

# Laser ablation and cleaning - precision and high-rate processes

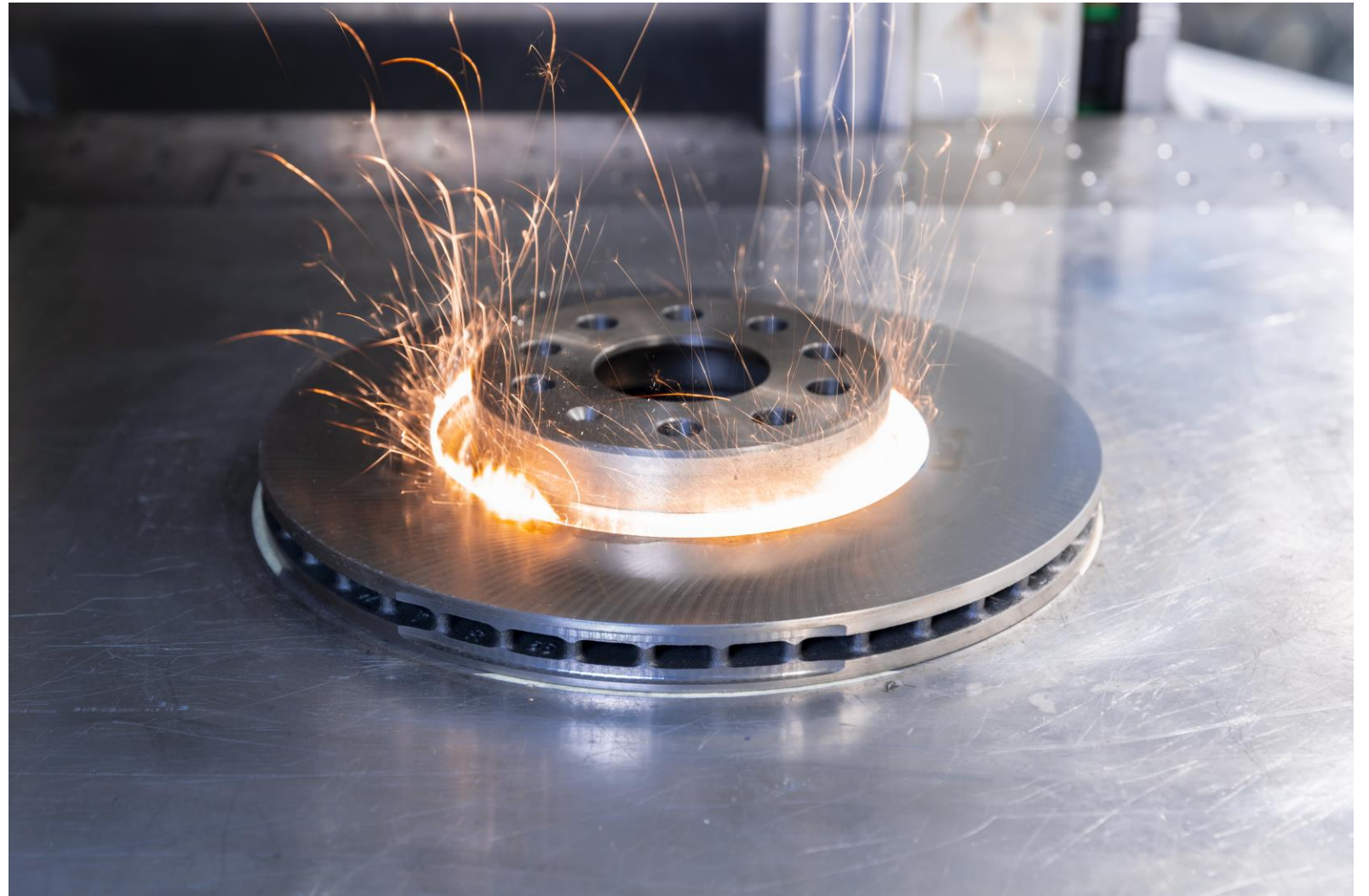
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# Structure

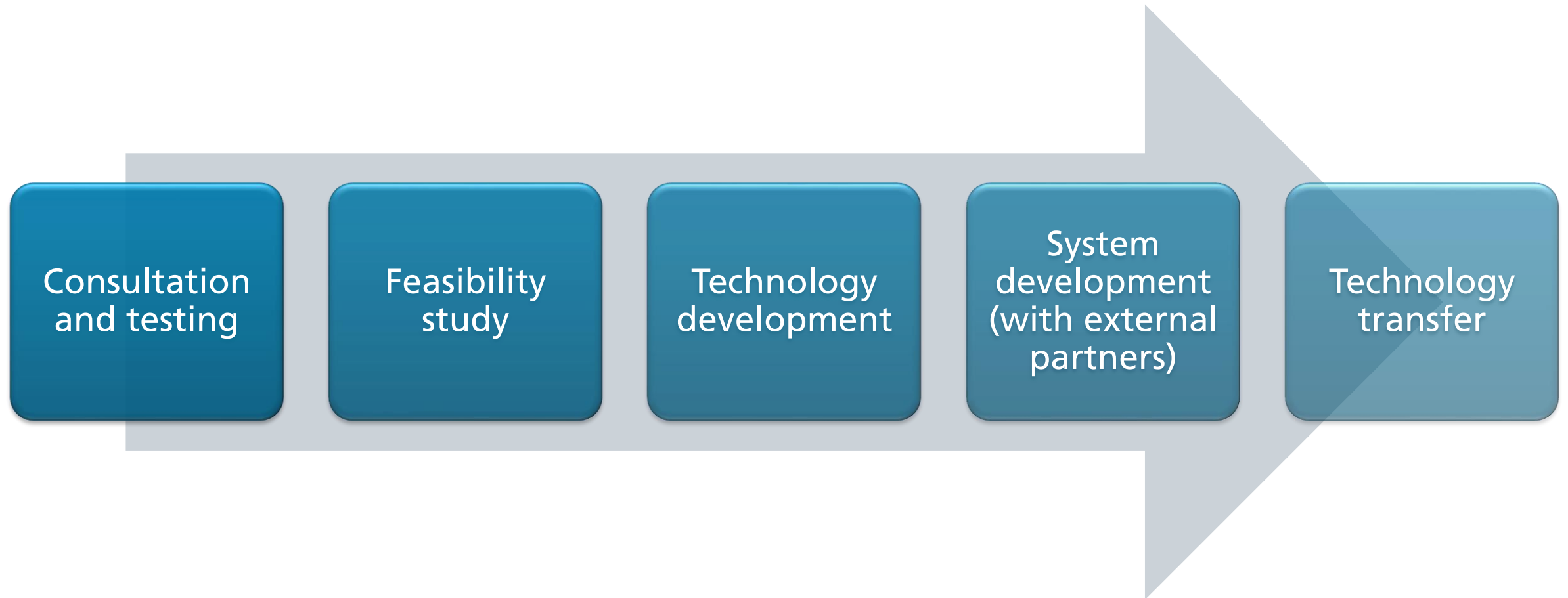
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- **Introduction IWS**
- **Laser as tool**
  - Continuous wave vs. pulsed
  - Beam deflection
- **Ablation process**
  - Laser cleaning
  - Laser structuring
- **Application examples**



# Offer spectrum Fraunhofer IWS

Possibilities of collaboration



# Technologies and expertise

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PVD- und nanotechnology



Chemical surface technology



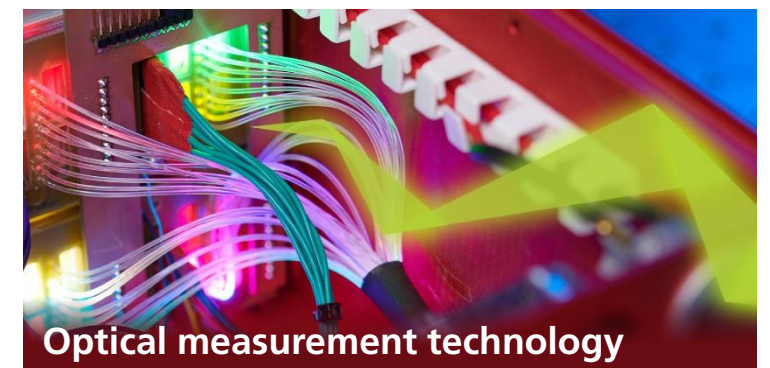
Additive manufacturing



Cutting and Welding



Material characterization and testing

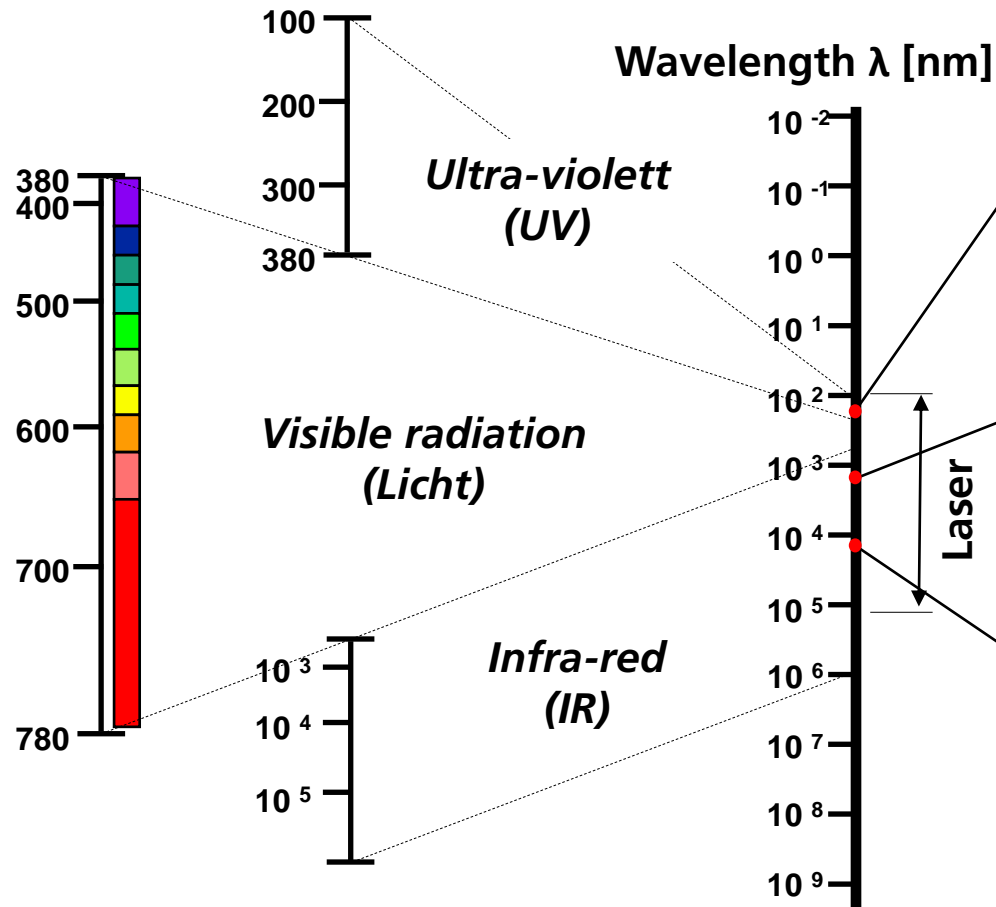
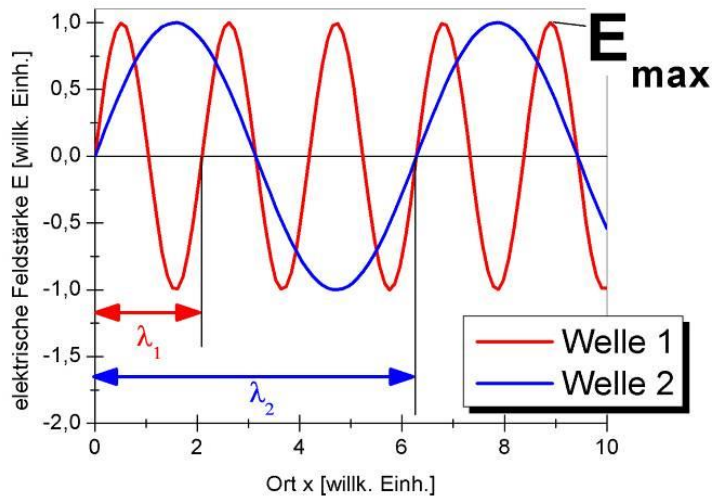


Optical measurement technology



# Laser as tool

## Electromagnetic radiation



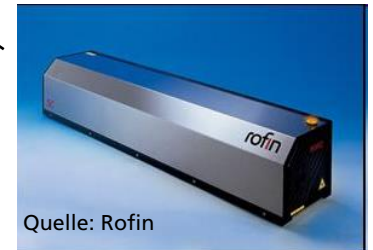
### Excimerlaser



### Fiberlaser



### CO<sub>2</sub>-Laser

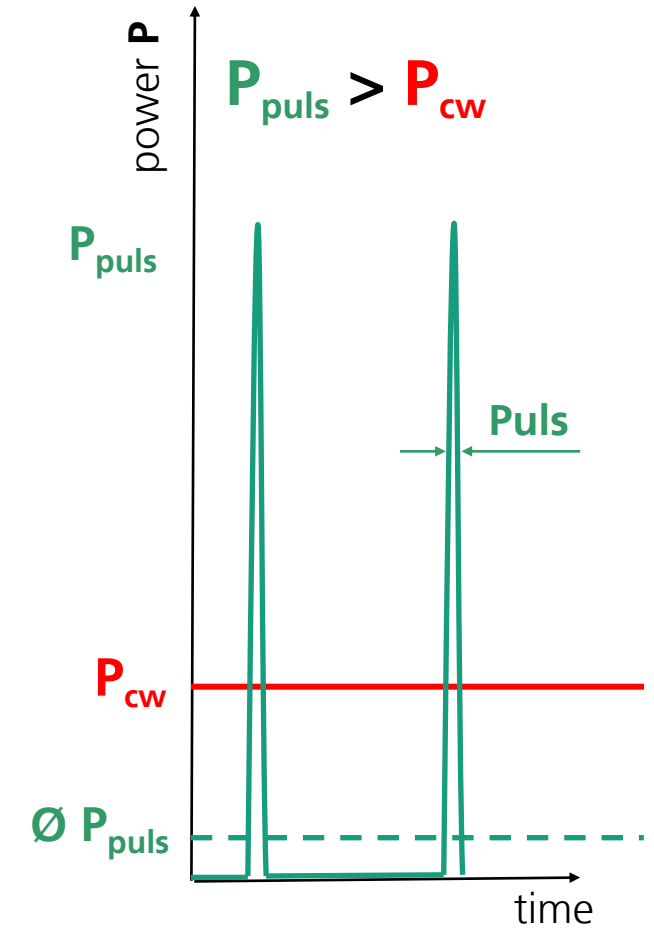


# Laser as tool

## Continuous wave (cw) vs. pulsed lasers

- Lasers can emit radiation continuously (cw) or pulsed

	<b>cw</b>	<b>gepulst</b>
Power delivery	continuous	Charging and abrupt release
Average output power	W ... kW	several 100 Watts
Pulse width	-	ns - fs
Peak power	kW	MW - TW
Field of application	High-rate ablation	High-precision processes



# Laser as tool

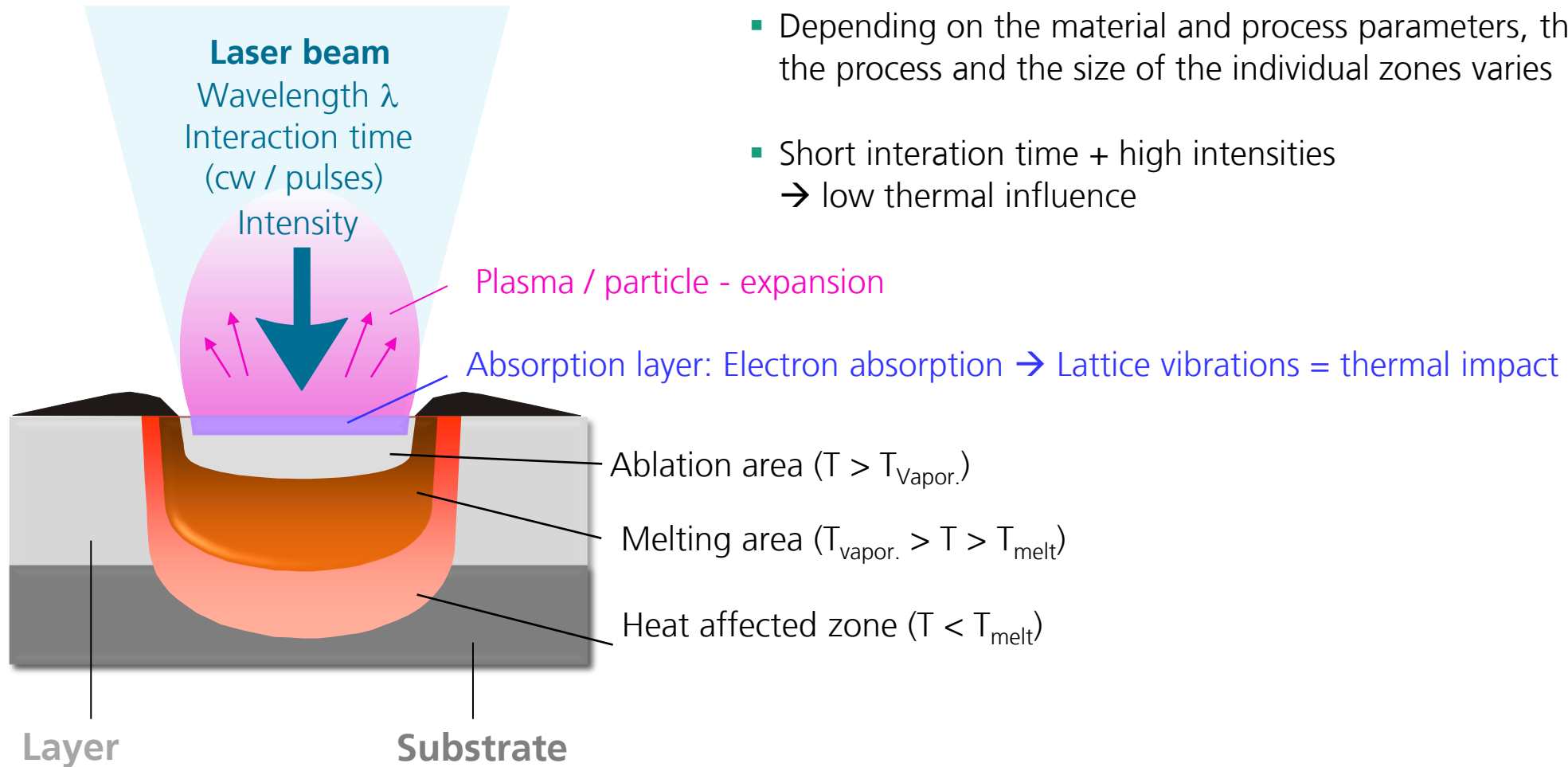
## Beam deflection

- Beam deflection systems - Galvanometer scanner: electrically driven tilting mirrors
- Precise, fast and accurate repeatable beam guidance
- Spot velocity: 1...20 m/s
- Collimation and focusing optics
- f-theta lens (plan field correction)



# Ablation process

## Interaction between Laser and material



- Depending on the material and process parameters, the character of the process and the size of the individual zones varies
- Short interaction time + high intensities  
 $\rightarrow$  low thermal influence



# Ablation process

Layer removal – Laser cleaning

Process is based on different physical properties of layer and substrate

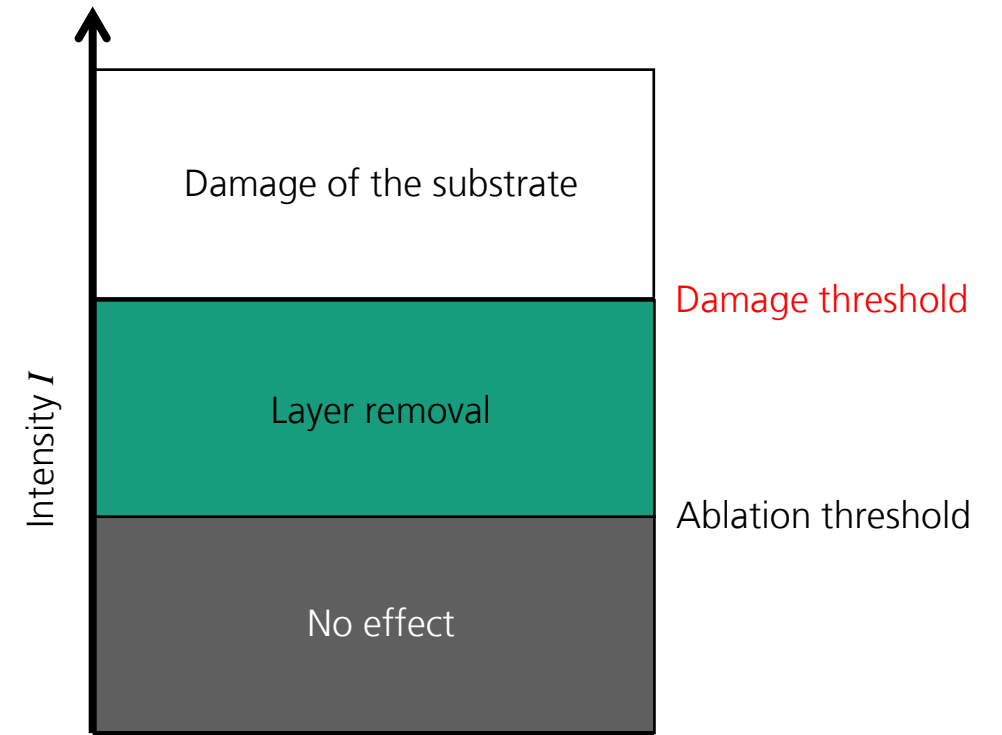
## optical:

- Absorption for the specific wavelength

## thermal:

- Melting temperature / vaporization temperature
- Thermal conductivity
- Thermal expansion coefficient

$$I_{\text{threshold,layer}} < I_{\text{Laser}} < I_{\text{threshold,substrate}}$$



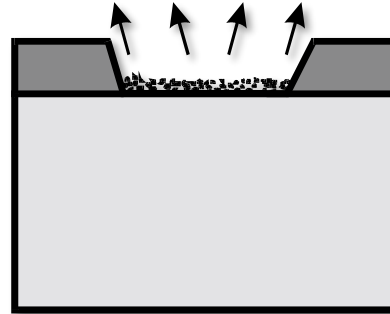
# Ablation process

## Ablation mechanisms – Laser cleaning

**Absorption layer**



**Absorption substrate**

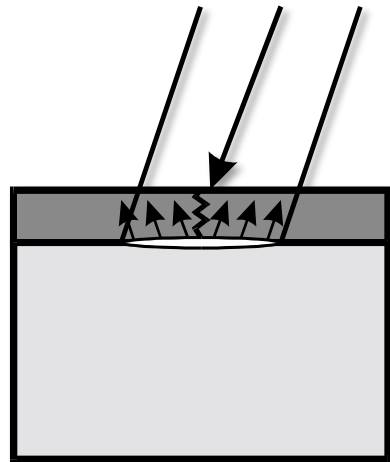


- Layer absorbs the laser beam - melting and vaporization
- Vapour pressure ejects molten material
- Self-regulating process due to different properties of layer and substrate

**Absorption layer**



**Absorption substrate**



- Transmission through layer, absorption of the laser in the material
- Vapour pressure at the interface breaks up the layer

# Ablation process

## Ablation mechanisms – Laser cleaning

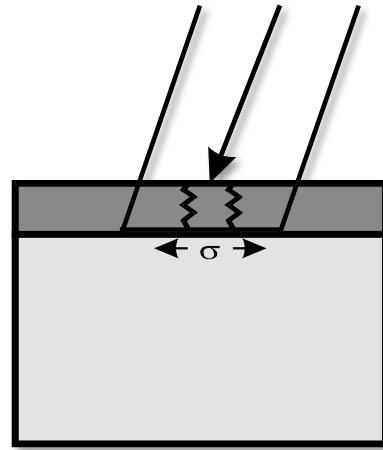
Absorption layer



Thermal expansion  
layer



Thermal expansion  
substrate

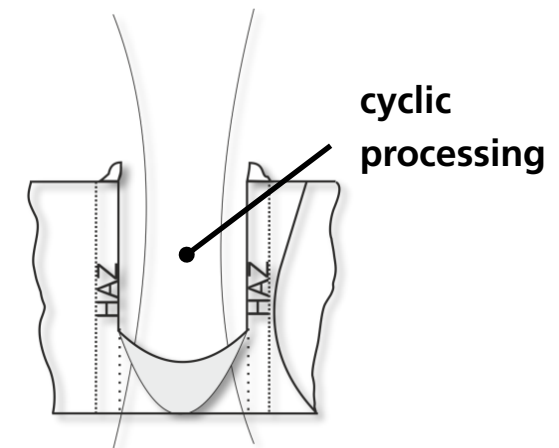
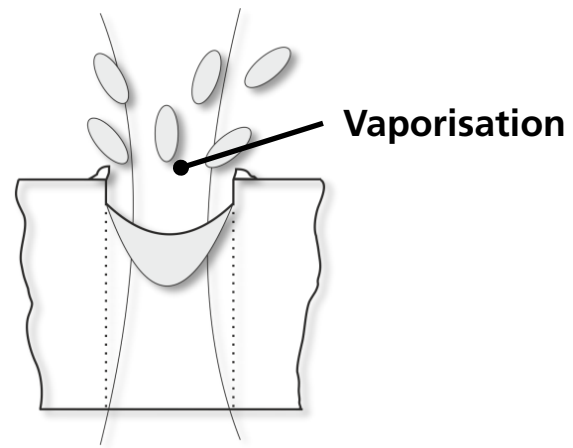
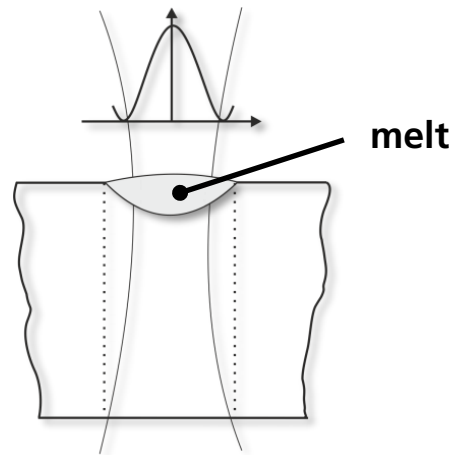


- Absorption of the laser beam leads to heating of the layer
- Thermal induced stress due to different thermal expansion between layer and substrate

# Ablation process

## Laser structuring

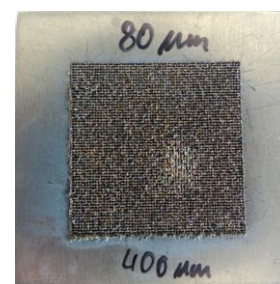
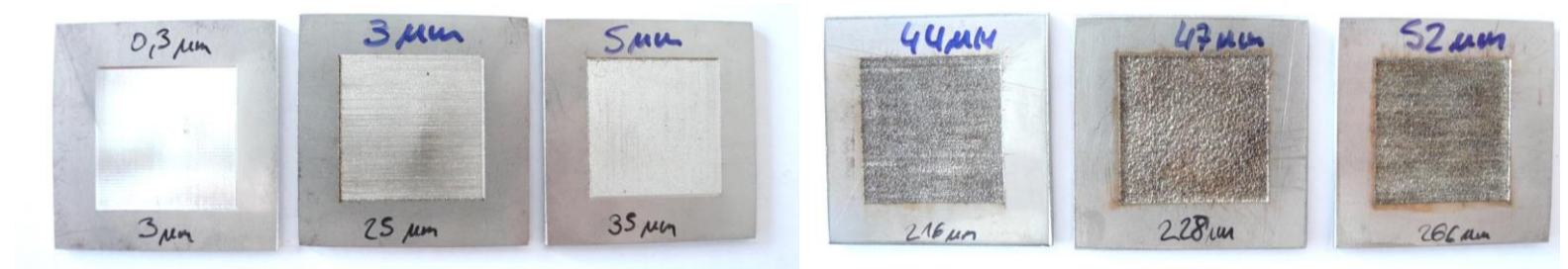
- Absorption of the laser beam by the material
- Melting and evaporation due to short interaction time and high intensity - Ejection of the material due to resulting vapour pressure
- locally limited process - heat influence dependent on interaction time



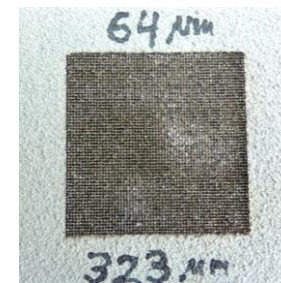
# Ablation process

## Laser structuring

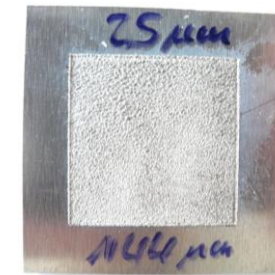
- Wide range of roughnesses
- Different materials
- Adjustable process parameters (Laser power, spot velocity, ablation strategy)
- Result depends essentially on the absorption behavior and the melting temperature of the material



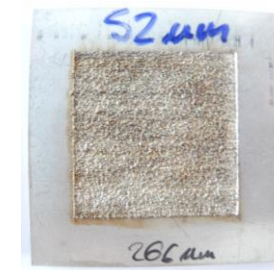
Titan  
3.7164



beschichtetes  
Aluminium



Aluminium  
3.3206



Edelstahl  
1.4301



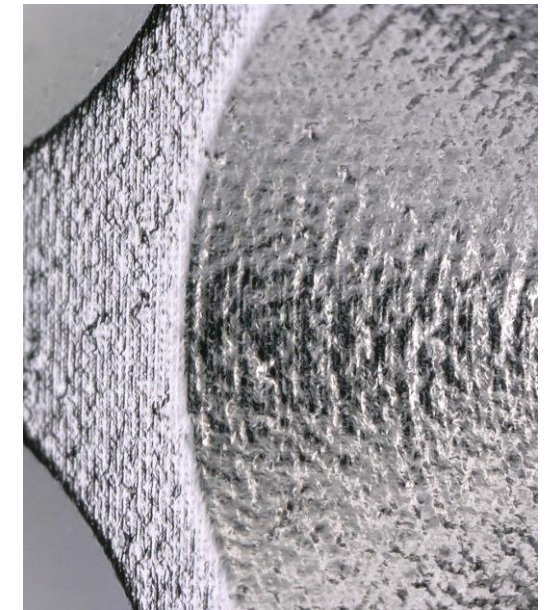
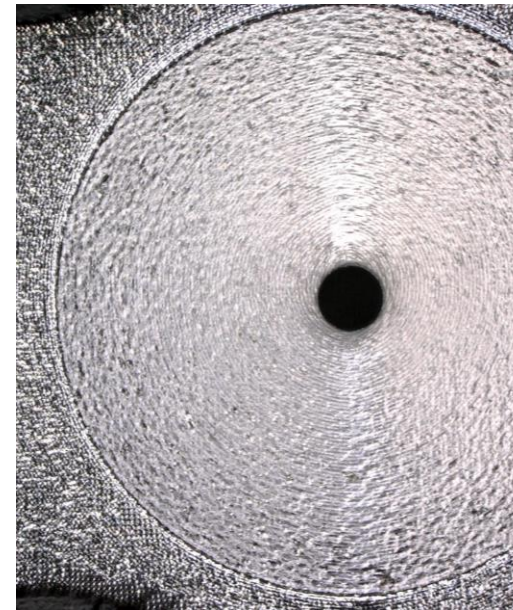
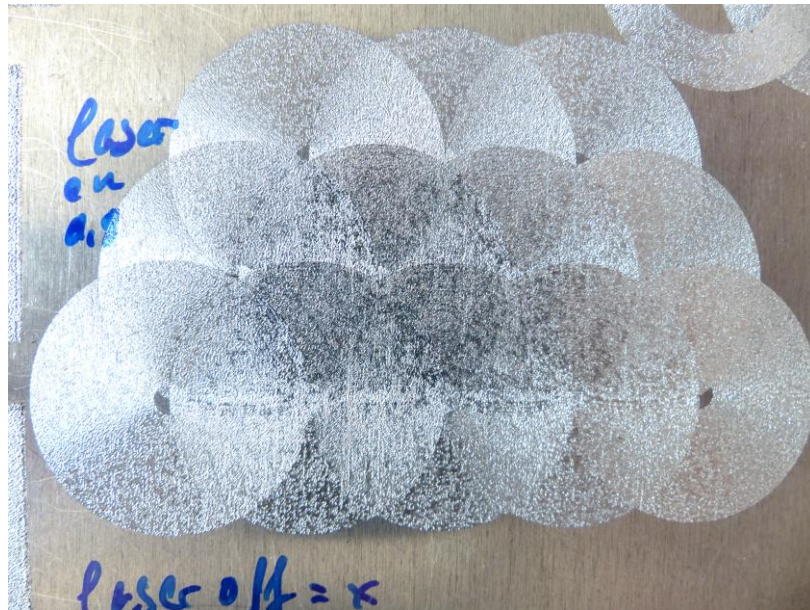
Keramik  
Al<sub>2</sub>O<sub>3</sub>



# Ablation process

## Laser structuring

- Free shaping - structuring of 2.5D - 3D components possible
- No masking, the structuring area can be defined by CAD software





# Applications

## Coating removal

- Removal of paint, rust, grease

## Restoration

- Stone, wood, metal, glass, textile

## Surface preparation

- Generating functional surface structures
- Joining pre-treatment (Bonding, Soldering, Welding)
- Coating preparation



Entfernen der Isolationschicht von Kupfer-Pins



Marble restoration



Removal of dirt and structuring of the surface

# Application examples Laser cleaning

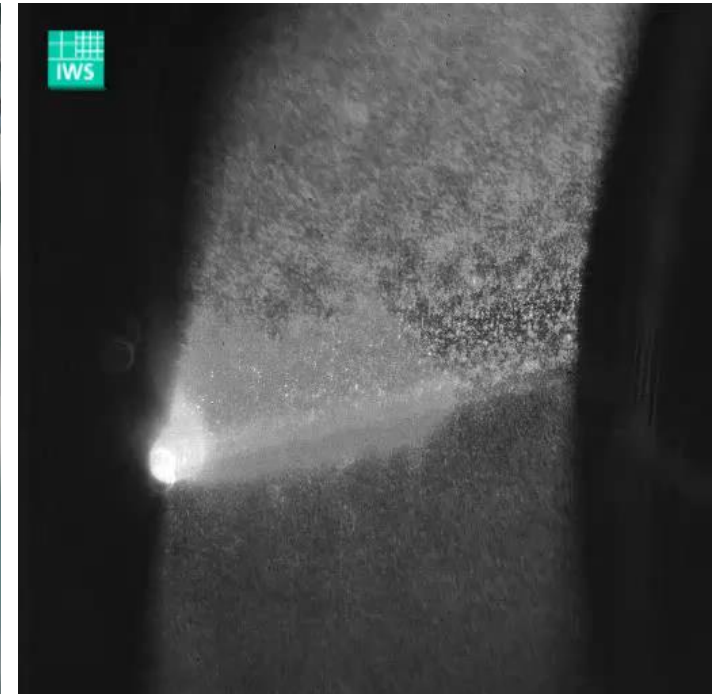
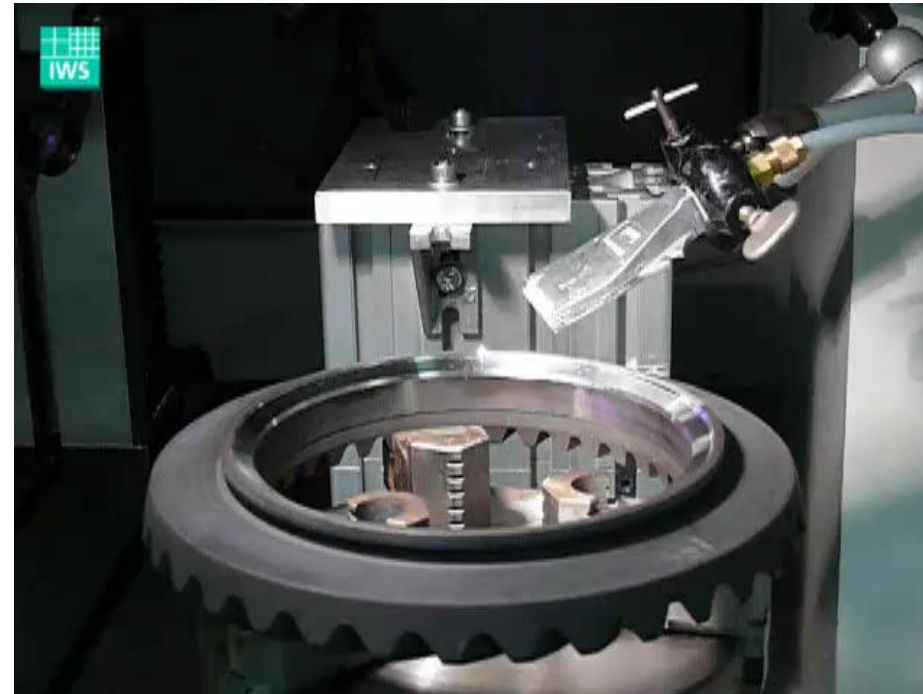
Local paint removal from battery boxes for joining preparation



Paint locally removed

# Application examples Laser cleaning

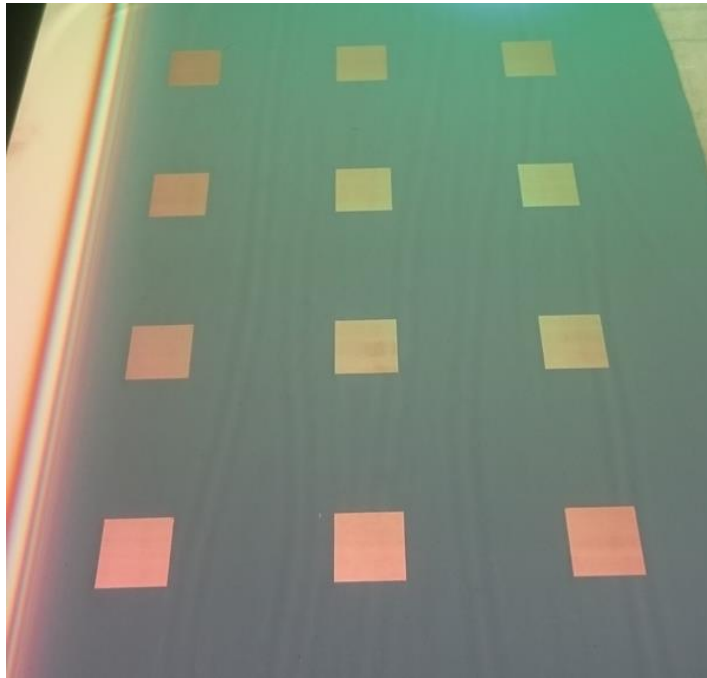
Local removal of a phosphate coating before welding





# Application examples Laser cleaning

Different examples

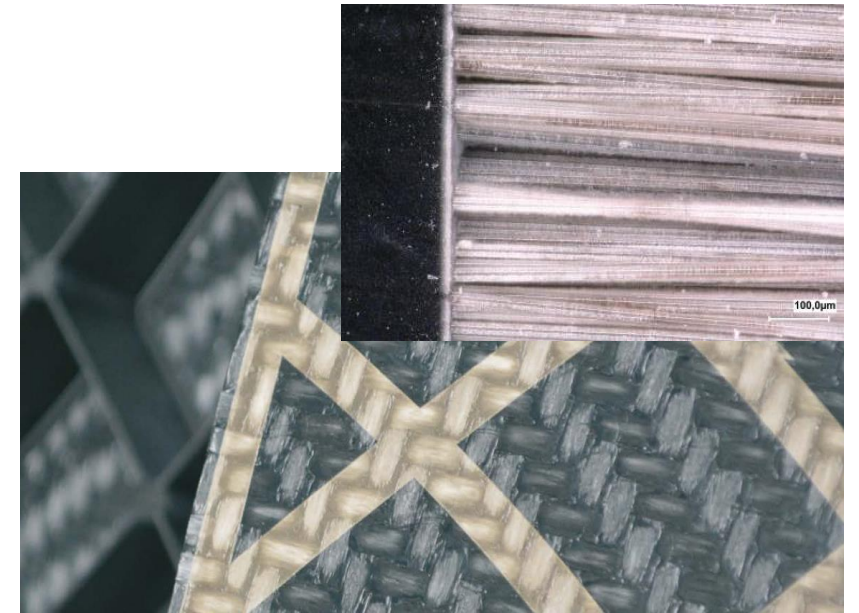


Local removal of silicon on copper, battery electrodes



Lange & Söhne

High precision, decorative ablation of carbon coating at gold substrate (detail size: 20  $\mu\text{m}$ )

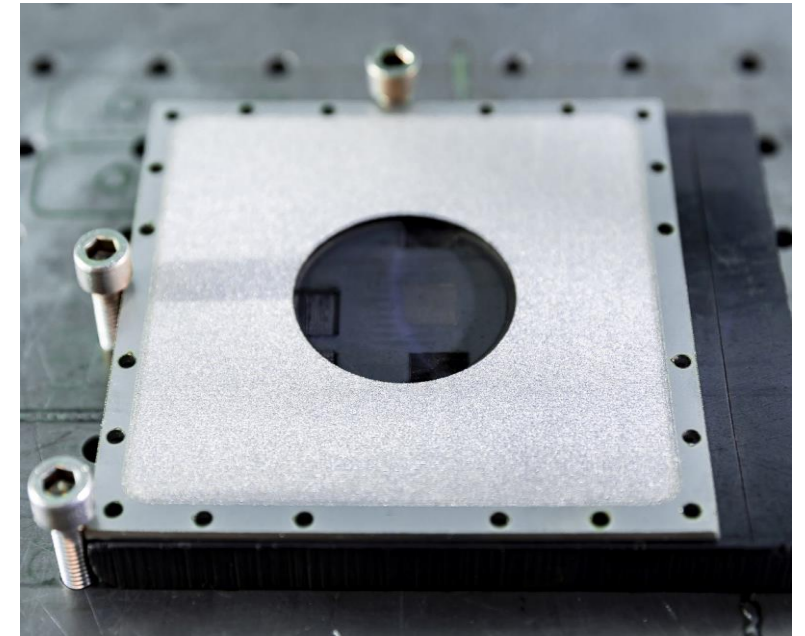
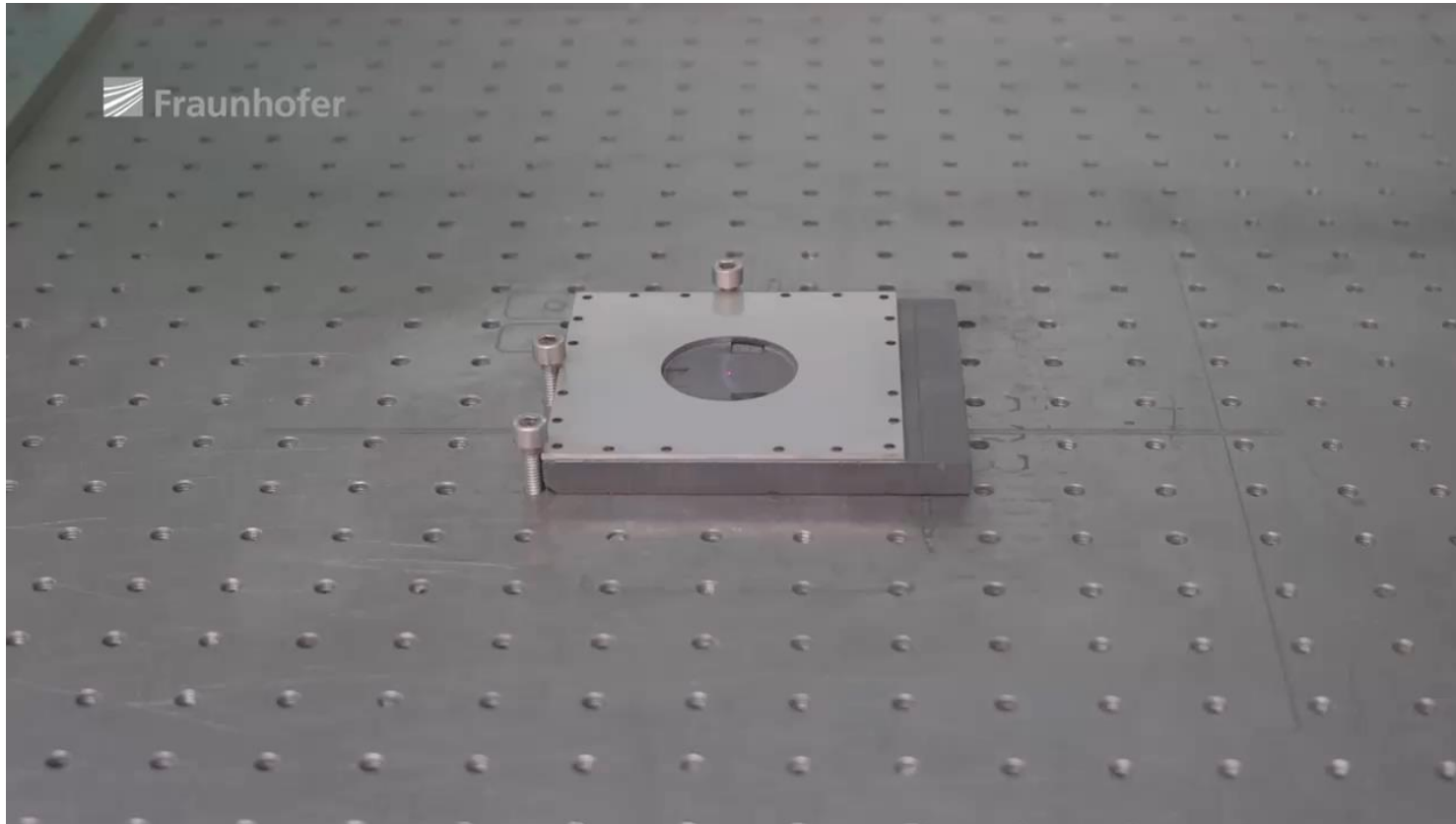


Matrix removal at GFRP for reliable bonding in an overmolding process

# Application example Laser structuring

## Structuring an aperture plate for coating application

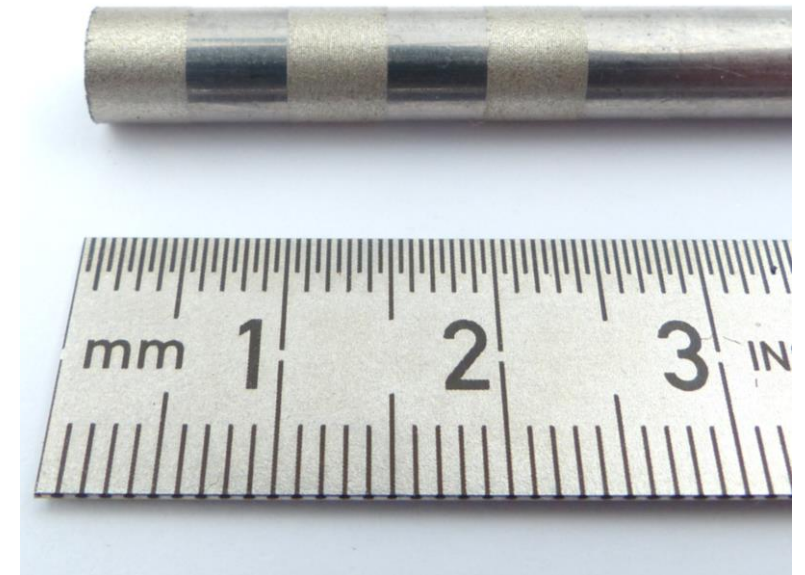
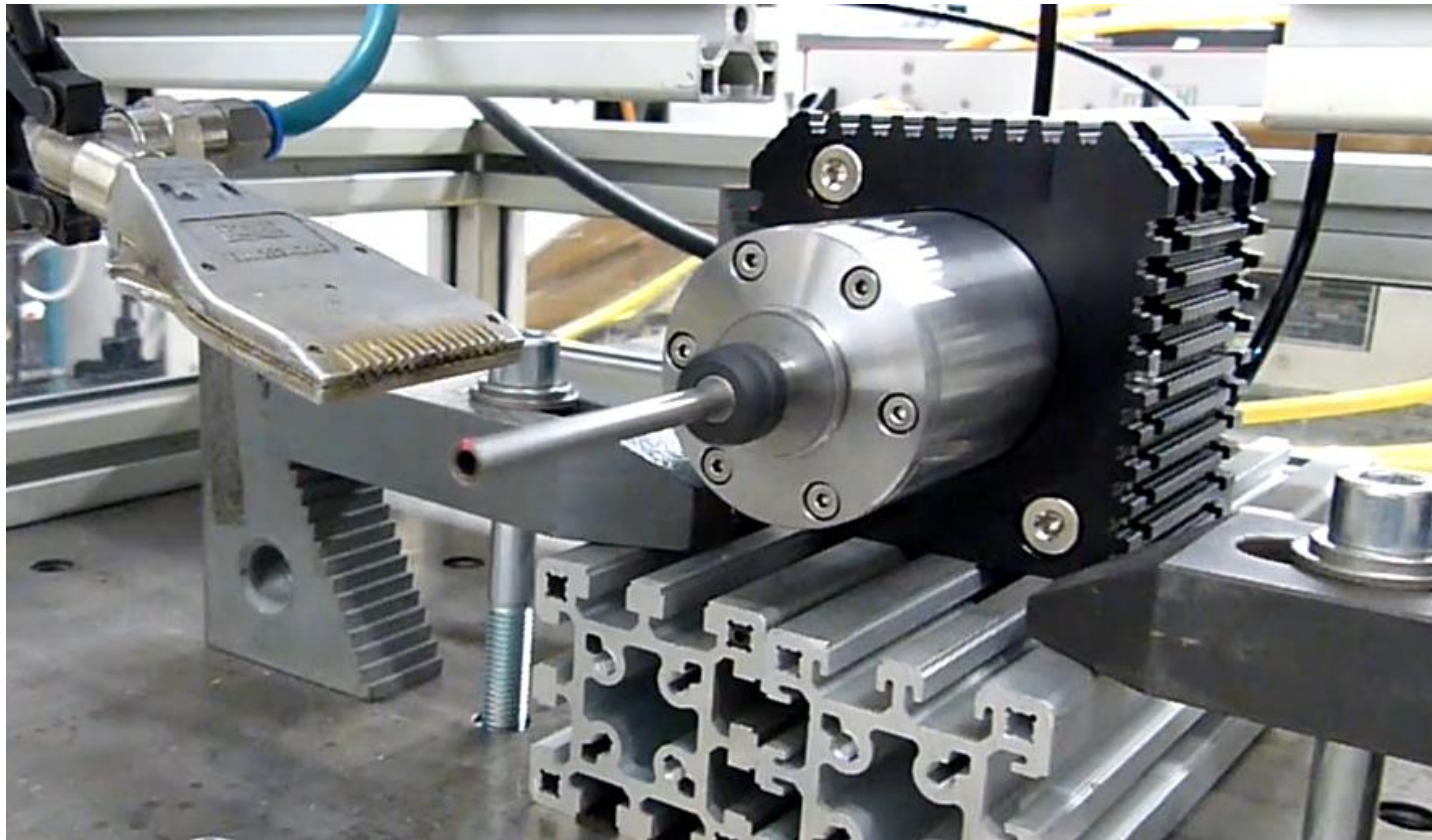
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Structured aperture plate

# Application example Laser structuring

Structuring of tube material



structured tube



# Summary

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## Advantages of Laser cleaning and structuring

- Universal process for a wide range of materials and coatings
- Precise variation of results through process parameter control
- Contour creation by software: free-forming and masking possible without additional process steps
- Spectrum: high-precision ablation to high-rate surface ablation
- No contaminating process media

# Kontakt

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