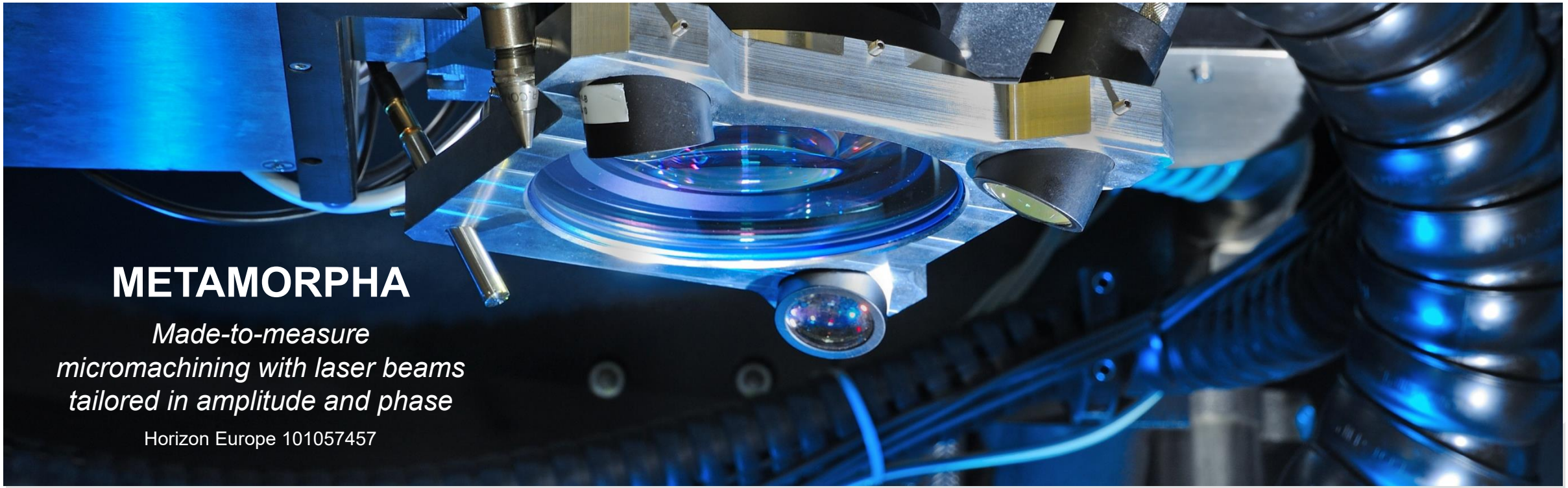


METAMORPHA

Made-to-measure micromachining with laser beams tailored in amplitude and phase

Horizon Europe 101057457

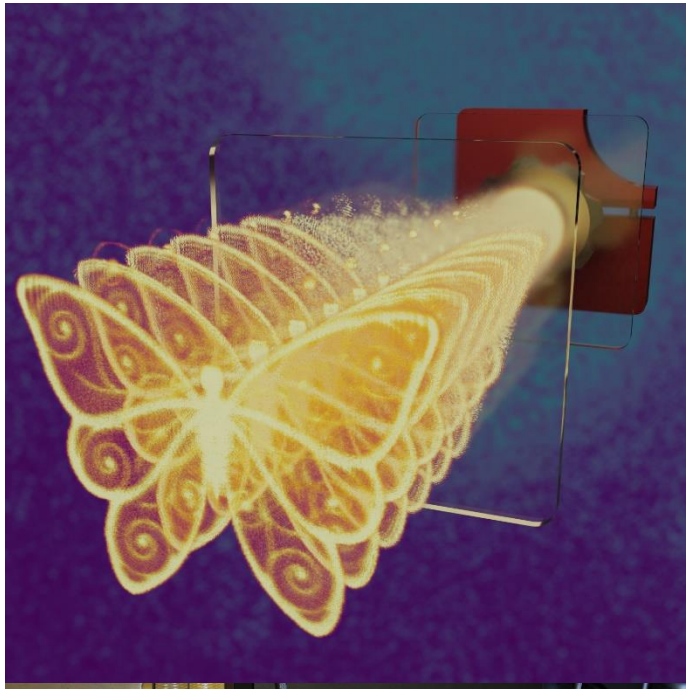
Project overview

EFFRA Manufacturing Partnership Days; 17-18 Nov-2026

Bruce Napier; Vivid Components Germany

Presentation outline

- **Project overview**
- Use cases
- Results
- LIMES Cluster





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Project overview

Single agile USP laser micromachining platform

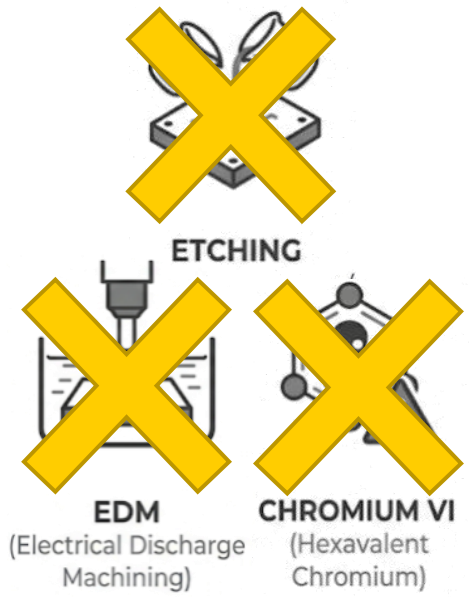
→ Replace conventional manufacturing process chains

Goal: resource-efficient manufacturing

All-digital dynamic beam tailoring

In-line process control

Made-to-measure laser processes.





Consortium

PHILIPS

- End user: consumer product

thyssenkrupp

- End user: embossing roller

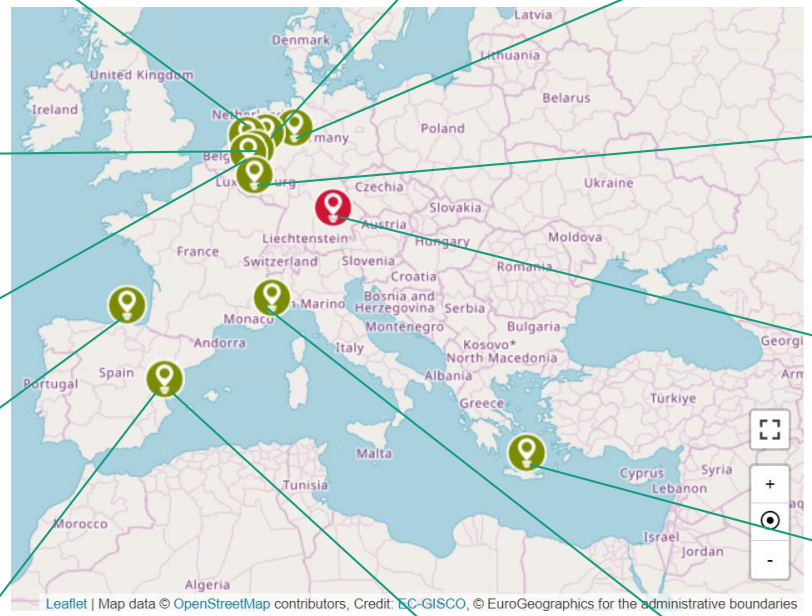
VIVID COMPONENTS

- Project management
- Dissemination

metamorpha

TOS | RWTH AACHEN UNIVERSITY

- Optics design
- Phase mask design



CERATIZIT GROUP

- End user: carbide punch

LASEA LASER SOLUTIONS

- Machine integration

Fraunhofer ILT

- Project management
- Laser process dev.
- FPGA-based system control

DATAPIXEL QUALITY CONTROL ENGINEERING

- 3D quality sensor

fentISS

- Real-time system

UNIVERSITAT POLITÈCNICA DE VALÈNCIA

- ML algorithms

ARDITEC

- Sustainability assessment

FORTH FOUNDATION FOR RESEARCH AND TECHNOLOGY - HELLAS

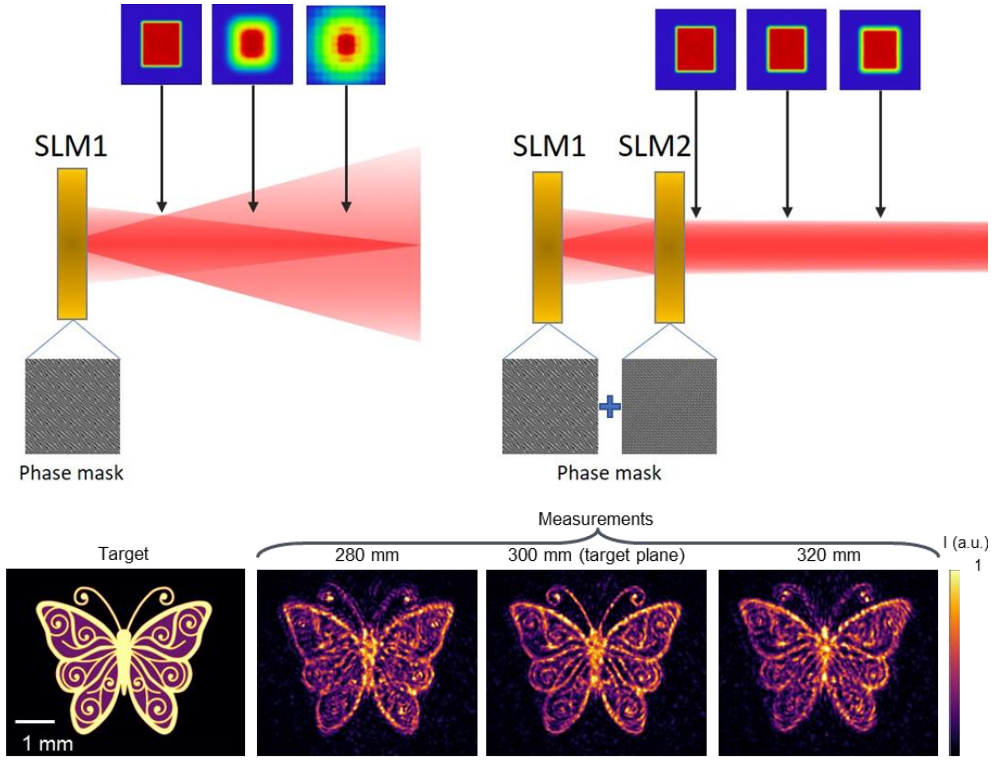
- Laser process simulation

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Beam shaping module – More capabilities with cascaded SLMs

Control over beam propagation



P. Buske, A. Völl, J. Stollenwerk, C. Holly., "Diffractive Neural Networks Built from Spatial Light Modulators for Laser Beam Shaping in the NIR and VIS," International Optical Design Conference (Québec City, 2023) ***Student Paper Award***

Combination of novel beam tailoring and ablation simulation leads to new process strategies

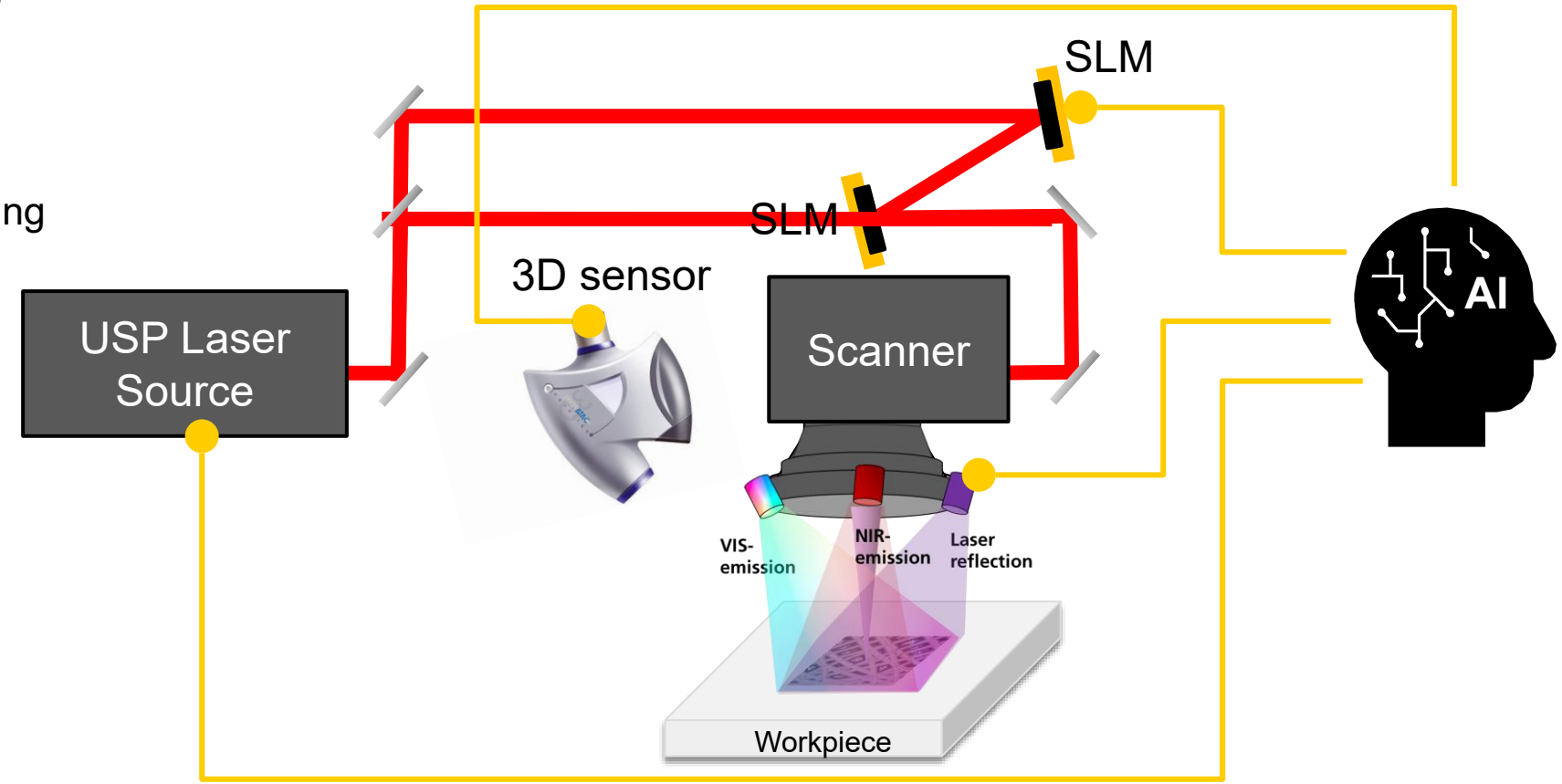
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Machine Concept

- Compatible with 3/5-axis-systems and roller set-ups
- Arbitrary 3D beam shaping using two cascaded SLMs
- In-line measurements
- Real-time measurements
- Edge AI and offline AI process planning and evaluation

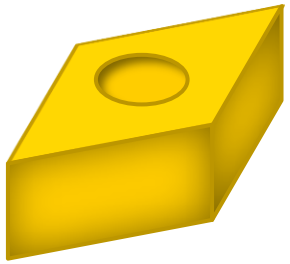
→ Zero-defect production
→ Tailored processes
→ Refurbishment of worn structures.



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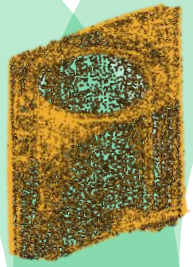
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Adaptive machining

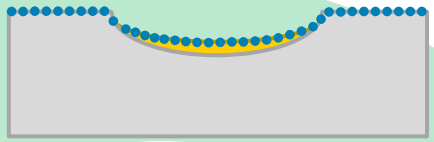


TARGET

Measured point cloud



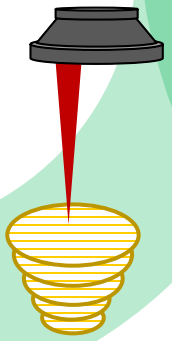
Expected vs. measured volume



Residual volume

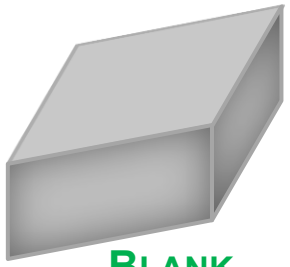


Laser ablation



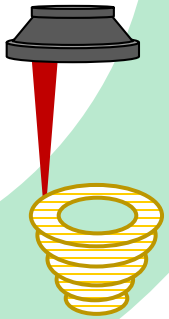
Slicing of volume





BLANK

Laser ablation

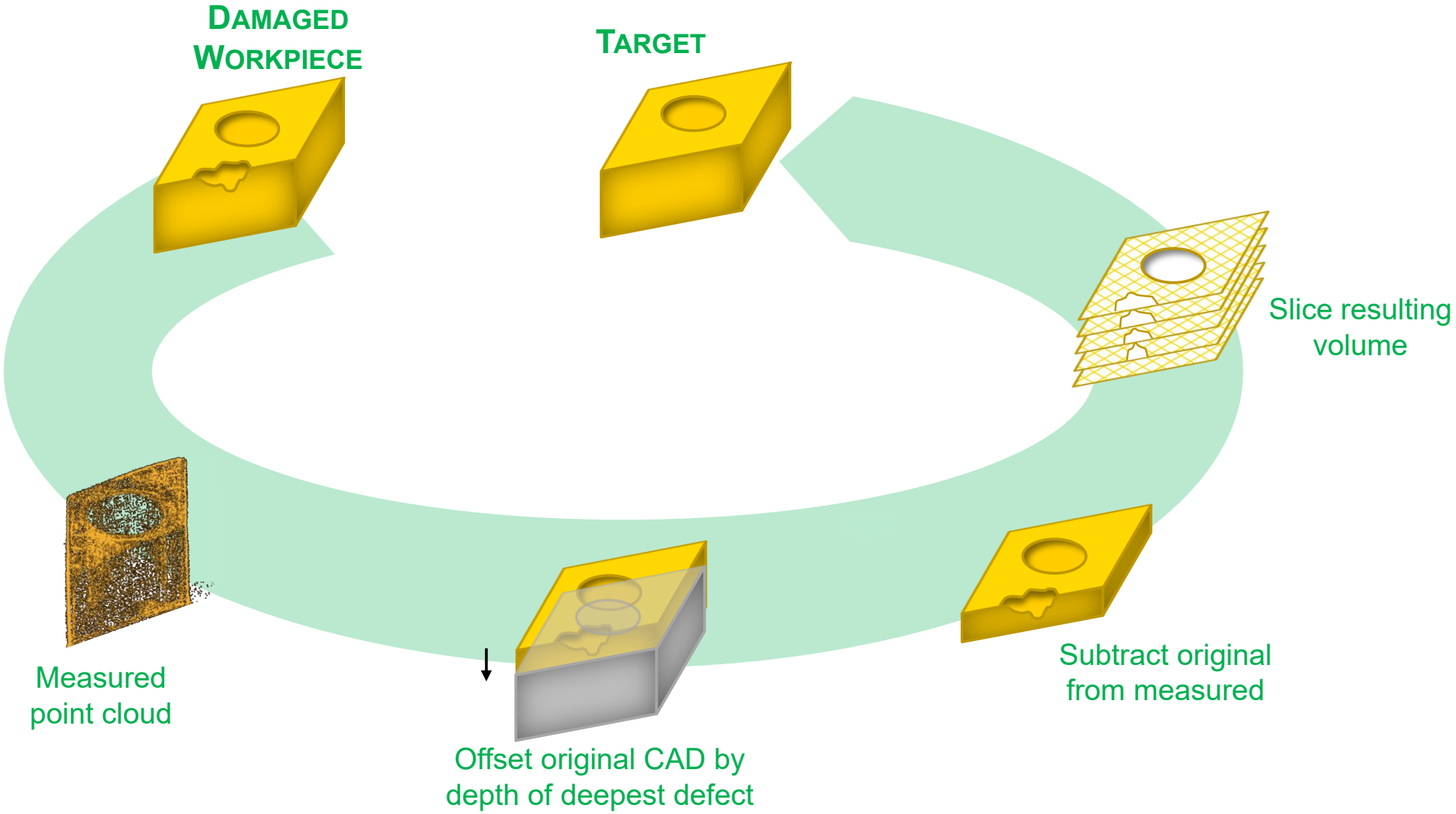


Sliced residual volume

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Remanufacture

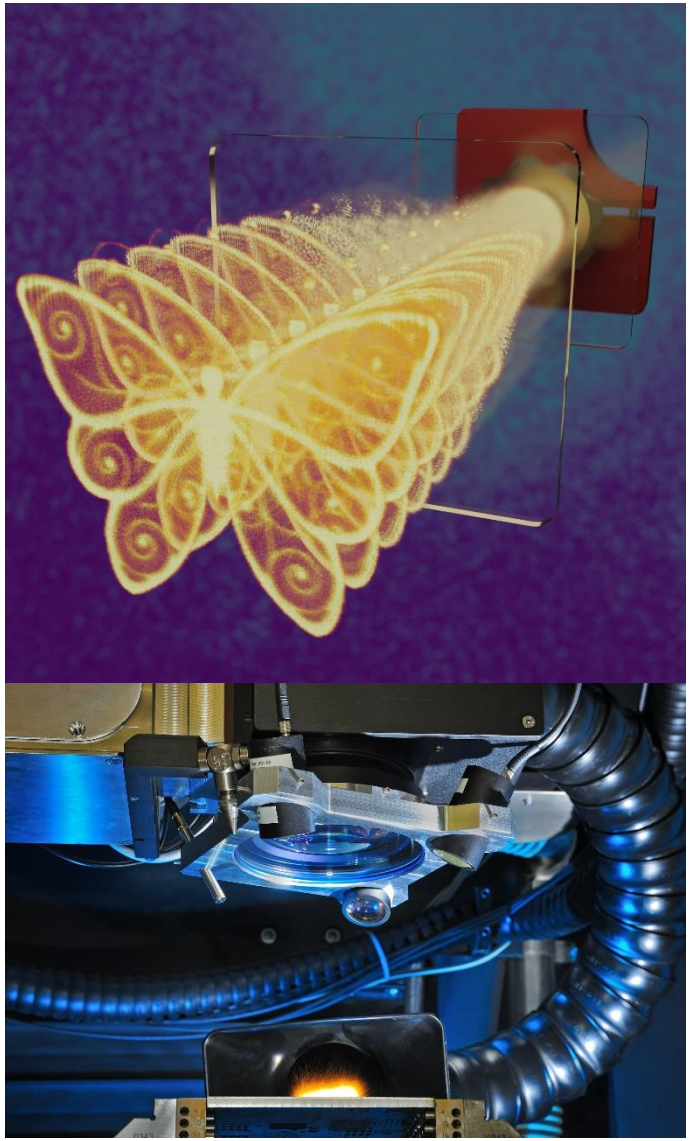


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Presentation outline

- Project overview
- **Use cases**
- Results
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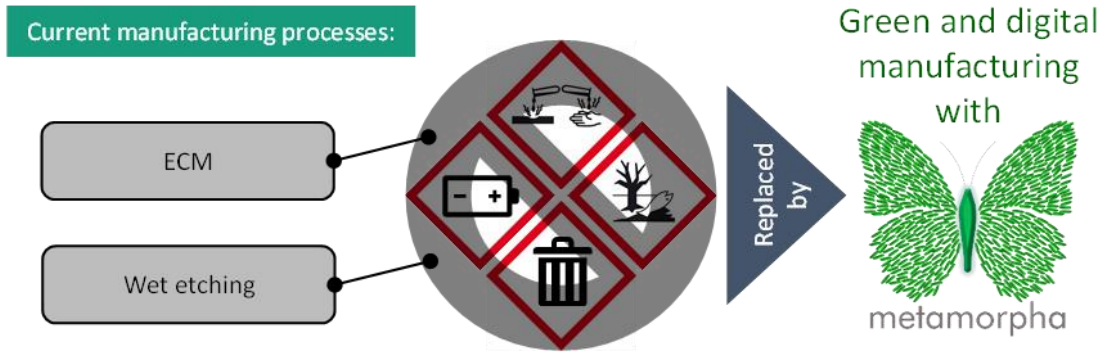
Use case 1: Personal healthcare product

PHILIPS

- Small metal parts
- Volume: ~30 million pieces per year

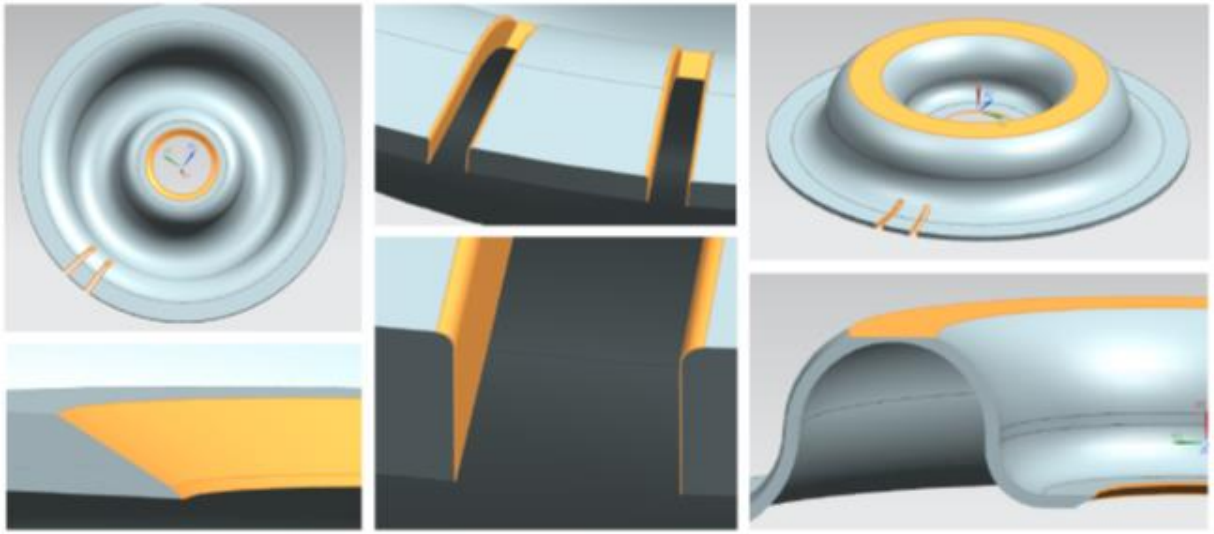
Current manufacturing technologies:

1. Wet chemical etching
2. ECM to cut slots
3. Second ECM for surface finish



METAMORPHA targets

- Full replacement of manufacturing technologies
- Maintaining geometry and cycle time.



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Use case 2: Large patterned steel rollers

thyssenkrupp

Fields of Application for Steel Sheets



Why Micro-Structures on Steel Sheets?

- Better properties for bending or deep drawing
- Better adhesion (e.g. for paint or glue)

Tailored Micro-Structure Design

Example structure A



creates better bending

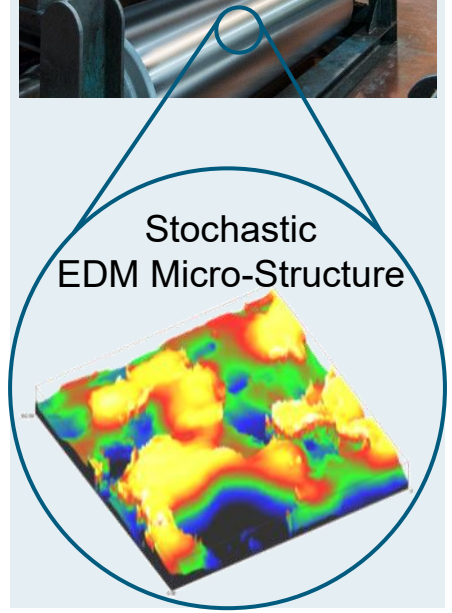
Example structure B



creates better adhesion

State-of-the-Art: *Electrical discharge machining (EDM)*





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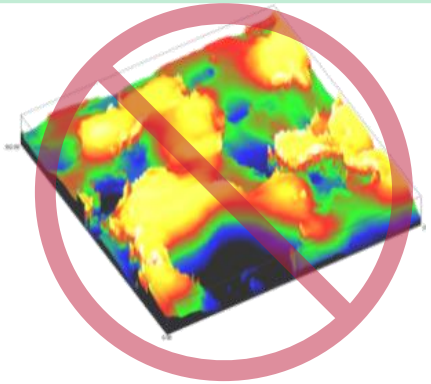
Use case 2: Large patterned steel rollers

- ~13000 m² area processed per year
  → Energy consumption in GWh range

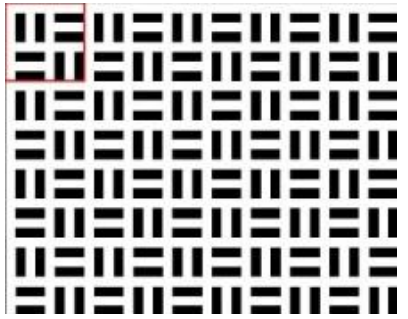
- METAMORPHA targets
  - Replacement of EDM (stochastic process)

- Impact on reduction of energy and waste
  - 70-90 % less energy consumption
  - No grinding sludge
  - Deterministic structures
    - Tailored micro-structure design
    - Refurbishment.

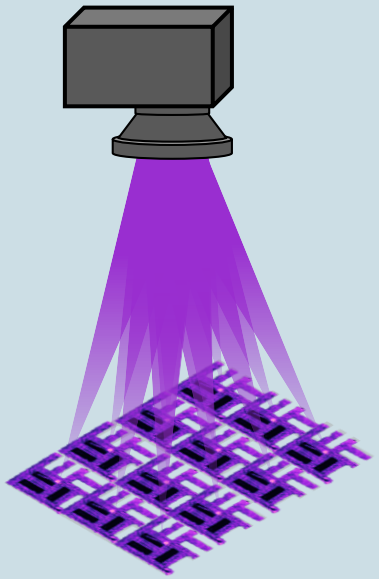
Current stochastic EDM structure



Deterministic target structure



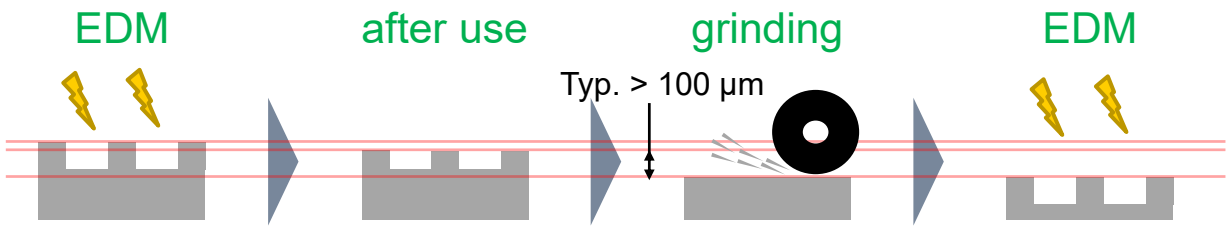
OPTICAL STAMPING



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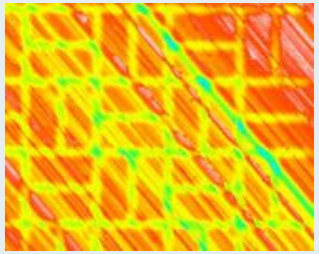
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Use case 2: reworking rollers

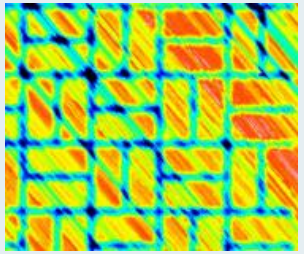


Tool Refurbishment

1) Measure and locate worn structure



2) Re-write structure

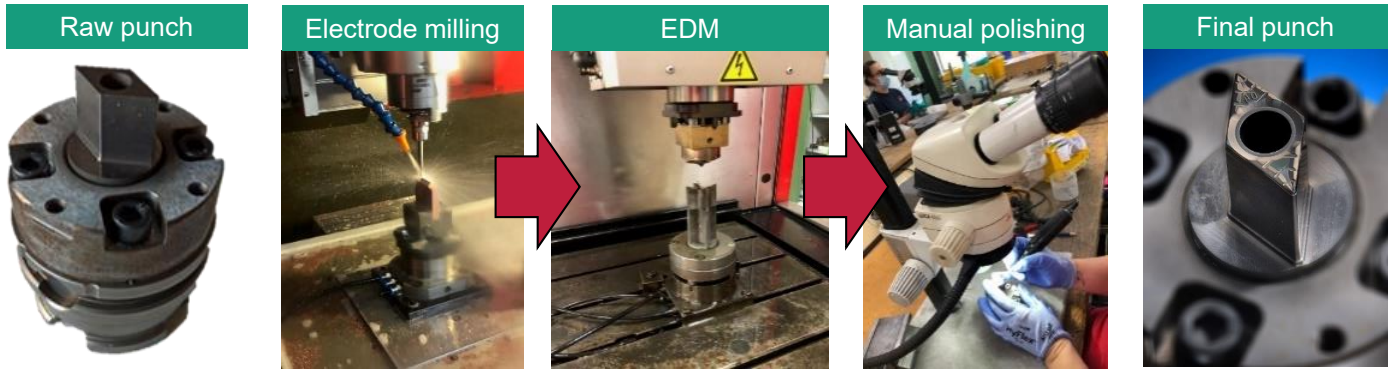


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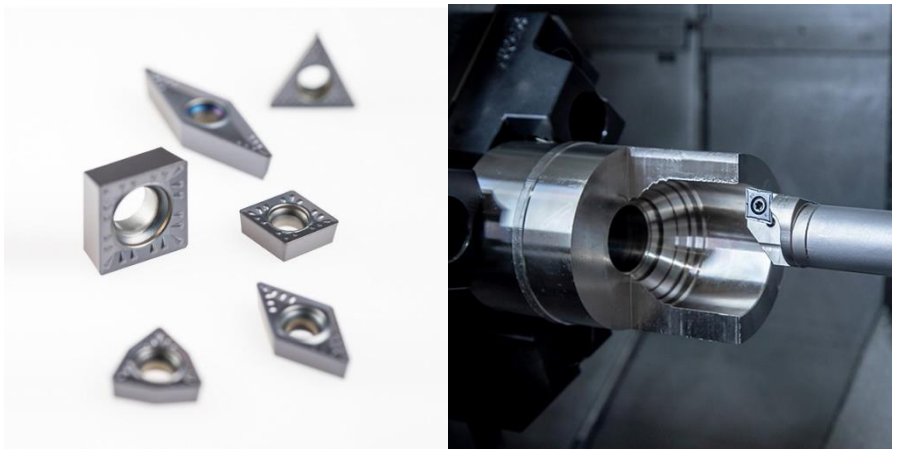
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Use case 3: Hard carbide parts

- Carbide punches for tool insert production
- Extremely hard materials → very difficult to machine
- Current process chain:

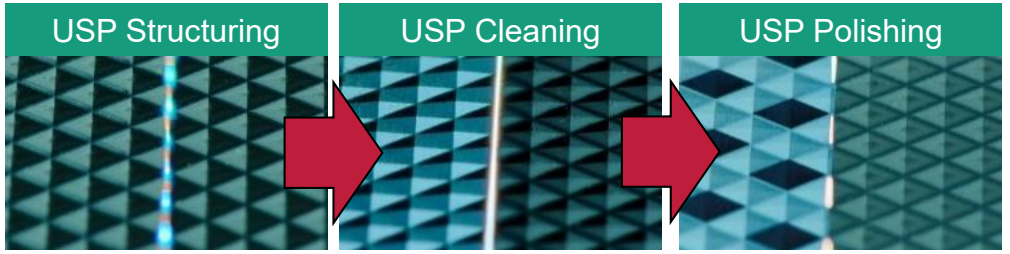


Punched tool inserts



- METAMORPHA targets:
  - Replacement by full laser-based process chain
  - Refurbishment of worn punches
- Impact
  - Reduction of process time from >10 h to <2 h
  - >85 % less energy consumption.

Ultrashort pulse (USP) laser process chain

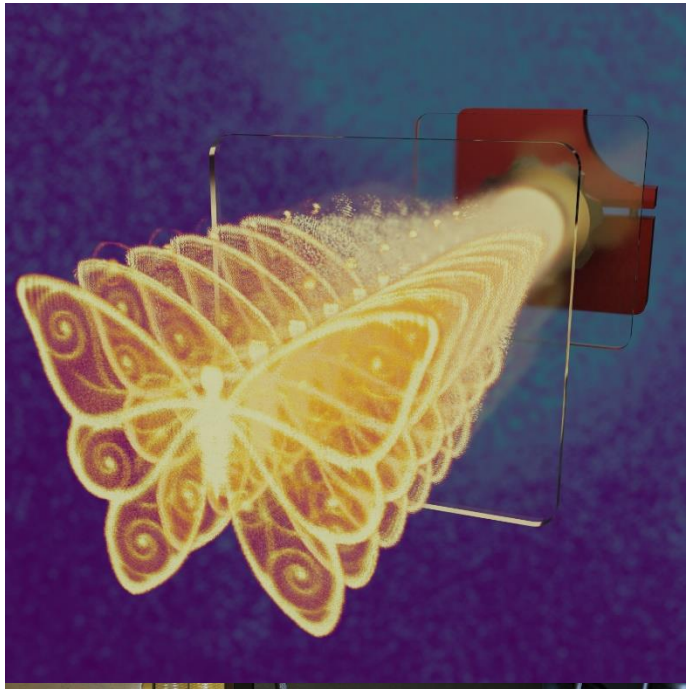


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Presentation outline

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Comparative analysis between current manufacturing processes vs METAMORPHA

Baseline scenario current manufacturing	METAMORPHA laser machining			
	Savings	Environmental benefits	Economic benefits	Social benefits
PHILIPS  Environmental performance • LCA Single-score: 5,7 µPt • Carbon footprint: 0,065 kg CO_2^{-eq} Economic performance: • Production cost: 0,28€ - 0,40€	Reduction • Waste (~100 %) • Energy (-15/60 %) • Time (-80 %)	• LCA Single-score 3,1 µPt **(-45 %)** • Carbon footprint 0,049 kg CO_2^{-eq} **(-25 %)** • Water Use **(-70 %)**	• New CAPEX **2M€** • OPEX savings **1,2M€ (-80 %)** (energy, waste, labour) • Production cost **0,4€ (similar cost)** • Calculated NPV 10yr **+8M€**	• S-LCA Single-score 1,16 Pt **(-35 %)** • Corruption 0,20 Pt **(-35 %)** • Occup Tox&Haz 0,15 Pt **(-34 %)** • Injuries & Fatal. 0,12 Pt **(-34 %)**
thyssenkrupp  Environmental performance • LCA Single-score: 1,96 mPt • Carbon footprint: 24,8 kg CO_2^{-eq} Economic performance • Production cost: 72€ - 96€	Reduction • Waste (~100 %) • Energy (-90/95 %) • Time (-70 %)	• LCA Single-score 0,18 mPt **(-90 %)** • Carbon footprint 1,3 kg CO_2^{-eq} **(-94 %)** • Fossil resource use **(-92 %)**	• New CAPEX **5.3M€** • OPEX savings **250k€ (-74 %)** (energy, waste, labour) • Production cost **95€ (-42 %)** • Calculated NPV 10yr **+8M€**	• S-LCA Single-score 25,4 Pt **(-98 %)** • Corruption 3,18 Pt **(-99 %)** • Occup Tox&Haz 4,29 Pt **(-98 %)** • Injuries & Fatal. 5,15 Pt **(-98 %)**
CERATIZIT GROUP  Environmental performance • LCA Single-score: 5,8 mPt • Carbon footprint: 13 kg CO_2^{-eq} Economic performance: • Production cost: 133€ - 156€	Reduction • Waste (~100 %) • Energy (-57 %) • Time (-90 %)	• LCA Single-score 2,1 mPt **(-64 %)** • Carbon footprint 6,8 kg CO_2^{-eq} **(-48 %)** • Freshwater ecotoxicity **(-80 %)**	• New CAPEX **1 M€** • OPEX savings **+900k€ (-84 %)** (energy, waste, labour) • Production cost **155€ (-70 %)** • Calculated NPV 10yr **+7M€**	• S-LCA Single-score 814 Pt **(-56 %)** • Corruption 132 Pt **(-58 %)** • Occup Tox&Haz 94,9 Pt **(-56 %)** • Injuries & Fatal. 85 Pt **(-59 %)**

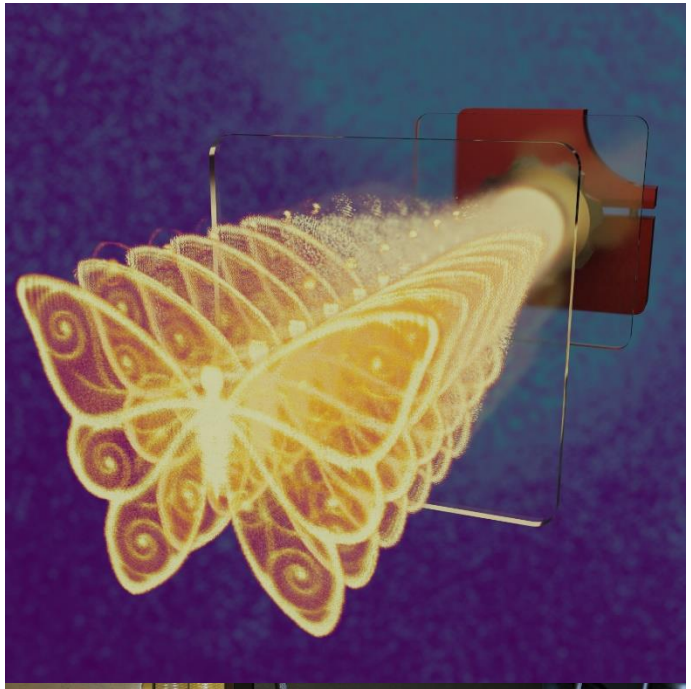
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LIMES Cluster

- Cluster of EU-funded projects working on sustainable laser manufacturing
- Established by METAMORPHA in 2022
- Objectives
  - Coordinate dissemination activities
  - Knowledge exchange between consortia
  - Combine efforts on common topics
  - Avoid duplication of work.

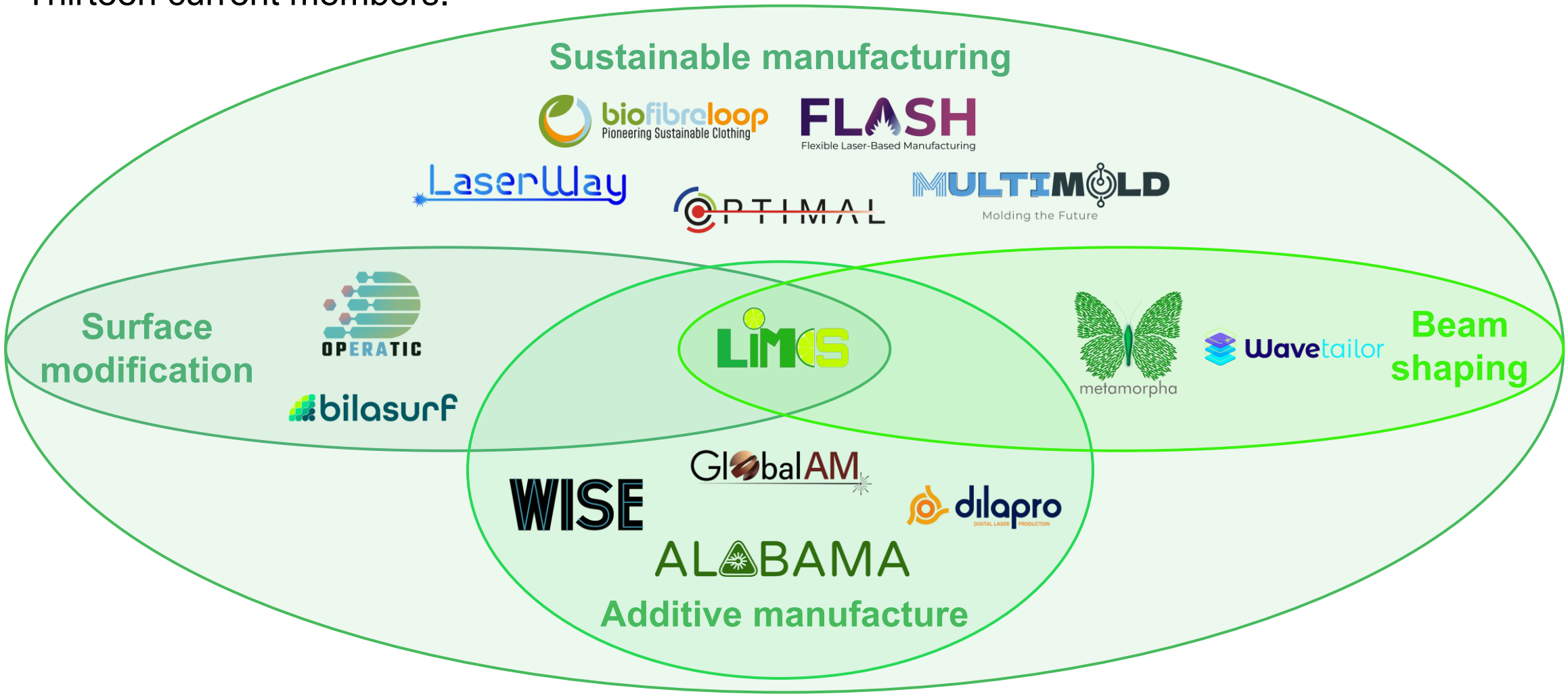
Laser-based Innovation for Manufacturing Excellence and Sustainability Cluster

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Current LIMES projects

- Broad interlinked topics on sustainable laser manufacturing
- Thirteen current members.



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Thank you for your attention!

https://metamorpha.eu

MEMBER OF LiMCS
LASER-BASED INNOVATION FOR MANUFACTURING EXCELLENCE AND SUSTAINABILITY CLUSTER

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https://www.linkedin.com/company/metamorpha

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