

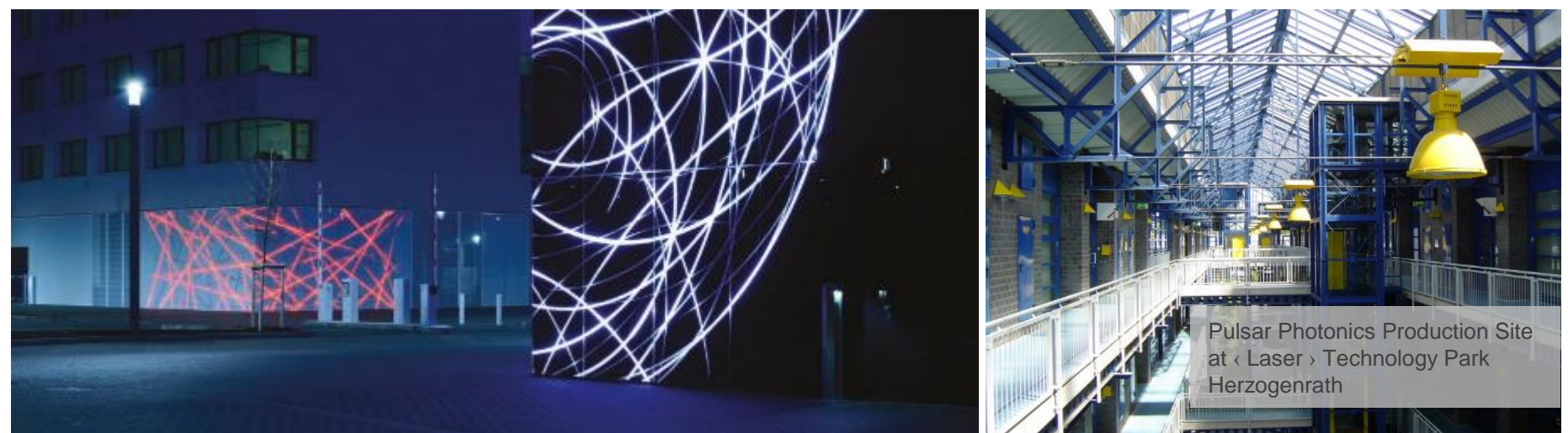
# Increasing laser processing efficiency with ultrashort pulsed lasers using a **Multi Beam Scanner**

Pulsar Photonics GmbH

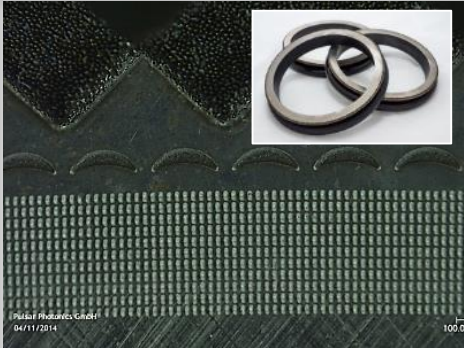
Ultrafast Laser Processing Forum, KIMM Daejeon  
September 16th 2015 – CEO Joachim Ryll

# About *Who we are and what we do*

- Strong focus on industrial ready systems
- Combining Process & System Technologies for (USP) Laser micro machining
- Foundation in 2013 – spin-off of the Fraunhofer ILT in Aachen
- Managed by 3 PhD engineers

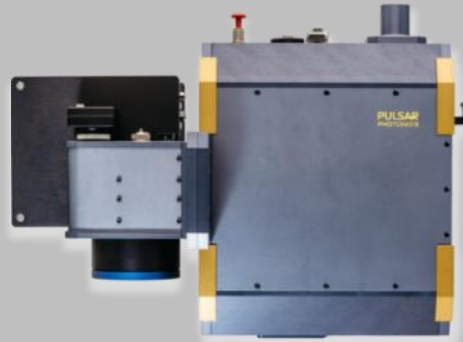


## applications



- feasibility studies
- process development
- job-shop

## tooling



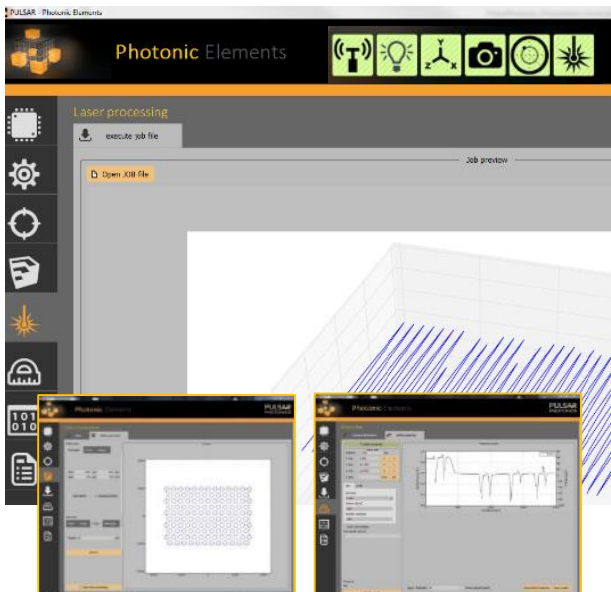
- conceptual design
- metrologies
- processing heads

## systems



- machine concepts
- automation
- lean systems

- Lightweight to heavy systems
- CAD / CAM processing
- 2D-Scanning Processes
- ns-fs laser sources



- Components between laser source and work pc
- Processing heads
- Work pc inspection
- Laser beam control
- software tools, e.g. machine conditioning



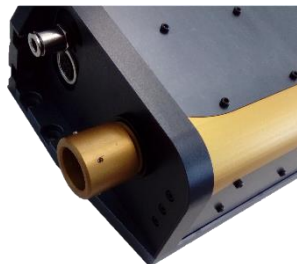
Multi Beam Scanner  
**MBS G3**



Scanning Platform  
**P2 plus**



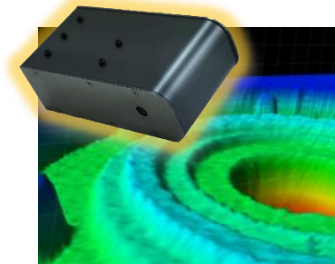
Camera Module  
**CM-R1**



motorized Zoom  
**ZM-R1**



Sensor Grid  
**SM-40**



Topography Measure  
**TM-R1**

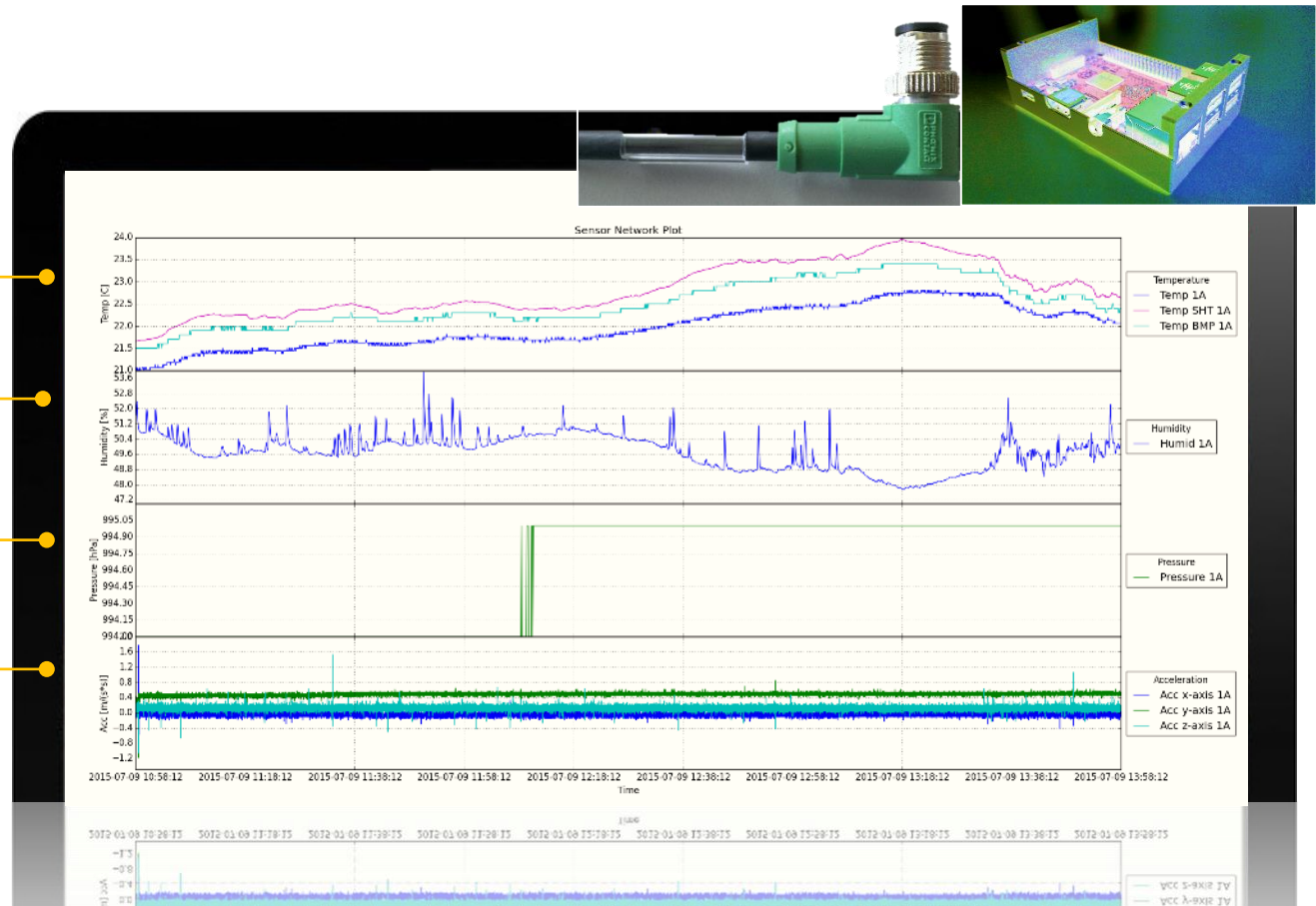
- time-coordinated matching of machine, laser and sensor data
- clear process data review
- benefits by advanced quality inspection routines and cost control

temperature

humidity

pressure

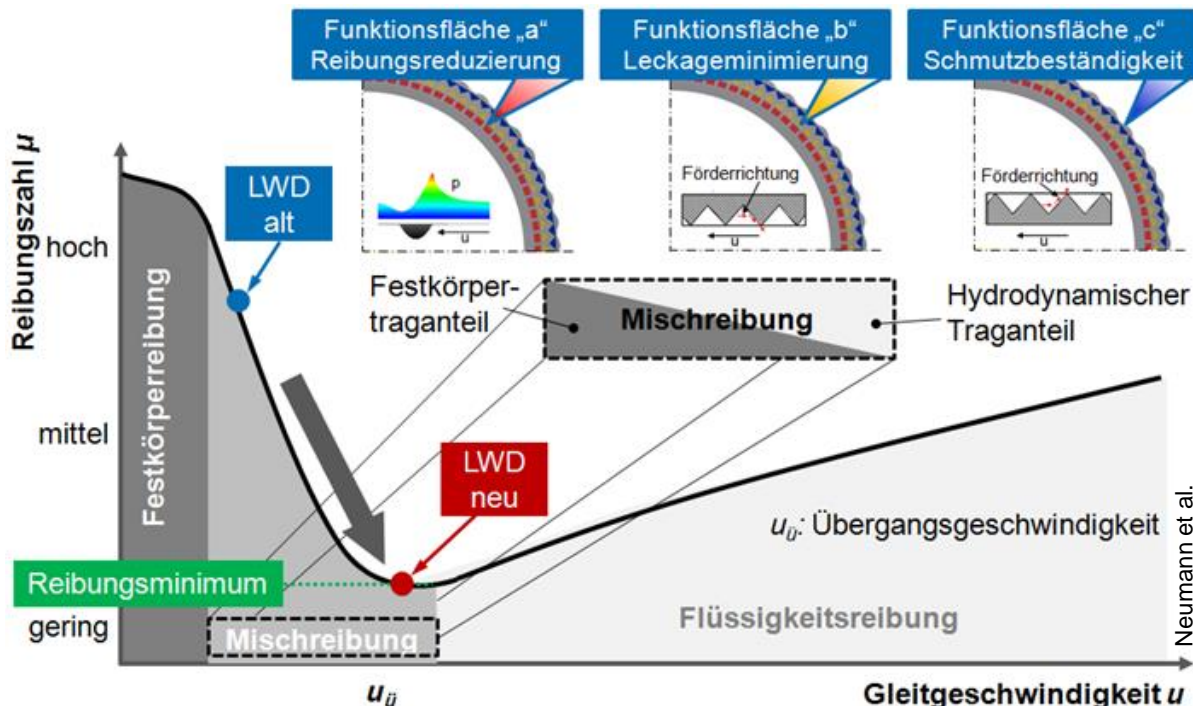
jerk



# Applications

## Mechanical face seals / Laufwerk dichtungen

- Friction Reduction by laser micro structuring
- High-speed operation
- Increase in leakage not allowed



# Applications

*Mechanical face seals / Laufwerkdichtungen*



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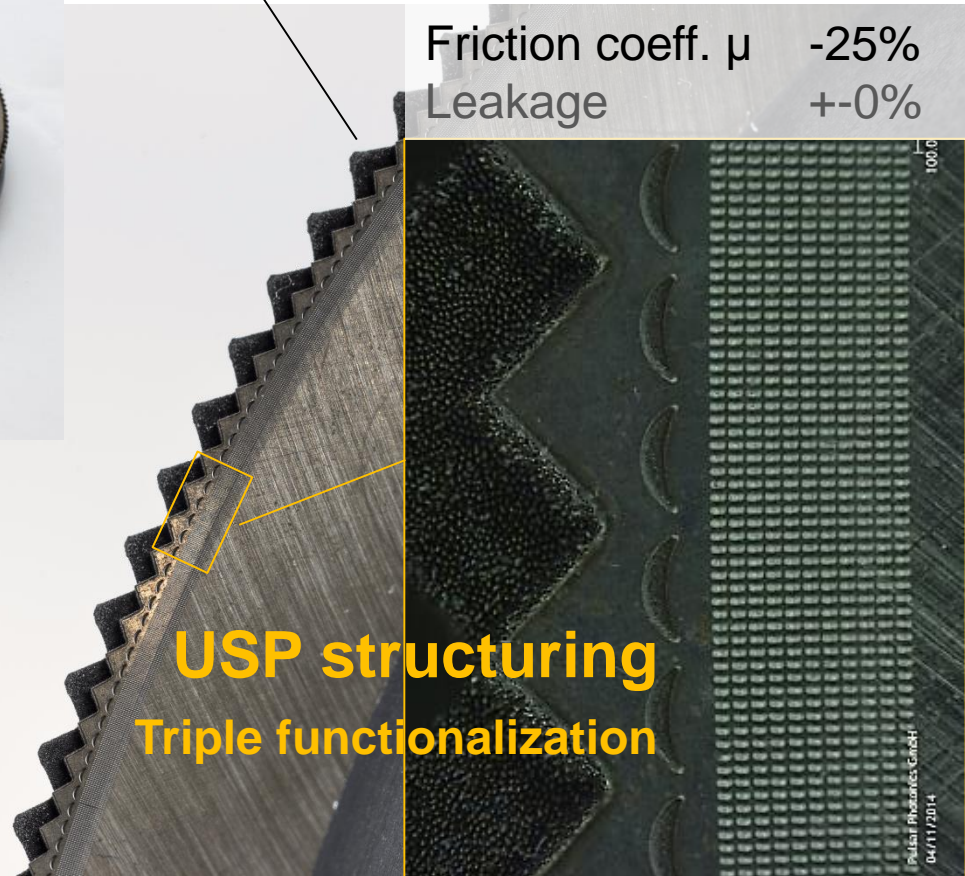


Macro structure  
eroded

Sliding and sealing surface  
lapped

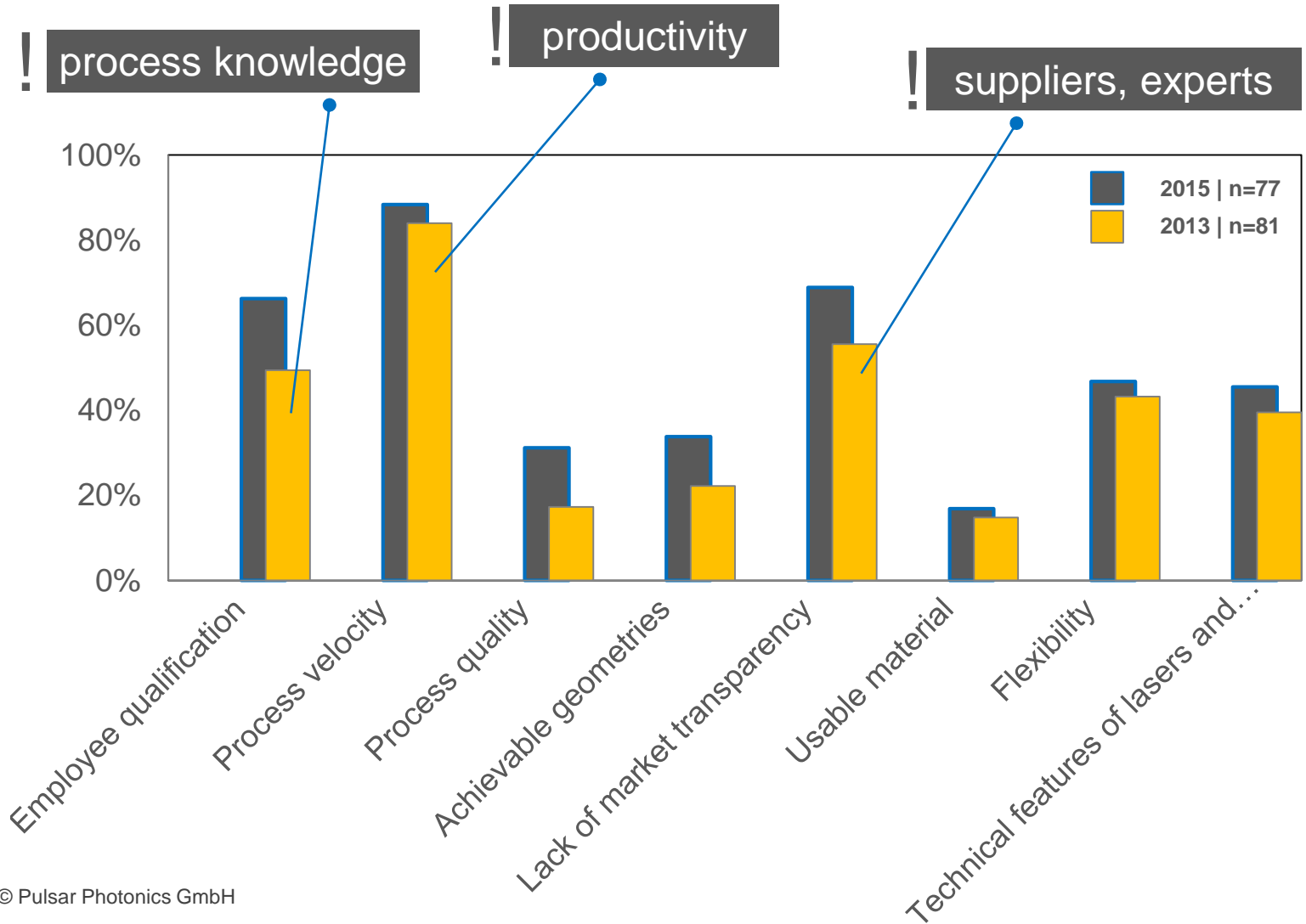
Secondary sealing element  
NBR-Rubber

Friction coeff.  $\mu$  -25%  
Leakage +-0%



**USP structuring**  
**Triple functionalization**

Pulsar Photonics GmbH  
04/11/2014



Survey among ultrafast laser experts during german ultra fast laser forum, Aachen 2013, 2015.

# Factors that limit increase in productivity

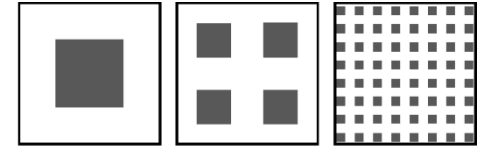
## Overview

USP Laser Source  
(50-500 W)



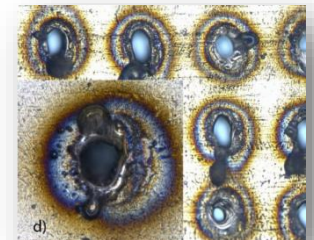
### Scanning System

- Scan efficiency



### Work piece

- Heat accumulation

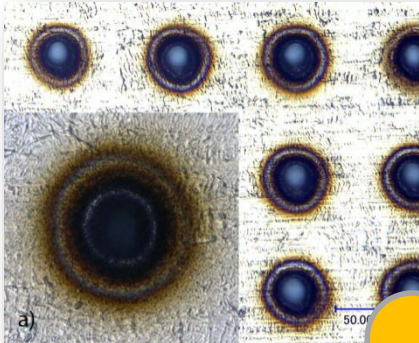


# Factors that limit increase in productivity

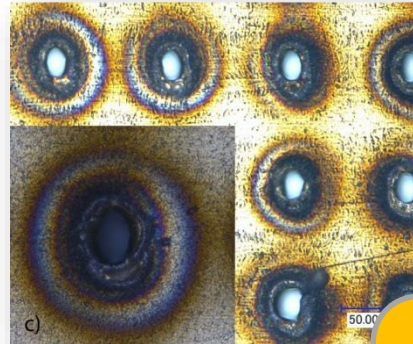
*Heat accumulation in the work piece*

- ⇒ Energy input per volume and time is limited!
- ⇒ Inefficient usage of your laser systems power potential (50-500 W)

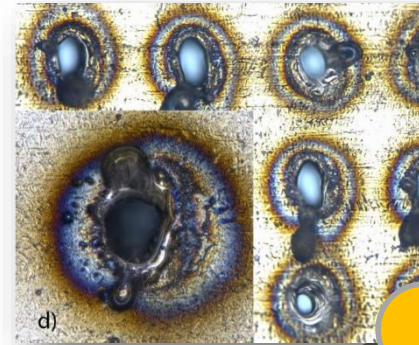
USP Laser, Point & Shoot,  
Steel foil, 1030 nm, 6ps,  
800 kHz



2W

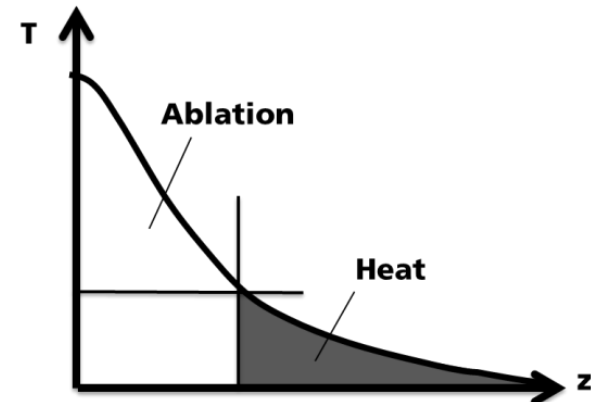


7W



10W

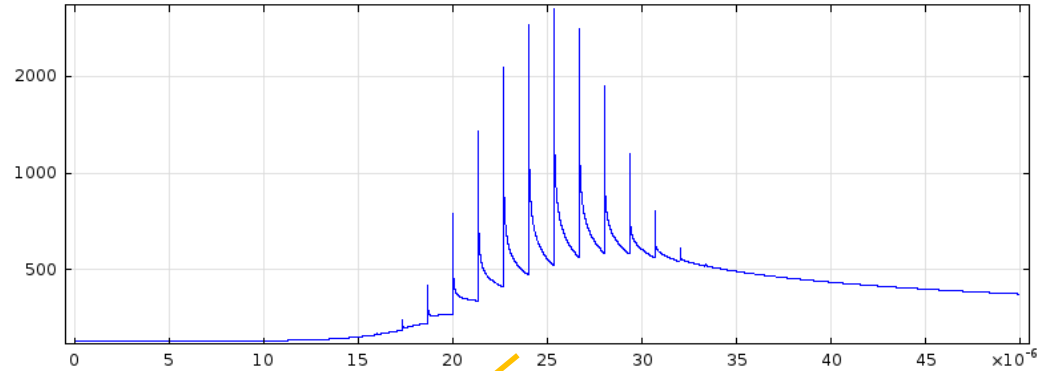
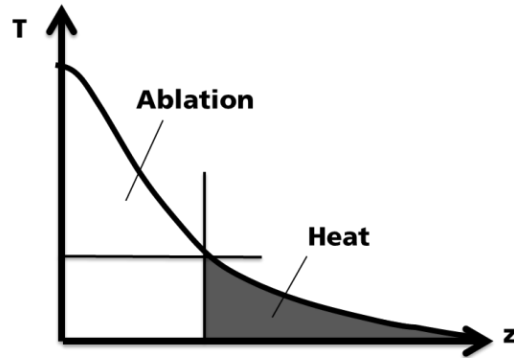
Laser power



# Factors that limit increase in productivity

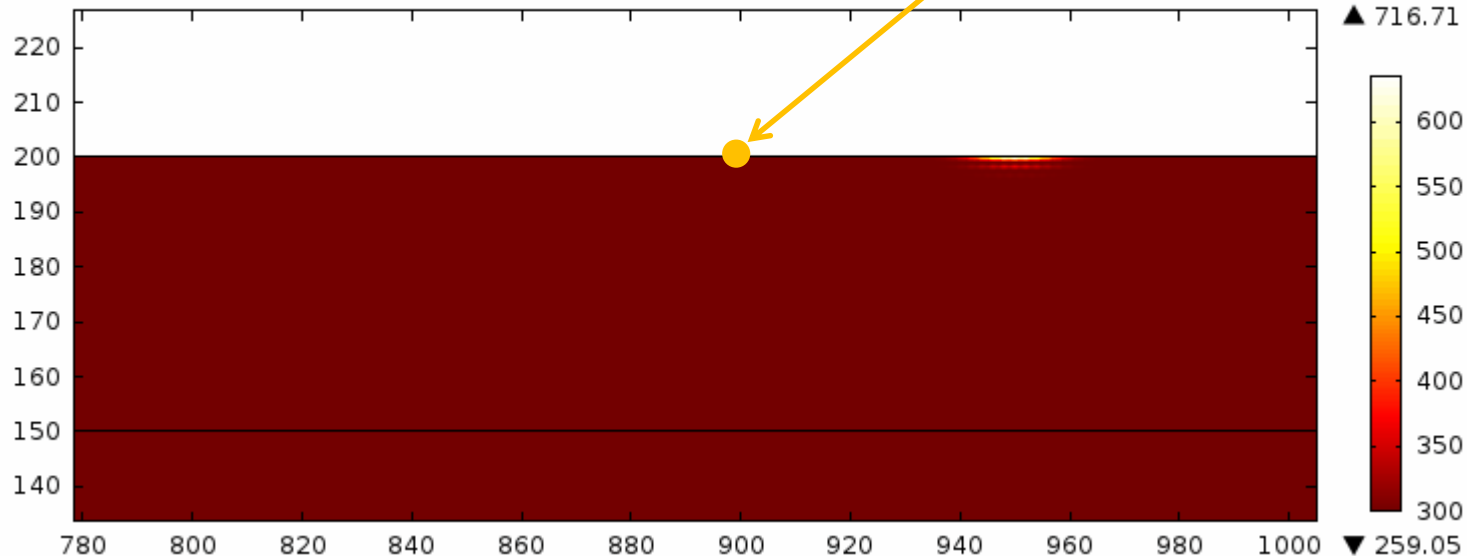
*Heat accumulation in the work piece*

COMSOL  
MULTIPHYSICS



Time=0 Surface: Temperature (K)

COMSOL  
MULTIPHYSICS



# Efficiency *Choosing the right scanning system*

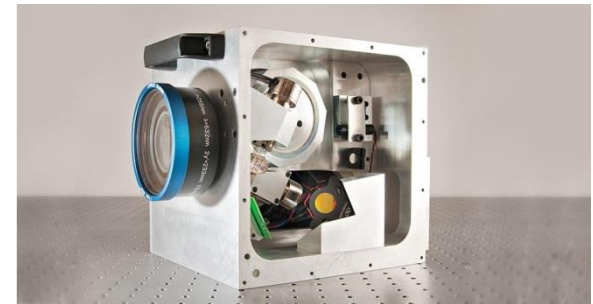
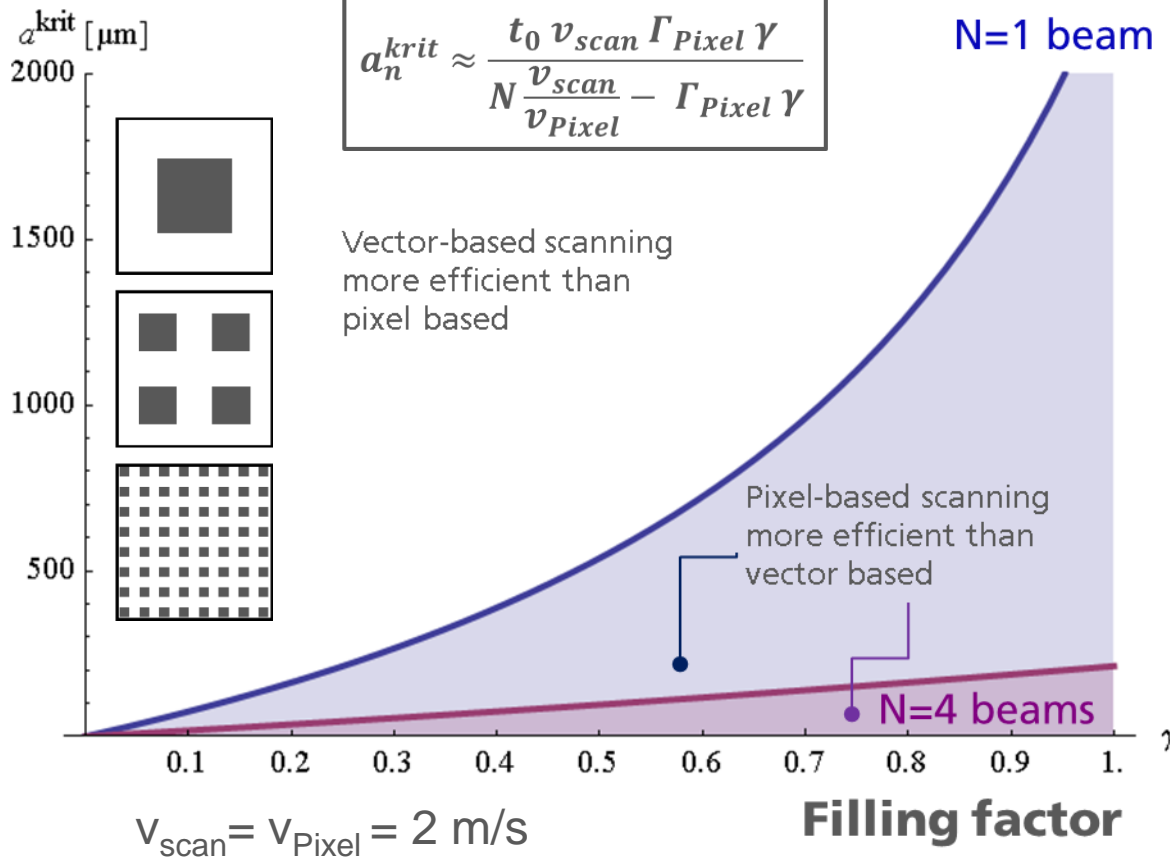
## Critical scan-length

(Minimal vector length for that the scanning time for vector based scanning is shorter than for pixel based scanning)

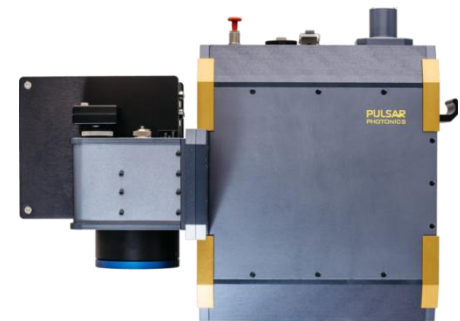
$$a_n^{krit} \approx \frac{t_0 v_{scan} \Gamma_{Pixel} \gamma}{N \frac{v_{scan}}{v_{Pixel}} - \Gamma_{Pixel} \gamma}$$

Vector-based scanning more efficient than pixel based

Pixel-based scanning more efficient than vector based



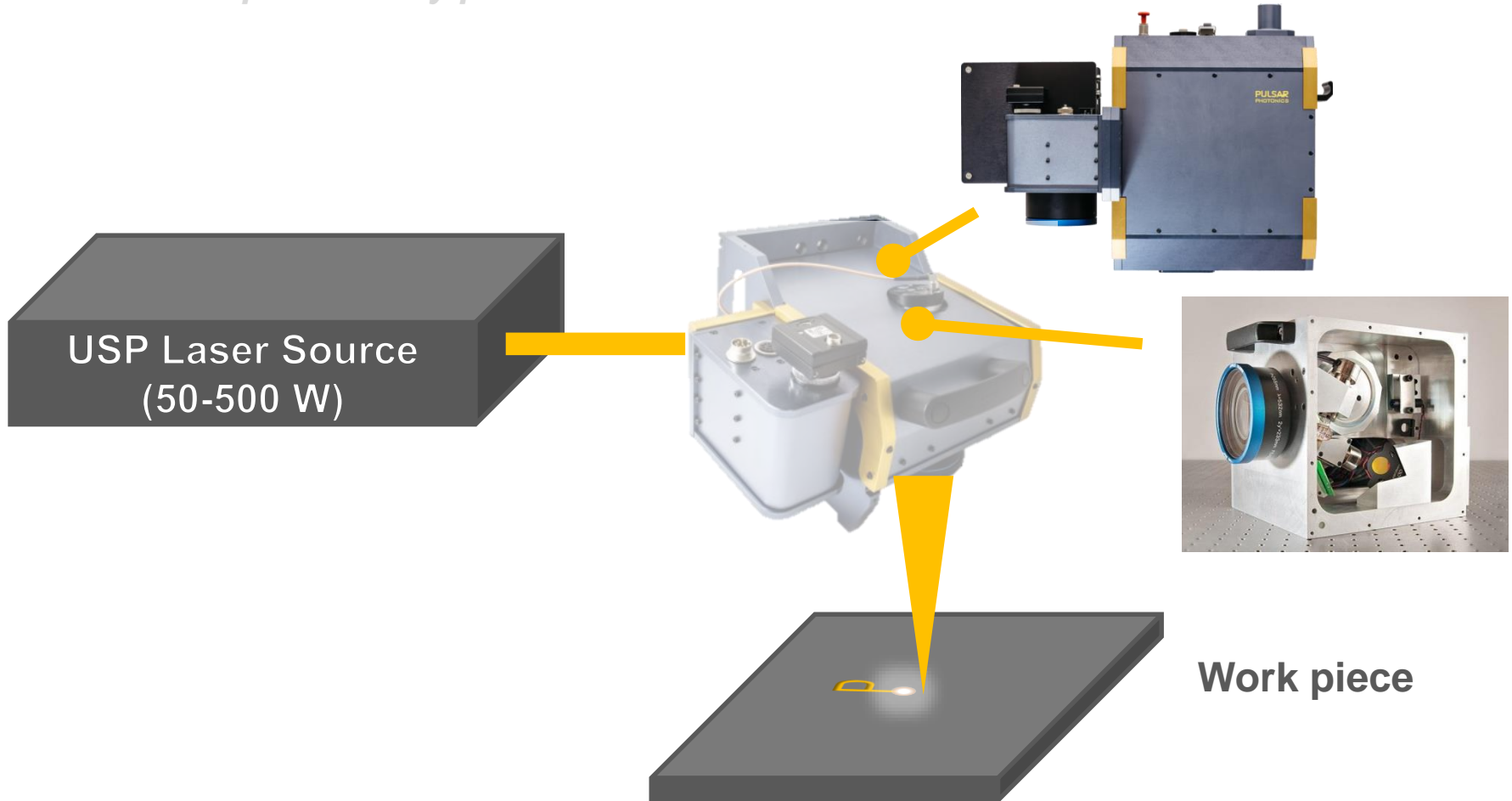
Source: Lincolnlaser



# Factors that limit increase in productivity

*Solution to productivity problem*

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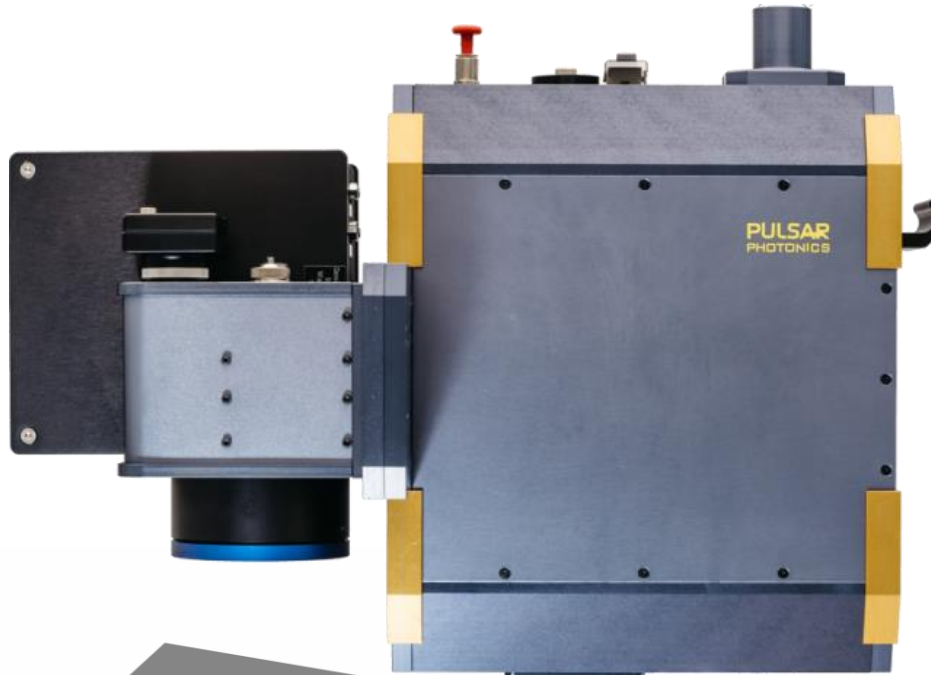
## Thermal management

realized by adapted and efficient scanning systems is key to high productivity USP processing

# Multi Beam Scanner

*parallel processing by beam splitting*

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PHOTONICS



- Max. 100 W
- Beam Diameter: 3-6 mm
- 523 nm / 1064 nm
- Beam splitter  
(free design of DOE)
- 22 kg (scanner included)
- Allignment control
- Ini-software tools

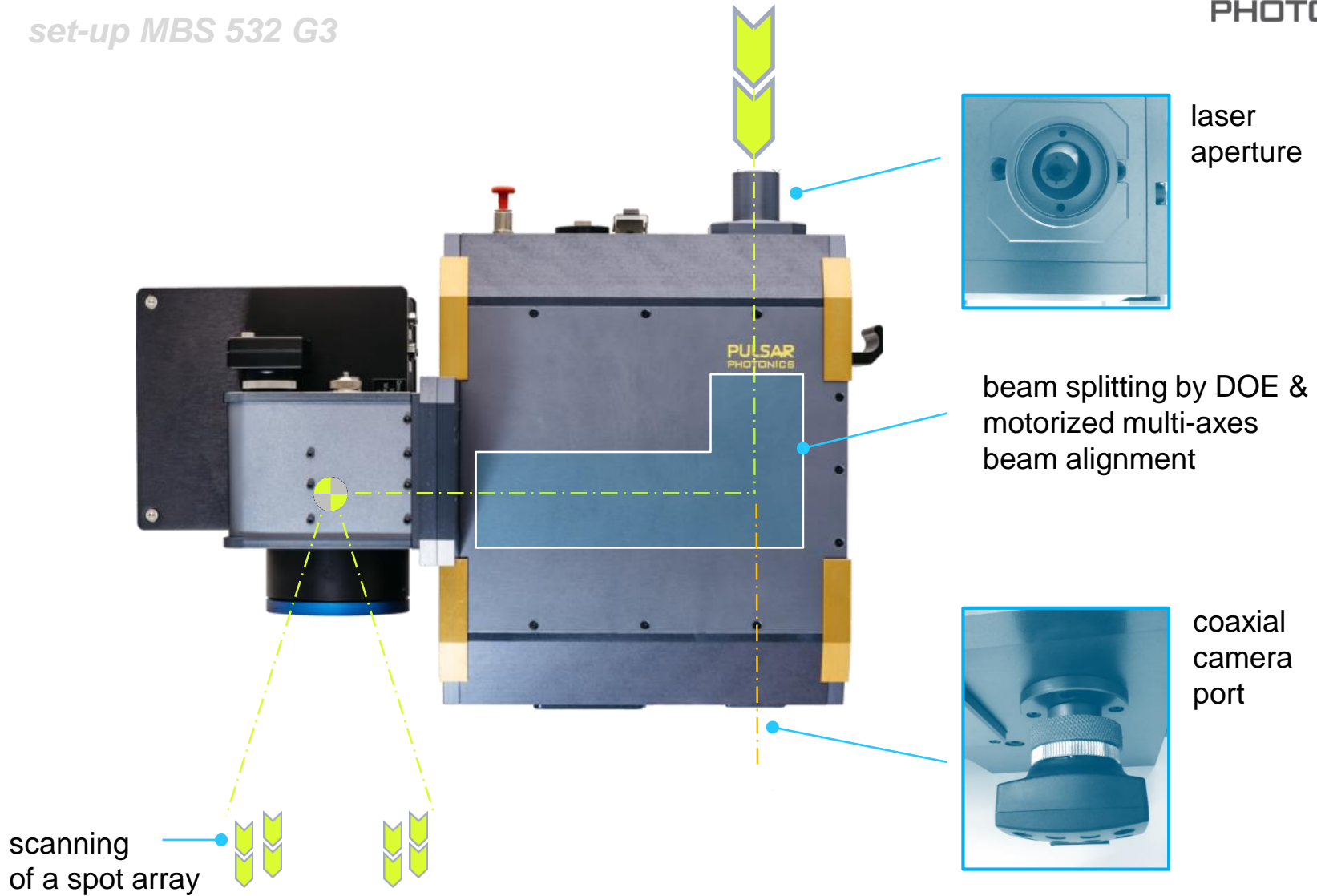
Youtube Video:

<https://www.youtube.com/watch?v=Q7JLcfmZICY>

# Multi Beam Scanner

set-up MBS 532 G3

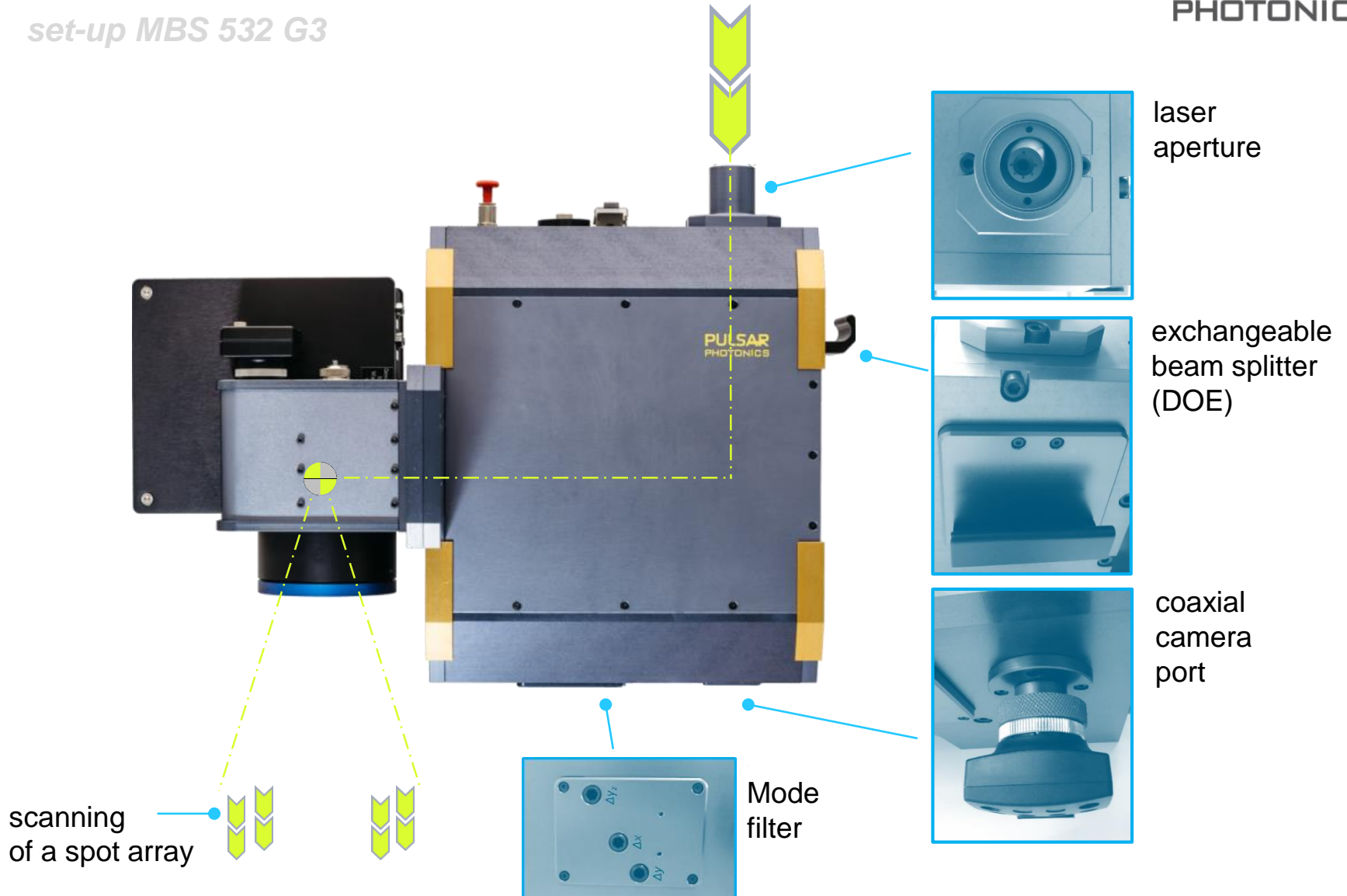
**PULSAR**  
PHOTONICS



# Multi Beam Scanner

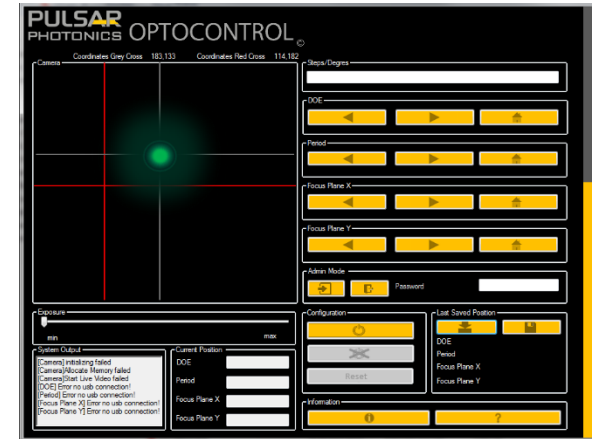
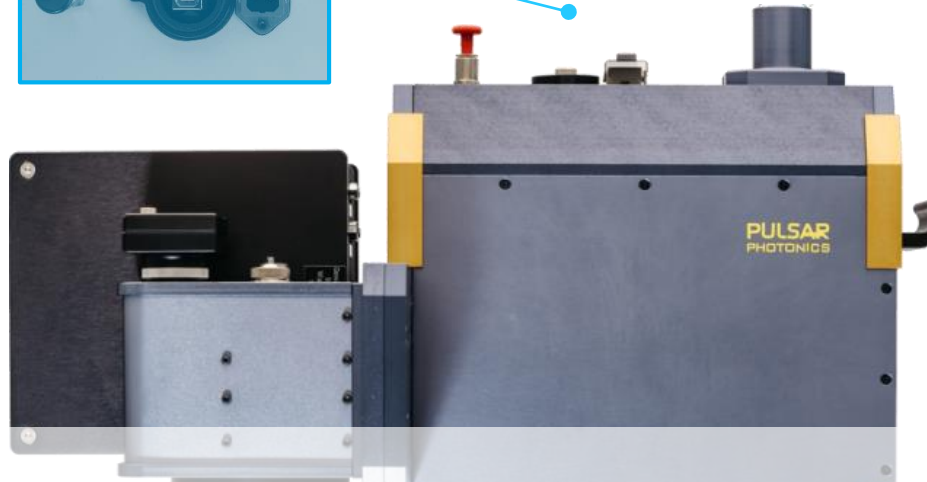
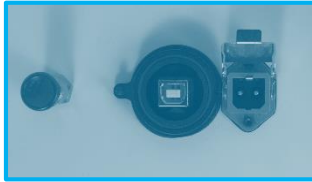
set-up MBS 532 G3

**PULSAR**  
PHOTONICS

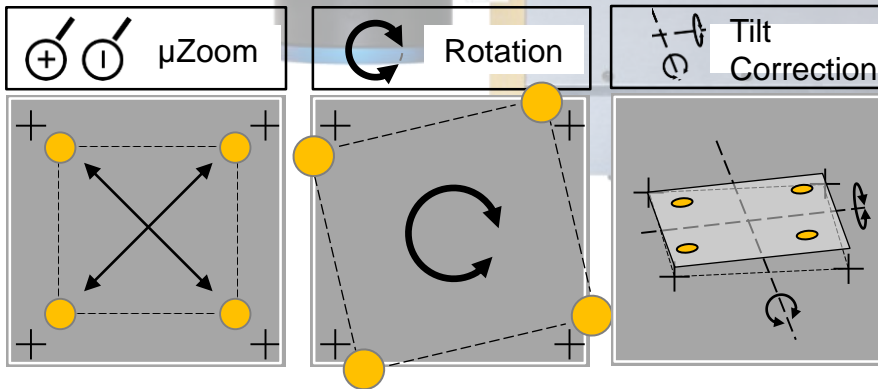


# Multi Beam Scanner *multi axes alignment*

supply  
interfaces

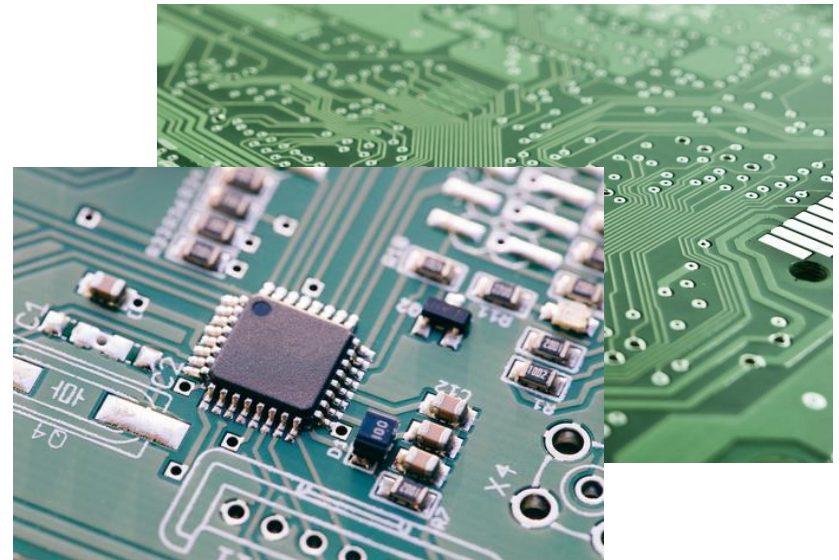
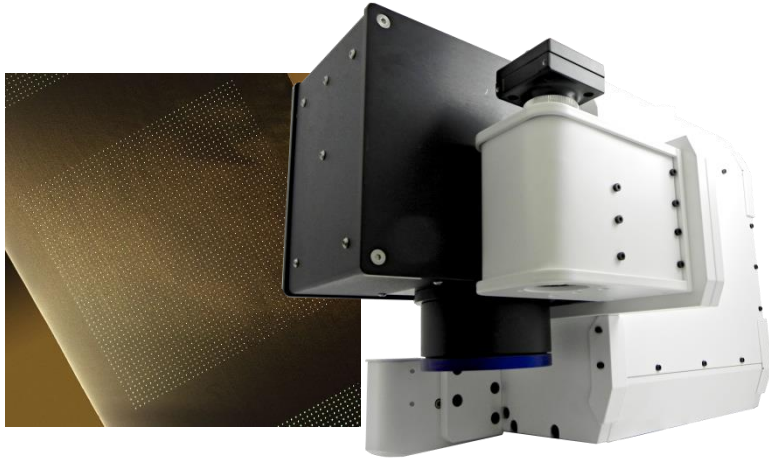


software kit  
*initial alignment*



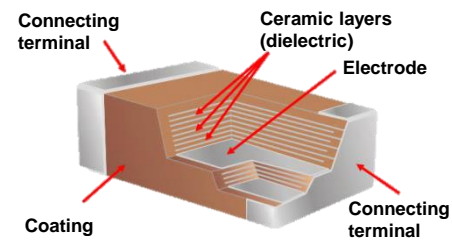
# Applications

*Multi Beam Technology for LTCC Processing*



## Green ceramics on carrier foil

- Via-hole diameter  $\text{\O}20\text{-}25\ \mu\text{m}$
- Hole distance  $100\ \mu\text{m}$
- Target Drilling rate  $5.000\ \text{sec}^{-1}$
- Multi beam approach  $4\times 4$



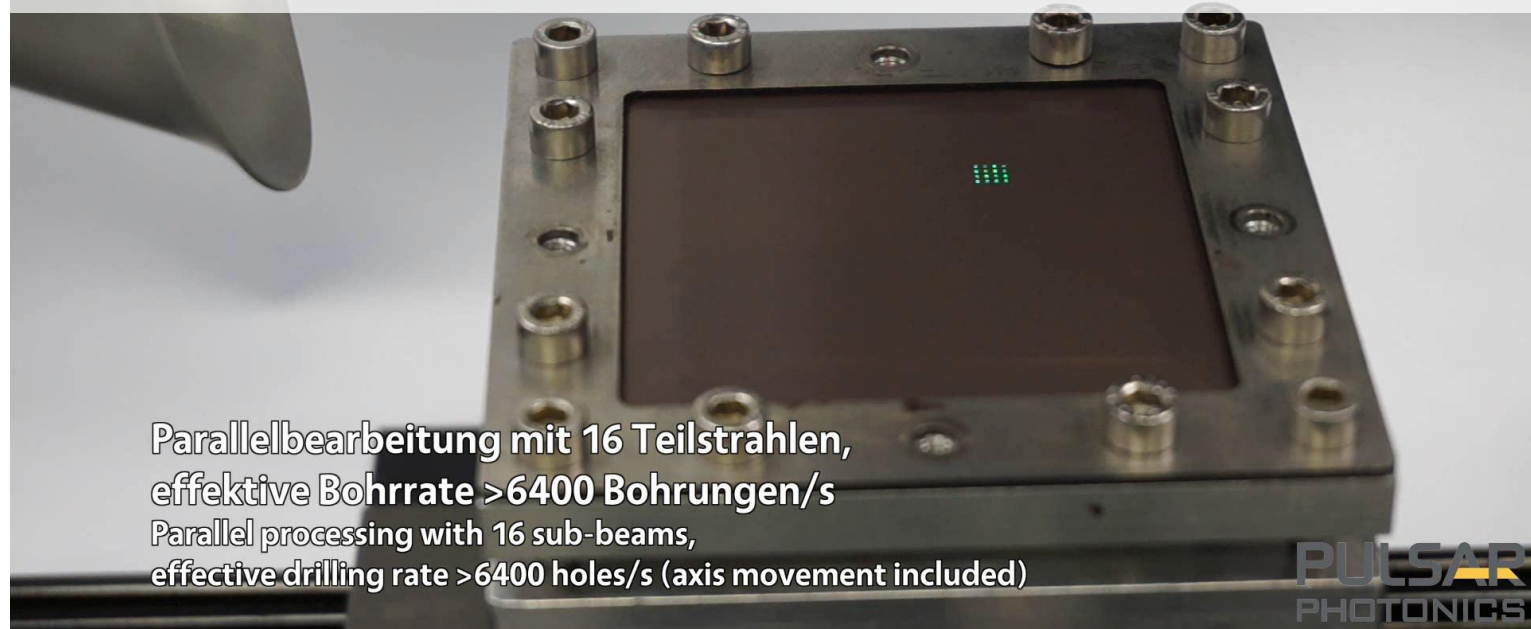
# Applications

Process video – Laser drilling with up to 14 kHz

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PHOTONICS

Youtube Video:

<https://www.youtube.com/watch?v=imokZf5xRps>

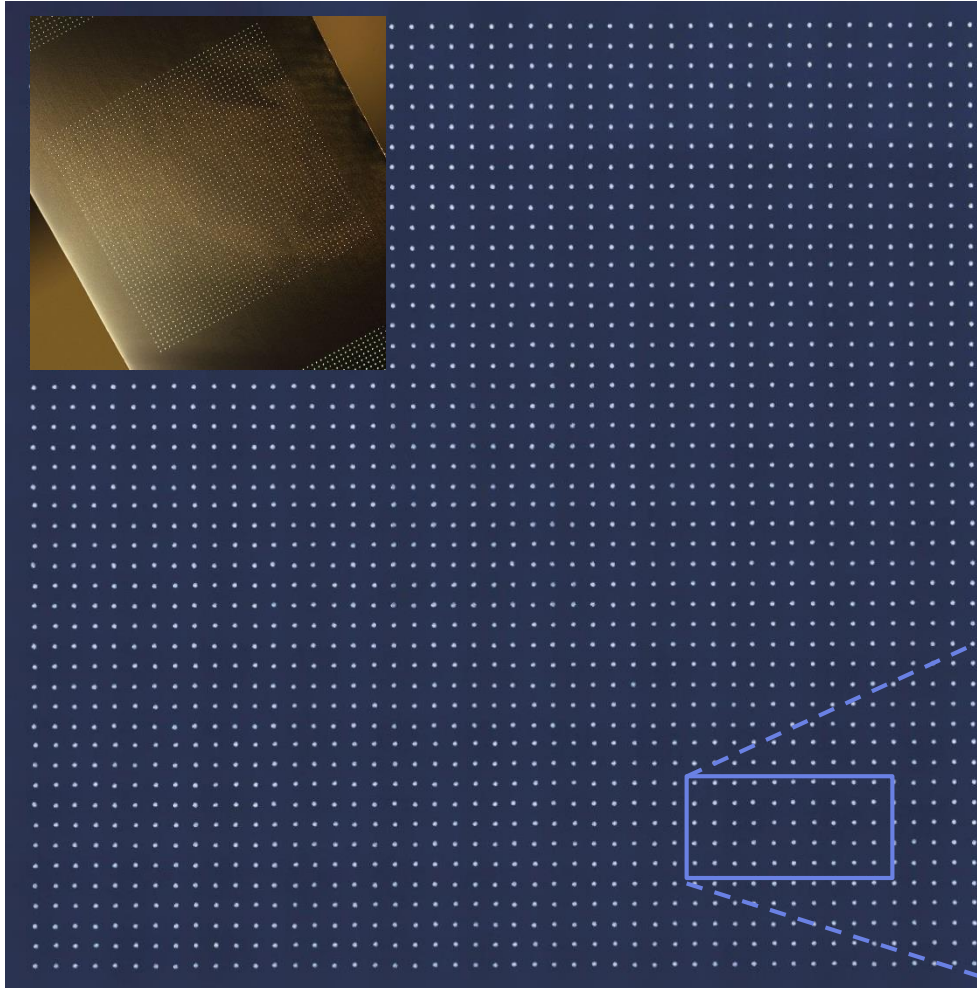


Parallelbearbeitung mit 16 Teilstrahlen,  
effektive Bohrrate >6400 Bohrungen/s  
Parallel processing with 16 sub-beams,  
effective drilling rate >6400 holes/s (axis movement included)

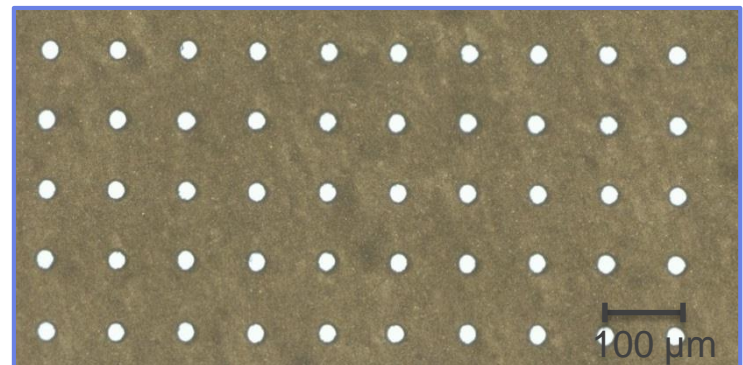
**PULSAR**  
PHOTONICS

# Applications

## Multi Beam Technology for LTCC Processing

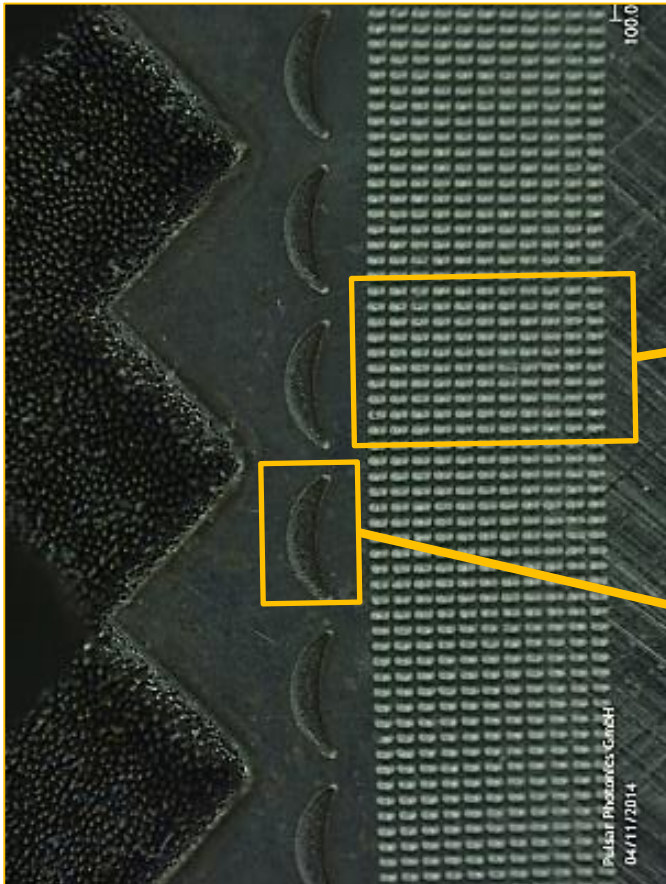


- Laserpower 40 W
- Tool MBS 532ct G2
- Multibeam 4x4
- Spot Field 5x5 mm<sup>2</sup>
- Hole diameter  $\text{Ø}23 \pm 1,5 \mu\text{m}$
- Drilling rate max. 14 kHz  
mean > 6.4 kHz
- *state of the art* 2 kHz

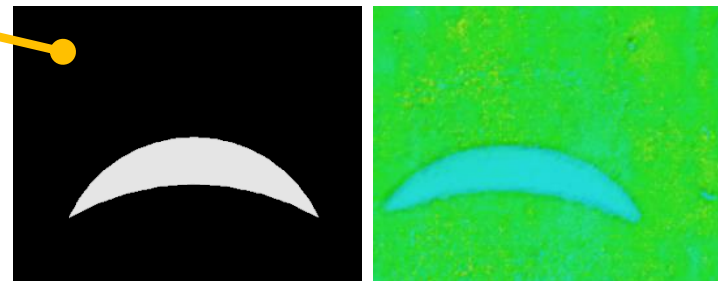


# Applications

Approaches to increase productivity for partially periodic structures



MBS processing by changing beam splitter pattern

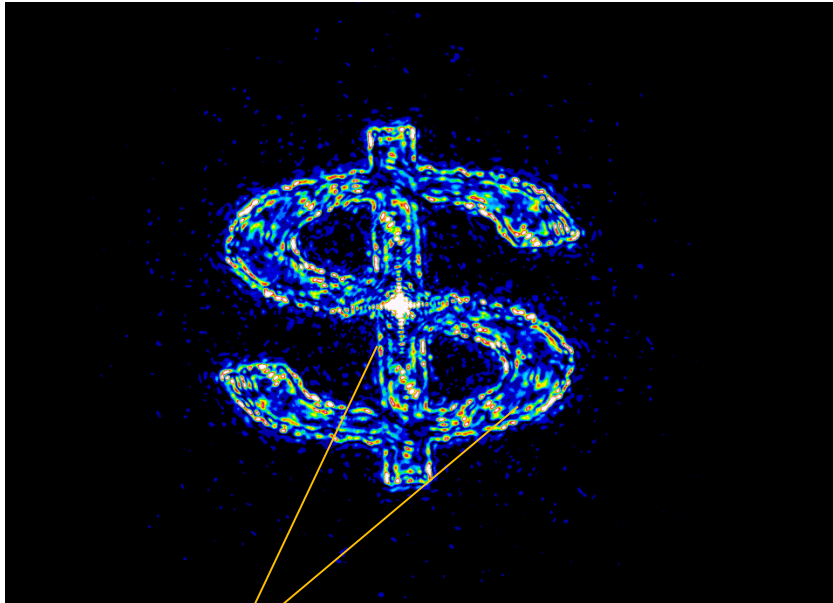


CAM-Image Full shape processing by "Optical stamping"

# “Optical Stamping”

*Using shaped intensity distributions for laser processing*

- DOEs with complete Structures lead to insufficient processing quality
- Speckles are caused by interference of coherent laser light

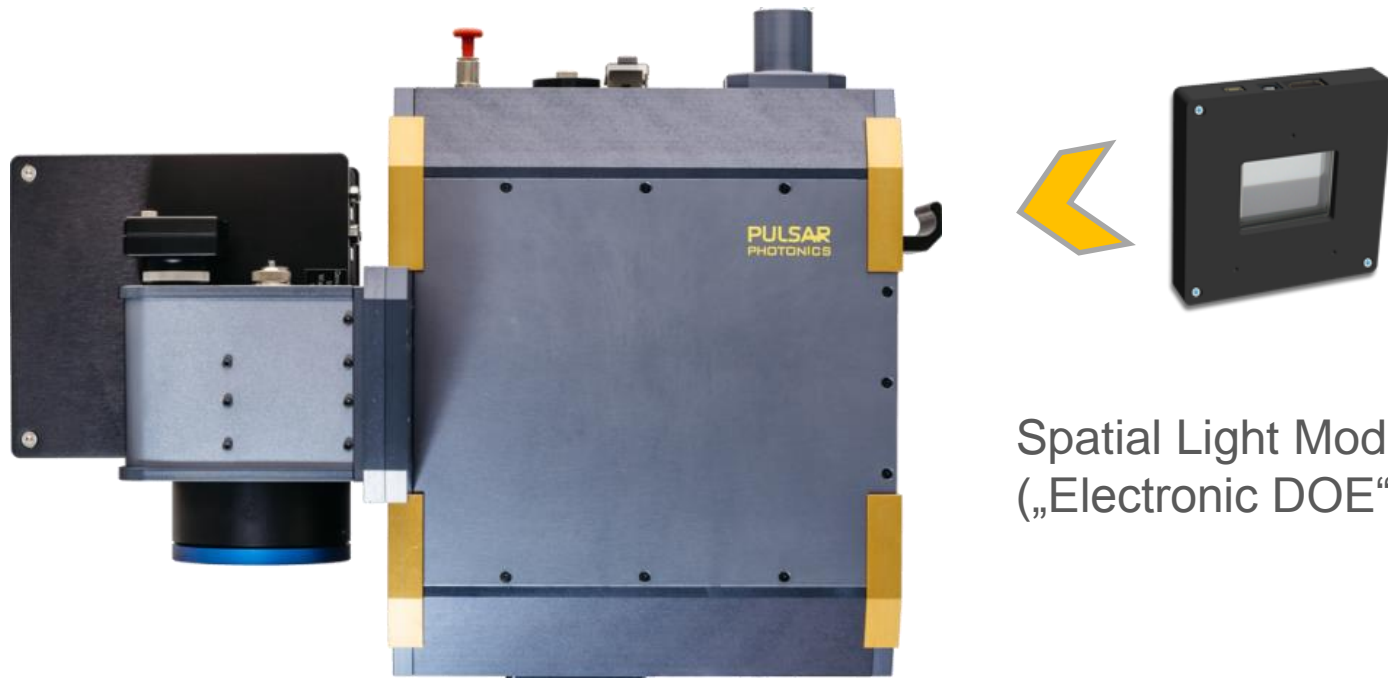


**Speckles interference (single mode)**



**Inhomogeneous ablation**

- New approach substitution of DOE by spatial light modulator

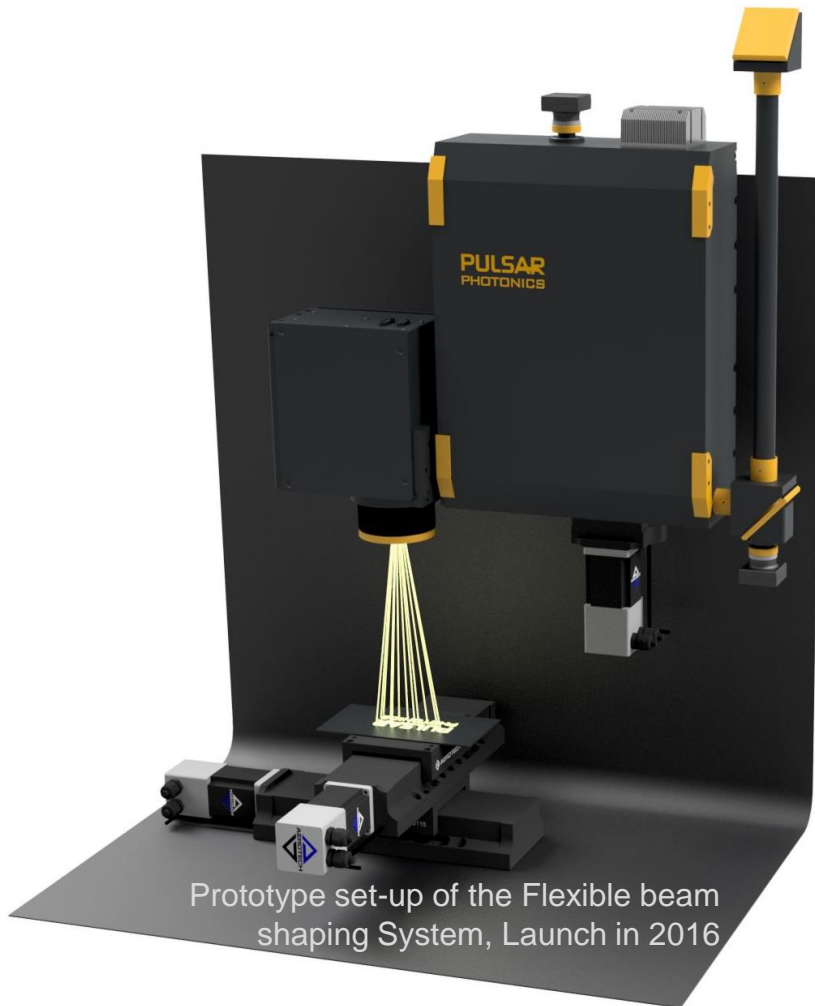


Spatial Light Modulator  
(„Electronic DOE“)

MBS G3 as  
*Developing Platform for SLS*

# FBS *flexible beam shaping – prototype*

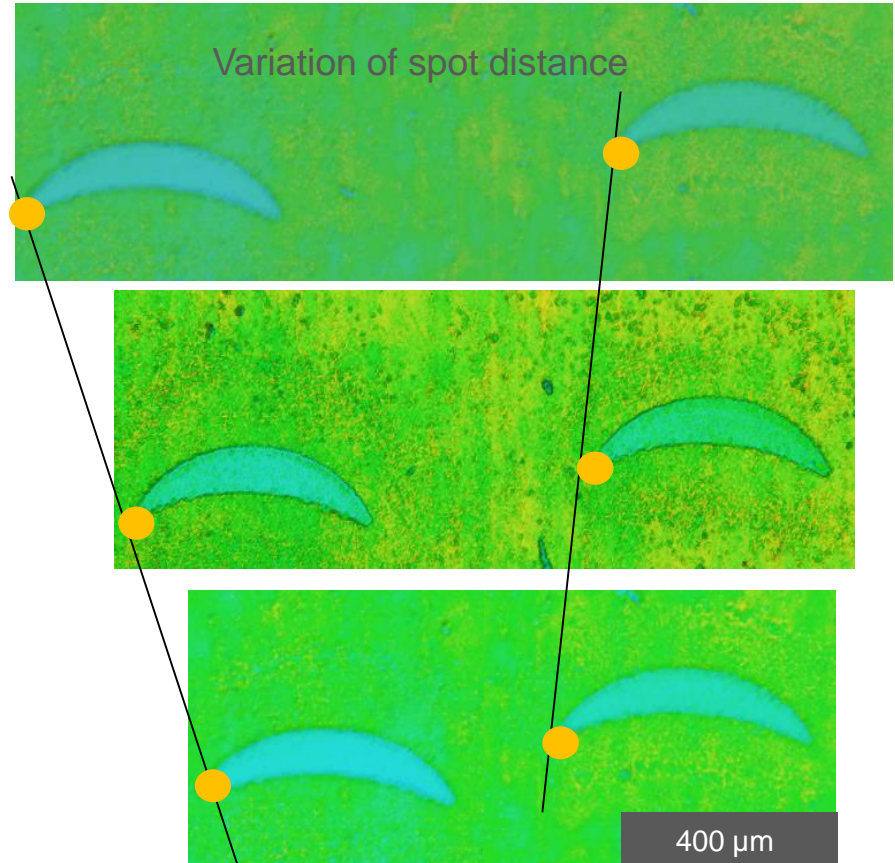
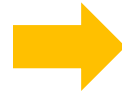
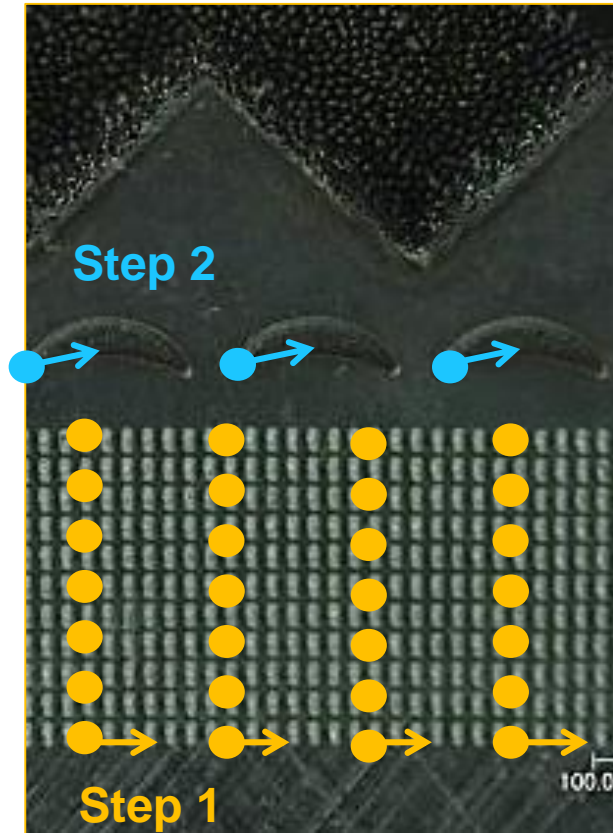
NEW  
2016



Prototype set-up of the Flexible beam shaping System, Launch in 2016

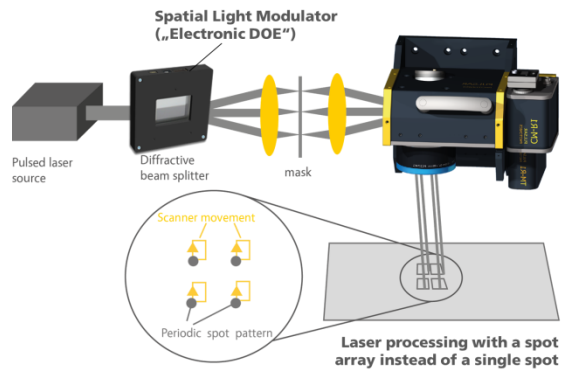
# PULSAR PHOTONICS

Result of the first feasibility study,  
ablation in steel: Speckle-free ablation by  
variable beam splitting using FBS

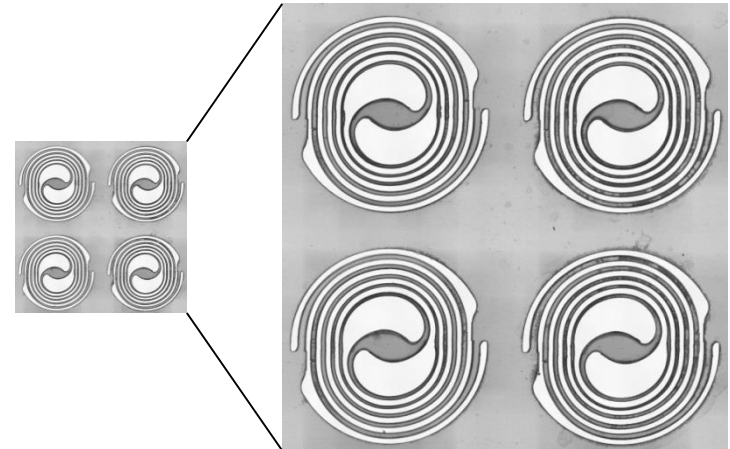


- Flexible Beam splitting using FBS
- Laser ablation in 2D using scanner

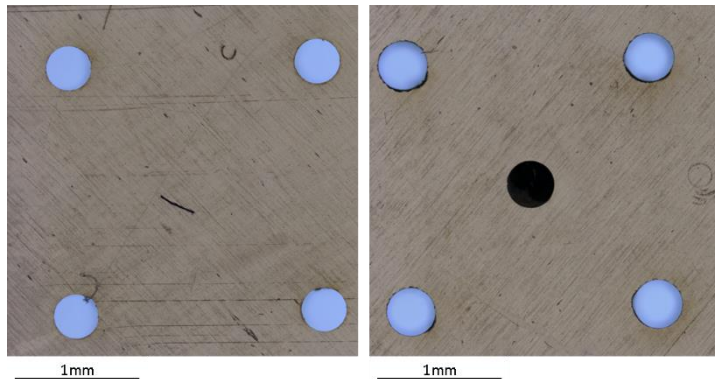
## ■ Flexible laser processing using SLMs



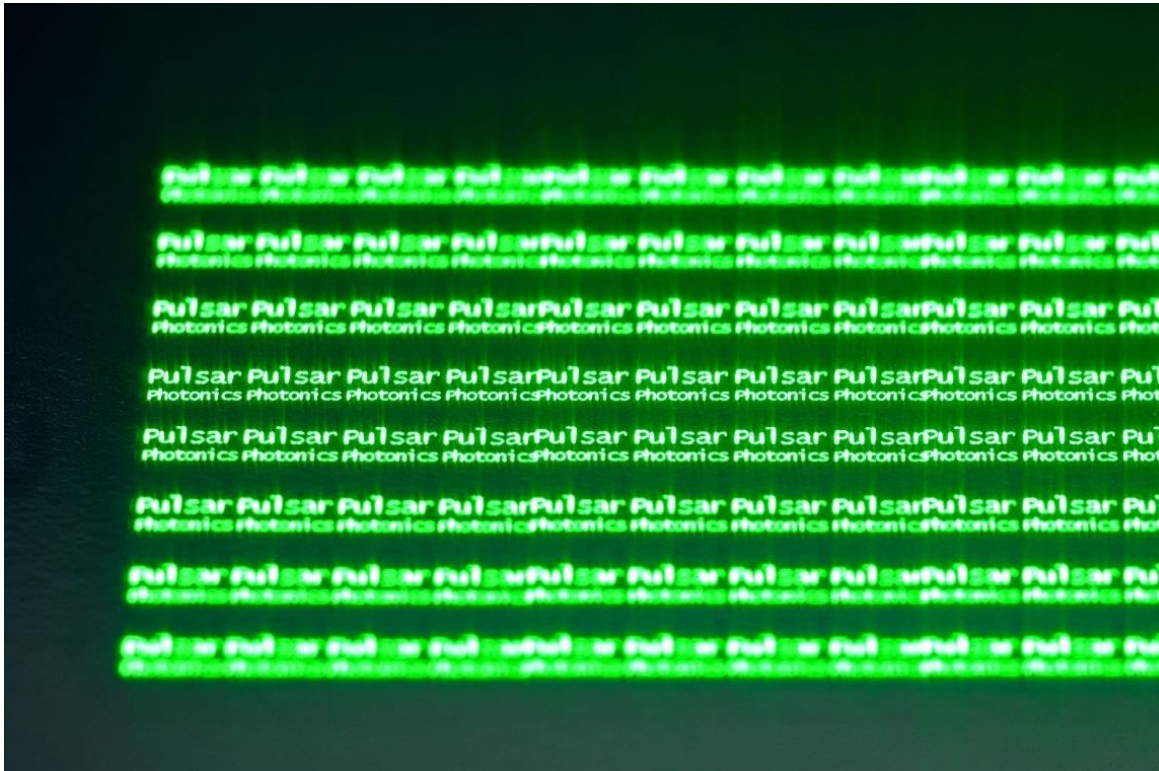
## ■ Increase working area of MBS



## ■ Multi beam helical laser drilling system



# Thank you for your attention!



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