SWITZERLAND INNOVATION
PARK BIEL/BIENNE

# OPTICAL ADVANCES IN METAL 3D PRINTING

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# "Switzerland Innovation" National Initiative
# 6 Parks located in Innovation Hot Spots

SWITZERLAND INNOVATION
PARK BIEL/BIENNE


Mission of Switzerland Innovation:

**Creation of a platform for accelerated implementation of R&D results into economically viable industrial products and production.**

**Not-for-profit, tax liberated,**
**Eligible for national and EC funding**

Park Biel/Bienne implementation:

1. **R&D projects in relevant industrial domains**
2. **Provision of space, facilities and technologies to start-ups and innovative SMEs**
3. **Innovation services to SMEs**

Swiss HealthTech Center

SWISS SMART FACTORY ®

Swiss Advanced Manufacturing Center

Swiss Battery Technology Center

# Technologies and Topics at SAMC

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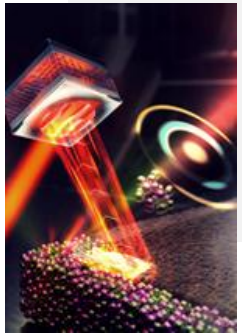
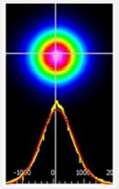
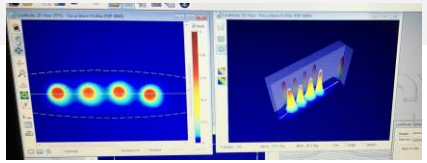
## OPTICS AND LASERS IN ADVANCED MANUFACTURING

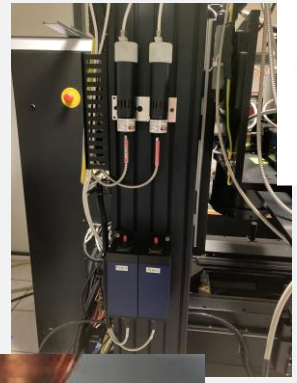
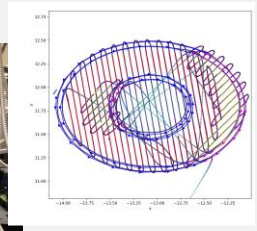
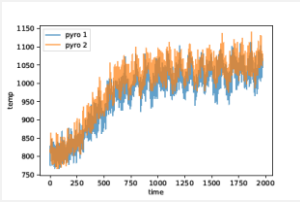
- Laser Powder Bed Fusion (LPBF)
- Optical systems development
- Laser source engineering
- Freeform beam shaping
- Optical glass fibers and applications (drawing tower jointly operated with BFH and UniBE)
- Laser energy deposition in multimaterial systems

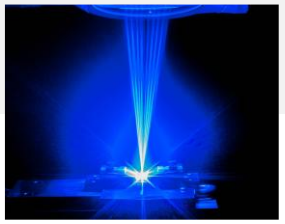


## PROCESS MONITORING & CONTROL

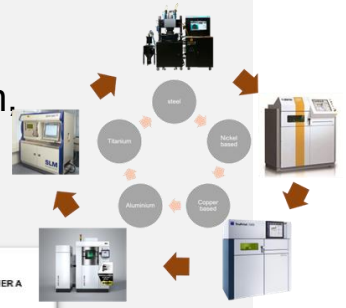
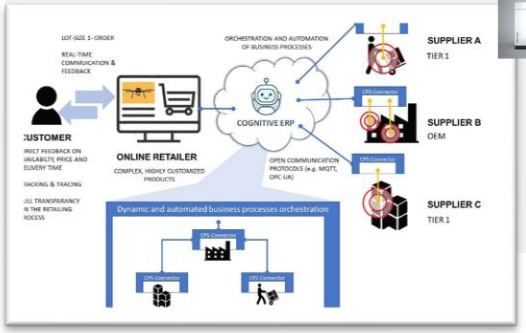
- Welding process monitoring
- Control of process conditions
- Control of material properties
- Transfer of technology

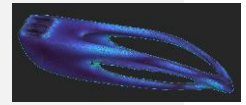






## SMART PRODUCTION

- Design for AM
- Smart process advisory
- De-localized production
- MaaS in metal 3D Printing
- Circular supply chains & design for circularity
- Production companion, remote upskilling

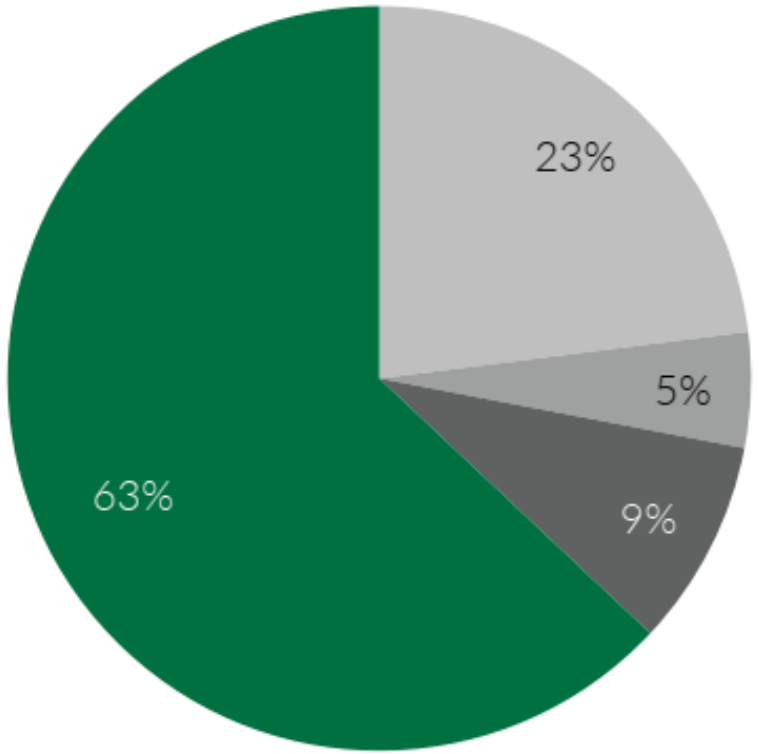



# AM in industry

Many companies with high-value metal products have already engaged with AM

Application category of printed metal parts 2023[1]

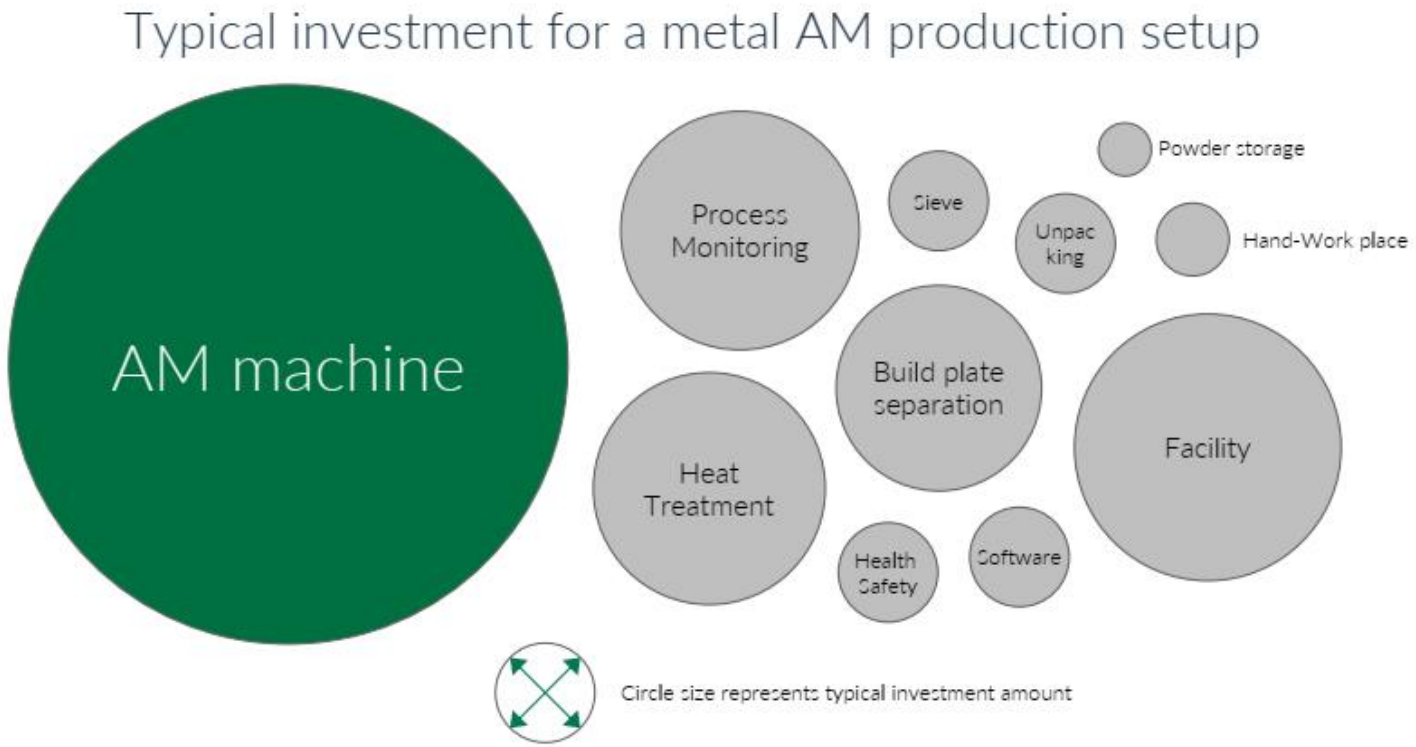
- Prototype and R&D
- Jigs / tools
- Molds
- End parts and spare parts




[1]Source: additive-manufacturing-report.com

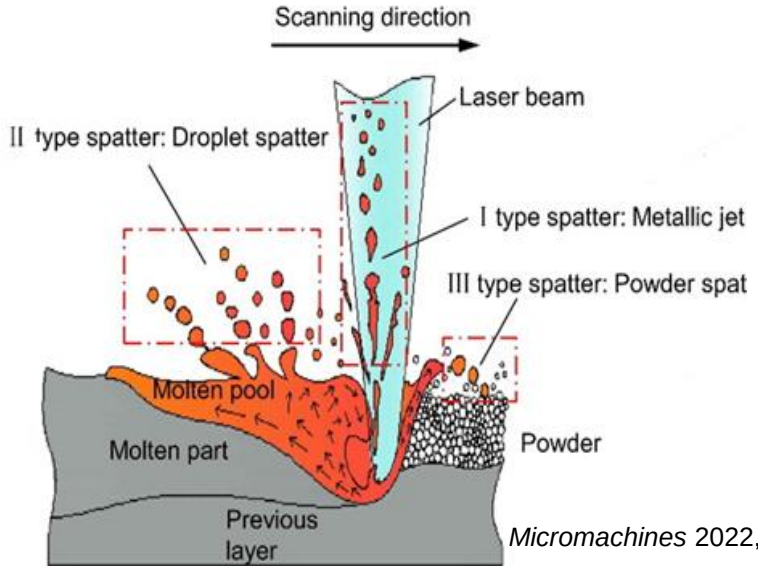
# Investment for metal AM:

- The initial upfront investment can easily exceed 1.5 million USD before the first print job begins
- The learning process is time consuming and variable for each part
- Multidisciplinary technology with little cross-field communication
- Low efficiency process



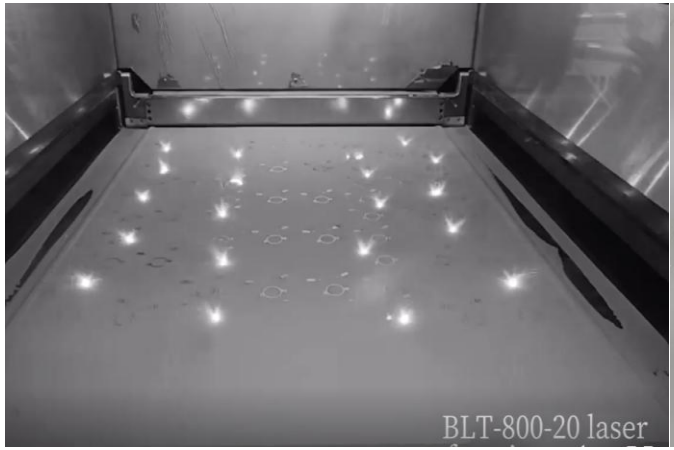
# LPBF process: Productivity improvement

- **Increase layer thickness**
  - Reduce part accuracy
  - Increase surface roughness
  - Increase spatter and pore formation




*Micromachines* 2022, *13*(8), 1366

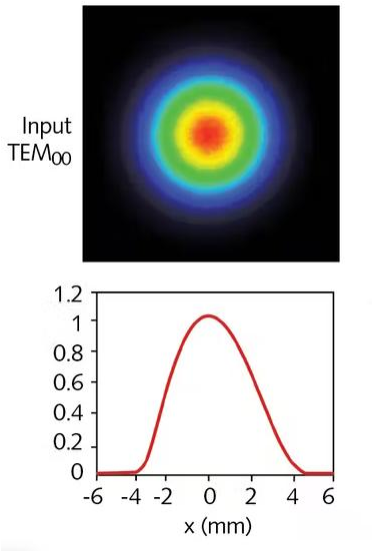
- **Increase number of lasers**
  - Increase machine cost
  - Challenges in fume extraction
  - High maintenance cost

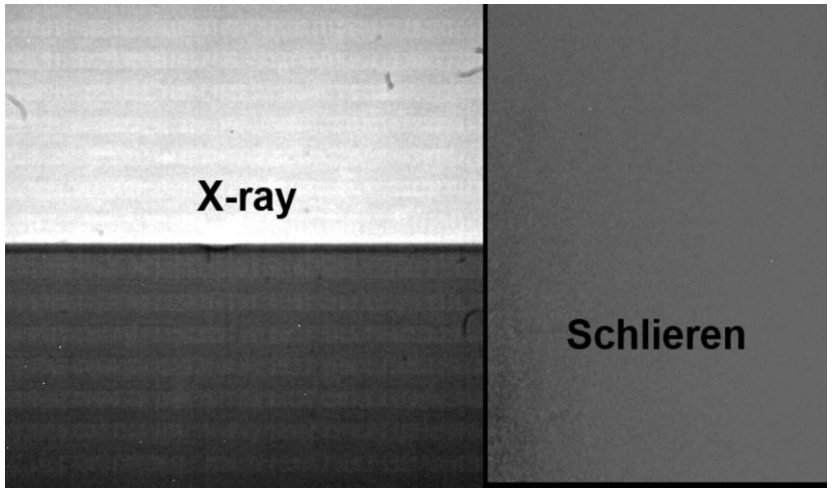



# Are we using the optimum beam shape?

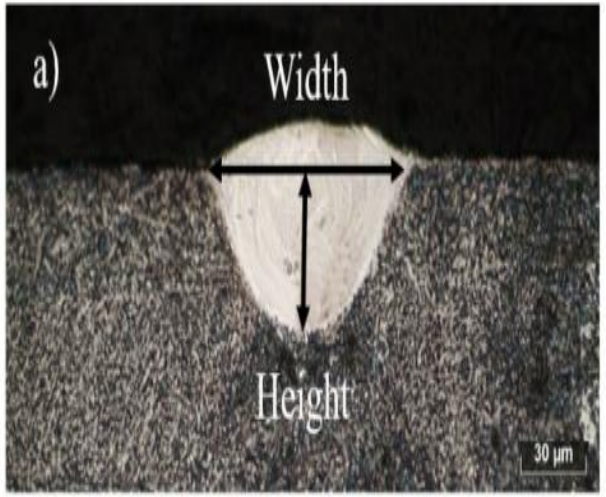
- Single mode gaussian distribution

**Stability**

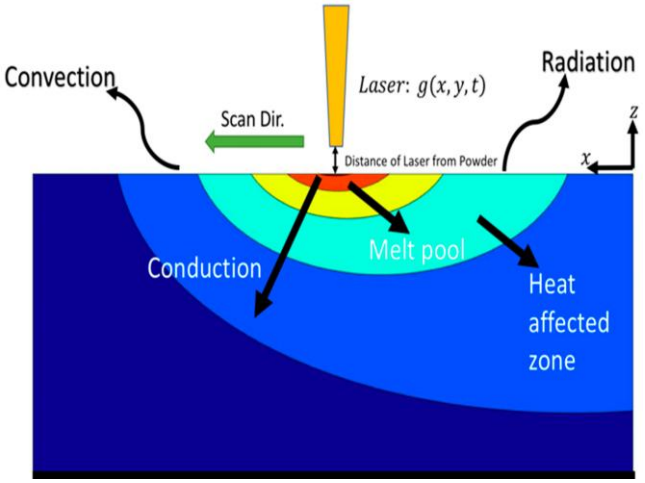



**Productivity**




**Materials properties**

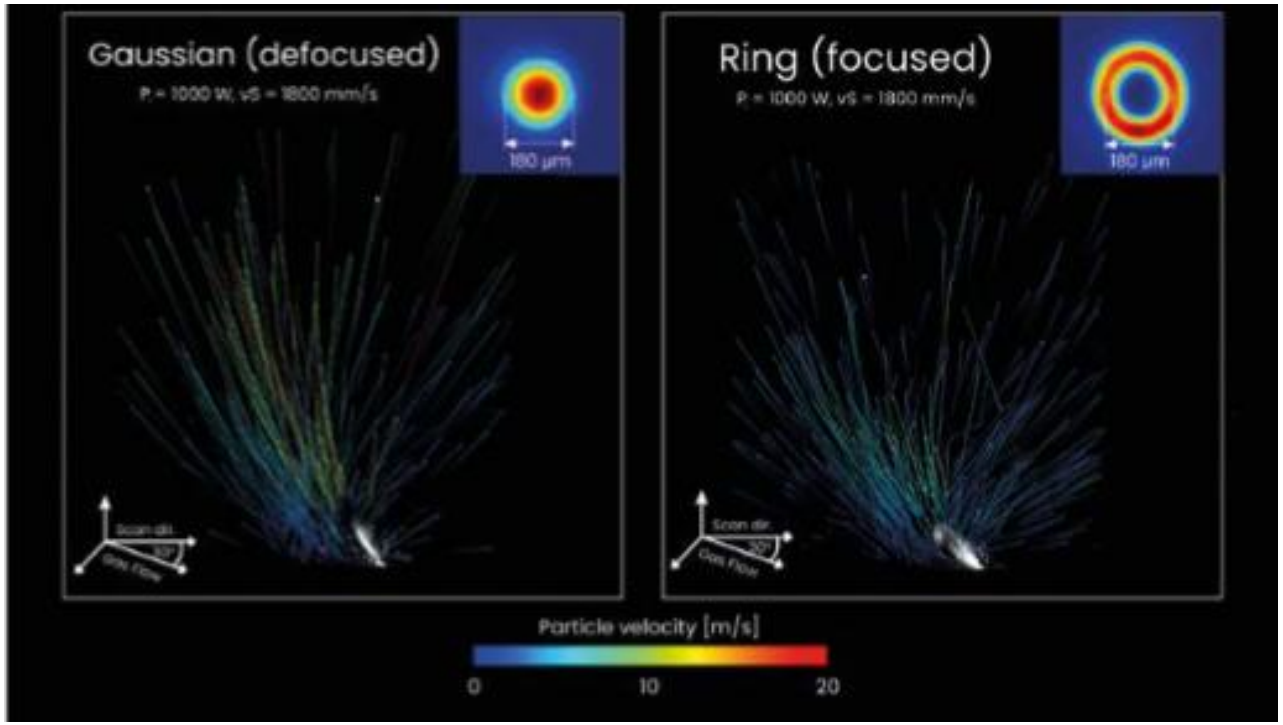


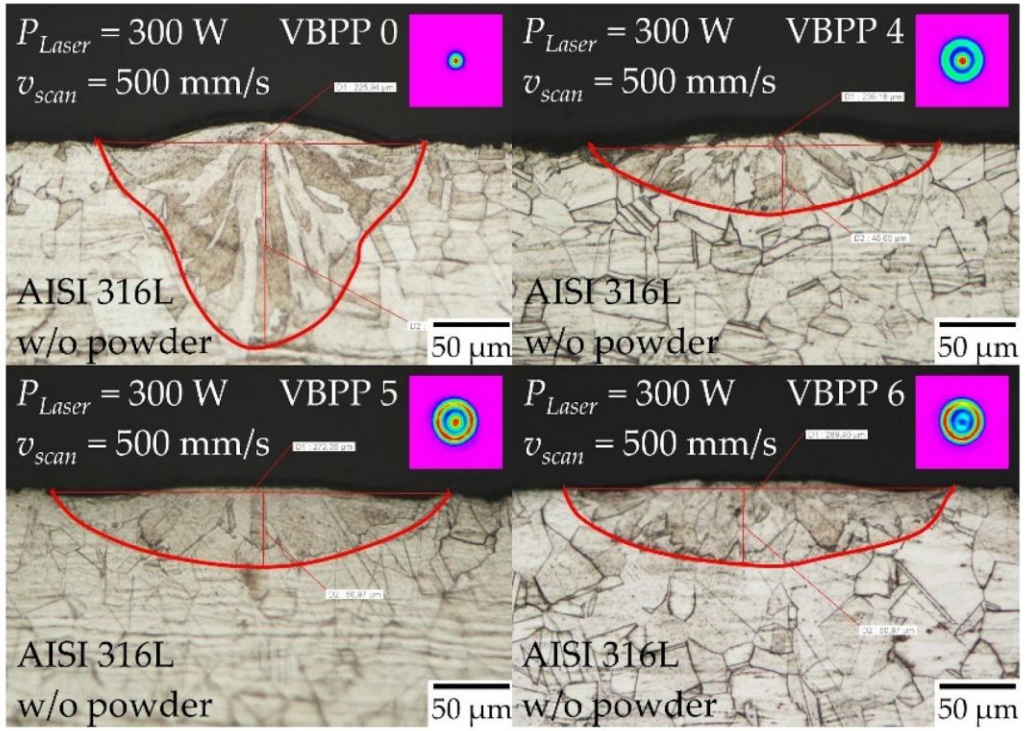

I. Bitharas et al. Nature Communications, May 2022

Chernyshikhin et. al. Materials MPDI 2021

Shi et al. Acta Mat 2020

# LPBF process: Beam shaping

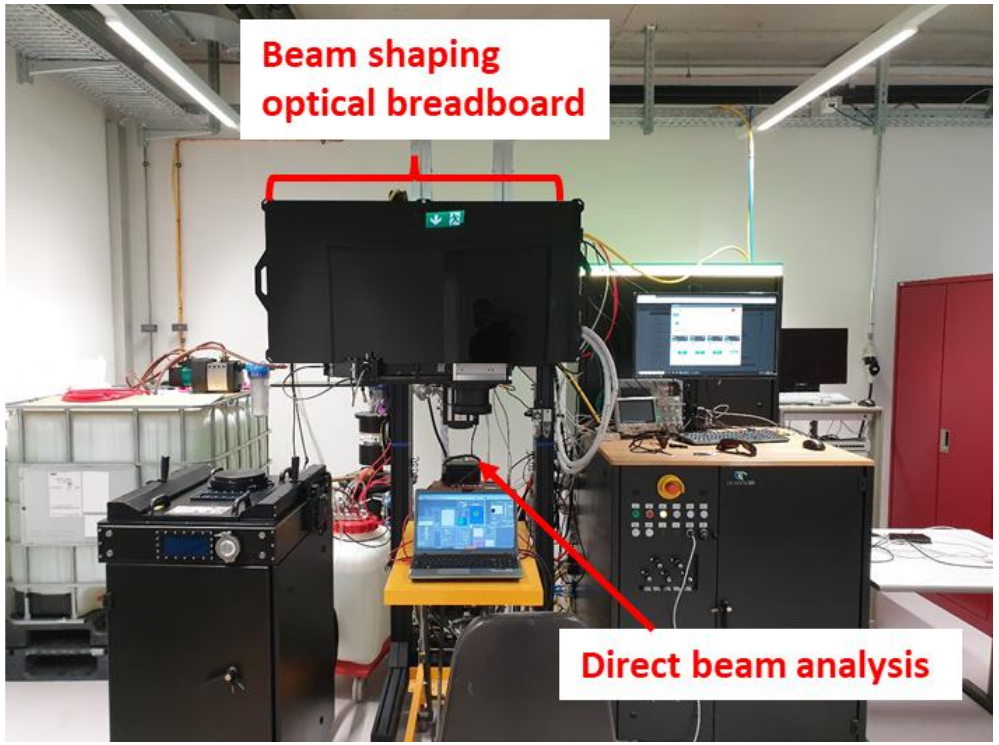



Paillier et al. PhotonicViews 2024
Grünewald et al. Metals 2021

# Beam shaping: from gaussian to freeform laser beam

- **Liquid crystal on silicon for beam shaping technology**
- **300W power handling**

# Beam shaping: from gaussian to freeform laser beam

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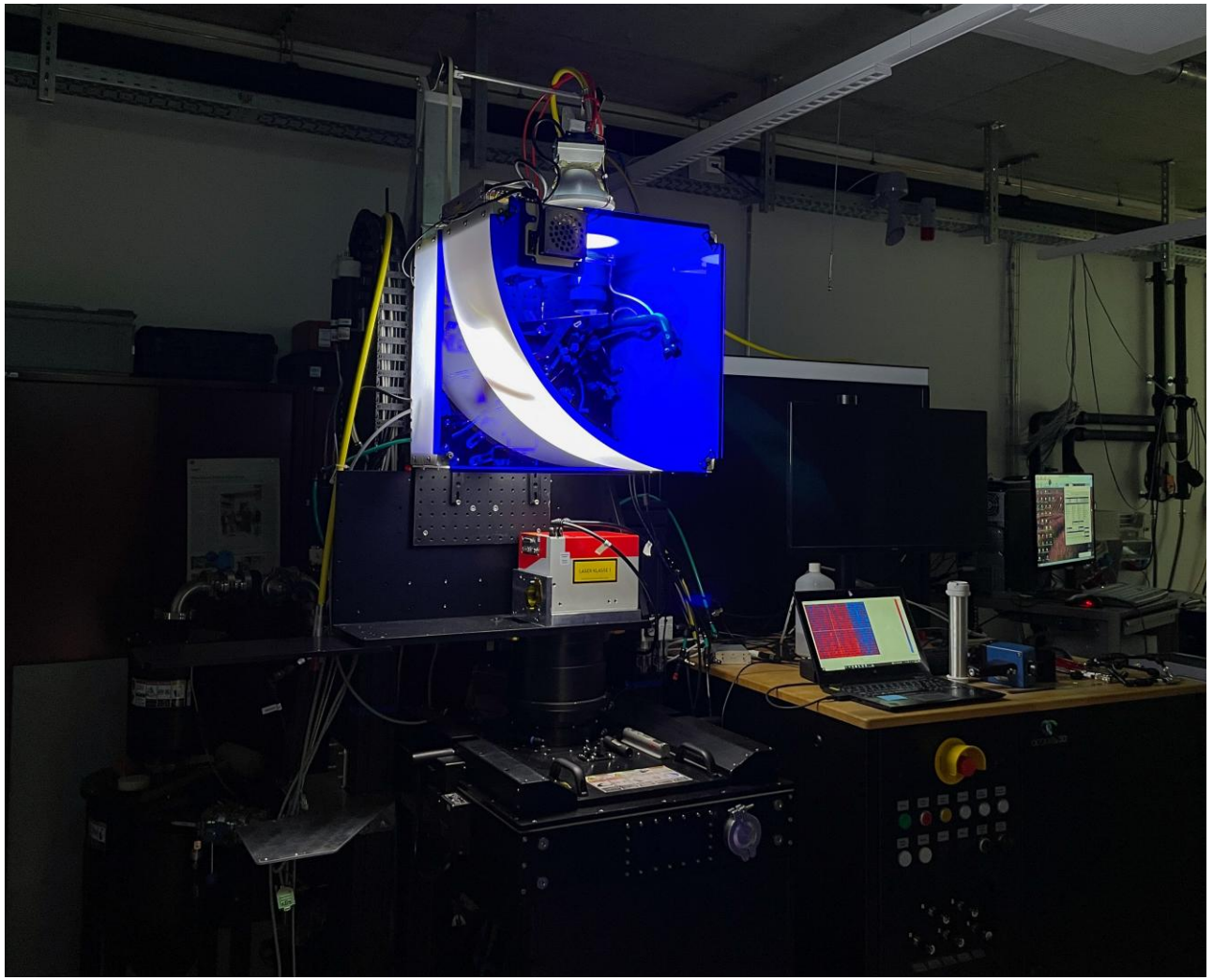
- **Improving total power handling (1KW tested)**
- **Beam rotation and adaptation**
- **High thermal stability of the optical setup**



# IMPACT 4530: Support in industrialization and applications development

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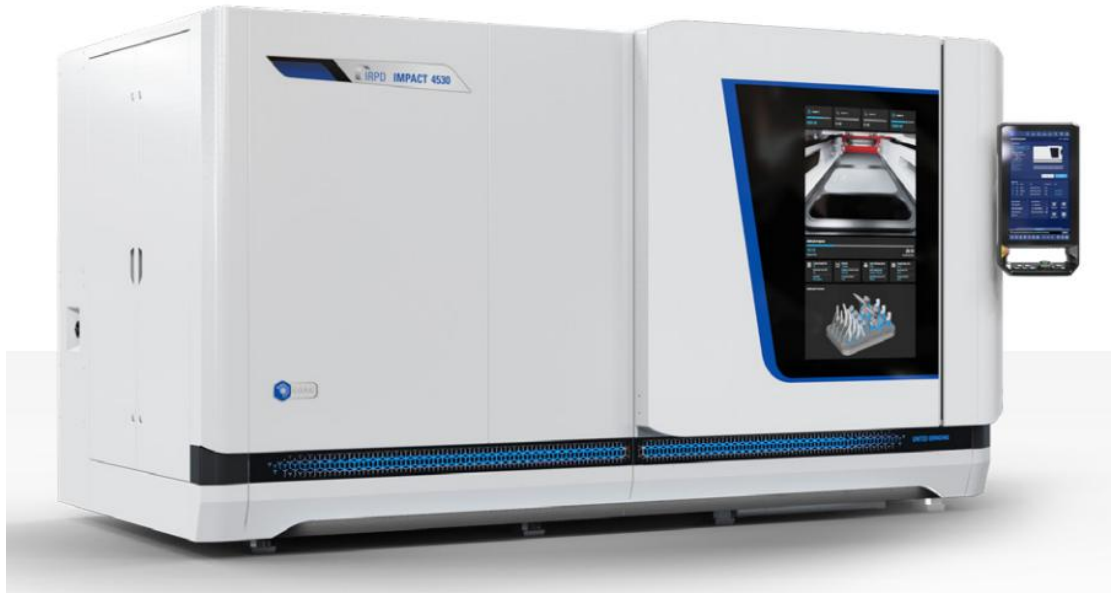
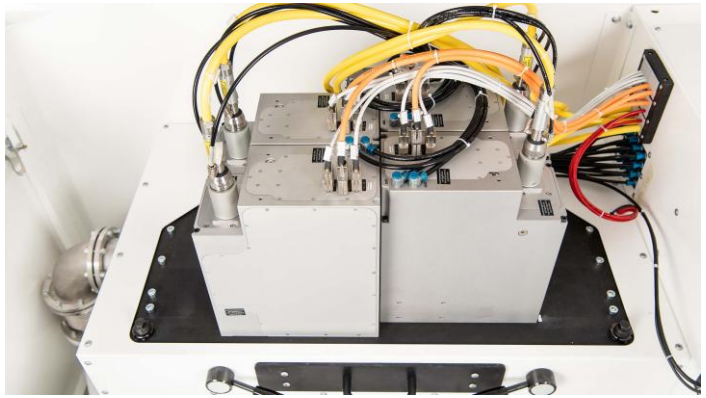
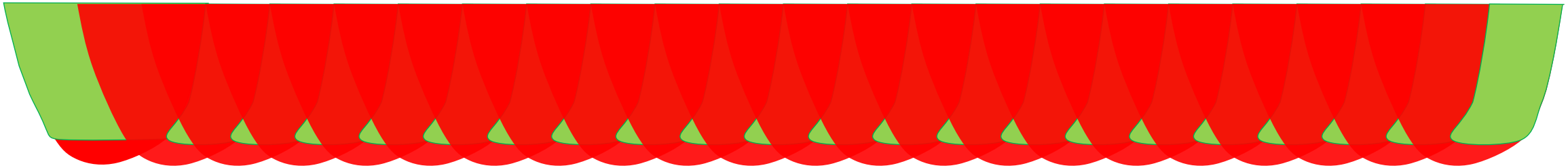


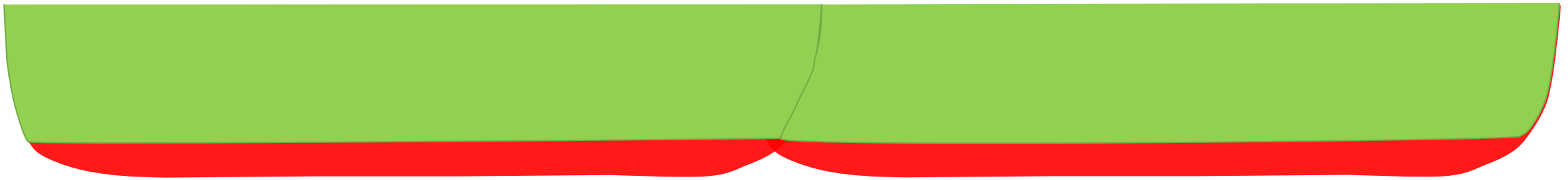



# Modifying the melt pool size and shape

- **drastically increased process efficiency in hatching due to reduced unnecessary remelting ( Green= new added/melted part  Red= Remelting )**



- Hatching distance= **60 µm**
- High overlap to avoid defect



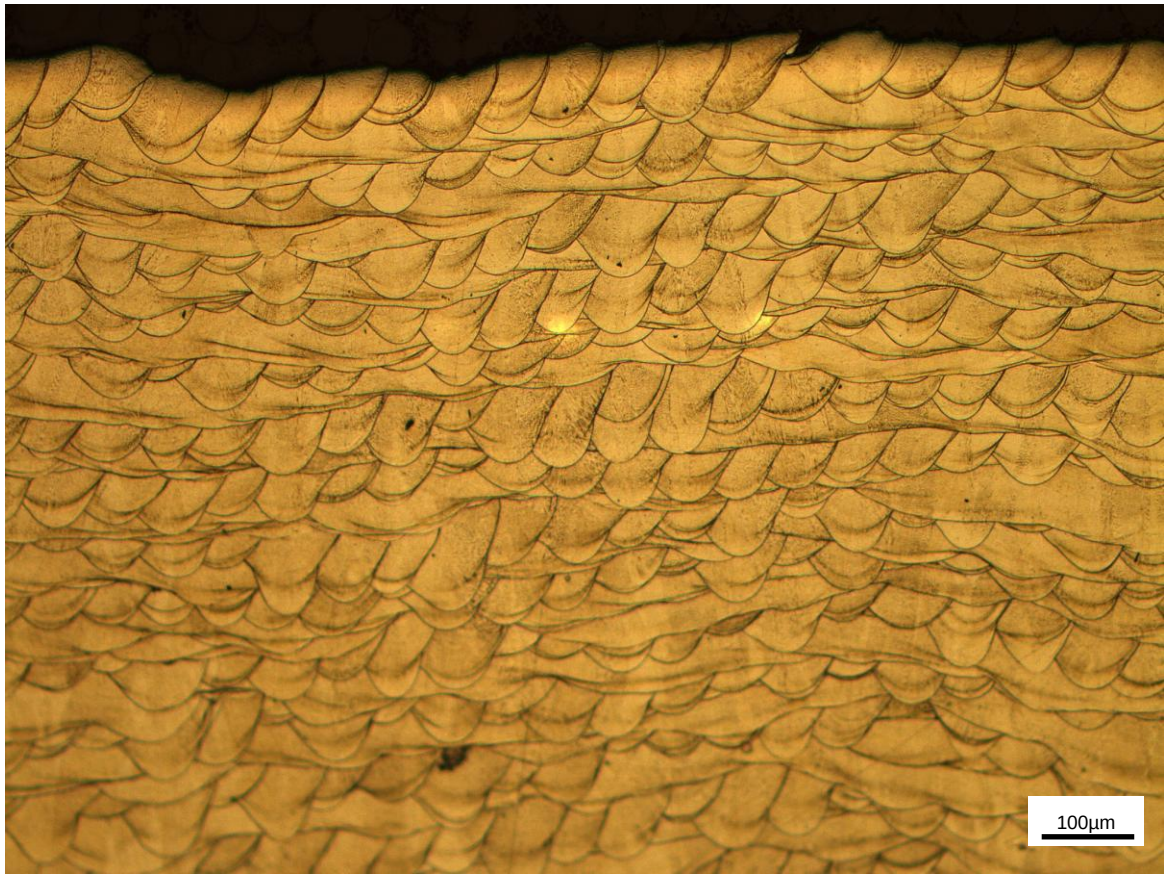
- Hatching distance= **350 µm**
- Minimum required overlap

- Increase productivity
- Reduce evaporation, spatters and defects

# Modifying the melt pool size and shape

- Printed 316L parts

**Gaussian beam**




- Melt pool aspect ratio (width/depth) ~ **1.2**
- More than **140%** remelting of the previous layer
- Hatching distance= **60** µm
- VED = **75** J/mm3

**Shaped beam**


- Melt pool aspect ratio (width/depth) ~ **8**
- About **50%** remelting of the previous layer
- Hatching distance= **350** µm
- VED = **50** J/mm3

# Modifying the melt pool size and shape

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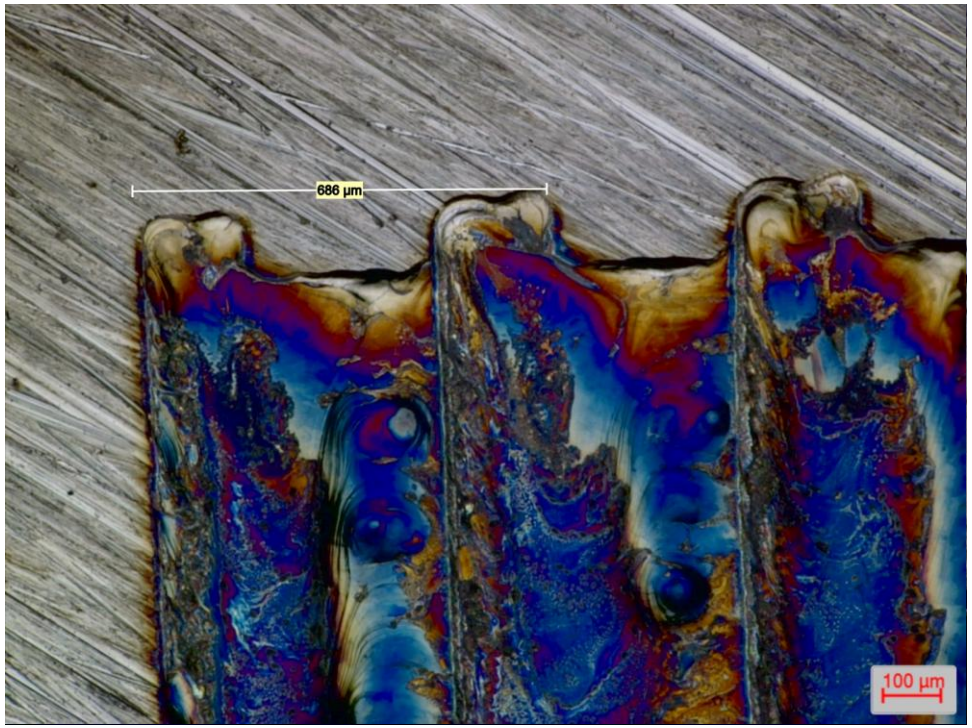
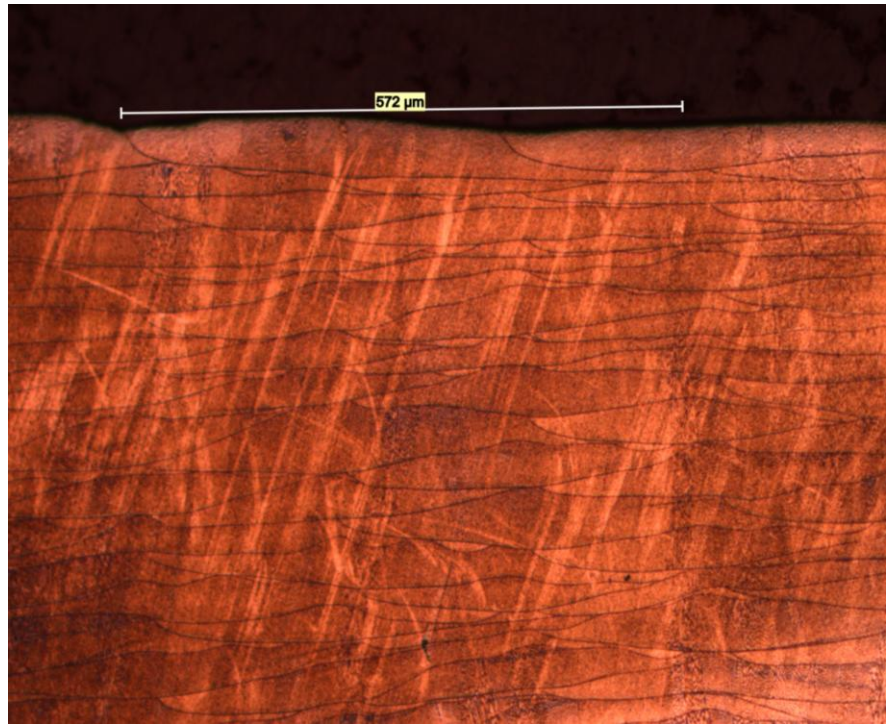
5X productivity improvement




Beam shaping track top view

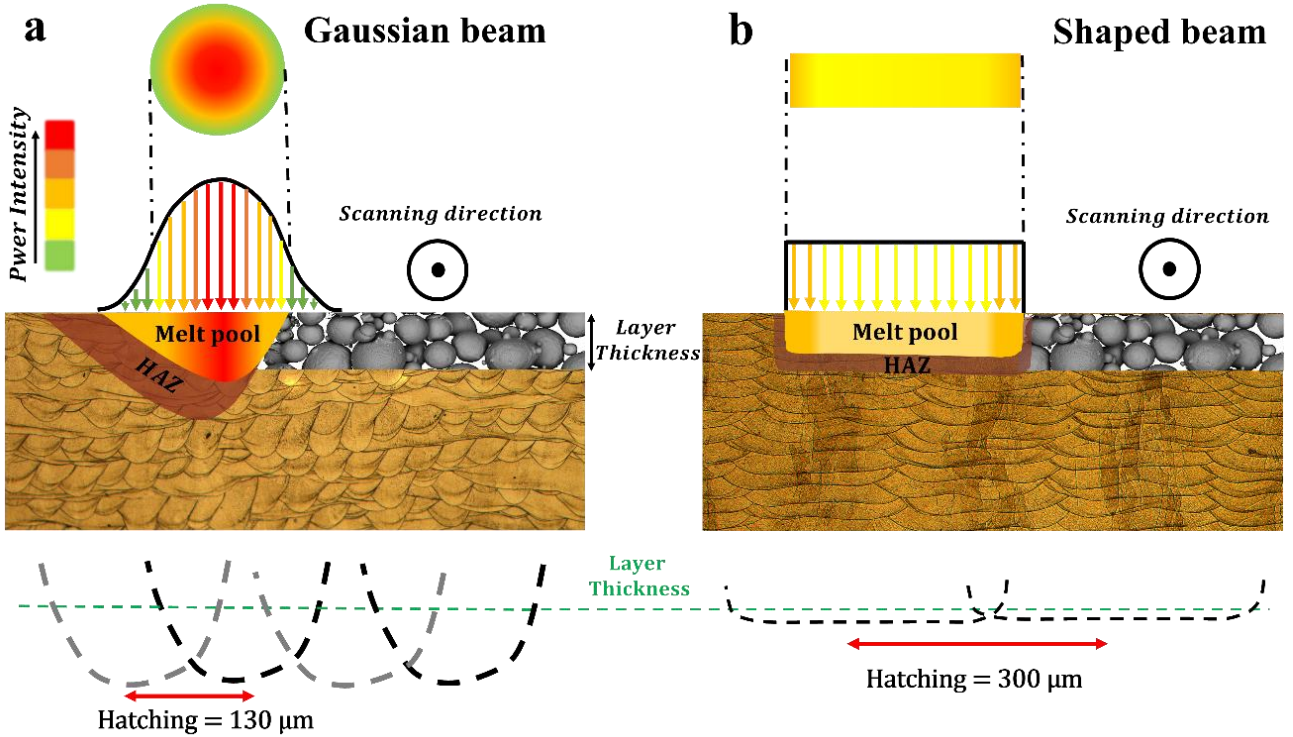

Gaussian single track top view

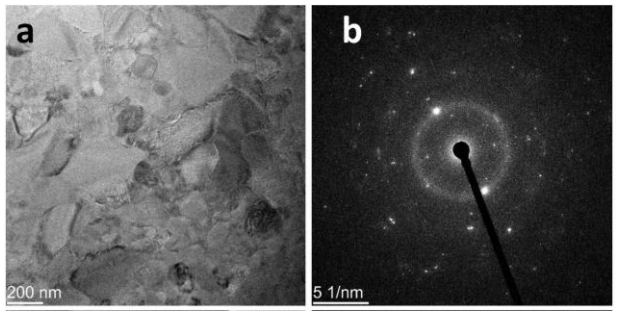


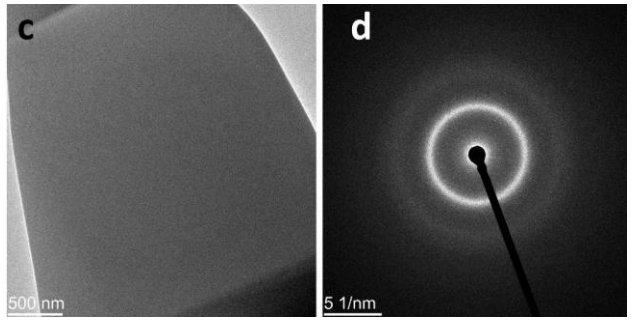

Beam shaping melt pool cross section

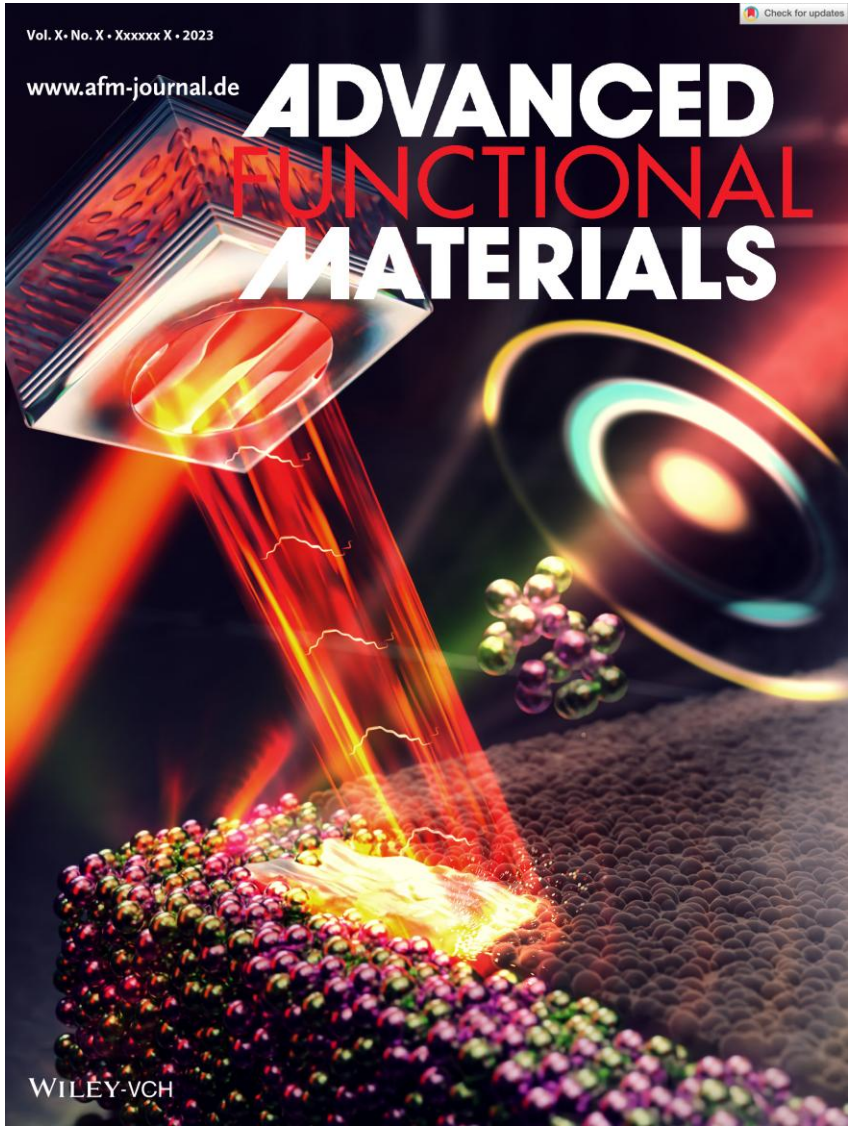
# Additive Manufacturing of BMGs using beam shaping

Bulk metallic glass (BMG) materials offer exceptional physical and mechanical properties such as high strength, elasticity, and corrosion resistance

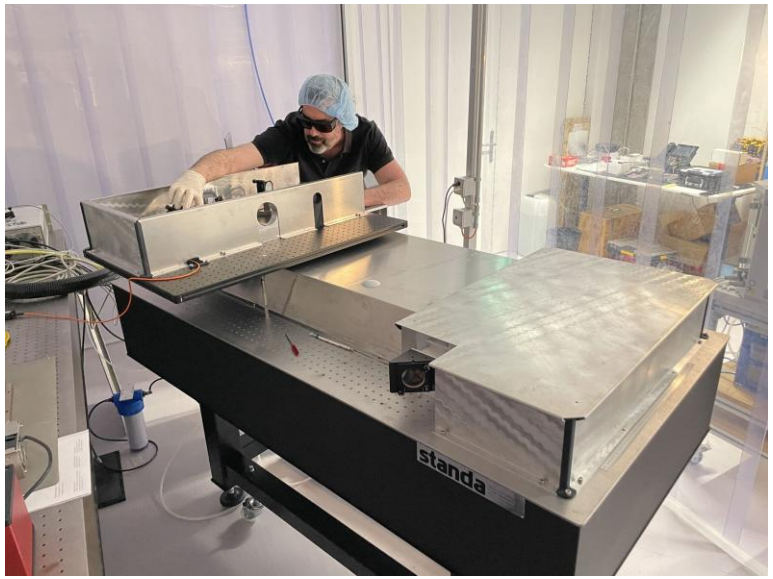


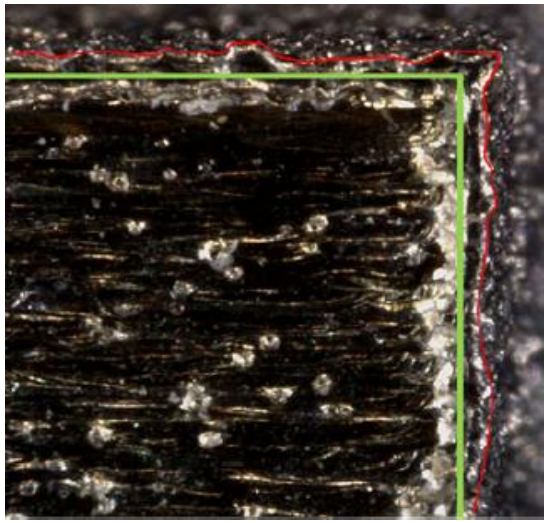



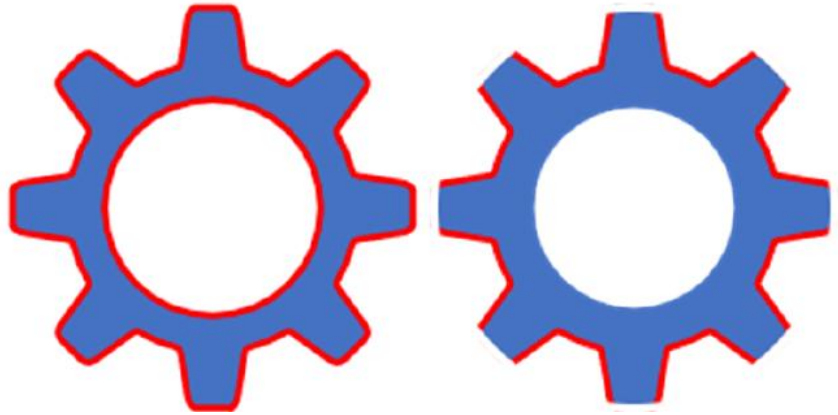



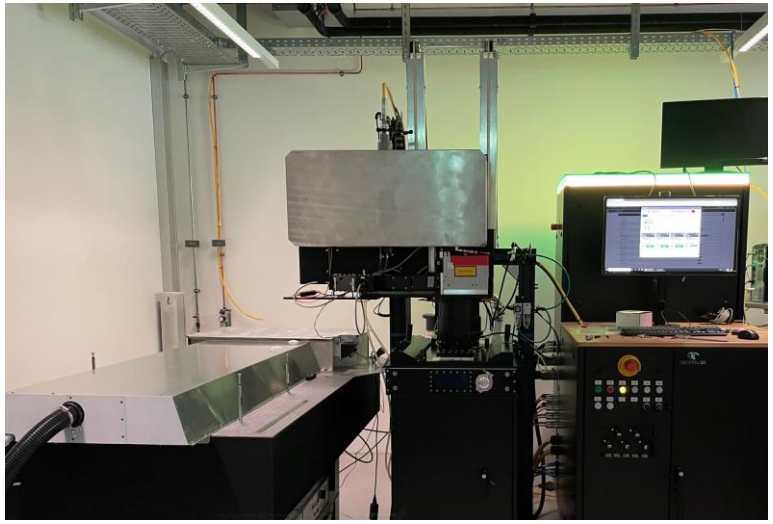



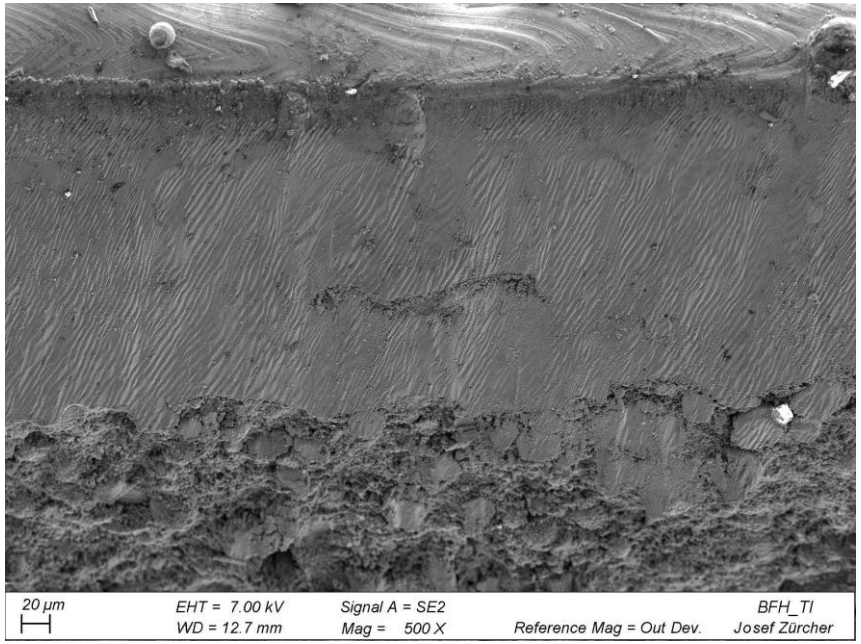
# Manufacturing high-quality net shape geometries











# Blue laser application center

2020
15W@50µm

2022
100W@100µm

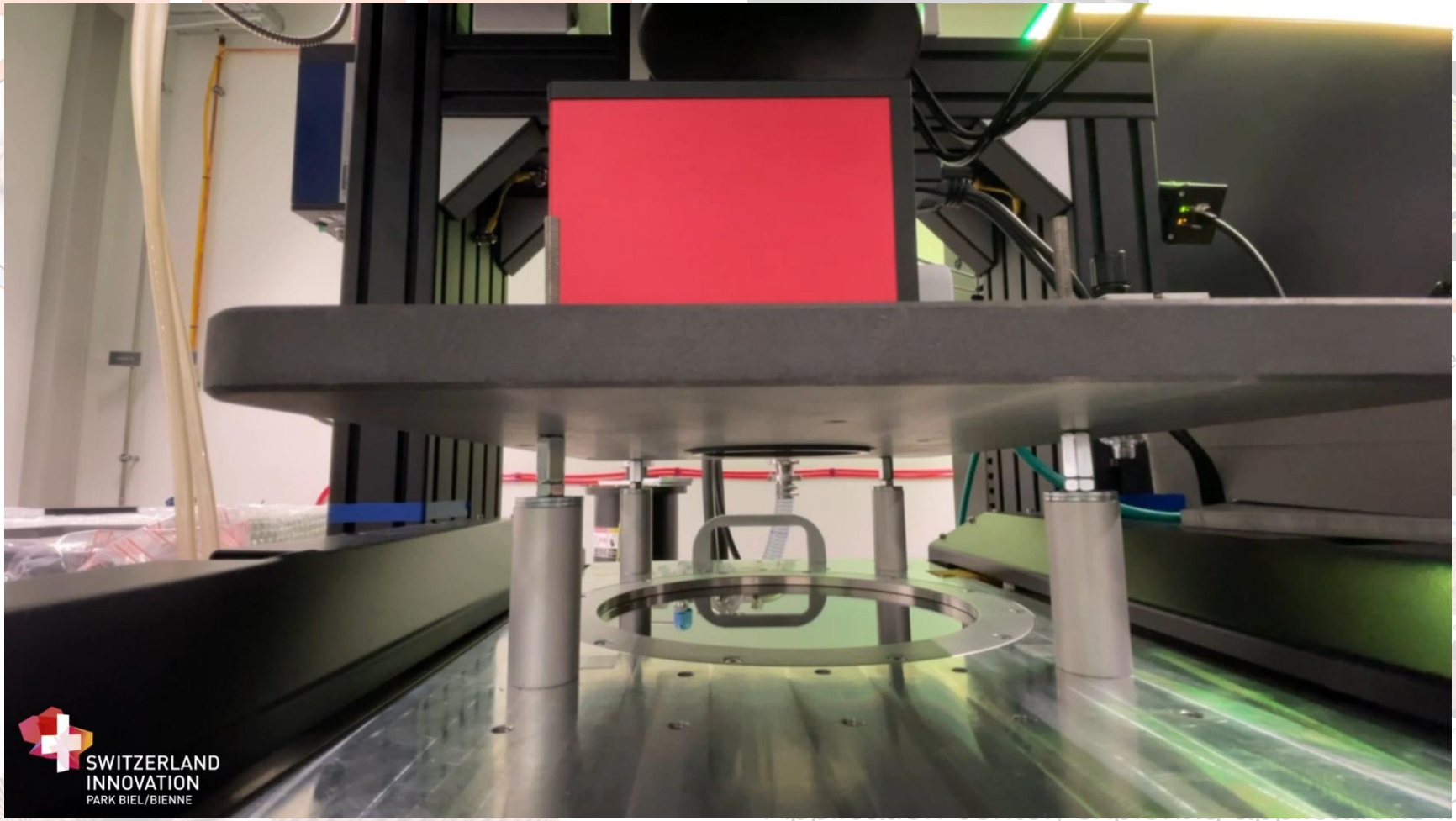
2023 Q4
250W@100µm

Precious metals welding

printing

feasibility

ecious metal welding




3D

different fields
additive manufacturing, welding of dissimilar materials etc.

*Figures are symbolic for potential applications

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# THANK YOU!

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