LUT University

LAND OF THE CURIOUS

POWDER BED FUSION

LUT University

Research Group of Laser Materials Processing

AM TECHNOLOGIES (PROCESSES) BY ISO/ASTM 52900:2015

LUT University

1. **binder jetting,** *n*—an additive manufacturing process in which a liquid bonding agent is selectively deposited to join powder materials.
2. **directed energy deposition,** *n*—an additive manufacturing process in which focused thermal energy is used to fuse materials by melting as they are being deposited.
3. **material extrusion,** *n*—an additive manufacturing process in which material is selectively dispensed through a nozzle or orifice.
4. **material jetting,** *n*—an additive manufacturing process in which droplets of build material are selectively deposited
5. **powder bed fusion,** *n*—an additive manufacturing process in which thermal energy selectively fuses regions of a powder bed.
6. **sheet lamination,** *n*—an additive manufacturing process in which sheets of material are bonded to form an object.
7. **vat photopolymerization,** *n*—an additive manufacturing process in which liquid photopolymer in a vat is selectively cured by light-activated polymerization.

- **Principle of powder bed fusion**
- Materials and systems
- Examples

POWDER BED FUSION

- Laser beam based
  - •Uses laser beam heat to melt and fuse material together
  - •Selectively melt and fuse regions of the powder bed
  - •Finer surface finish

- Electron beam based
  - •Uses electron beam heat to melt and fuse together
  - •Require separate heating of chamber
  - •Require a vacuum and fuses all the powder
  - •Rougher surface finish

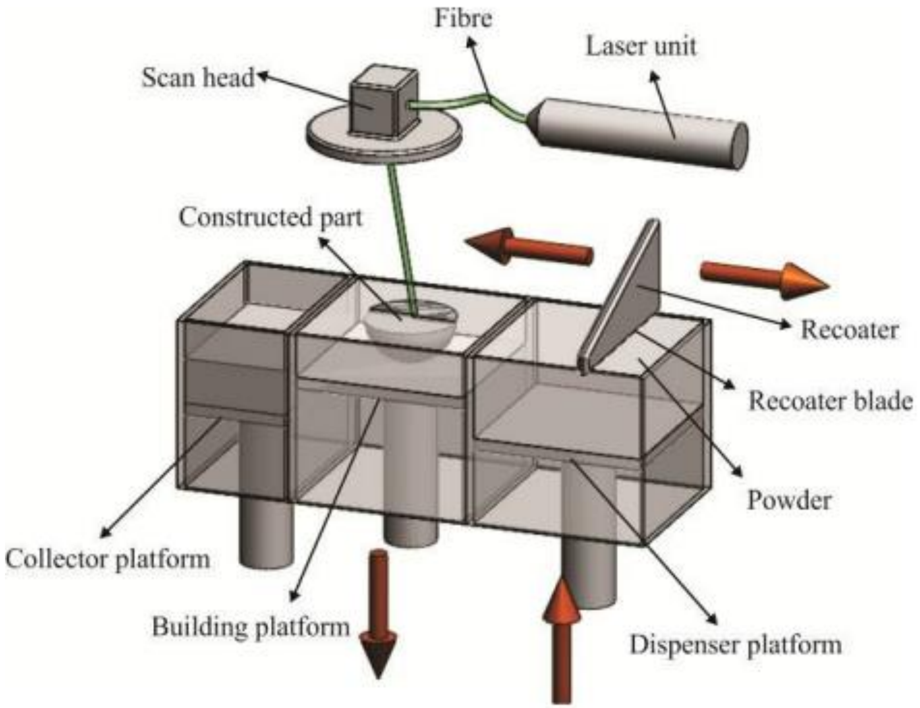
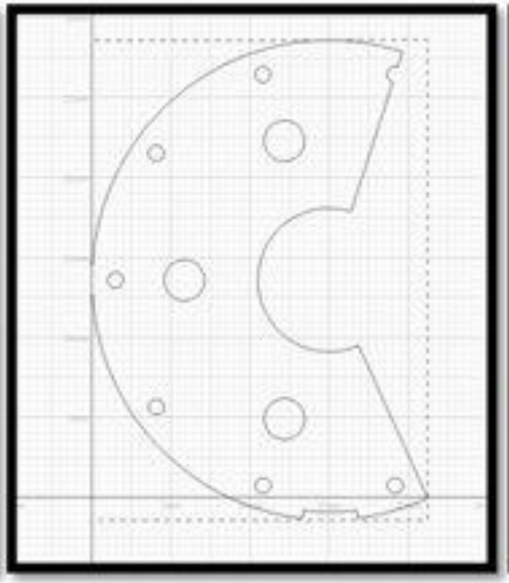


Image source: http://alvarestech.com/temp/cobef2011/grima.ufsc.br/cobef2011/media/trabalhos/COF11-0502

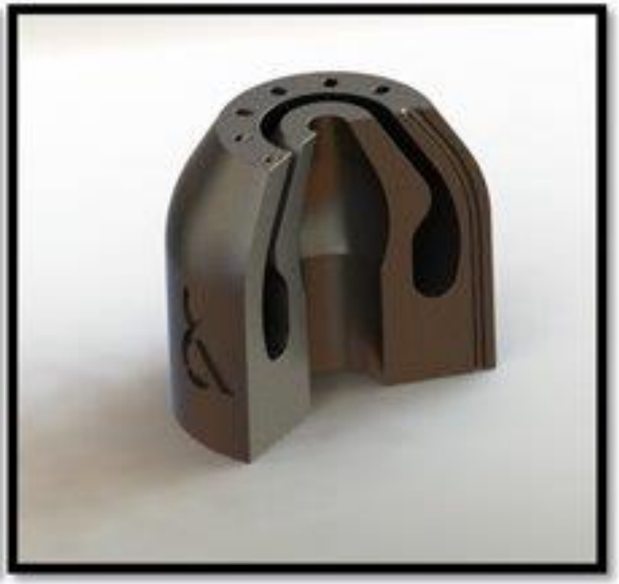
WORKFLOW AND WORKING PRINCIPLE OF PBF

Solid computer model

STL file



2D slicing



3D printed part

WORKFLOW AND WORKING PRINCIPLE OF PBF

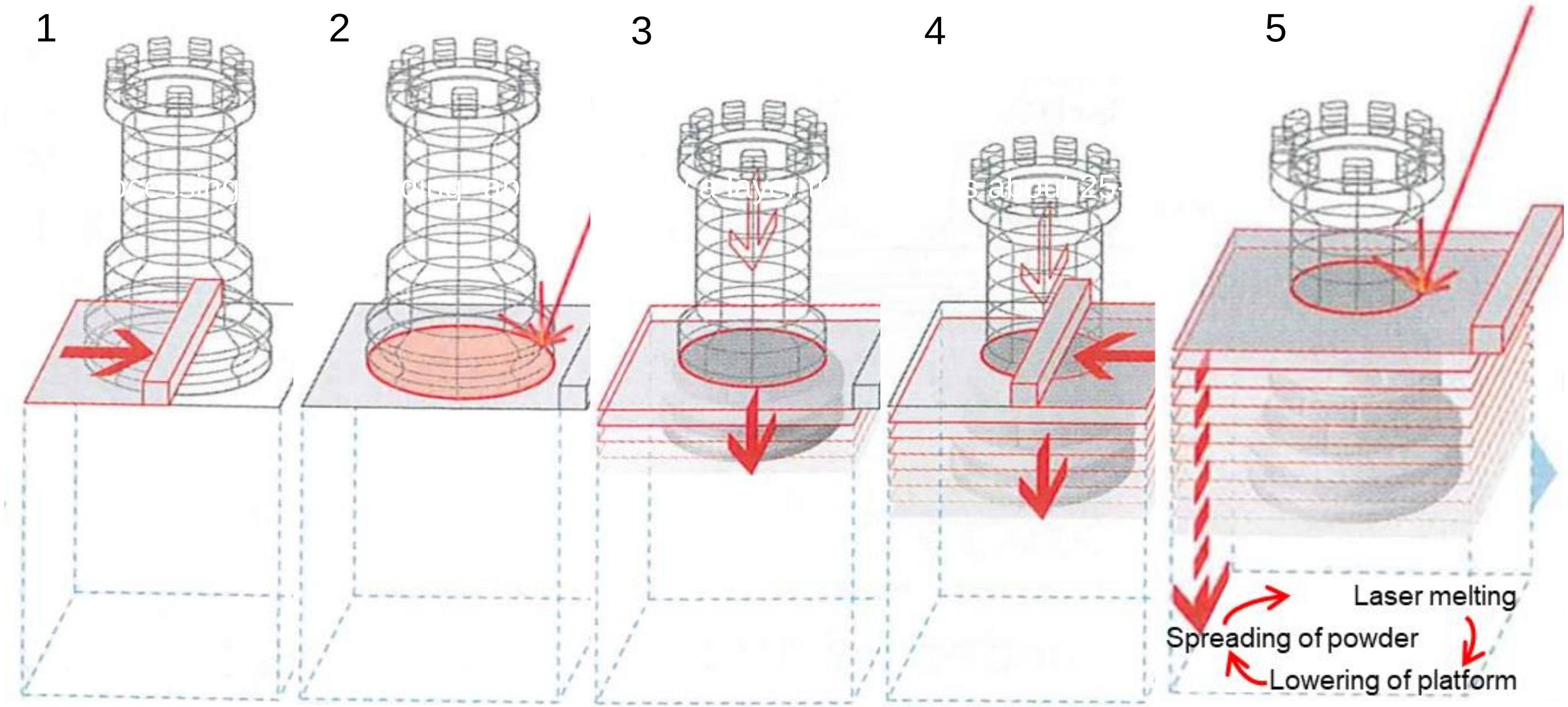
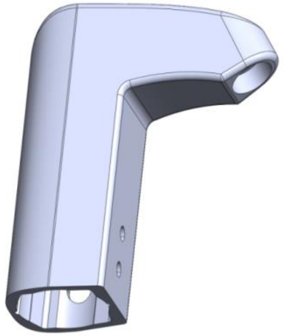
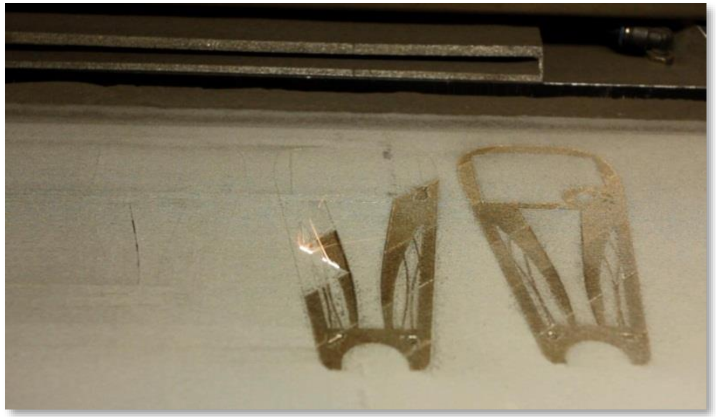


Image source: Photonik International 2011

WORKFLOW AND WORKING PRINCIPLE OF PBF


3D model


L-PBF manufacturing


Removal of excess powder


Before and after post-processing


Ready physical model

ADVANTAGES AND DISADVANTAGES OF PBF

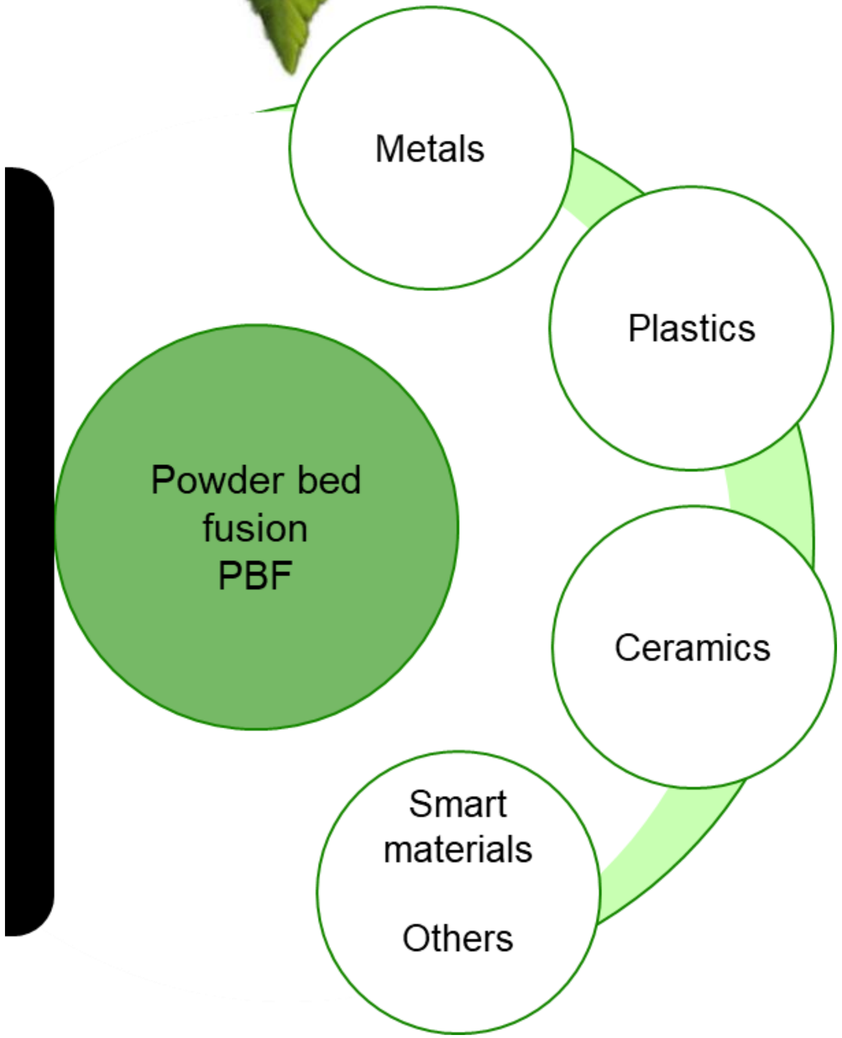
- Advantages
  - Optimised product design capable to mimic nature
  - Freedom of design/shape
  - Reduced weight of products
  - Increased and integrated functionality
  - Shorter time from idea to product
  - Reduced process steps and better supply chain
  - Complexity and smaller batch size does not affect cost

- Disadvantages/Limitations
  - Need of support
    - Conducts heat from the process to base plate
    - Supports overhanging structures
    - Anchors the part in place
  - Need of post-processing
  - Longer Print times

- Principle of powder bed fusion
- **Materials and systems**
- Examples

MATERIALS USED IN PBF

- The process is used mainly for for plastics, metals (particles, ceramics, etc)
- In some cases the material can be a combination of two different material types
    - E.g. metal and polymer
- The material is powdered with a particle size commonly slightly smaller than the layer thickness



SYSTEM MANUFACTURERS FOR POLYMERS

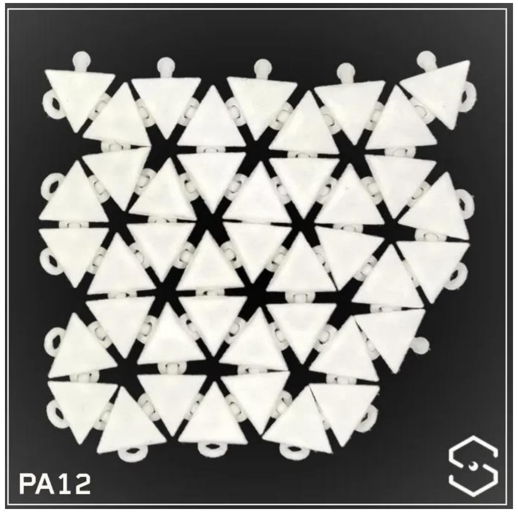
- For polymeric materials:
  - 3D systems
  - EOS
  - Blueprinter
  - Sharebot
  - Etc.

SHAREBOT SNOWWHITE2

DIMENSIONS	1500 X 600 X 520 mm
WEIGHT	ca. 120 Kg
PRINTING VOLUME	100 X 100 X 100 mm
Z RESOLUTION	50 Micron
XY RESOLUTION	100 Micron
LASER	Co2 – 14 Watt
SPOT DIMENSION	0.2 mm
SPEED (Z-AXIS)	35 mm/h
SCAN SPEED	up to 3500 mm/s
HEATED BUILD CHAMBER / MAX T°	up to 190°C
SLICER	Simplify3D Continuum
CONNECTIVITY	Ethernet- Sharebox

SHAREBOT

Motor



Textile sample

SYSTEM MANUFACTURERS FOR METALS

- For metallic materials:

  Concept Laser
  EOS
  Matsuura
  Realizer
  Renishaw
  SLM Solutions
  Etc.

EOS M 290

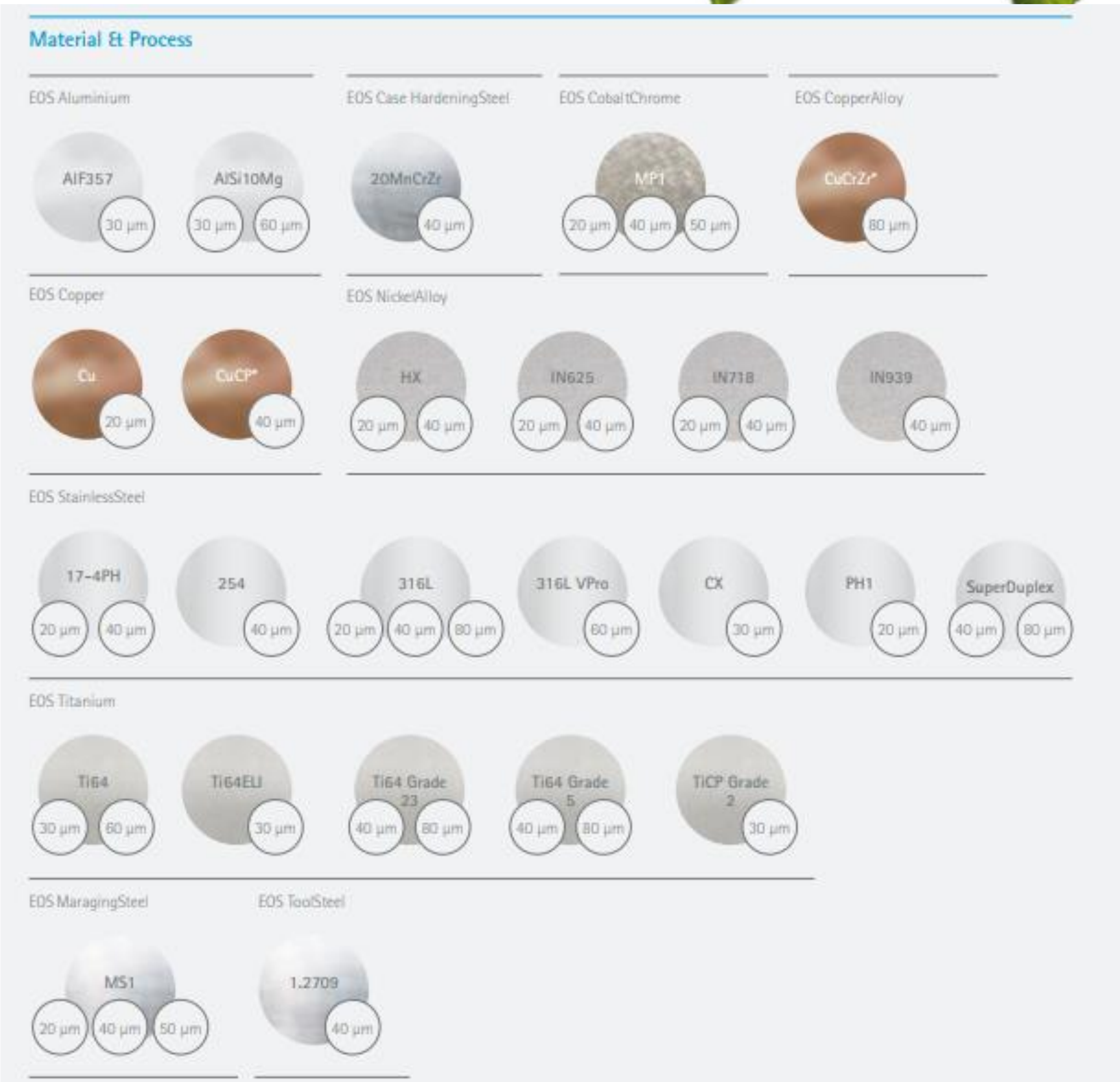
EOS M 290

Technical Data

Building volume	250 x 250 x 325 mm (9.85 x 9.85 x 12.8 in) (height incl. build plate)
Laser type	Yb fiber laser; 400 W
Precision optics	F-theta lens; high-speed scanner
Scanning speed	up to 7.0 m/s (23 ft/s)
Focus diameter	100 µm (0.004 in)
Power supply	32 A / 400 V
Power consumption	max. 8,5 kW / average 2,4 kW / with platform heating up to 3,2 kW
Compressed air supply	7,000 hPa; 20 m³/h (102 psi; 706 ft³/h)

Additively manufactured Liebherr valve block, built on the EOS M 290: Same performance, 35 percent lighter

EOS M290



Material & Process
EOS Aluminium
AlF357
30 µm
AlSi10Mg
30 µm
60 µm
EOS Case HardeningSteel
20MnCrZr
40 µm
EOS CobaltChrome
MP1
20 µm
40 µm
50 µm
EOS CopperAlloy
CuCrZr*
80 µm
EOS Copper
Cu
20 µm
CuCP*
40 µm
EOS NickelAlloy
HX
20 µm
40 µm
IN625
20 µm
40 µm
IN718
20 µm
40 µm
IN939
40 µm
EOS StainlessSteel
17-4PH
20 µm
40 µm
254
40 µm
316L
20 µm
40 µm
80 µm
316L VPro
60 µm
CX
30 µm
PH1
20 µm
SuperDuplex
40 µm
80 µm
EOS Titanium
Ti64
30 µm
60 µm
Ti64ELI
30 µm
Ti64 Grade 23
40 µm
80 µm
Ti64 Grade 5
40 µm
80 µm
TiCP Grade 2
30 µm
EOS MaragingSteel
MS1
20 µm
40 µm
50 µm
EOS ToolSteel
1.2709
40 µm

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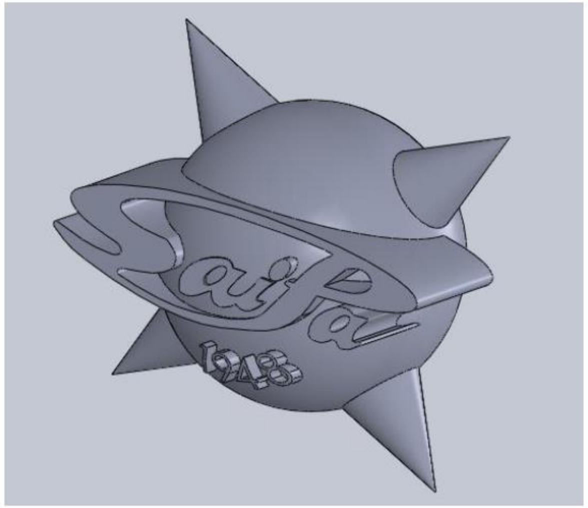
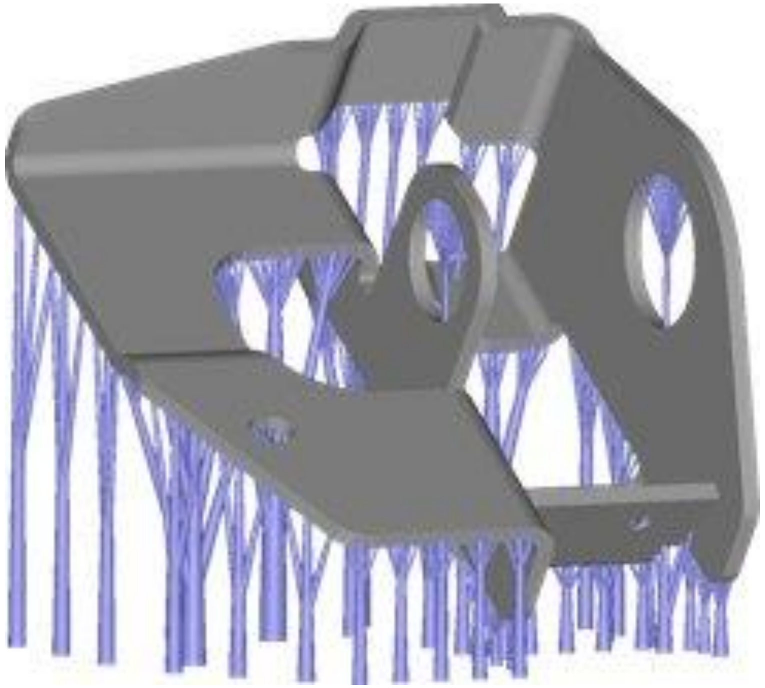
POWDER BED FUSION (METAL)

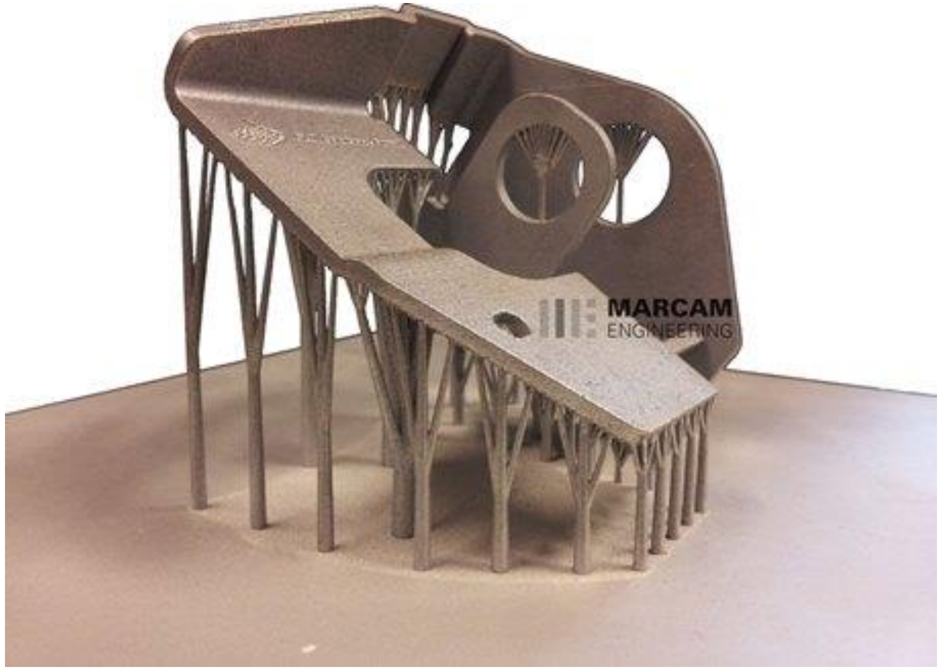


POWDER BED FUSION (METAL)

TO BE CONSIDERED DURING DESIGN

- Support structures





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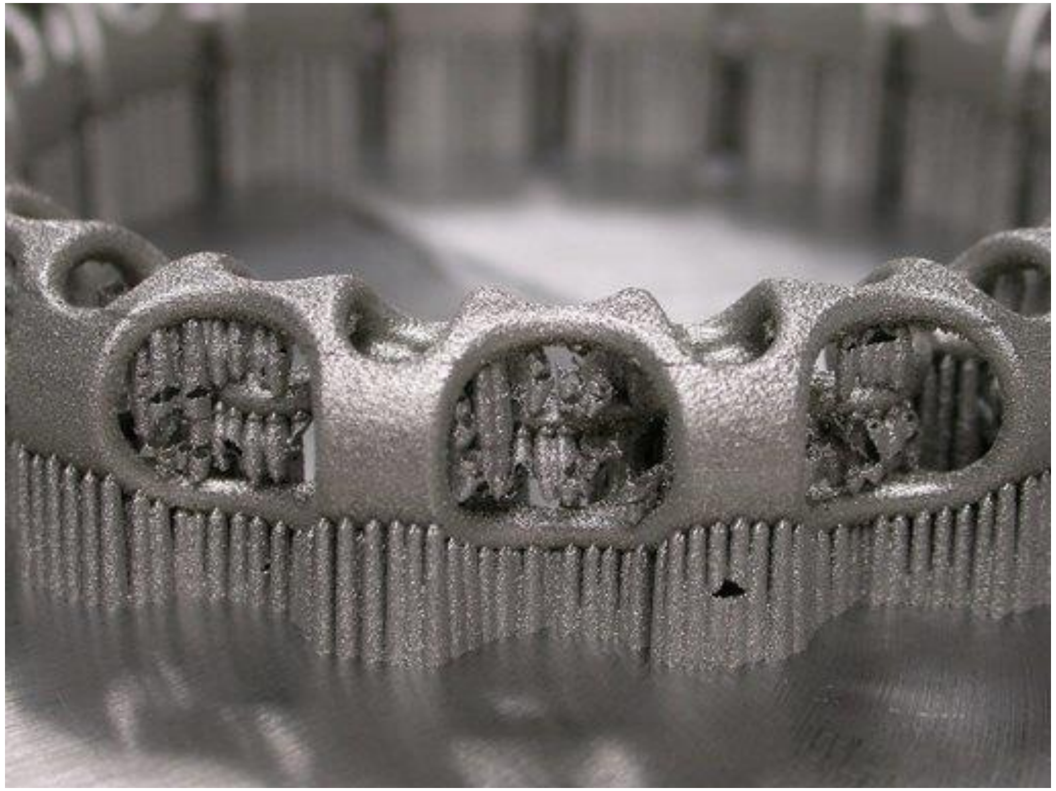


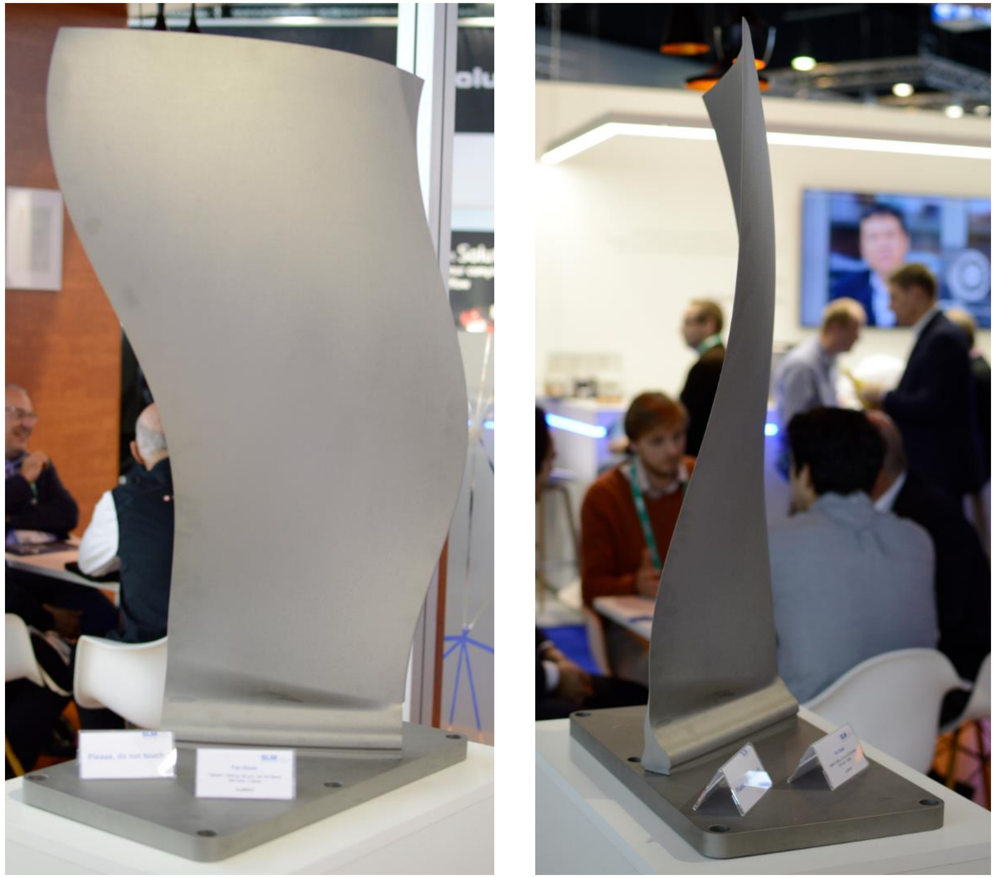
BRAKE CALIPER (BUGATTI CHIRON)

- Weight: 2900 g
- Material: Ti6Al4V
- Machine: SLM500 Quad, 4 pcs of 400 W lasers
- Build time: 45 h 25 min
- Layer thickness: 50 µm

Formnext / Markus Korpela

FAN BLADE

- Weight: 5400 g
- Material: Ti6Al4V
- Machine: SLM800
- Build time: 3 d 10 h 56 min
- Layer thickness: 60 µm



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CAM COVER (BUGATTI CHIRON)

- Size: h ~800 mm
- Material: AlSi10Mg
- Machine: SLM800, 700W
- Build time: 4 d 7 h 42 min
- Layer thickness: 60 µm

- 8 pieces built simultaneously

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INTEGRATED CHANNELS, OPTOMET

- Size: Ø 50 x 53 mm
- Material: Aluminium
- Machine: Lasertec 30 SLM
- Build time: 3.5 h

- Aerospace industry

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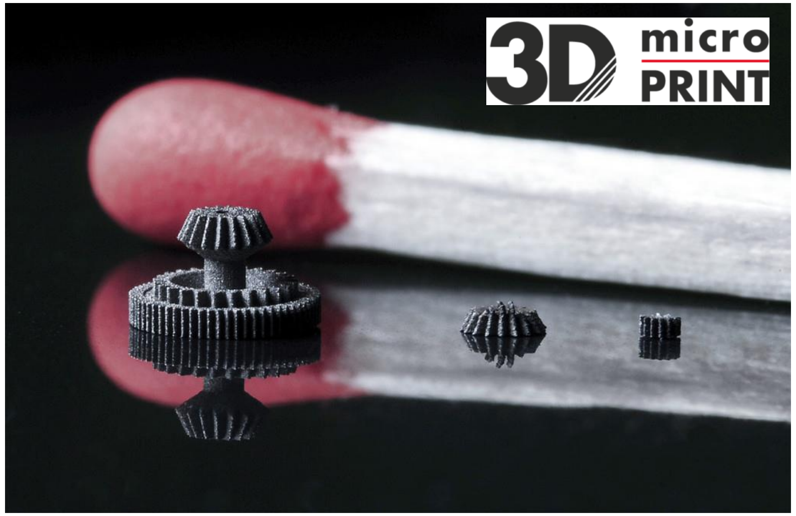
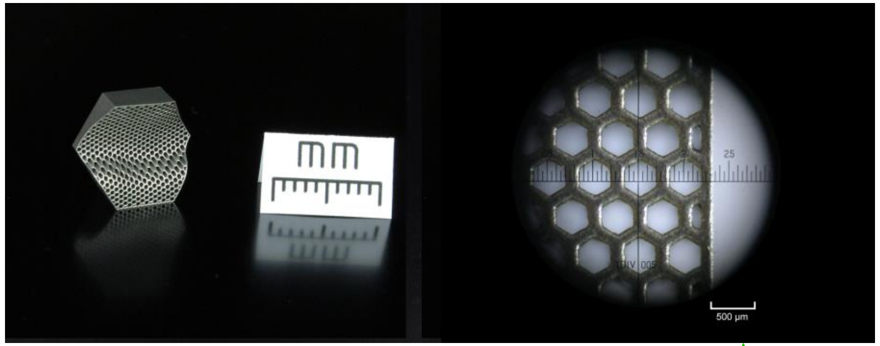
3D MICROPRINT GMBH

- EOS + 3D micromac → 3D MicroPrint GmbH
- Process: Micro laser sintering (MLS)
- The first system in 2013
- Metal powder (440 C, 316 L, 17-4 PH)
- Layer thicknesses of ≤ 5 µm
- Powder particle size of ≤ 5 µm
- Building platform Ø57 x 3 mm³
- Applications: automotive, medical and jewelry industries





500 µm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