SMART ADDITIVE APPLICATIONS

EPHJ Workshop Photonics4Masterpieces

Andreas Burn
Head of SAMC
June 13, 2024

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

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**

PARK INNOVAARE
PARK BASEL AREA
PARK OST
PARK ZURICH
PARK BIEL/BIENNE
PARK WEST EPFL

Ligament Healing
Noninvasive Neurostimulation
Medical 3D Printing
Ageing well
Medical imaging in Augm. Reality
Anheurism monitoring
Medical Training
Reha Robotics
MOWA – Modular Walking Orthesis
In-vitro testing platform

Swiss Advanced Manufacturing Center

Swiss Battery Technology Center

SWITZERLAND INNOVATION
PARK BIEL/BIENNE

Innovation ecosystems at SIPBB

iBATT
66 members

Companies at SIPBB

SSF association
~80 mebers

Program

5th INTERNATIONAL SMART FACTORY SUMMIT

Elevating Skills, Empowering Innovation:
Smart Factories for a Sustainable Future

12th-14th June 2024
Biel/Bienne, Switzerland

In collaboration with

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

Swiss CxO Forum

AMTTC – Advanced Manufacturing Technology Transfer Center

Technologies and Topics at SAMC

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
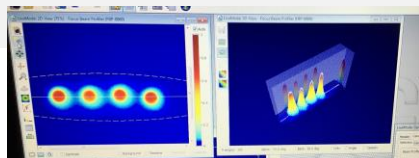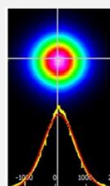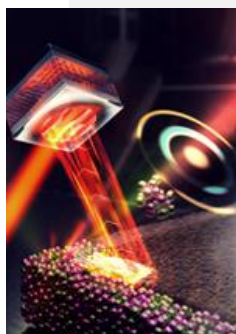
PROCESS MONITORING & CONTROL

- welding process monitoring
- control of process conditions
- control of material properties
- transfer of technology
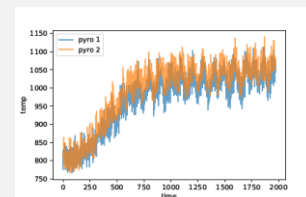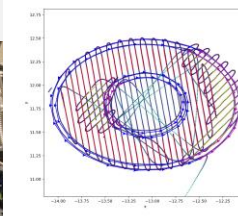
SMART PRODUCTION

- Design for AM
- Smart process advisory
- De-localized production
- MaaS in metal 3D Printing
- Circular supply chains & design for circularity
- Production companion, remote upskilling
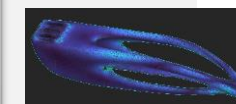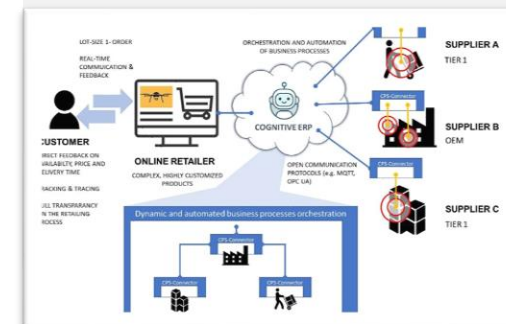
"Twinning to build an industrial ecosystem around the core principles of Industry4.0 and the Digital Twin"
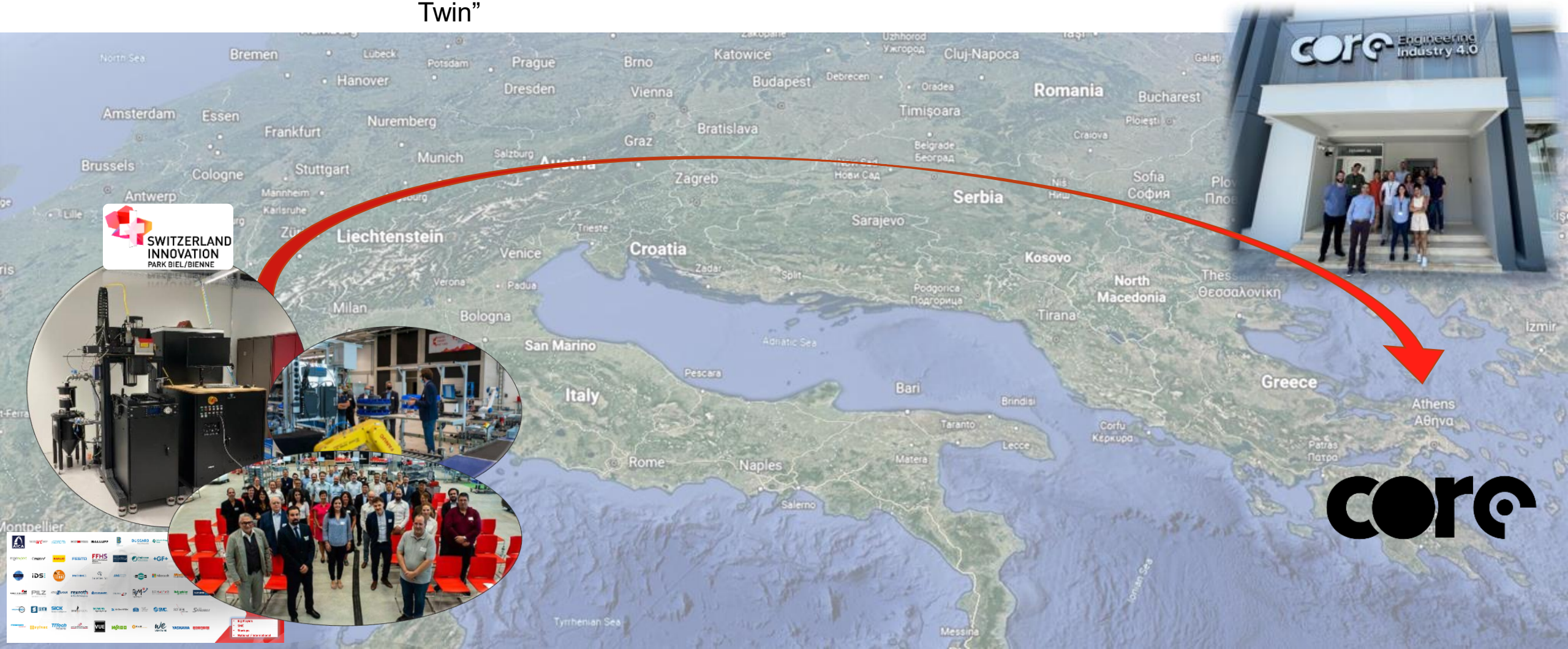
Laser Powder Bed Fusion

Different processes

..on different timescales

→ difficult to monitor efficiently
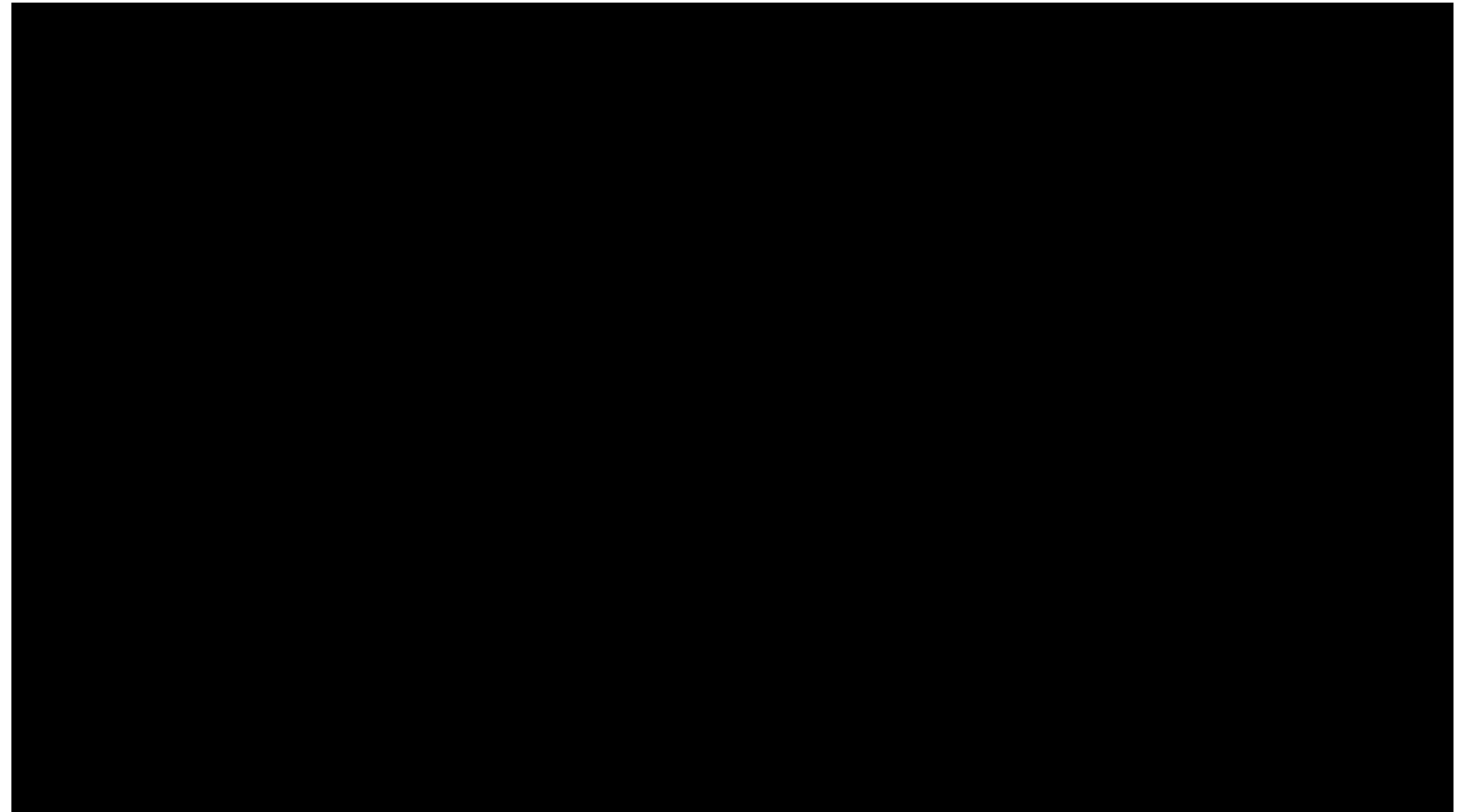
Digital Twins in a MaaS Scenario

- Typical: end-user, OEM, and producer are different entities
- …in different locations
- How to guarantee a certain quality level? and who is responsible?

- Digital Tools
  - Digital Twins of Processes and machines
  - PaaM, thermomechanische Simulation
  - gnereic description of processes – global DTs
  - exchange of data upstream and downstream
  - AR agent-based digital instructors and companions
  - DPP

Global digital twin
representing the manufacturing technology
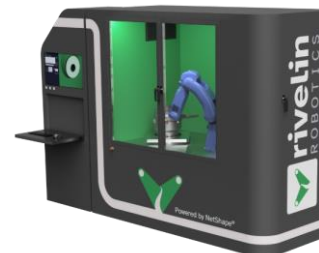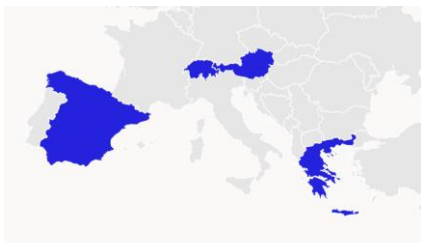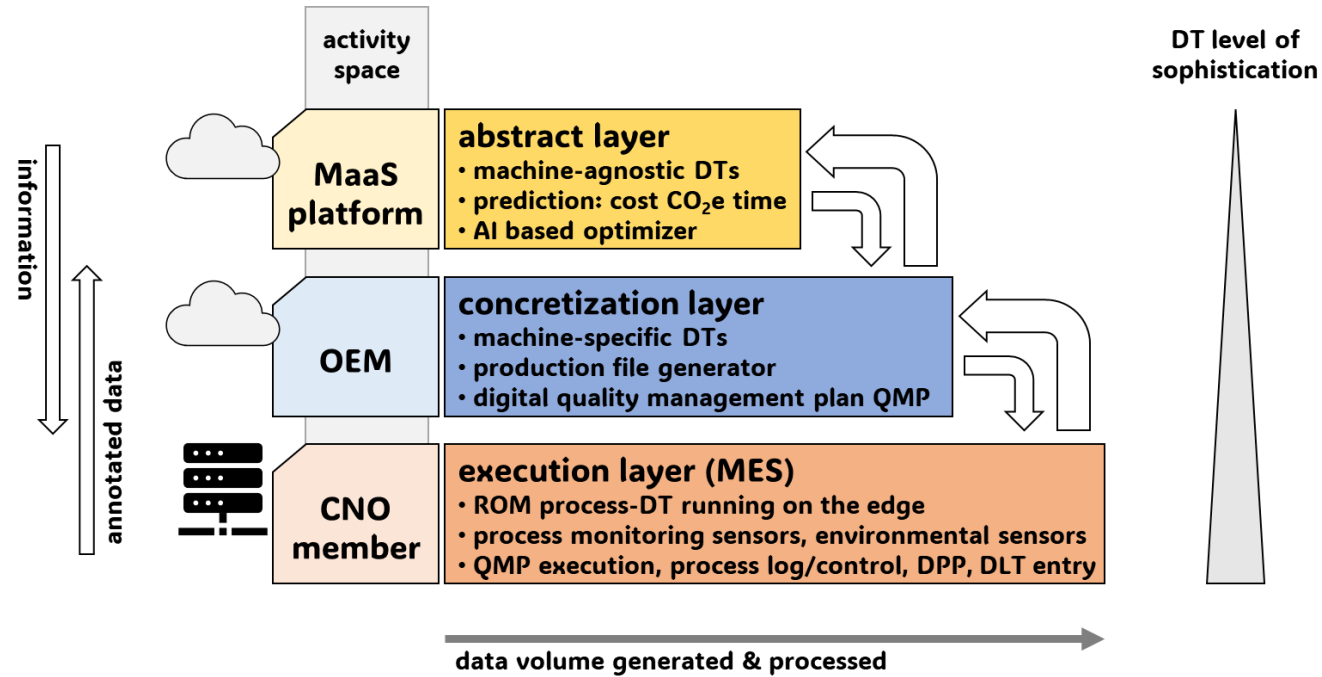
robotic post processing
with integrated measurement

Global Digital Twin

- Represents the main characteristics of a manufacturing technology

  - allows to predict range of scope 1-3 emission

  - predicts production time and cost

  - predicts part distortion

  - sets minimum technical requirements on equipment

  - can be used in simulation of circular supply chains
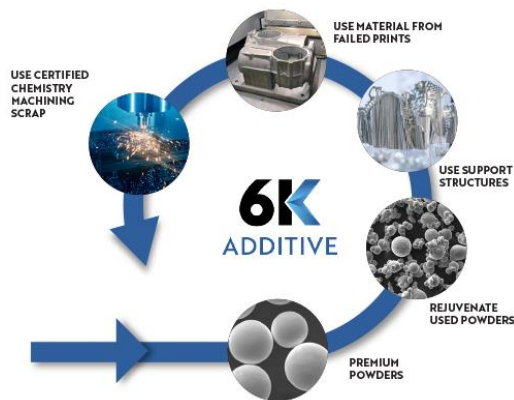
DT best practice atlas:
https://digital-twin-atlas.com
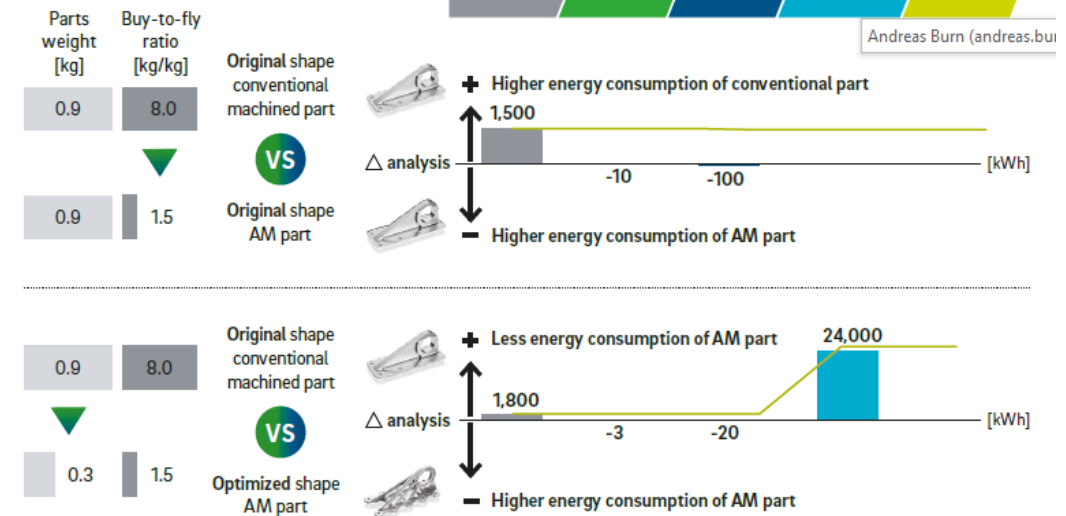
Machine specific digital twins reproduce specific properties of one machine

- predicts part quality and exact production time

- allows optimizing the result based on real laser scan path
  - strategy
  - planned density

- deformation reduction and compensation

- detection of defects

PaaM a digital production companion
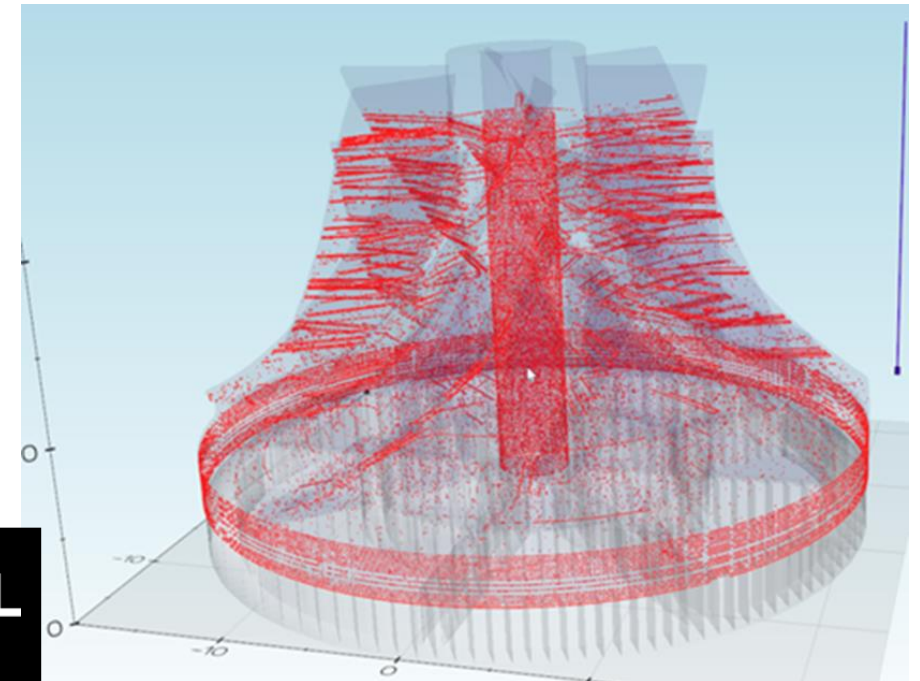
Trajectory analyzer

No filtering of vectors
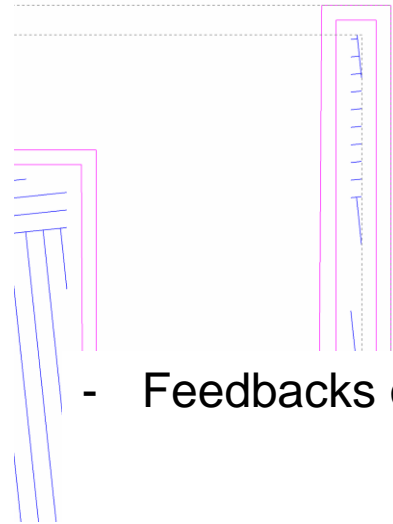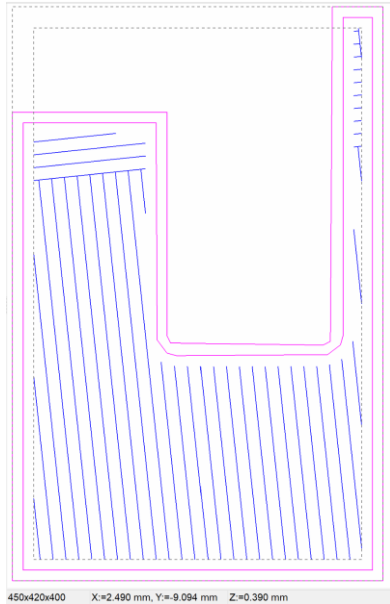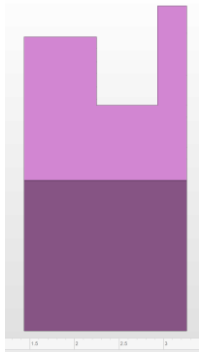
- Feedbacks on big data
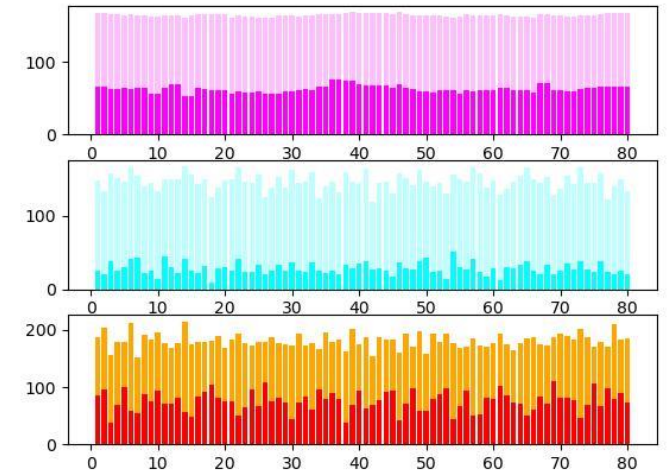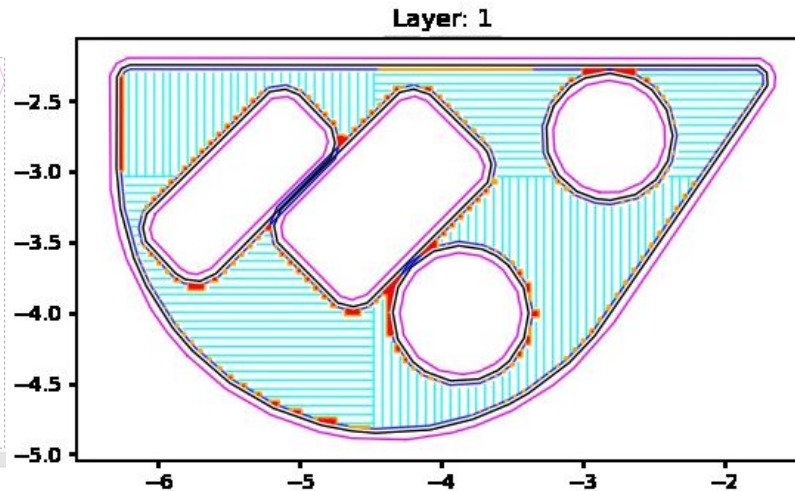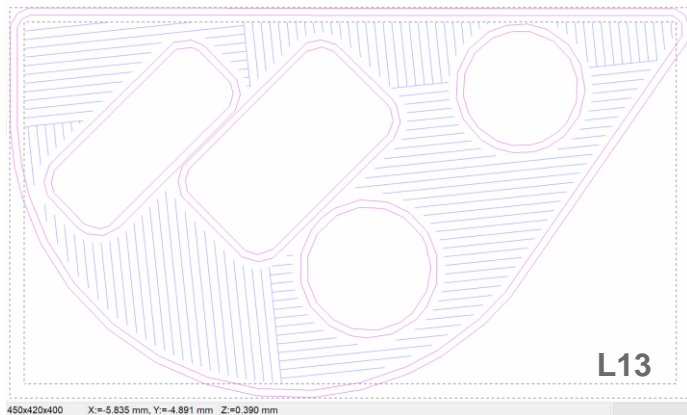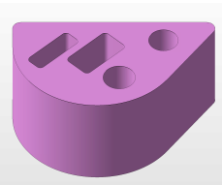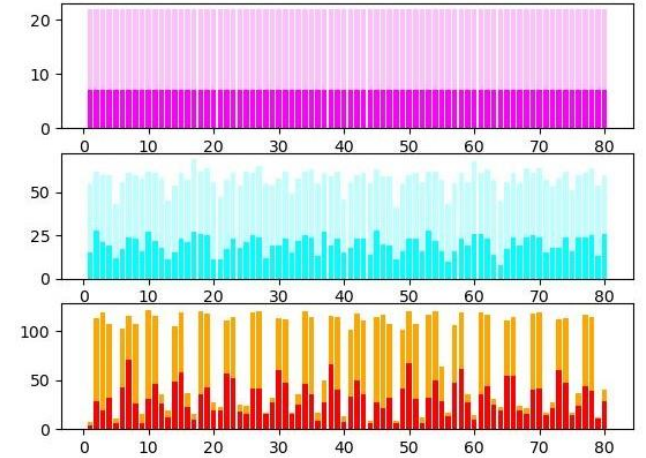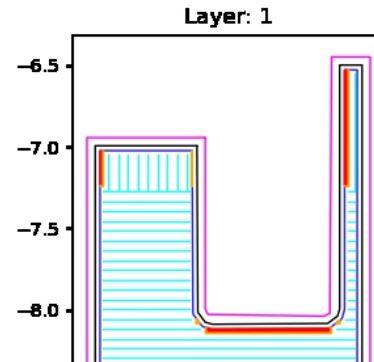
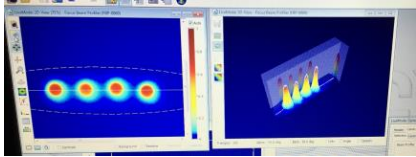# modular LPBF platform – create more free parameters

Customized optics and laser

Laser trajectory analysis
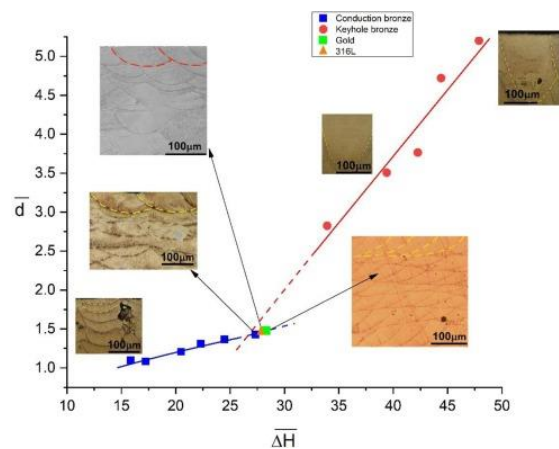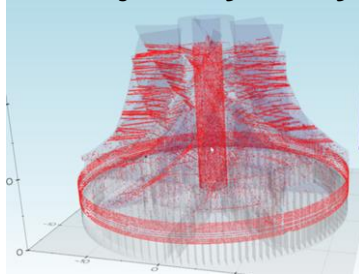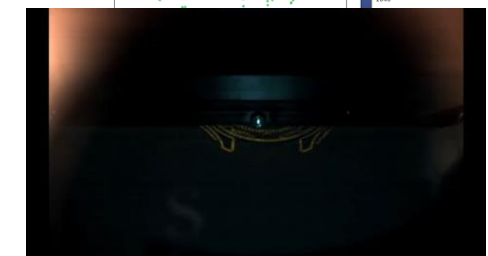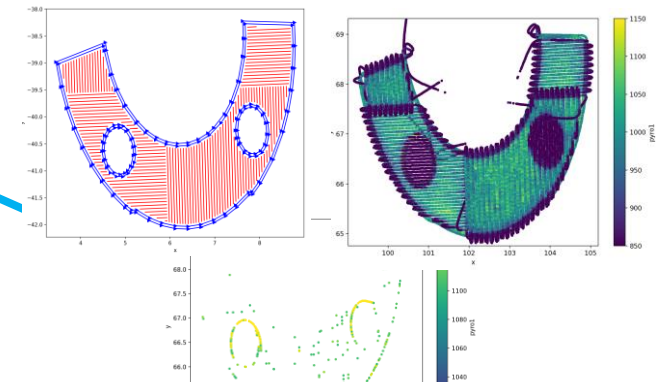
Pre-heating up to 800°C for stress reduction
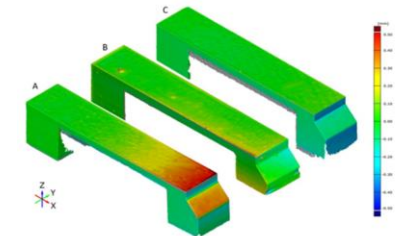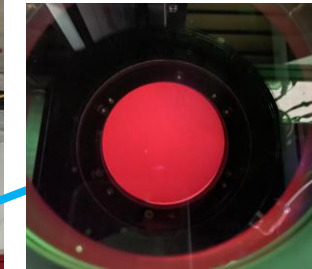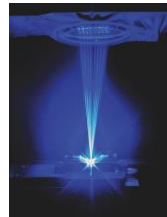
Figure 19. 3D scanned printed Ti6Al4V parts in different conditions: A)as built, B) modified support structure, and C) 800 C° in-situ heating.

Translation rules (Ghasemi et al.)
Validated for Ti64 with pre-heating

Support free printing

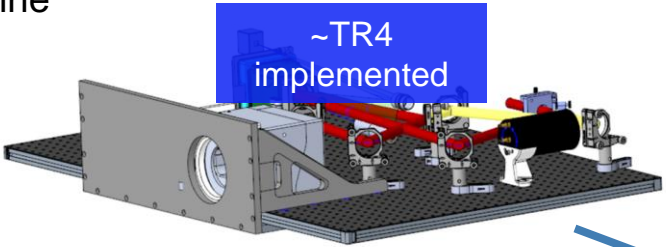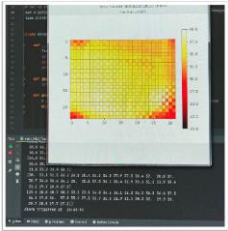**Process monitoring and control data analysis**

Main Technology Bricks in the LPBF Beam Shaping Collaborative Project

beam shaping engine
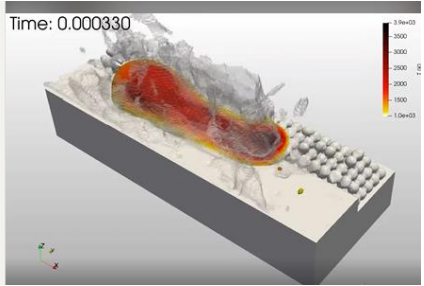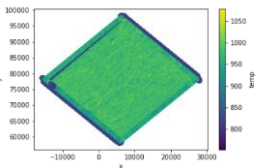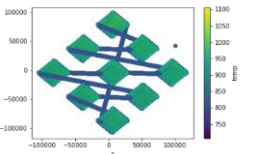
~TR4 implemented

hologram calculation
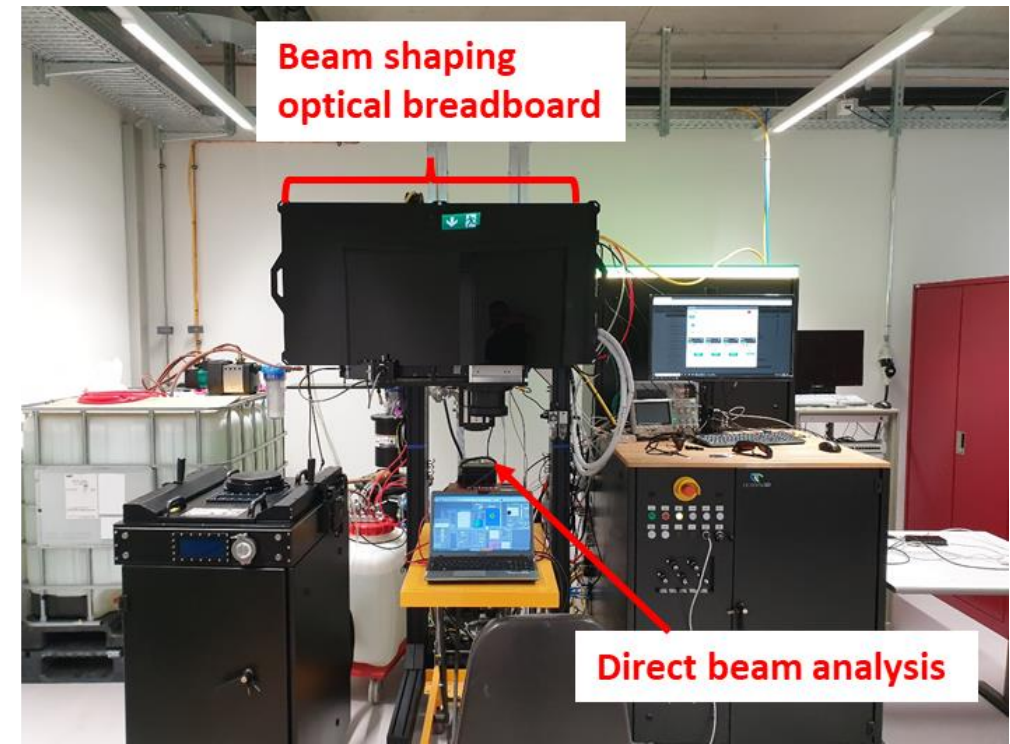
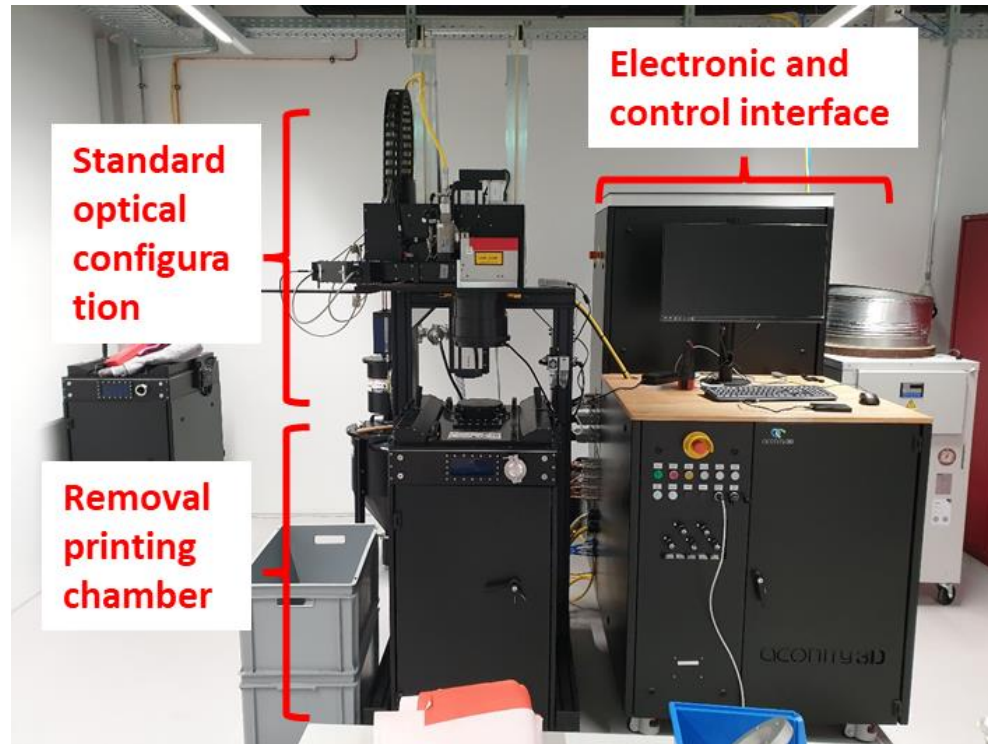monitoring of shaper operation state

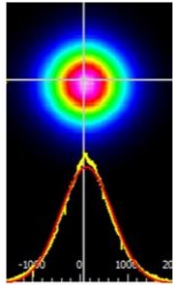simulation verification

LPBF process monitoring

Beam shaping: from gaussian to freeform laser beam

Standard optical configuration

Removal printing chamber

Electronic and control interface

Beam shaping optical breadboard
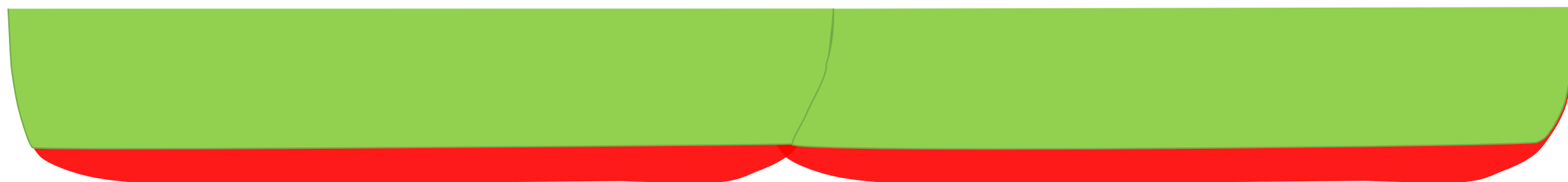
Direct beam analysis

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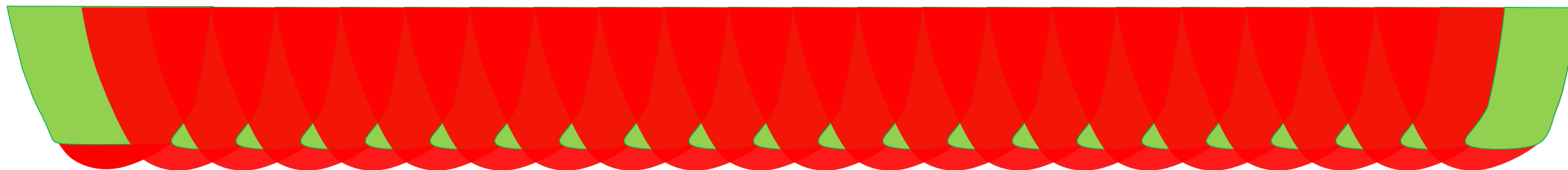
- Hatching distance= **60 μm**
- High overlap to avoid defect

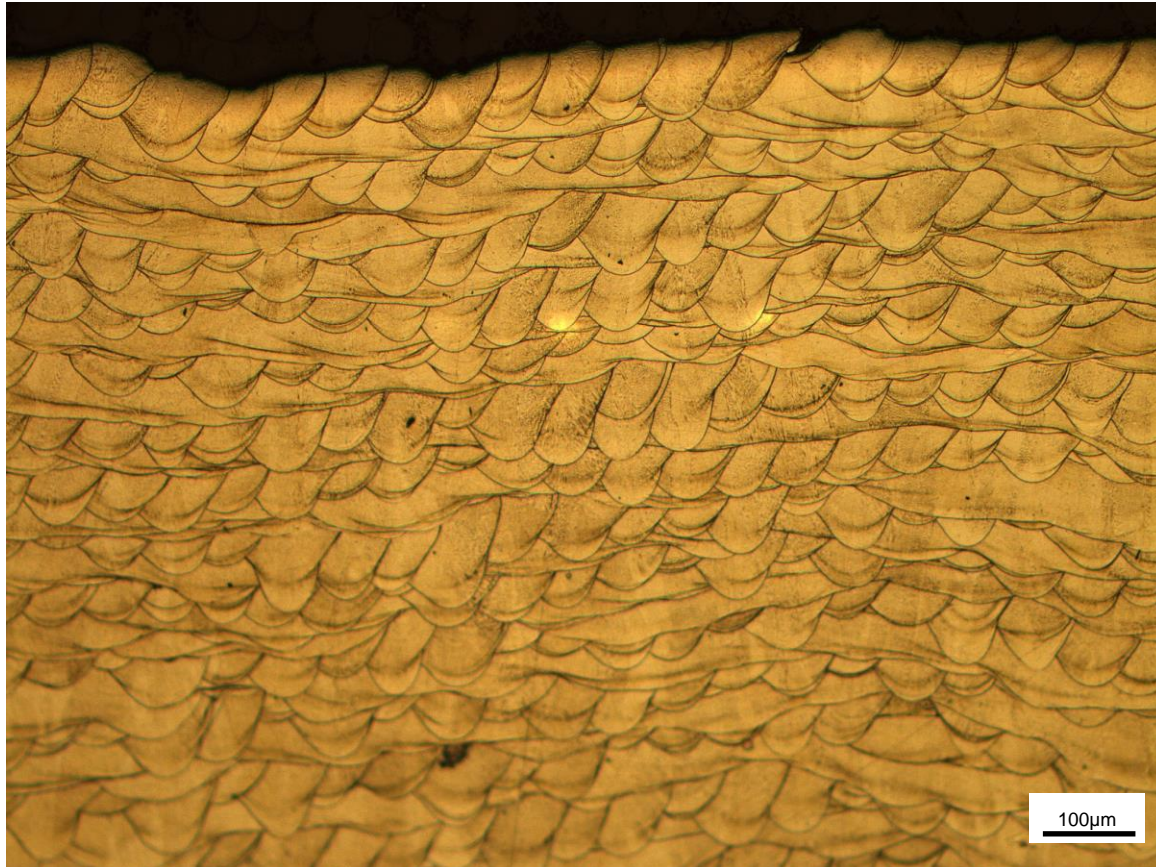- Hatching distance= **350 μm**
- Minimum required overlap

- Increase productivity
- Reduce evaporation, spatters and defects

Modifying the melt pool size and shape

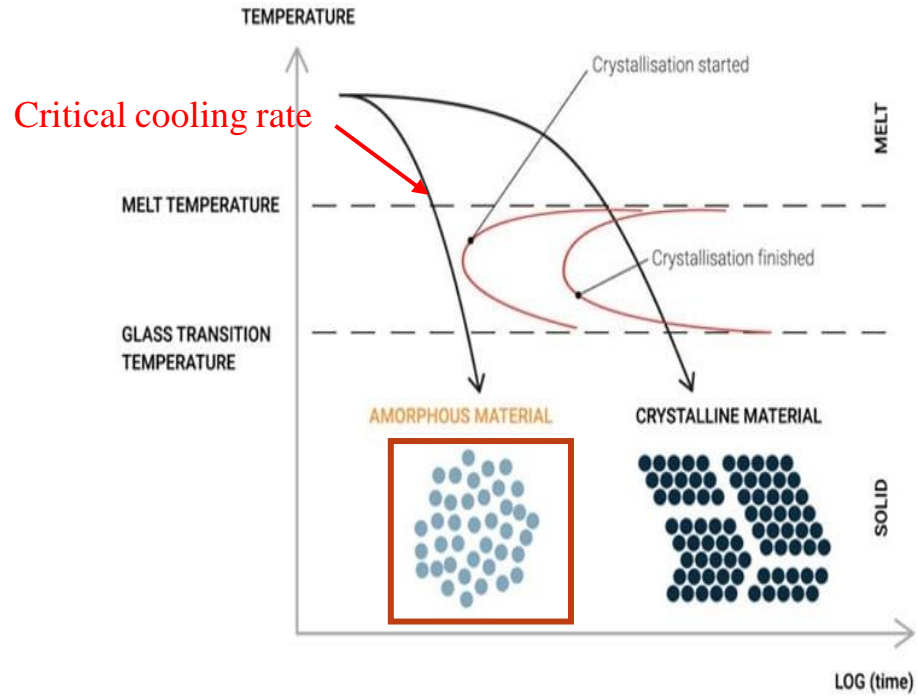- Printed 316L parts

Gaussian beam   **Shaped 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

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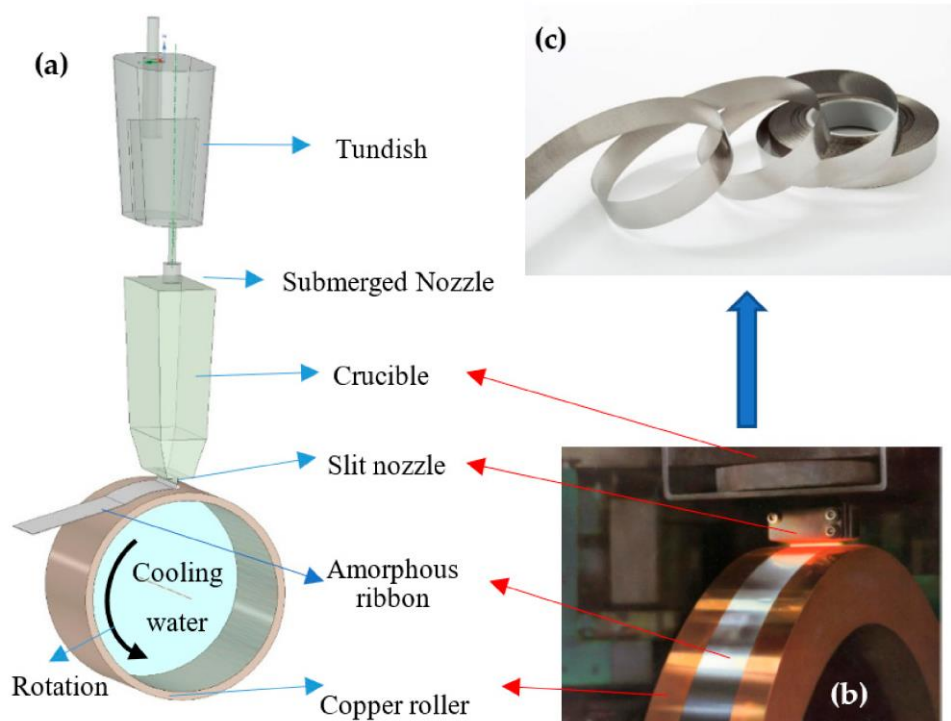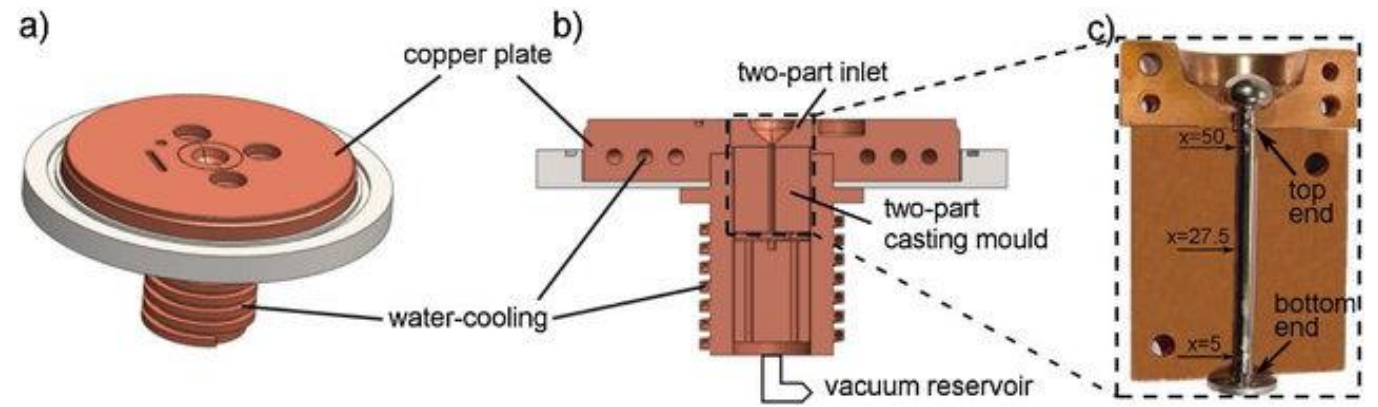- VED = **50** J/mm3

BMG- Atomic structure

Critical cooling rate

Steel surface   **BMG surface**

Yu Liu et. al, 2022
Tomasz Kozieł et. al, 2020

Manufacturing Process

Why LPBF of BMGs?

Time = 0.000000
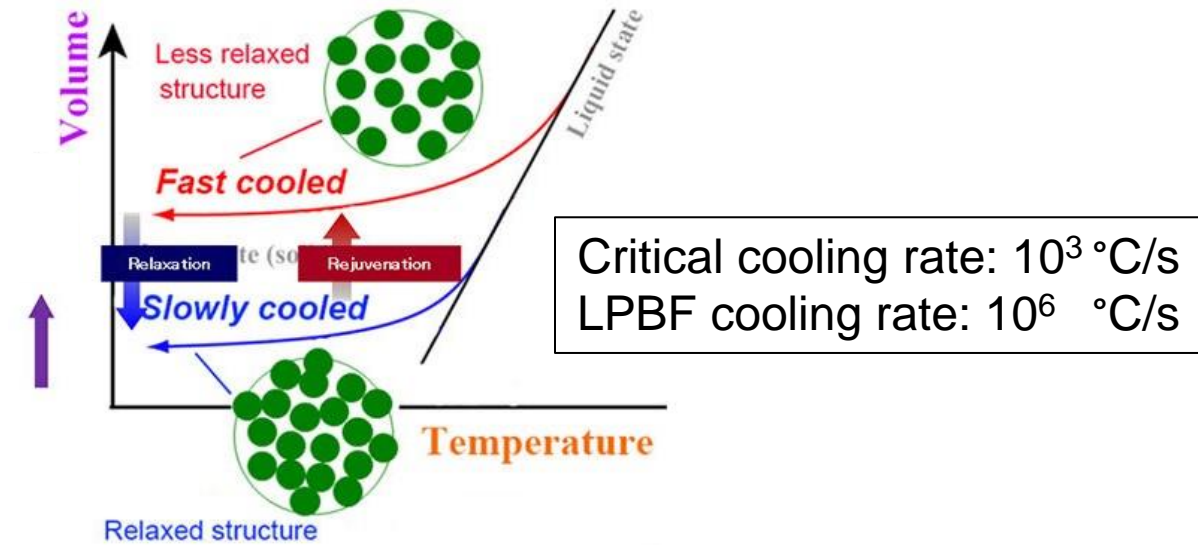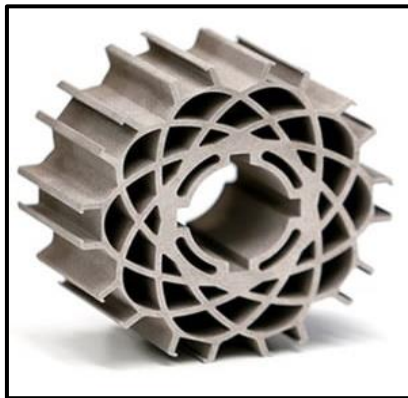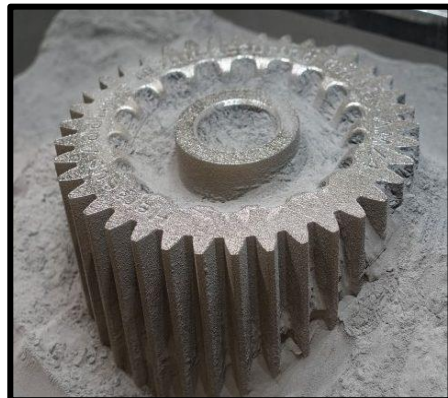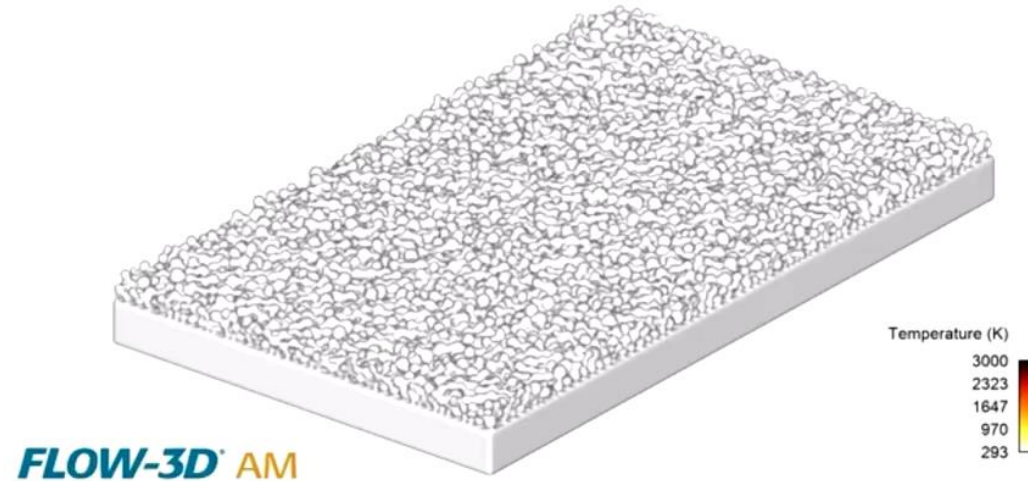
FLOW-3D AM

Temperature (K)
3000
2323
1647
970
293

Critical cooling rate: 10^3 °C/s
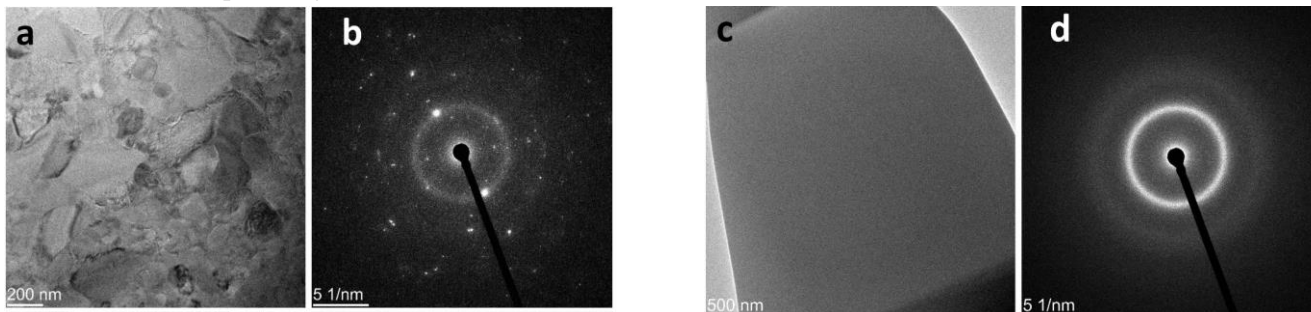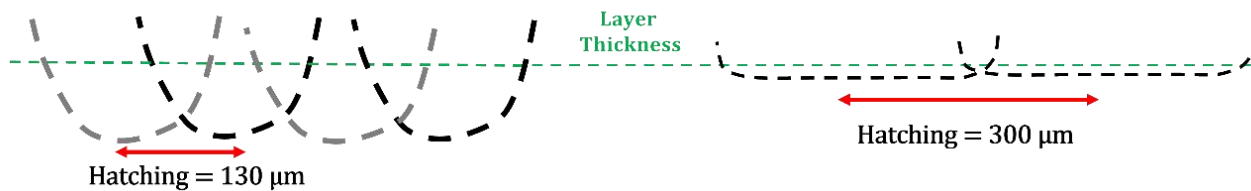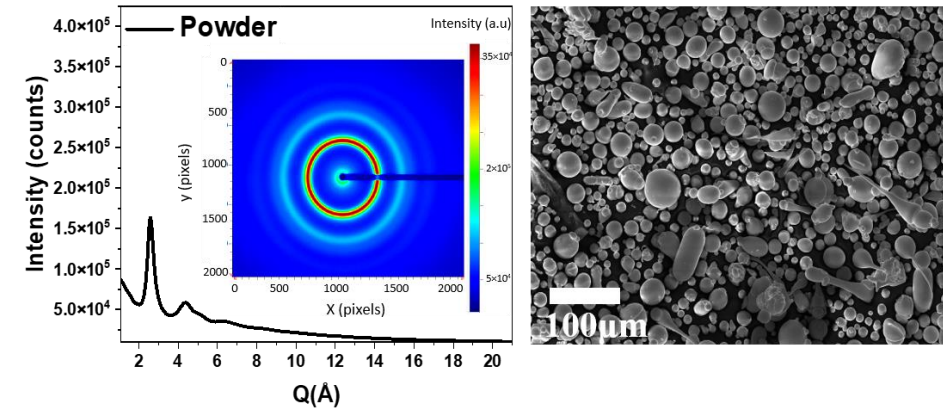LPBF cooling rate: 10^6 °C/s
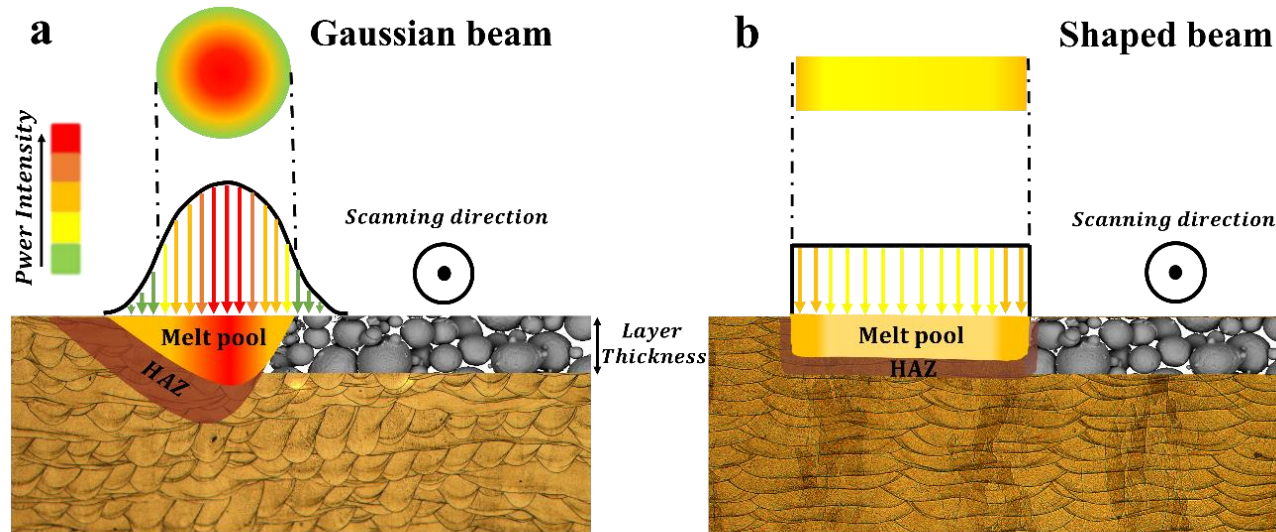
Wookha Ryu et. al, 2020
3D printed part with Exmet technology

19

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
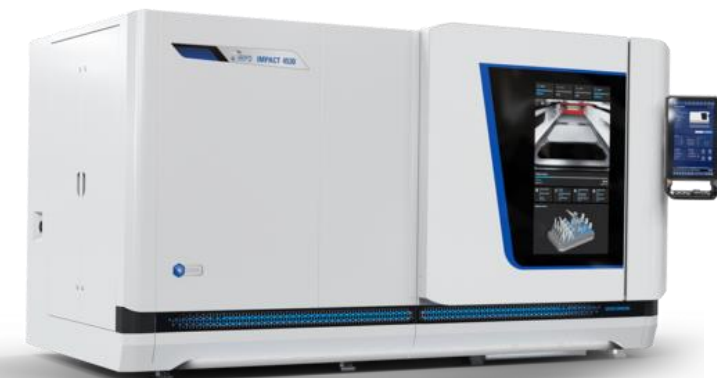
IRPD IMPACT 4530

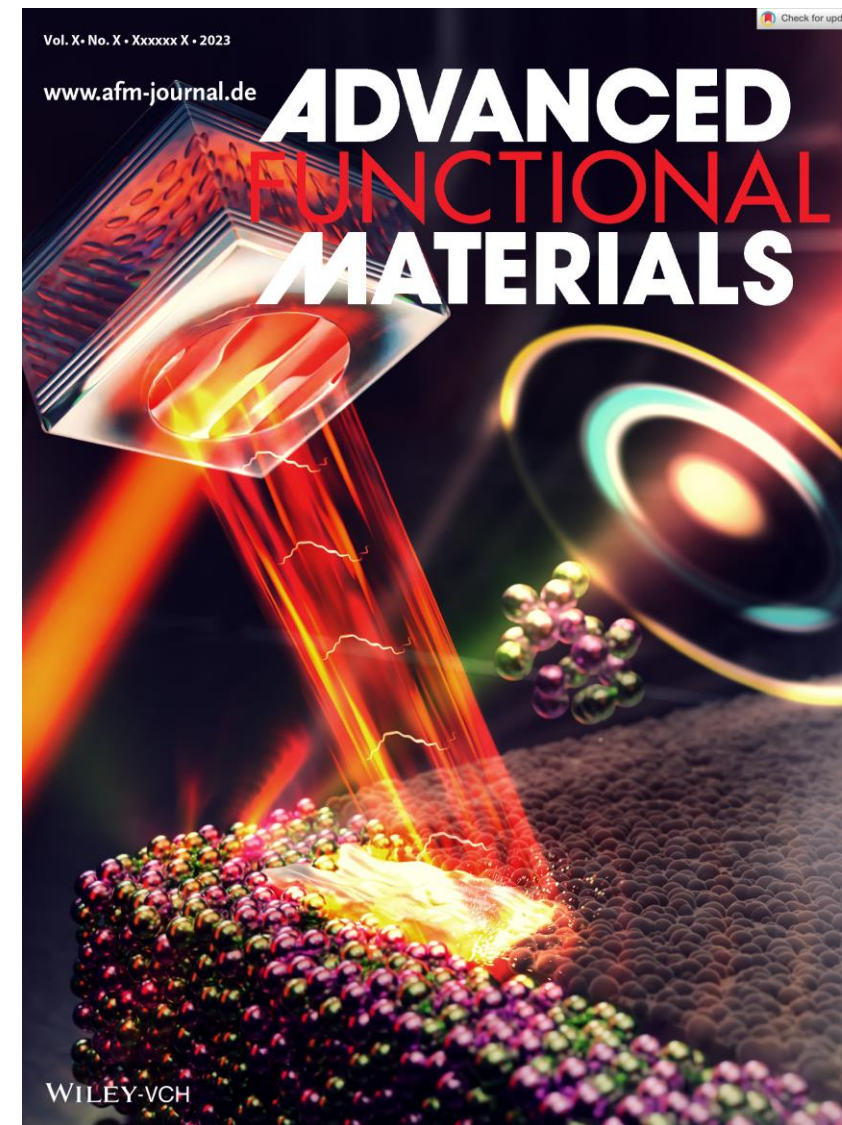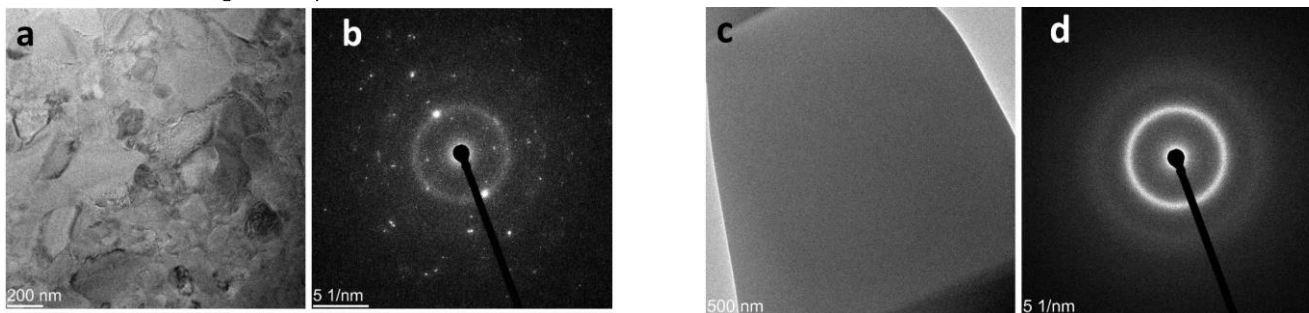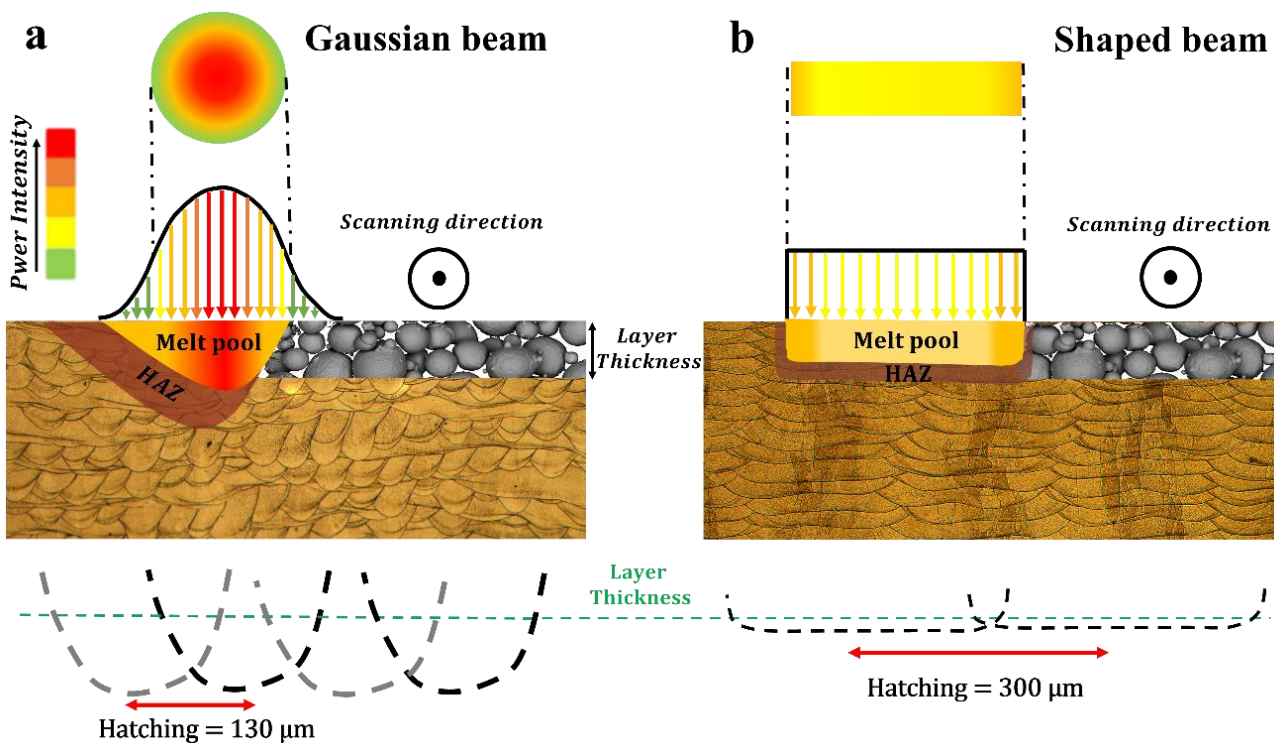# Additive Manufacturing of BMGs using beam shaping

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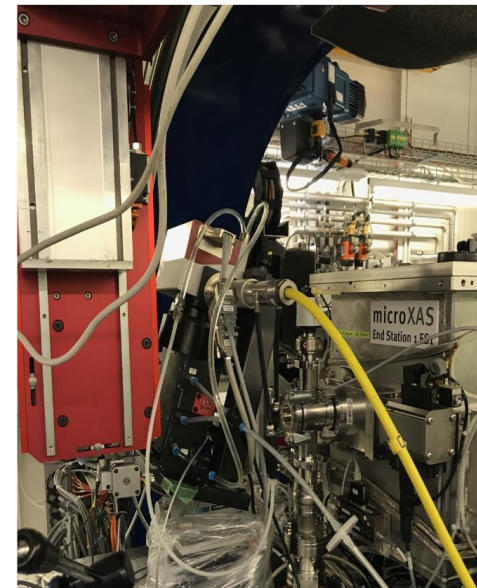
Additive Manufacturing of BMG

Operando experiments at synchrotron: Effect of beam shaping on LPBF of BMGs
Proposal preparation with Dr. Van Petegem, PSI Switzerland
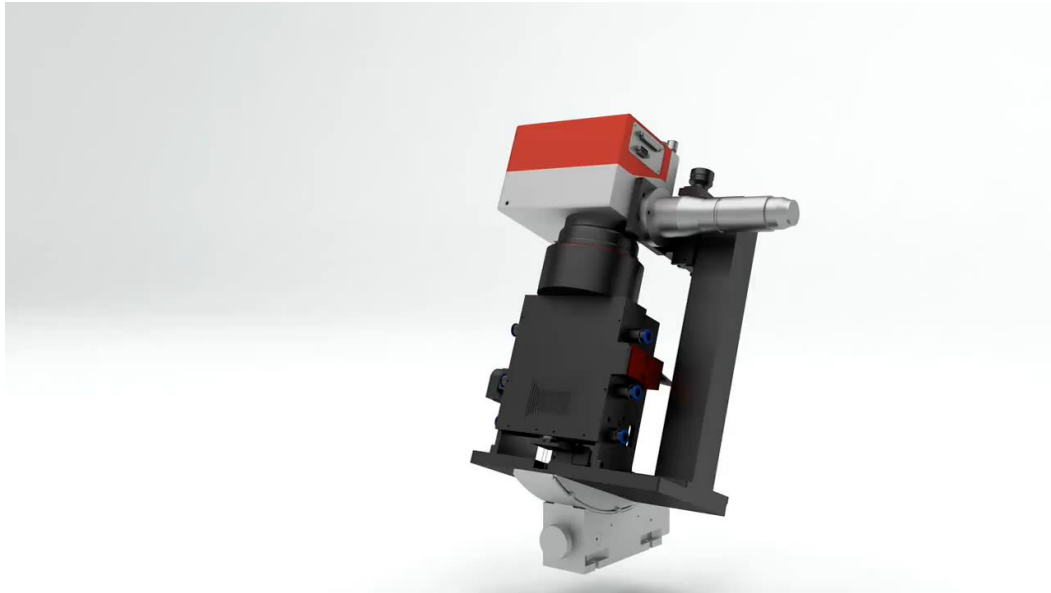
Mini-SLM machine developed at PSI, Dr. Steven Van Petegem

THANK YOU!

contact:

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andreas.burn@sipbb.ch