ULTRASHORT PULSED LASER PROCESSING AT 1 KILOWATT USING A FLEXIBLE MULTI BEAM APPROACH

Project Summary

PHOTONICS PUBLIC PRIVATE PARTNERSHIP

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 825201.

The MultiFlex Project

OBJECTIVE:

High Speed Ultrashort Pulsed Laser Processing Using Kilowatt Laser Power and Individually Modulated Multi-Beams

-Making Ultrafast Lasers Faster-

*Why **ultrashort** pulses?*

*Why **kilowatt** average power?*

*Why individually modulated **Multi-Beams**?*

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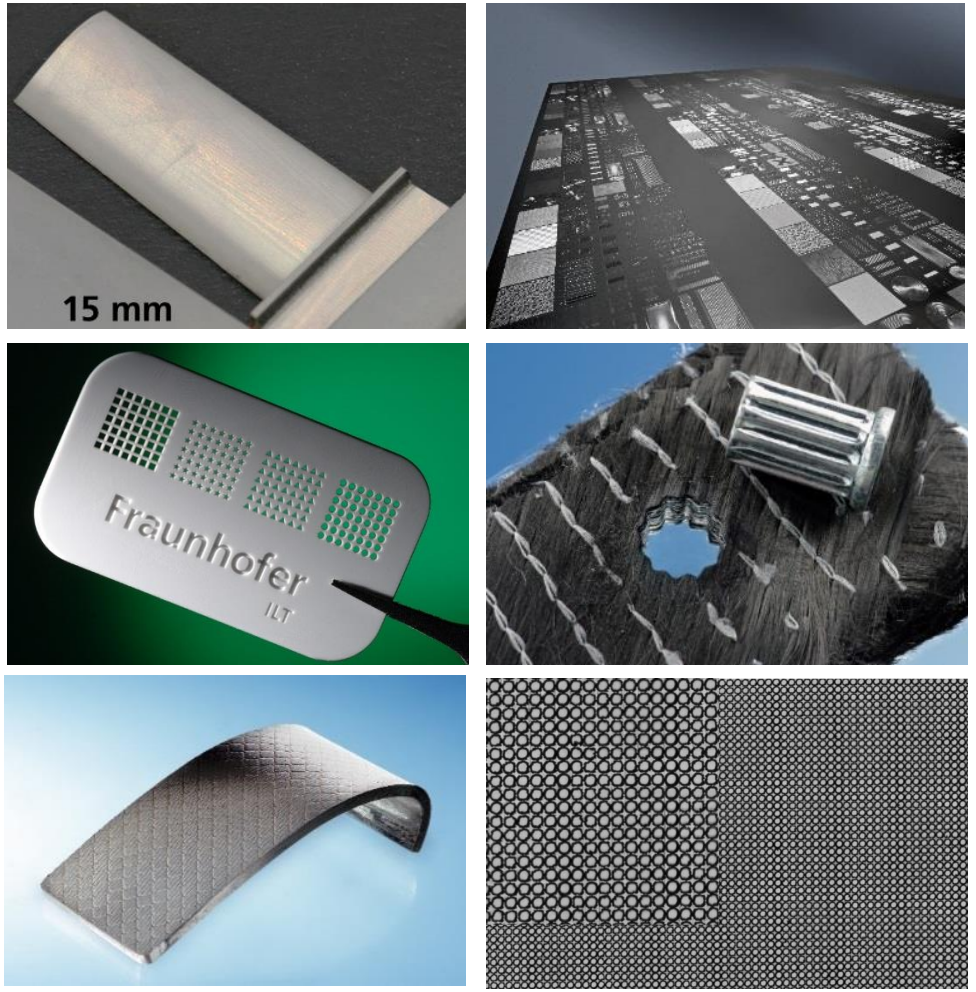
Why ultrashort pulses?

- Pulse duration < 10 ps
- Negligible thermal load
- Highly precise
- Nearly all kind of materials
- Non-contact processing
- Wear-free tool
- Truly digital process
- No use of environmentally harmful chemicals



Source: ILT

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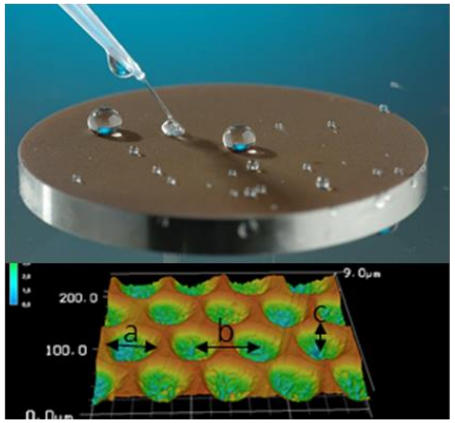
Applications of ultrafast laser processing

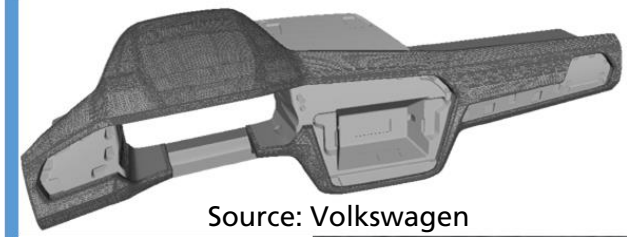
Structuring of functional surfaces



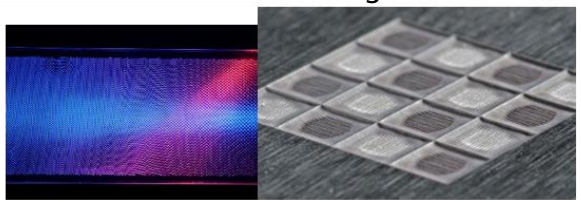
Source: ILT

- Self cleaning surfaces
- Friction reduction
- Anti-Icing
- Antibacterial surfaces
- Absorption enhancement

Structuring of molds and tools



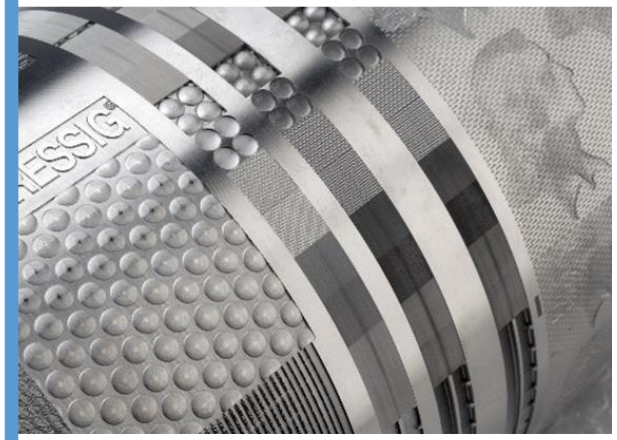
Source: Volkswagen



Source: ILT

- Design structures
- Haptic
- Illumination light guides
- Micro cavities

Structuring for embossing and printing applications



Source: ILT

- Printed electronics
- Security features
- Micro embossing
- Printing

Focus of MultiFlex

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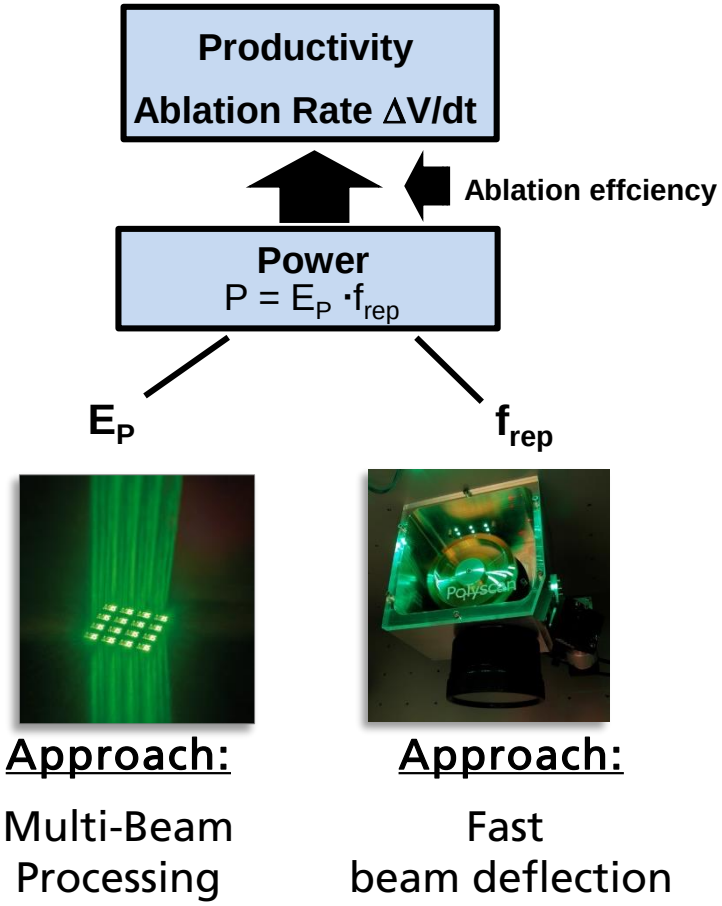
Why kilowatt average power?



- Typically ablation rates some mm³/min for ultrafast laser processing
- Quality excellent but productivity much too small for many industrial applications
- Productivity determined by average power

→ Power-scaling to the kW-range

- $P = E_P \cdot f_{rep}$
  - Scaling by pulse energy
  - Scaling by repetition rate

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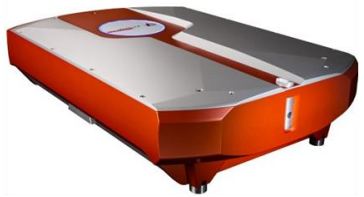
Why individually modulated Multi-Beams?

- Multi-Beam approach unlimited scalability in principle
- Restricted by field distortions
- Only periodic structures

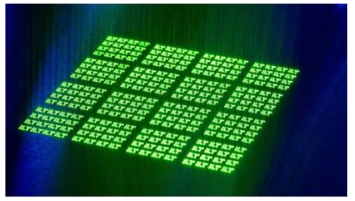
→ **Overcoming the restrictions by flexible multi beam approach**

Kilowatt USP Laser

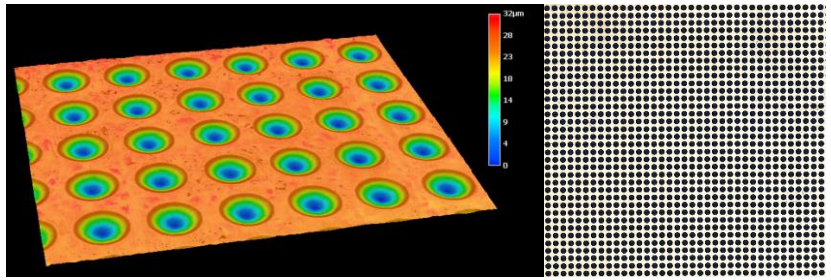


Source: Amplitude

Individually modulated multi-beam array

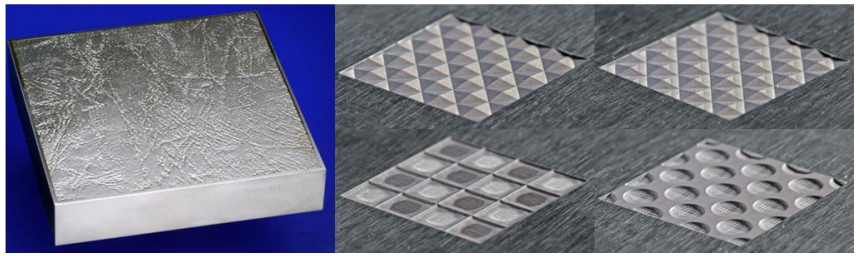


Source: ILT



Source: ILT

Arbitrary surface Structures with high throughput



Source: ILT

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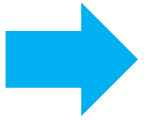
Why individually modulated Multi-Beams? Comparing Scaling Strategies

APPROACH:	FAST BEAM DEFLECTION	MULTI-BEAM-OPTIC
Repetition Rates:	High	Moderate
Pulse Energies:	low	High
Duty Cycle:	Low, dependent on Structure	High
Toolpaths:	Lines, One Direction	Arbitrary
5-Axis-Processing:	No	Restricted
Accuracy	High (with corrections)	Limited by field distortions
Possible structure types	Arbitrary structures	Periodic structures
Scalability	Limited by Oscillator Frequency (combination with multi beam needed for further upscaling)	Limited by optical system



Development of Multi-Beam-Structuring for 1 kW average power and arbitrary, non-periodic structures with high accuracy

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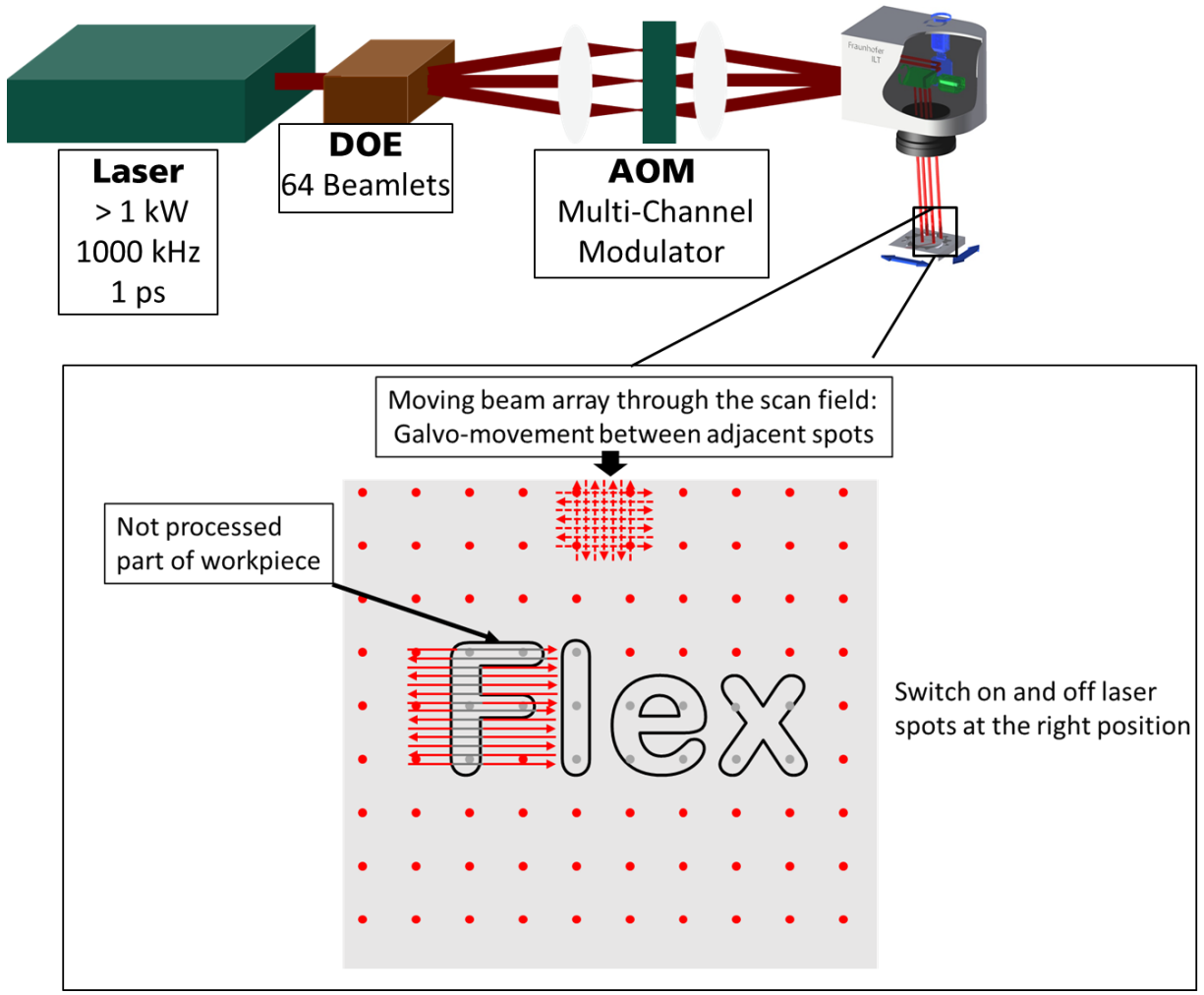
Concept and Idea: The “Laser Matrix Printer”

- FPGA-based control scheme
- Large spot distance (~5mm) to avoid thermal interactions
- Femtoseconds for high throughput, high quality and high reproducibility
- Pulse Bursts for increased surface quality
- Scan field correction for each beamlet
- Encoder-based control scheme/arbitrary scanning
- Use of pulse on demand/free-trigger



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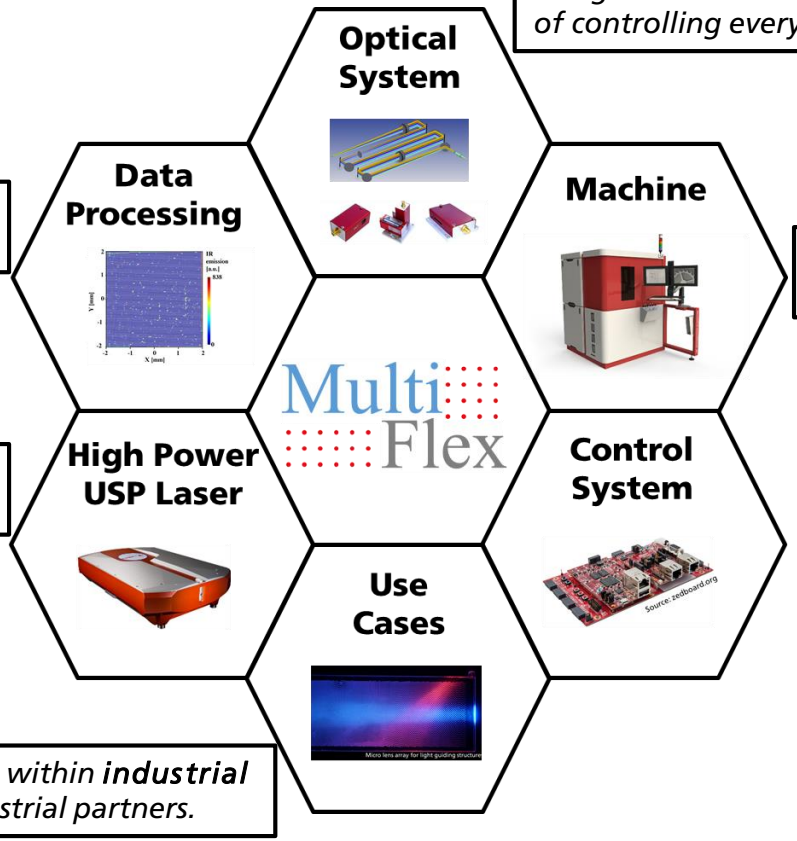
MultiFlex: The Project

*Design and realization of a **Multi-Beam-Optics** capable of controlling every single beamlet using **multi channel AOMs**.*

*Integrating a **data acquisition** and processing system to **monitor** optical system and process.*

*Developing an **ultrafast laser** with more than **1 kW** average power, **burst** capability and **free triggering**.*

***Validating** the developed solution within **industrial use cases** given by associated industrial partners.*



*Demonstrator machine to **integrate** all developed components and validate the developed technologies.*

*Developing an **FPGA-based** control system to control every single beamlet and **correcting field distortions** with highest precision.*

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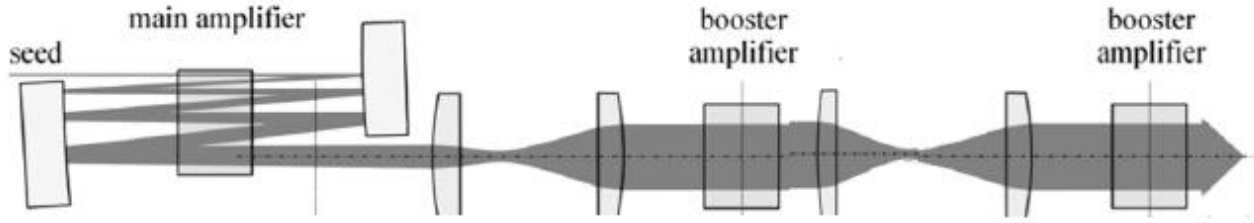
MultiFlex: Laser source

- Average power > 1 kW (1.3 kW)
- Pulse energy > 1 mJ
- Pulse Duration < 900 fs
- Variable pulse compression
- Pulse on demand
- Attenuator integrated
- Fiber seeder
- Output beam stabilisation
- 3 Stage Amplifier
  - Innoslab up to 400 W
  - 1st single pass booster up to 800 W
  - 2nd single pass booster up to 1.3 kW

Source: Amplitude



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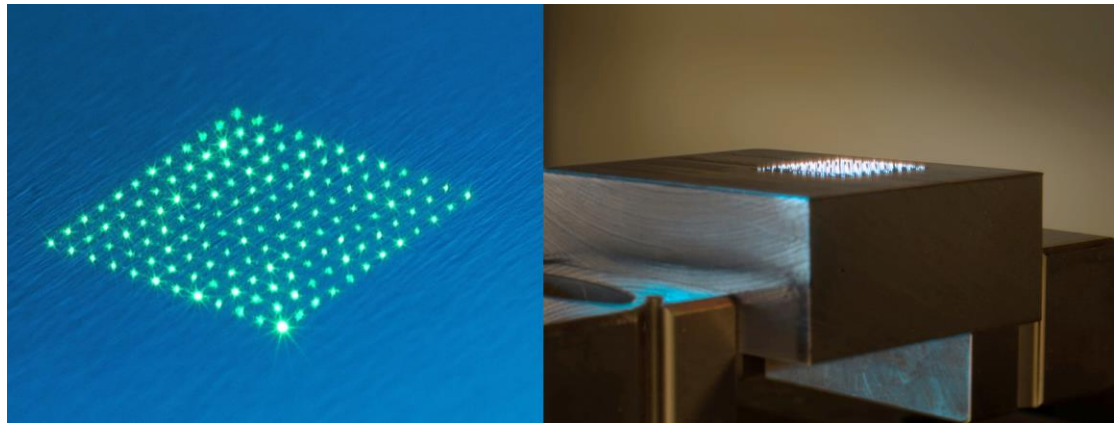
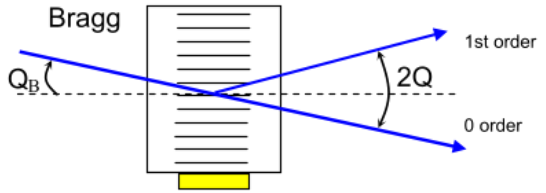
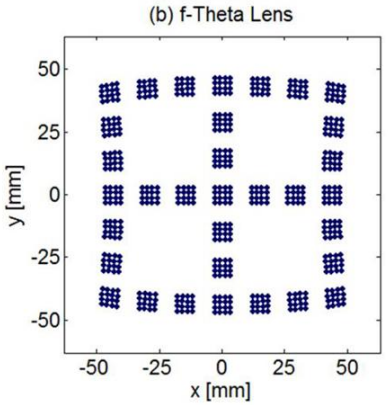
MultiFlex: Multi Beam Optics

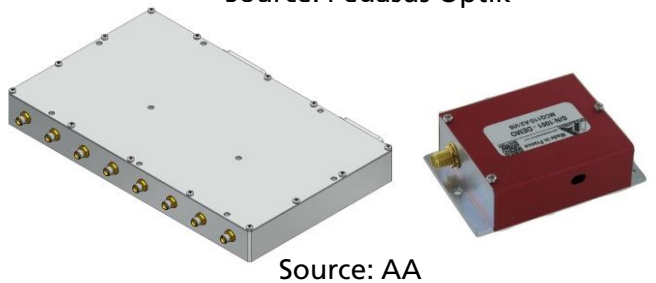
- Splitting high power laser beam into 64 beamlets
- Modulation of every single beam by acousto-optic modulator
- Use of 8 multi-channel modulators (8 channel each)
- 30 mm x 32 mm beam array
- Focus diameter < 30 µm
- Measuring and homogenization of intensity of beams within array
- Measuring spot accuracy for compensating distortions within control system





Source: Pegasus Optik





Source: AA

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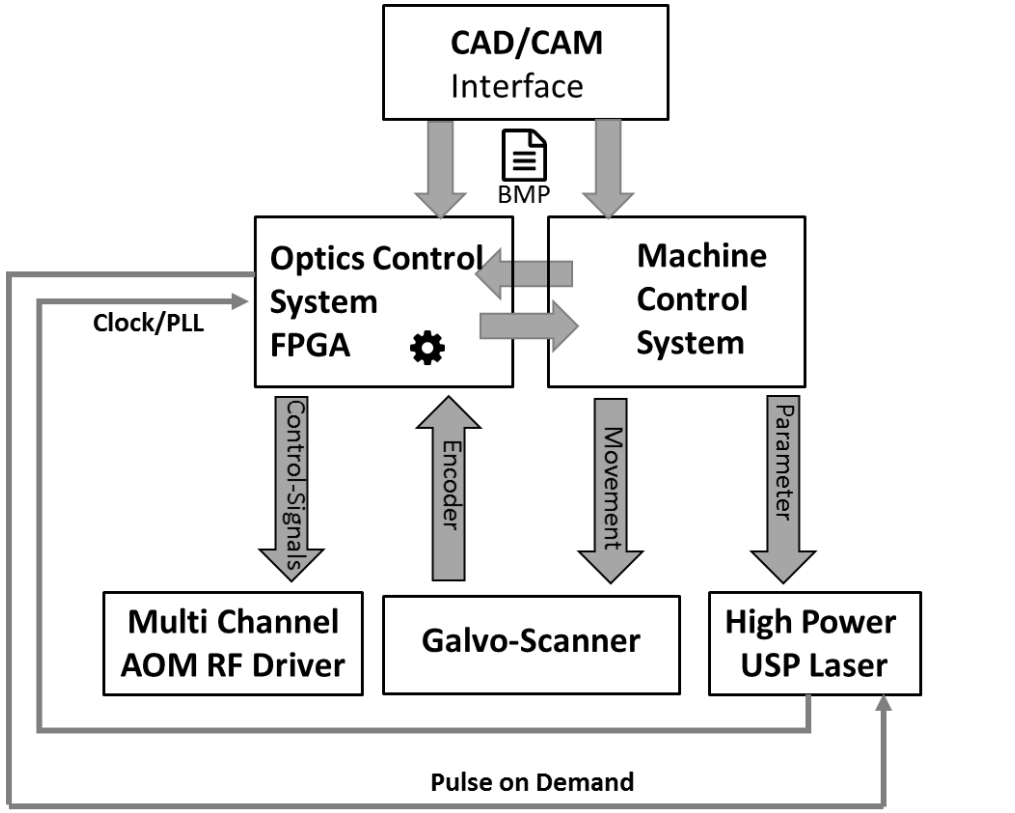
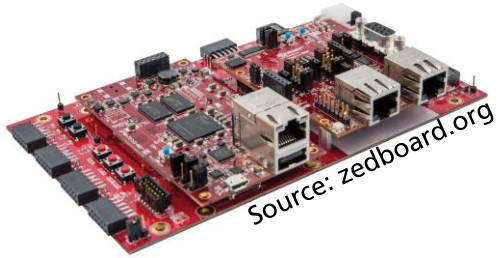
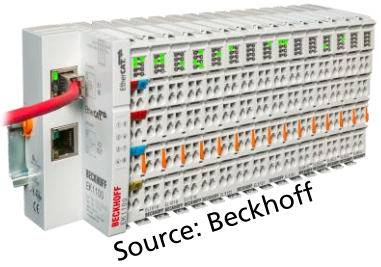
MultiFlex: Control system

- FPGA based control scheme
  - Sniffing and interpolating galvo positions
  - Control of single pulses with laser oscillator frequency (~50 MHz)
  - Control of each 64 modulators
- Pulse on demand
  - Efficient use of laser power
  - Distance based pulse triggering







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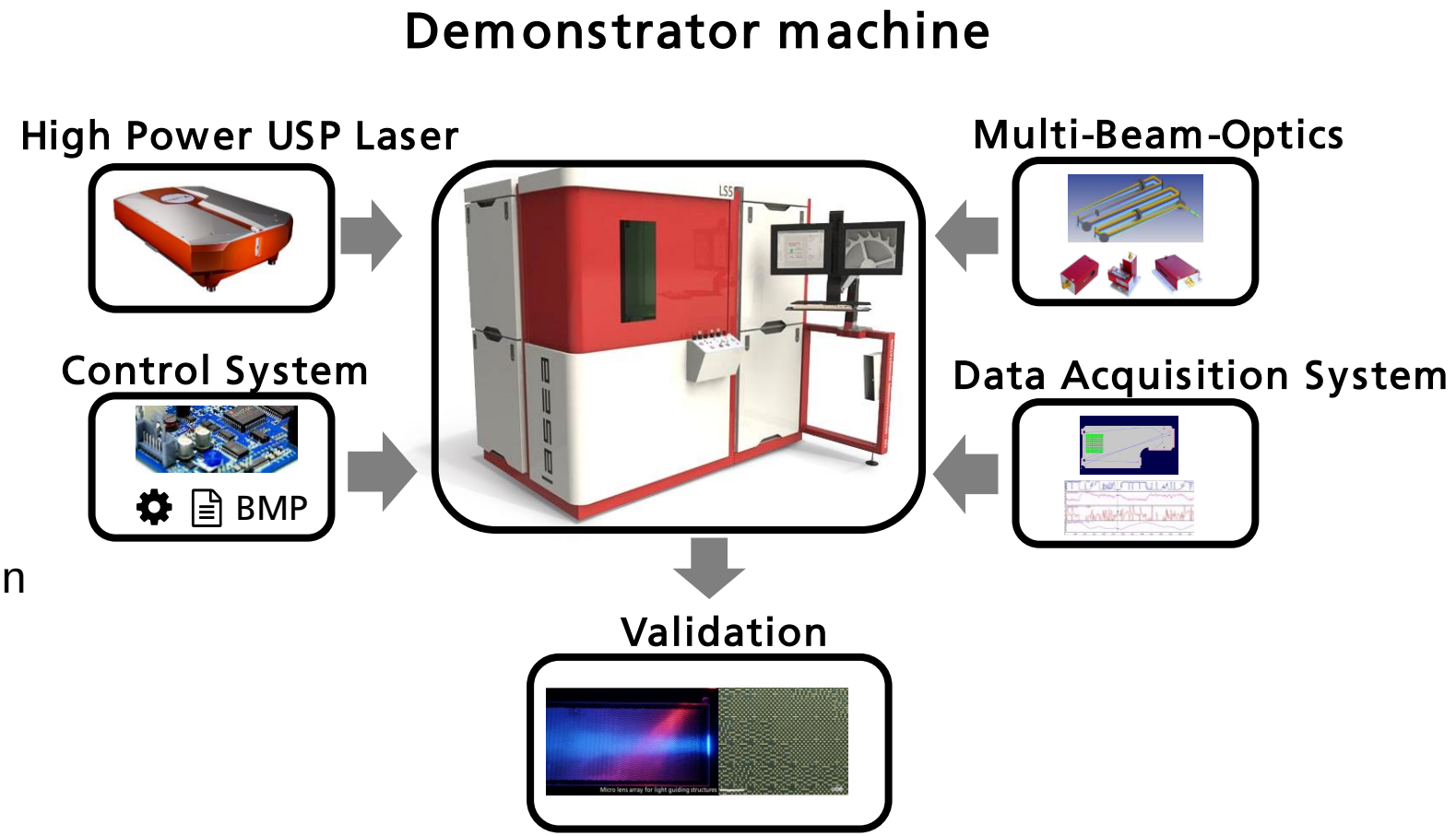
MultiFlex: Demonstrator Machine

Machine Tool

- Industrial-grade machine tool
- Integration of all developed components
- Integration of sensors
- 3-Axis handling System
- Geometry sensor
- Platform for validating use-cases in industrial-like environment



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MultiFlex: Use Cases

Light guiding by micro injection molded tool inserts

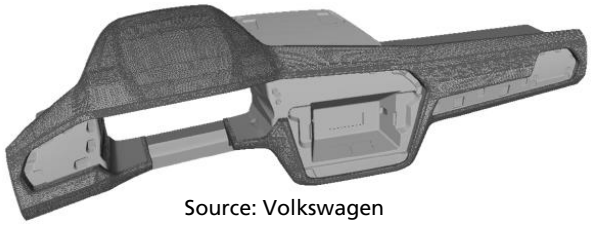
- Fabrication microstructures on tool insert with especially designed distribution and geometry
- Molded PMMA part acts as light guide for illumination
- Backlight for instrument clusters
- Lighting for interior like illuminated scuff plates

Source: Skoda

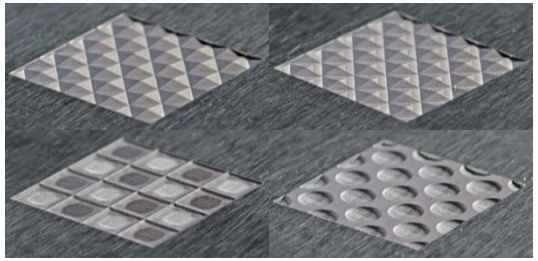
Source: Mercedes-Benz

Design structures for injection molding tools

- Fabrication of sophisticated distributed microstructures on tool insert
- Molded PMMA part acts as light guide for illumination
- Backlight for instrument clusters
- Lighting for interior like illuminated scuff plates



Source: Volkswagen



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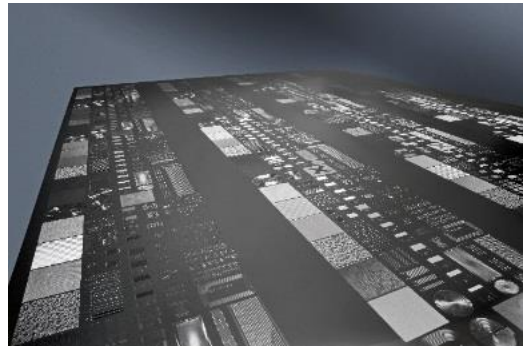
MultiFlex: Changing Ultrafast Laser Processing

- Productivity increase up to factor 100
- 10 times higher laser power
- 20 times faster control system
- New dimension of flexibility for Multi-beam processing
- New, large area applications possible
- Highest degree of freedom – pixel by pixel ablation
- Efficient use of available laser power
- Replacing environmental problematic technologies



Source: Airbus

Source: Winbro Group

Source: phereclus

Source: ILT

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The Consortium

- Optics design
- Thermo-optics

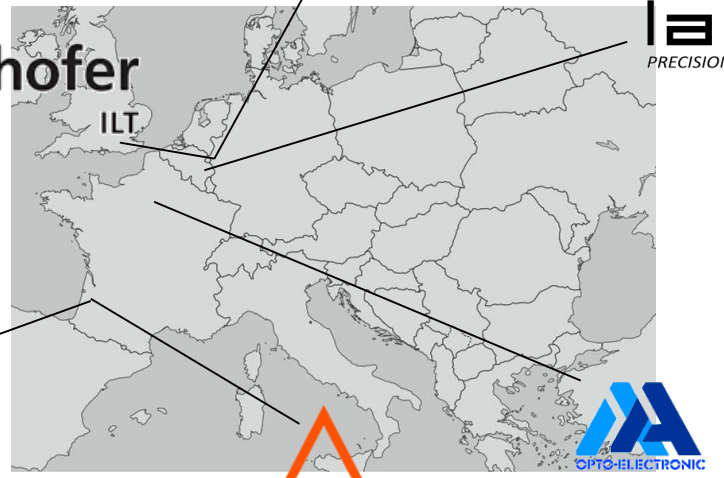
- Coordination
- Control system
- Data acquisition and processing
- Optics prototype
- Application / Validation

TOS Lehrstuhl für Technologie Optischer Systeme

Fraunhofer ILT

lasea PRECISION LASER SOLUTIONS

- Machine tool
- Control of Galvo and axis
- Integration of components
- Application



lasea ADVANCED OPTICAL SYSTEMS

OPTO-ELECTRONIC

Amplitude

- Design
- Optics assembly
- Integration

- AOMs
- Driver

- High Power USP Laser
- > 1 kW
- < 1 ps
- Burst
- Pulse-on-demand

Associated industry partners

Continental

Volkswagen

Procter & Gamble

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Where to find us?

- Webpage: www.multiflex-project.eu
- Twitter: @MultiFlex_EU
- LinkedIn: MultiFlex / Group

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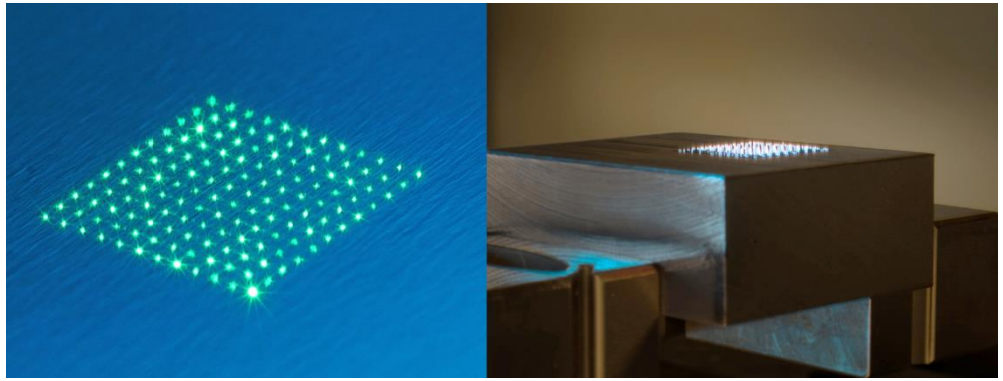

Source: ILT

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