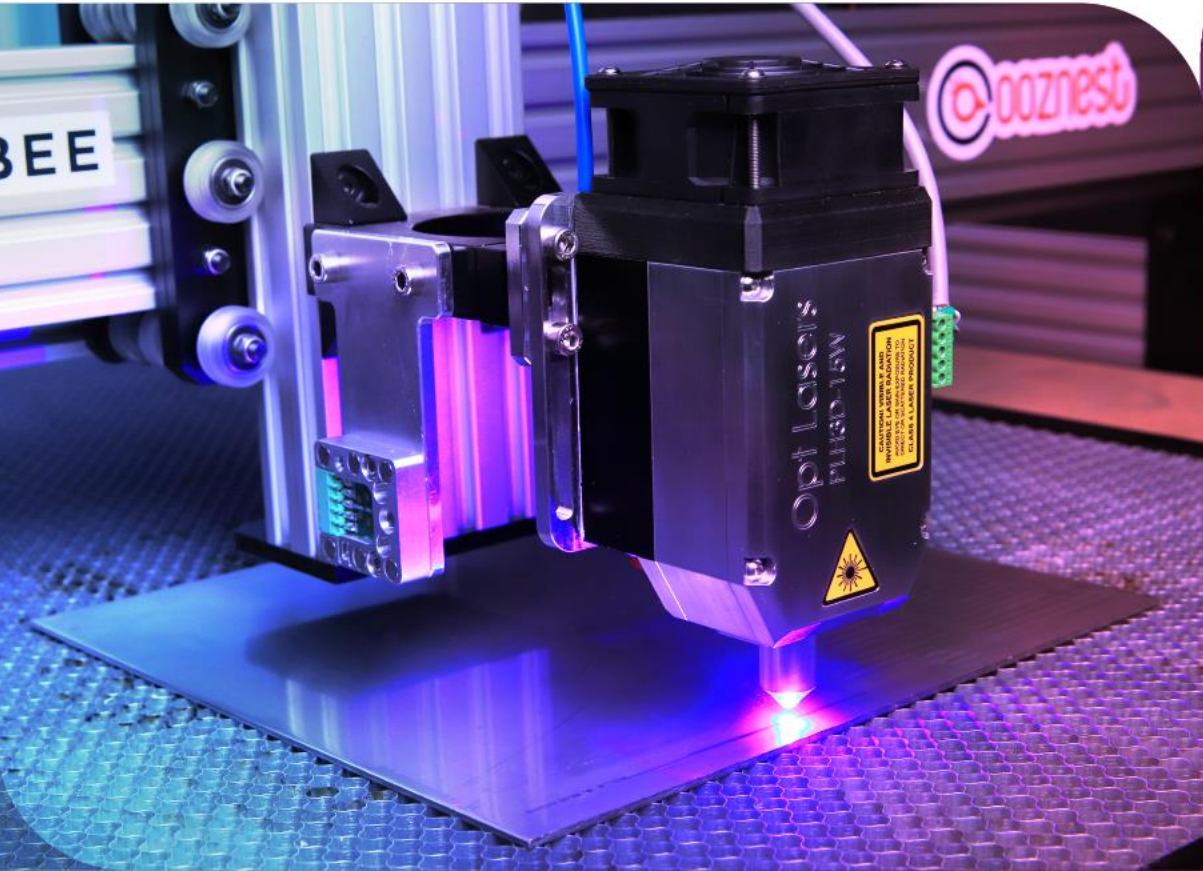


Continuous change of shape



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Any Question?

"If there are any questions or if something needs further explanation, please, don't hesitate to ask!"



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