Overview of AM applications within the industry at large

CERN - Workshop on Additive Manufacturing (AM) applications

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Agenda

- Introduction to Additive Manufacturing
- State-of-Art
- Latest trends

Brief introduction to AM

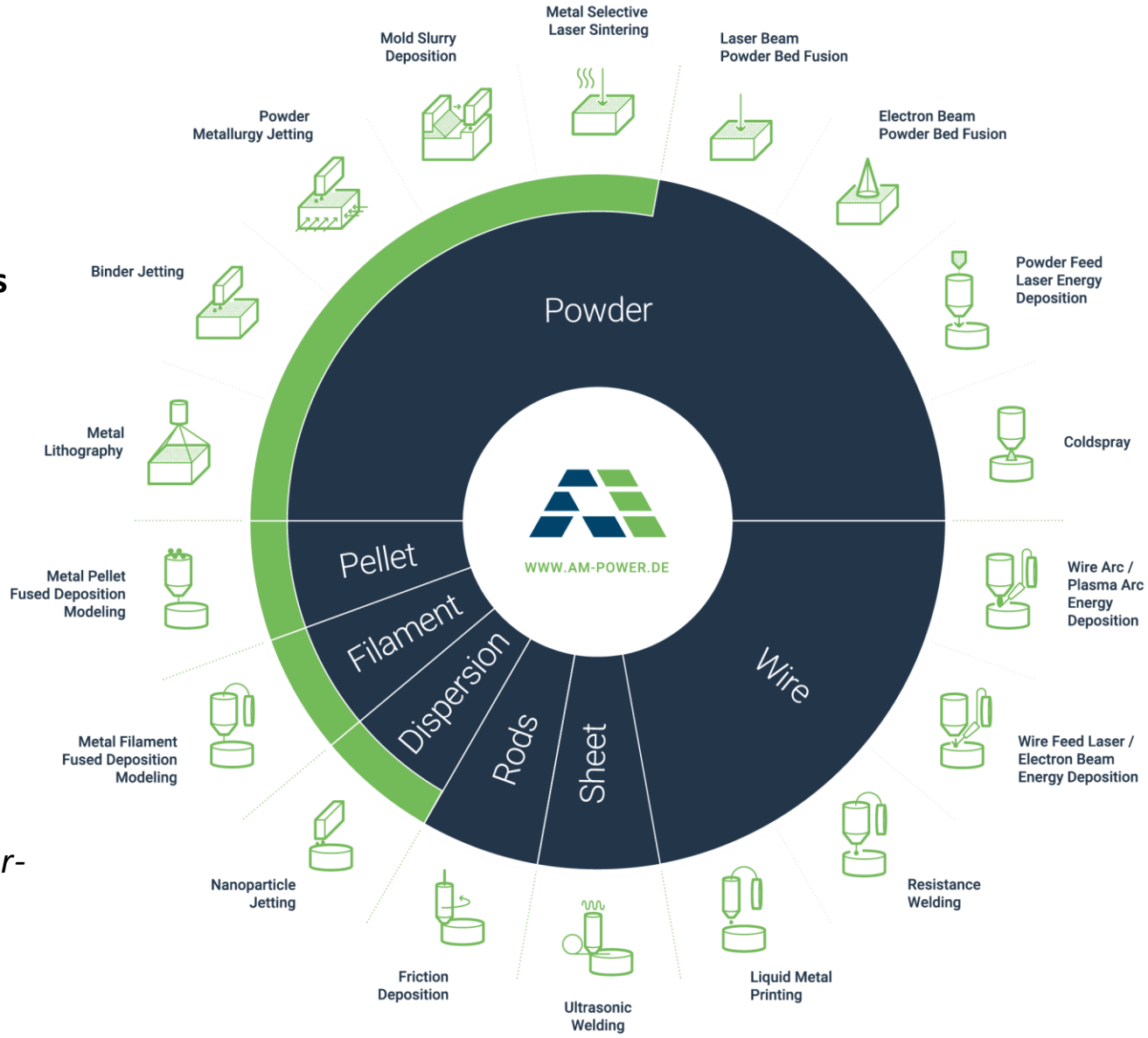
- **Additive Manufacturing (AM) is a primary shaping process**

Definition of a primary shaping process according to DIN 8580

“Fabrication of a solid body from a shapeless material through cohesion”

- Further AM it is defined as:

“…an process in which 3D bodies are manufactured in a layer-wise fashion”



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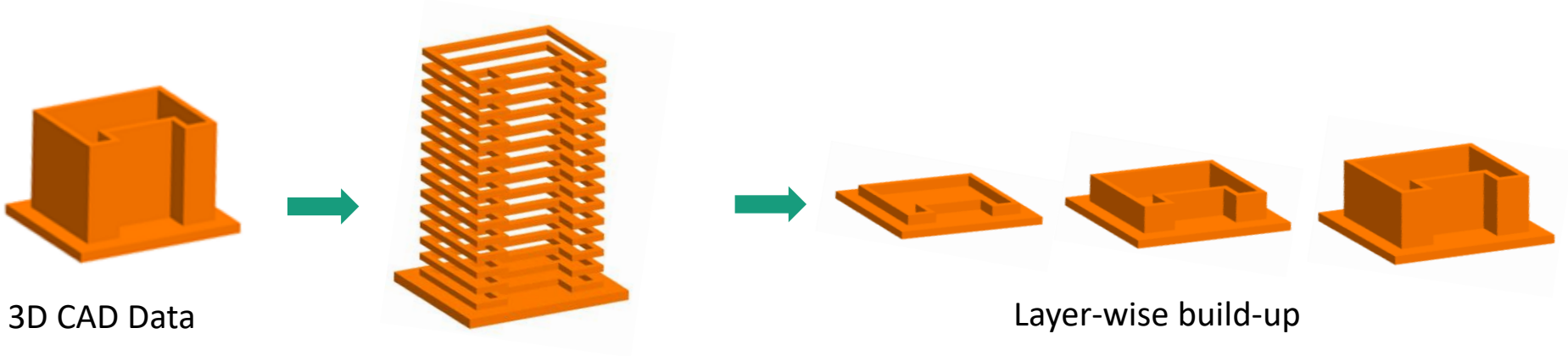
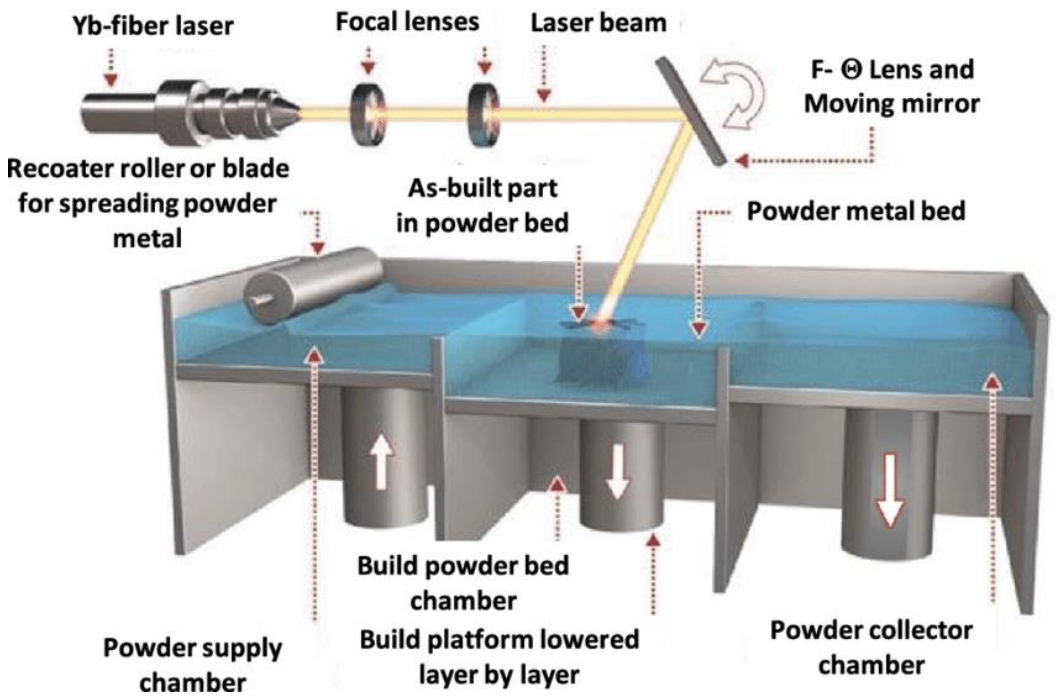
Brief introduction to AM



Brief introduction to AM

Laser Powder Bed Fusion



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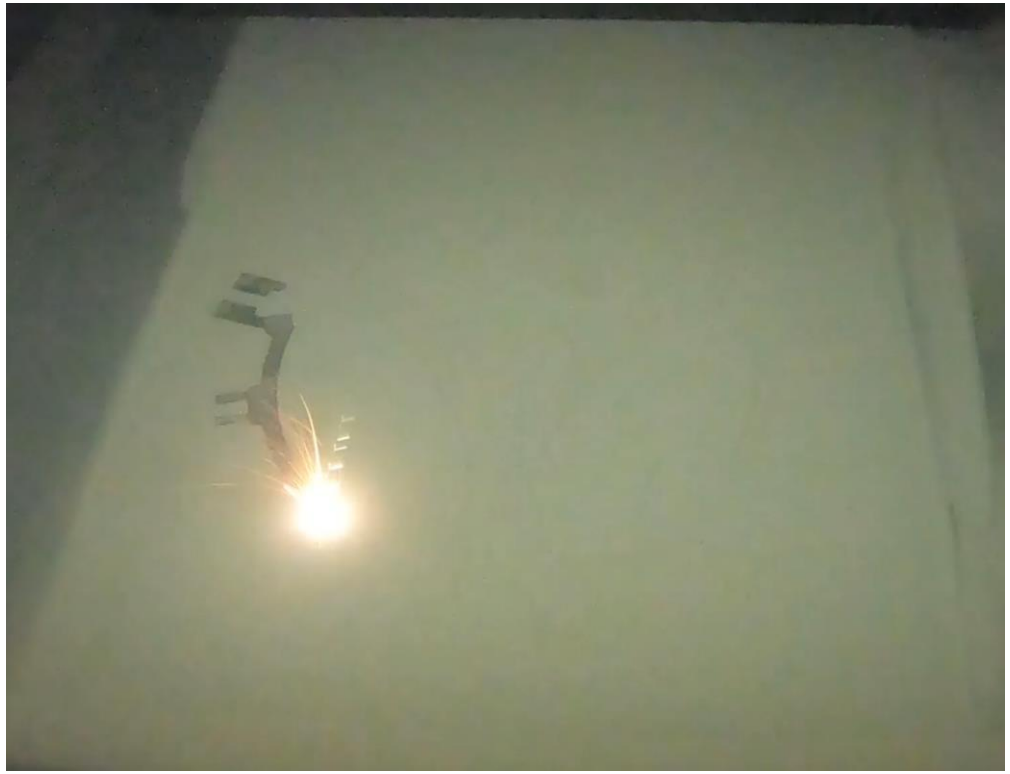

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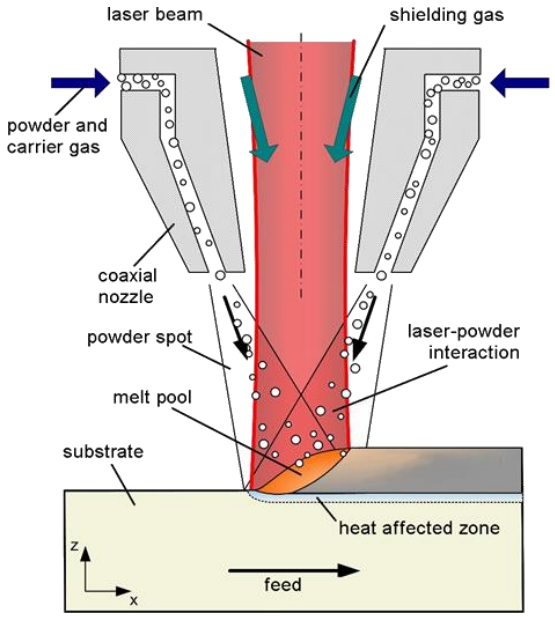
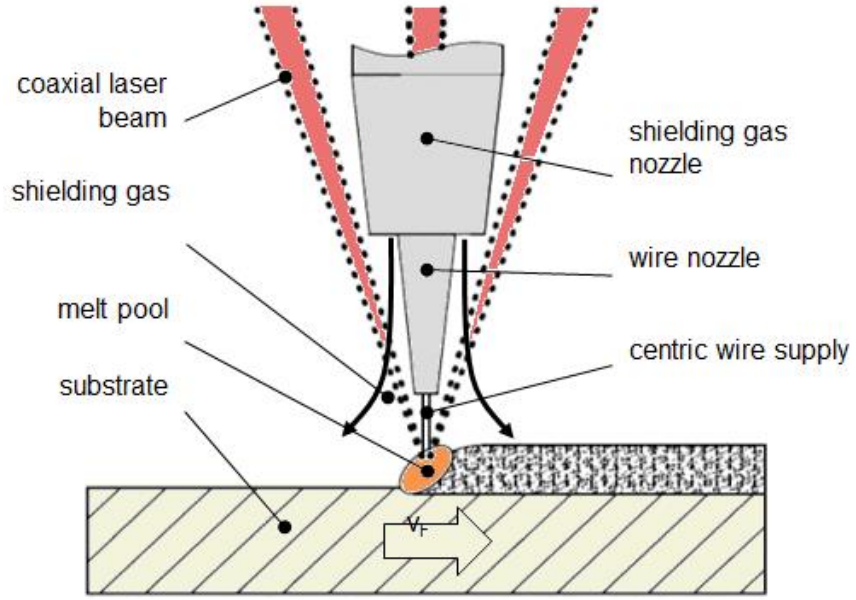
Brief introduction to AM

Direct Energy Deposition



- Powder



- Wire

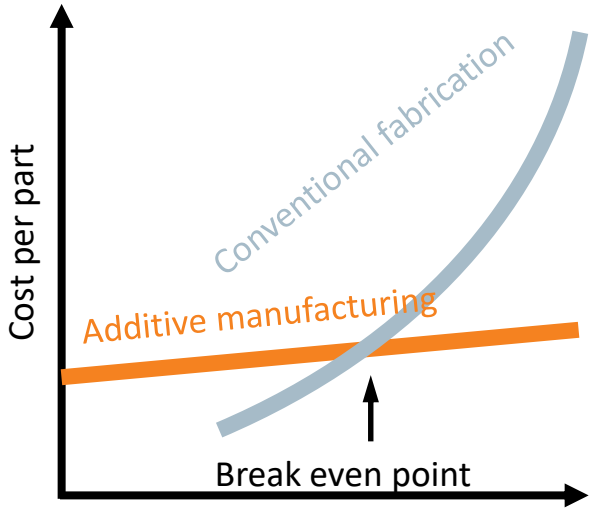
Brief introduction to AM

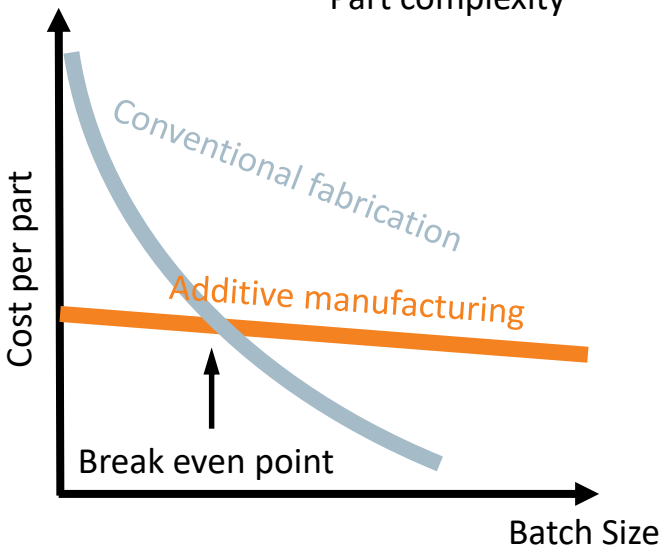
Advantages vs. disadvantages

Comparison between AM an conventional manufacturing

- ✓ Economic production of complex parts
- ✓ High material utilization
- ✓ Individualization
- ✓ Flexible production
- ✓ Repair and redesign
- ✓ Without tools
- ✓ Short lead times

- – Only close to net-shape
- – Surface roughness
- – Sensitive process chain
- – Anisotropic material properties
- – Repair and redesign
- – Support often structures needed
- – Fabrication speed comparatively low



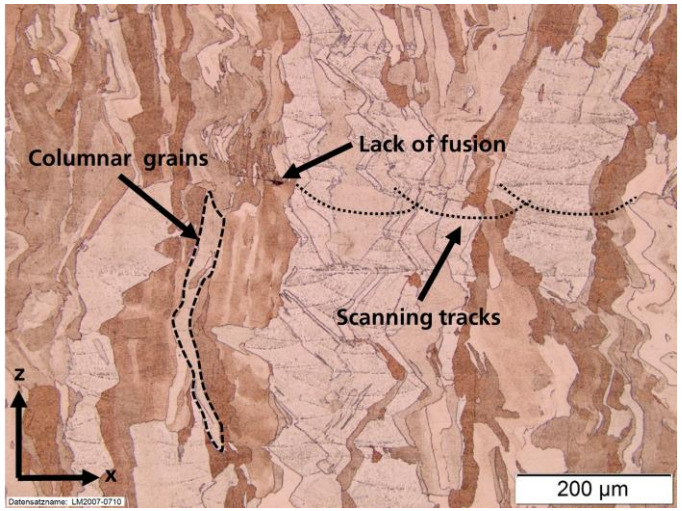


State of the Art

Laser Powder Bed Fusion

Process

- Due to layer-wise build-up defects can occur (e.g. lack of fusion, keyhole, gas porosity)
- Density up to 99.99 %
- Process leads to a fine crystalline microstructure
- Microstructure is often anisotropic (to build direction)
- Productivity ~ 20 - 170 cm^3/h (multiple Laser possible)
- Resolution 20 – 200 Ra µm
- Surface roughness typically ~ 5-15 µm



State of the Art

Laser Powder Bed Fusion

Printer / Equipment

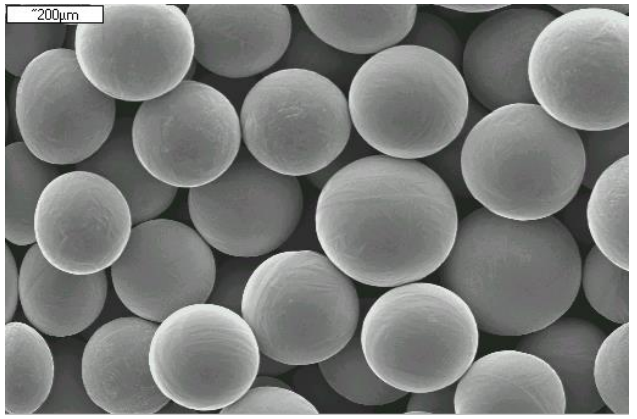
- Build size 800 x 400 x 500 mm³ (l x w x h) (Concept Laser Xline)
- One or multiple laser in one machine
- In situ-process monitoring
  - Imaging, melt pool, acoustic…
- Cost per machine ~ 500.000 € - 1.500.000 €
- Peripheral equipment necessary
  - Software (CAD, Process Simulation)
  - Powder recycling
  - Non destructive testing, geometrical scanner
  - Finishing (Support structures, build plate, surface polishing,…)

State of the Art

Laser Powder Bed Fusion

Material

- Spherical powder with good flowability needed
- Powder size distribution D_{10} = 15 … D_{90} = 50 µm
- Wide range of common validated materials
  (Ni-base, Ti-base, Al-base, Fe-base, stainless steel, magnetic, refractory material, …)
- Composites (Ceramic-Metal-Composites)



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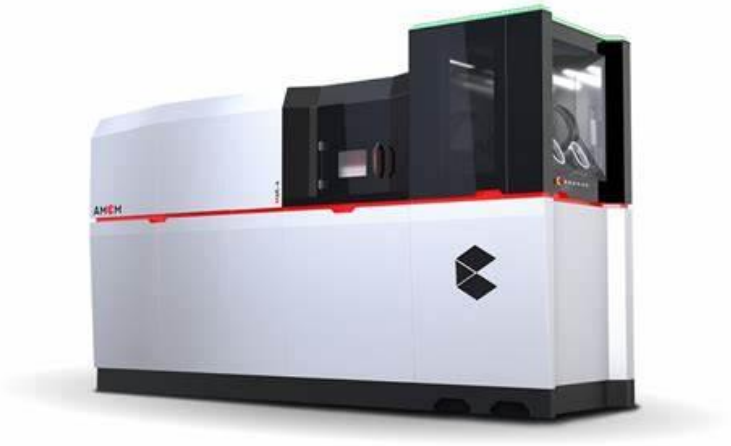
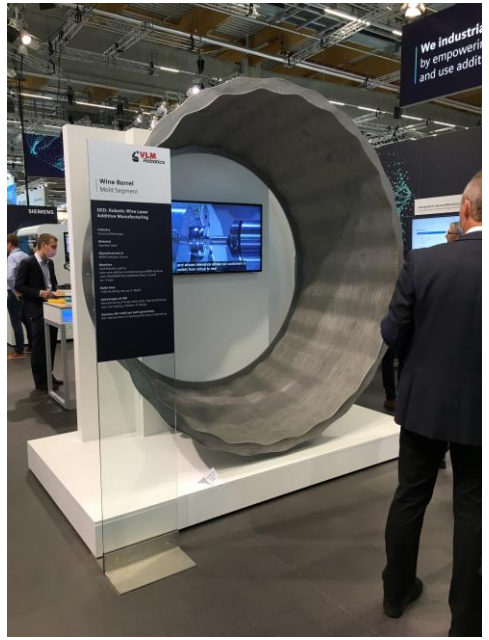
Latest trends

Additive Manufacturing LPBF



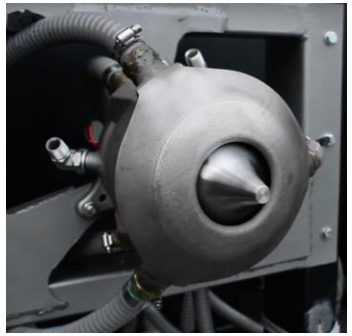
- Higher productivity through:
  - Multiple lasers
  - Increased laser power > 1 kW
  - Automated powder and part handling within machine -> costs >> 1 Mio.€
- Introduction of blue laser sources (65 % absorption, ~ 150 W needed)
- Increase in build-size ~ 1000 x 1000 x 1000 mm^3 -> still R&D
- Copper and Copper alloys
- Large parts…



Latest trends

Additive Manufacturing Applications

- Thrusters



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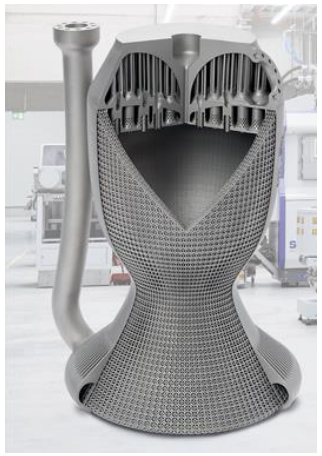

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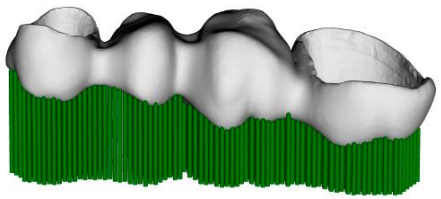
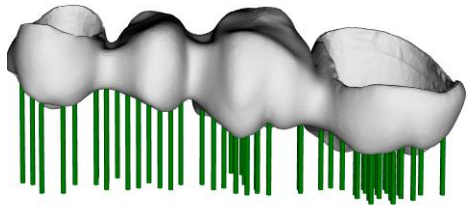
- Process monitoring -> process regulation (still R&D)
- Support less printing





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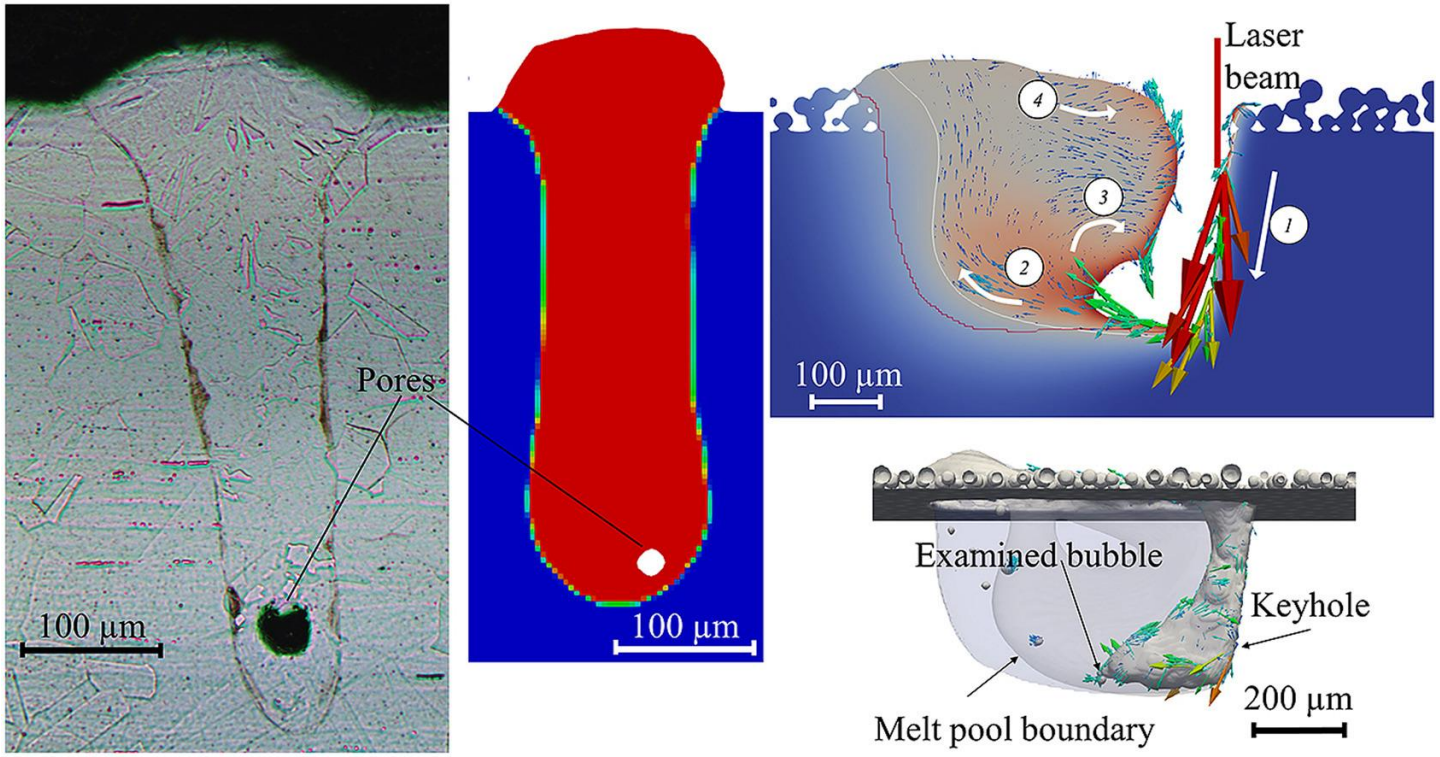
Defect Keyhole formation



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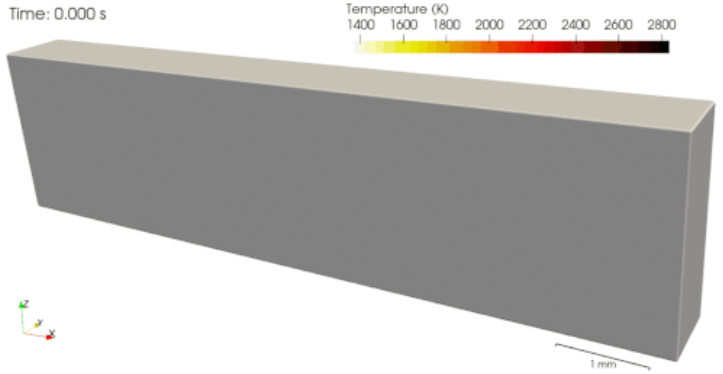
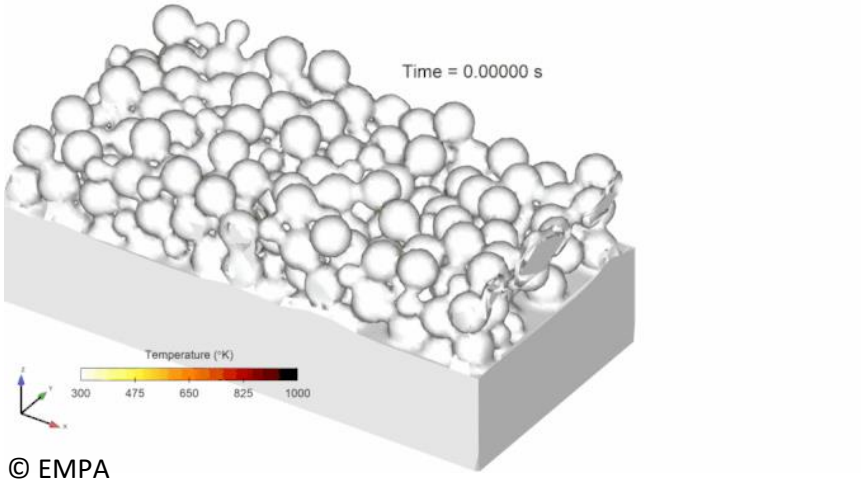
- Keyhole Mode



- Normal Mode



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