LITHOZ

www.lithoz.com

Lithography-based Metal Manufacturing

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Welcome to Lithoz

Company overview – focus on LMM

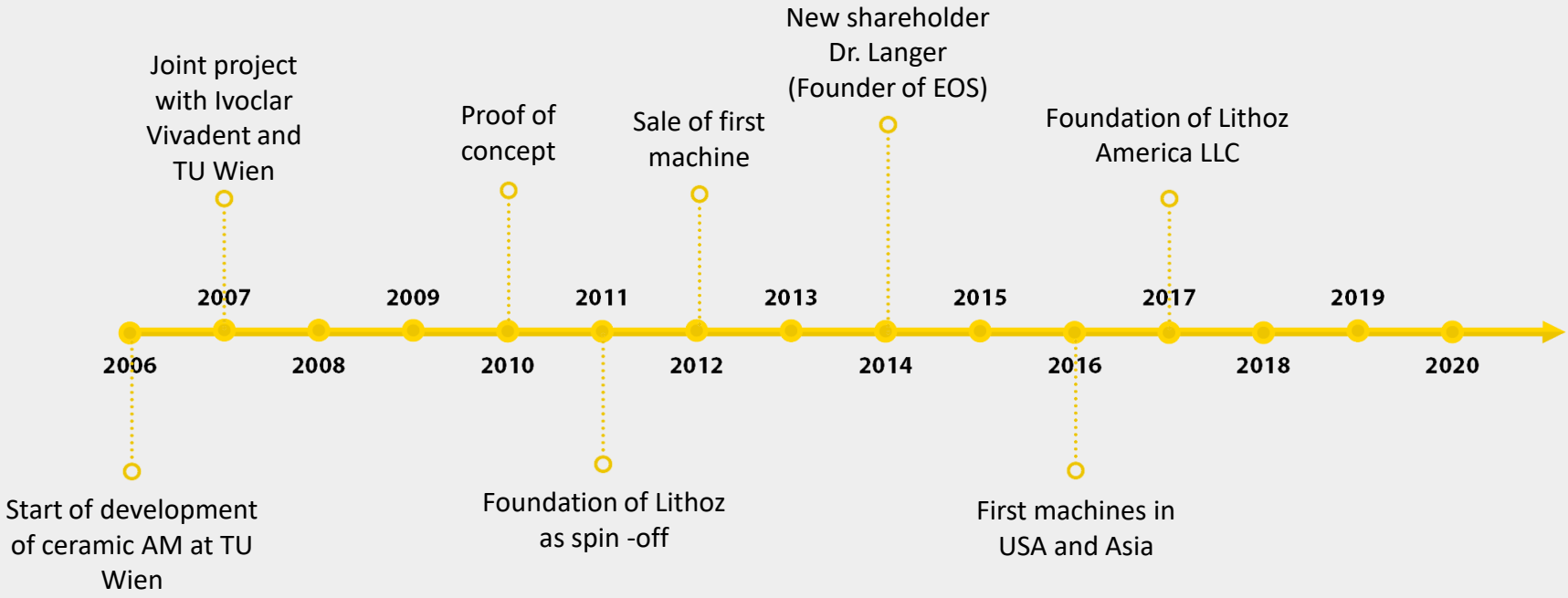
About Lithoz

System provider for additive manufacturing of ceramics

- Spin-off of the Vienna University of Technology (TU Wien)
- Market and innovation leader for precise and dense ceramic
- Development, production and sales of machines and material
- Customer specific solutions

LCM Printer CeraFab 7500

Lithoz Story



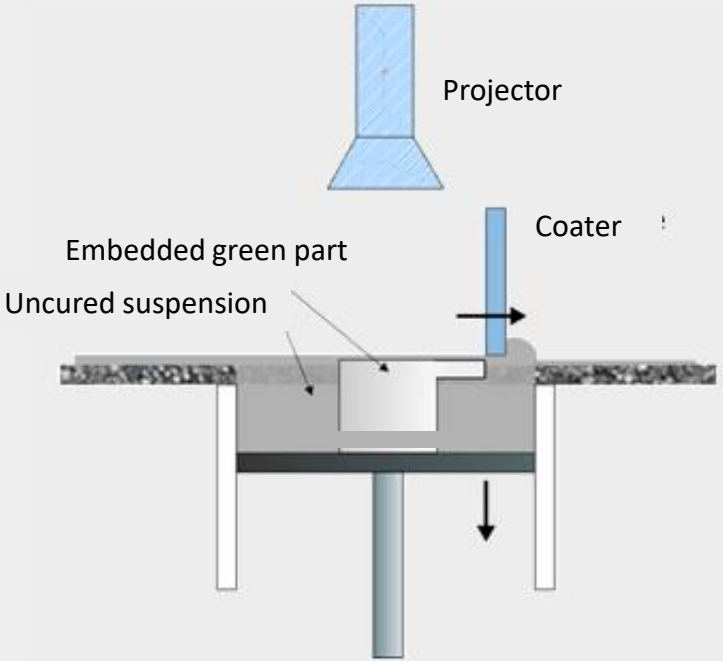
Different materials

LMM-Technology

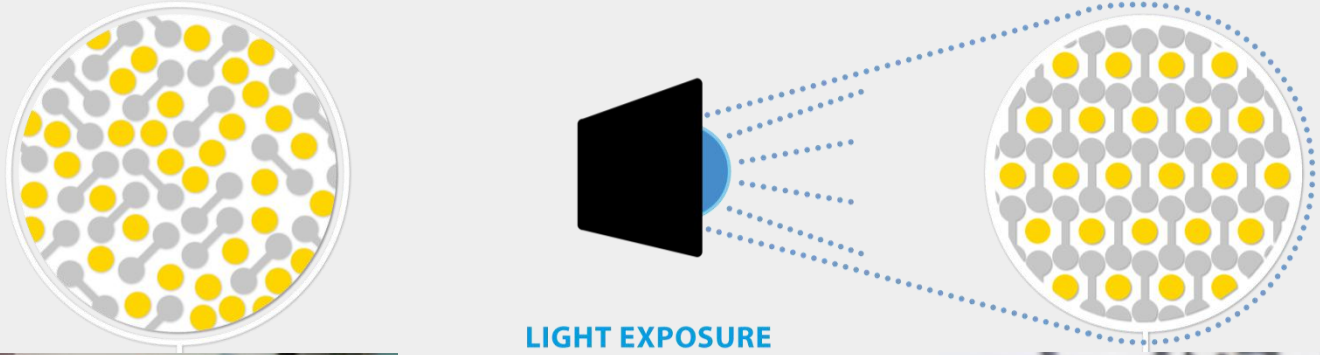
Lithography-based Metal Manufacturing

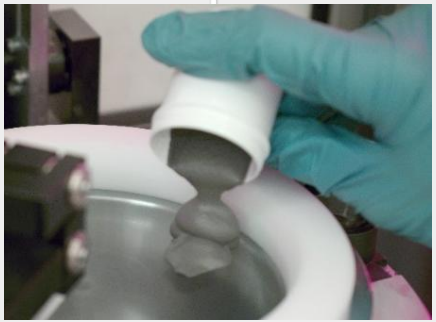
Lithography-based Metal Manufacturing

- Indirect Vat Polymerization AM method
- Debinding and sintering step
- Top Down VP machine setup
- Photo-reactive feedstock
- Pro: Light projection highly accurate



Photopolymerization





SLURRY

The structuring of the slurry is done by mask exposure.

GREEN BODY

METAL PARTICLE

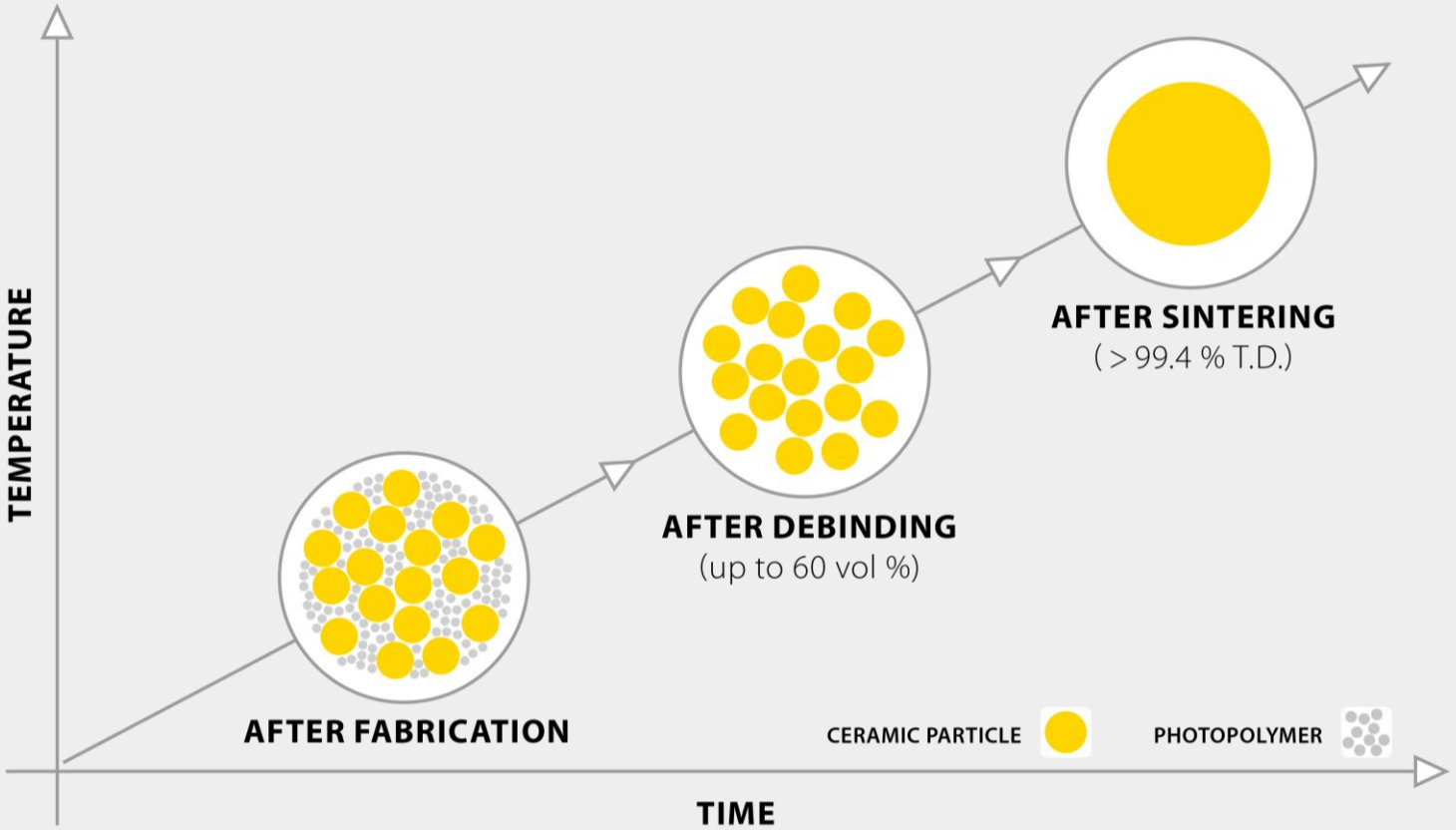
MONOMER

Current Machine HD40

- Desktop machine designed for material testing and small-scale production
- Building volume 75 x 43 x 100 mm³ (X Y Z)
- Resolution X,Y = 40 µm (Projector)
- Resolution Z = 5- 100 µm
- Print speed 6 mm/h in Z => app. 20 cm³/h
- Open material system
- Machine available Q4 2018

Rendering of desktop LMM machine

Postprocessing



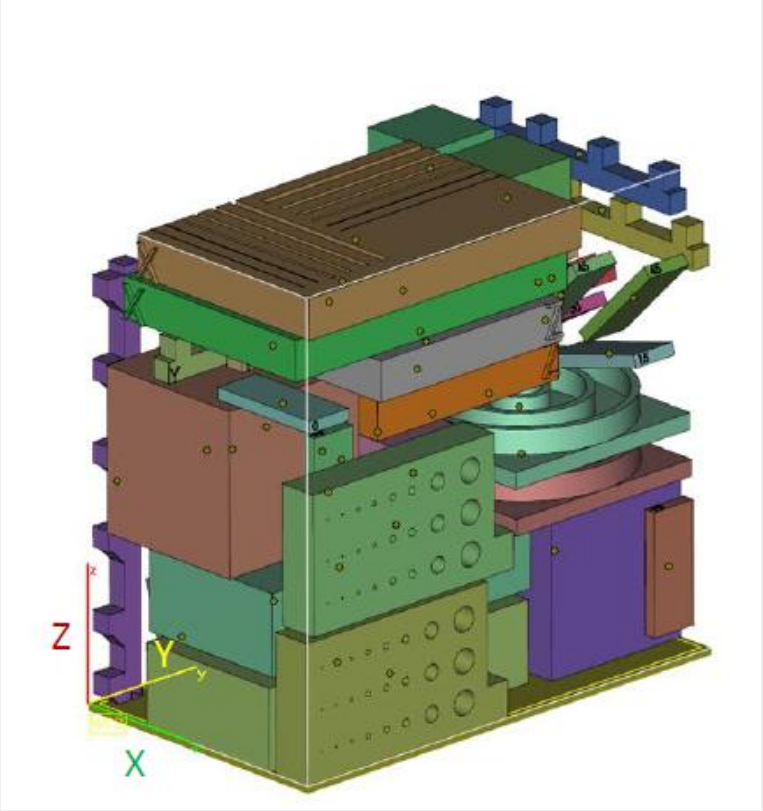
Achievable Results with LMM

Participation in benchmark study by mtc Manufacturing Technology Centre

LMM Resuls

MTC Benchmark Study

- Test of novel AM Processes
- 32 different Geometries
- Evaluation conducted by MTC
  - Roughness
  - Mech. properties
  - Microstructure
  - Resolution/Accuracy

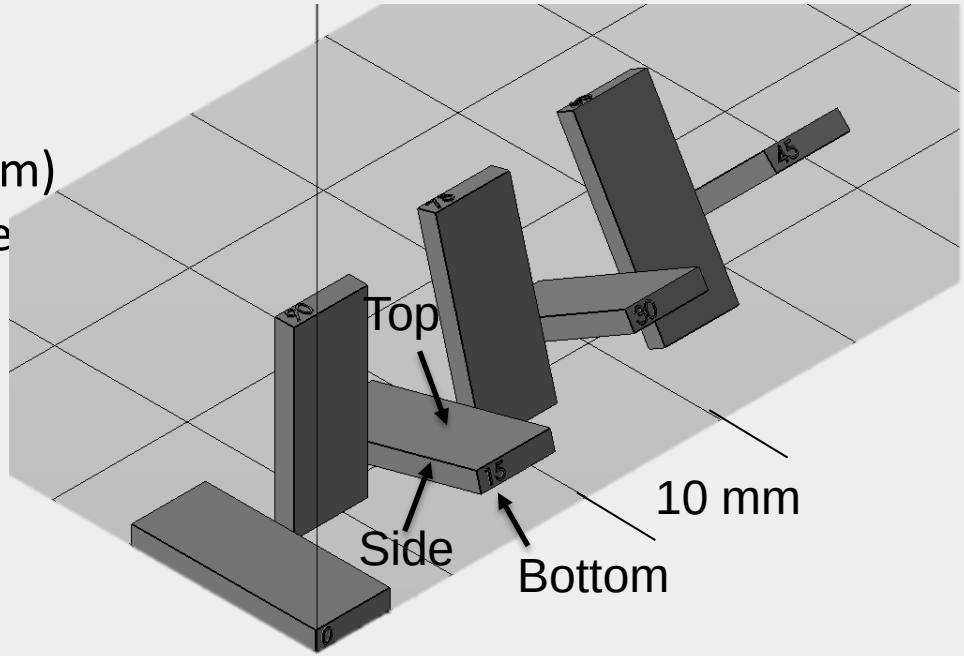


Testjob for MTC parts (43 x 75 mm²)

316L stainless steel

Evaluation of surface roughness

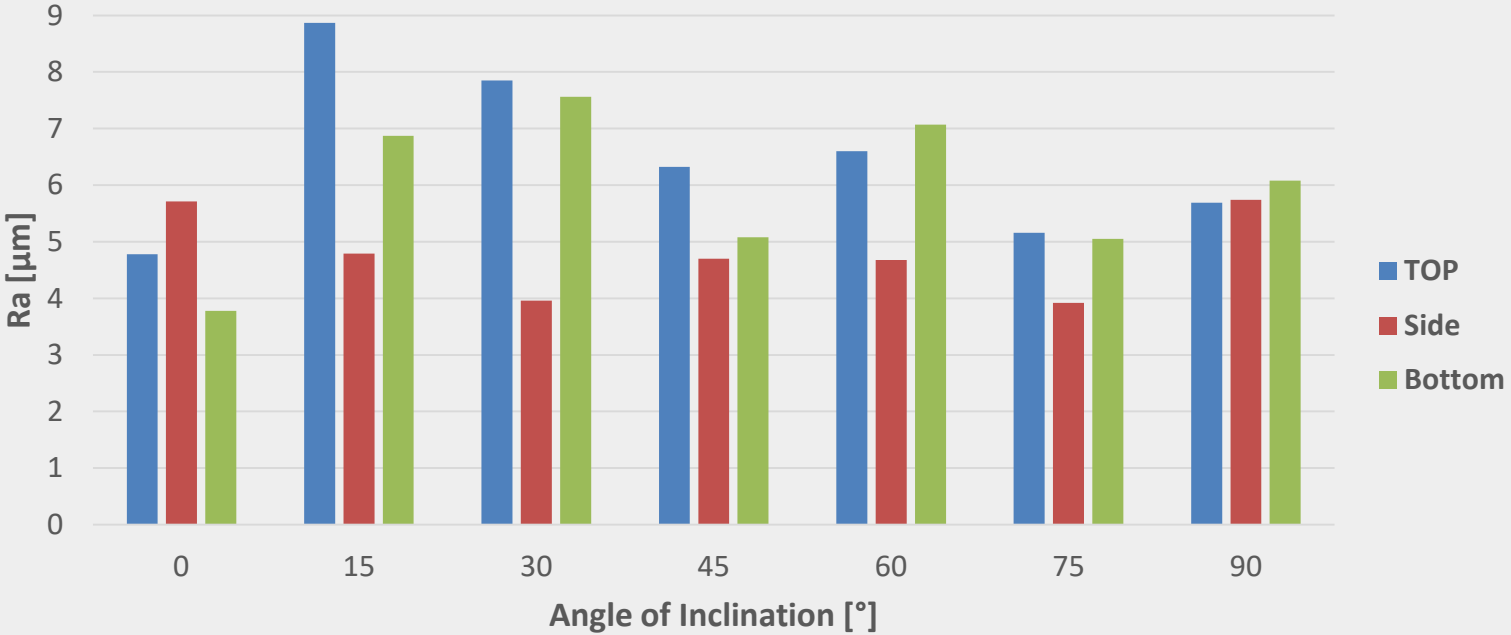
- Surfaces in various angles
- Alicona Confocal Microscopy
- Evaluation of Ra and Sa (4 x 3,8 mm)
- Top, side, bottom surface evaluate



Surface roughness test parts

LMM Results

LPBF 10 µm (oben)	25-42 µm	20-28 µm



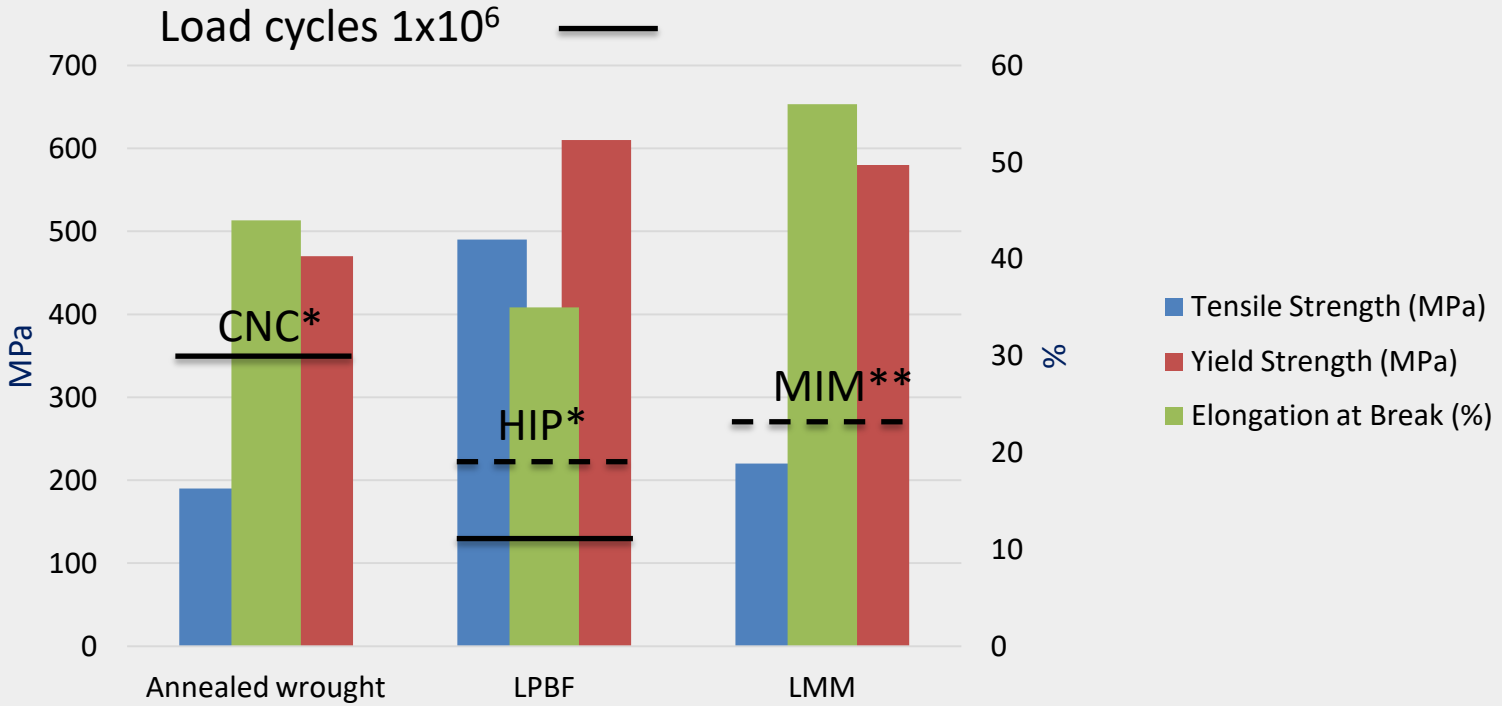
J. C. Fox, S. P. Moylan, and B. M. Lane, "Effect of Process Parameters on the Surface Roughness of Overhanging Structures in Laser Powder Bed Fusion Additive Manufacturing," *Procedia CIRP*, vol. 45, pp. 131–134, Jan. 2016.

LMM Resultate

Mechanical Properties

- Rods (D 8 mm, L 45 mm) oriented standing in Z direction
  - Tensile testing
  - Printed and tested in “weakest” direction
  - Surface machined

LMM Results



* T. M. Mower and M. J. Long, "Mechanical behavior of additive manufactured, powder-bed laser-fused materials," *Materials Science and Engineering: A*, vol. 651, pp. 198–213, Jan. 2016.

** H. Miura, R. Toyofuku, T. Baba, and T. Honda, "Fatigue Rupture Properties of SUS316L Stainless Steels Produced by Metal Injection Molding.," *Journal of the Japan Society of Powder and Powder Metallurgy*, vol. 44, pp. 432–436, May 1997.

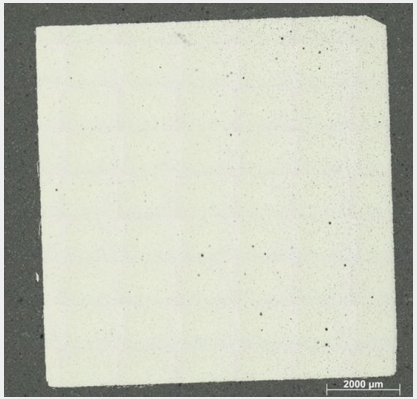
316L stainless steel

Evaluation of Microstructure

- Block 10 x 10 x 10 mm^3
- >98% of the theoretical density
- Chemistry OES: Arc Spark

Analyzed	Min	Max	Found	Units
Nickel			10.43	%
Chromium			17.00	%
Manganese			0.62	%
Silicon			0.53	%
Carbon			0.05	%
Sulfur			<0.004	%
Phosphorus			0.018	%
Molybdenum			2.36	%
Copper			0.09	%
Hydrogen			5 ppm	%
Nitrogen			0.0005	%
Oxygen			0.0011	%
Iron			REM	%

Measurement conducted by MTC according to ASTM E1086-14 and ASTM E1019-11

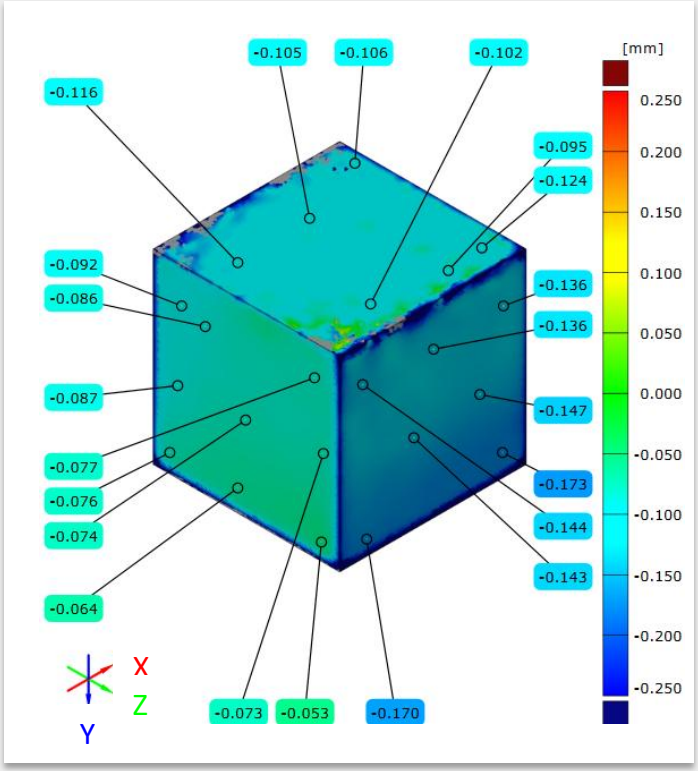


Optical microscopy image of test cube (10x10x10mm^3)

316L stainless steel

Evaluation of tooling factor

- Comparison of original STL to sintered component
- Cube 10 x 10 x 10 mm³
- X,Y, Z shrinkage compensation used 1,2
- **New value: X, Y = 1,21 ; Z = 1,217**

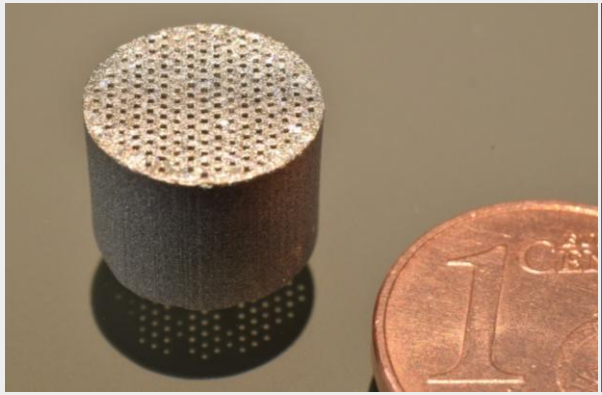


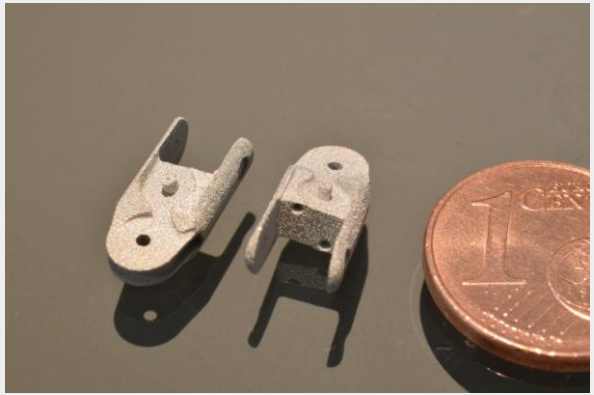
Test cube with uniform tooling factor 1,2

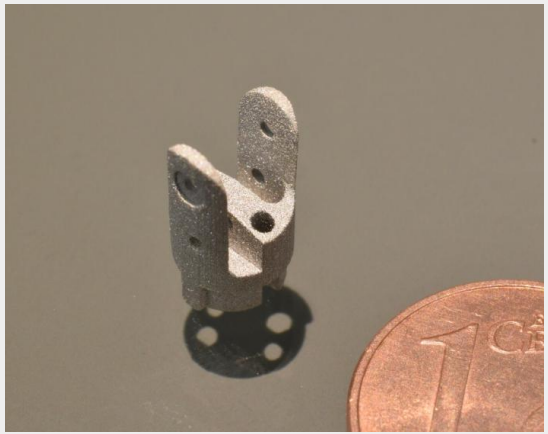
Printed Parts

316L Stainless Steel

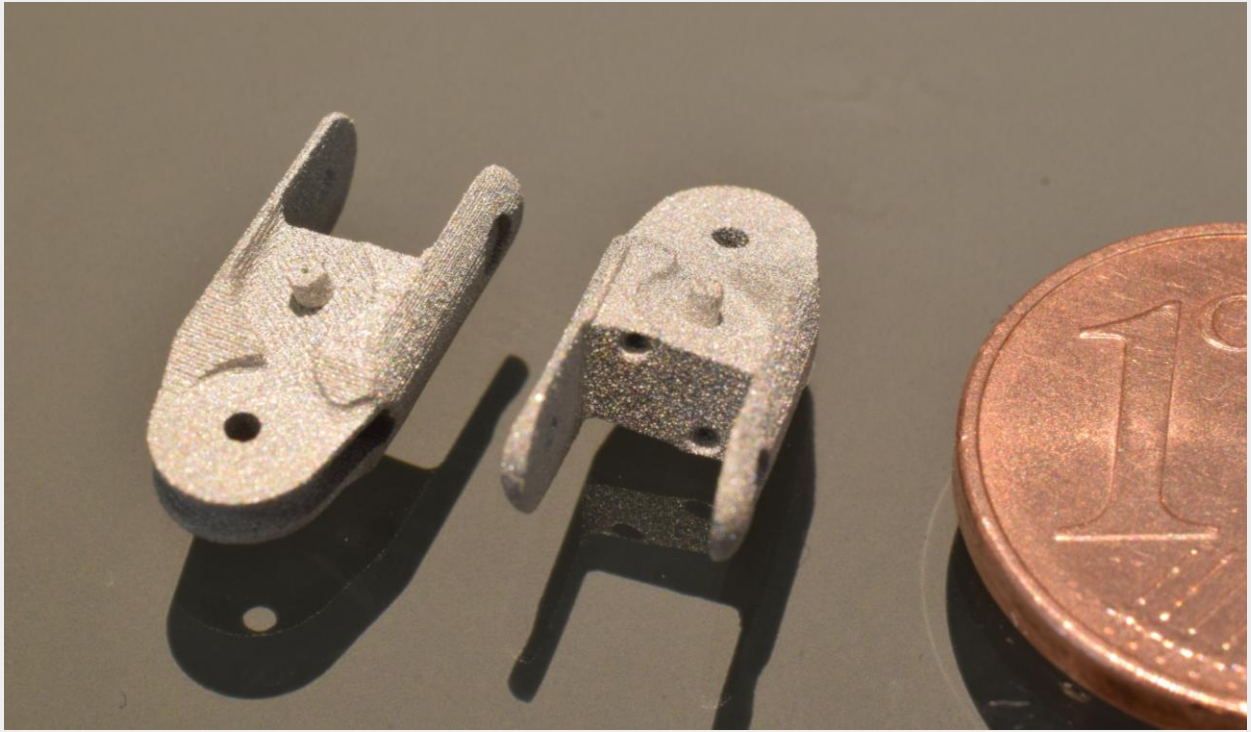
Printed Parts







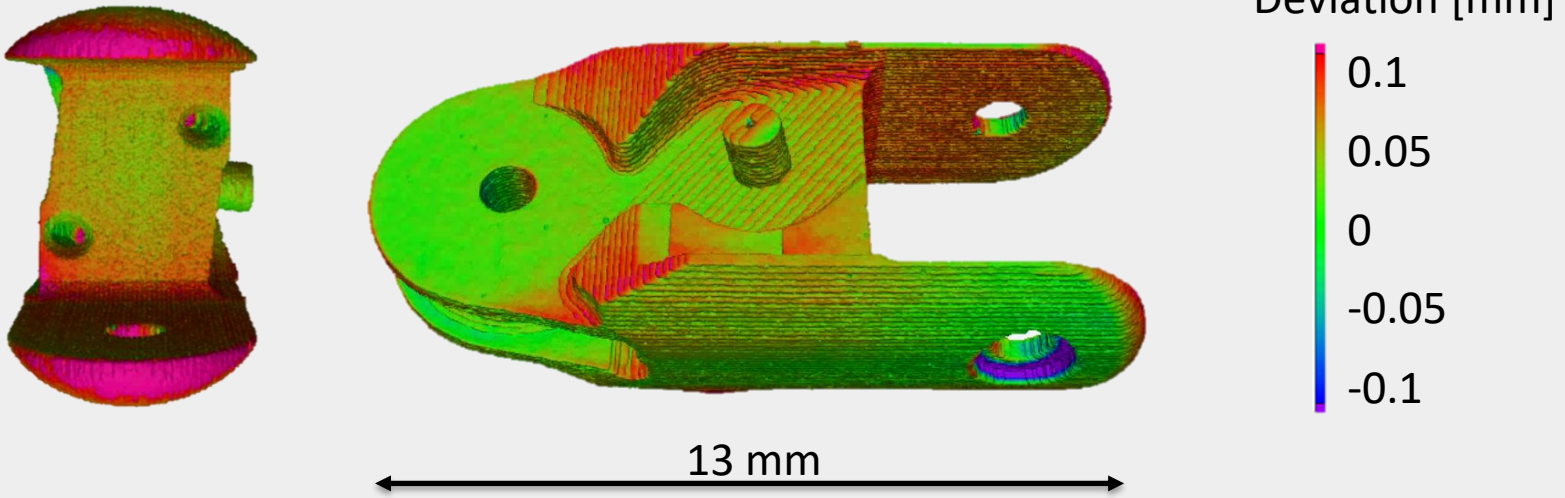
Printed Parts



316L stainless steel

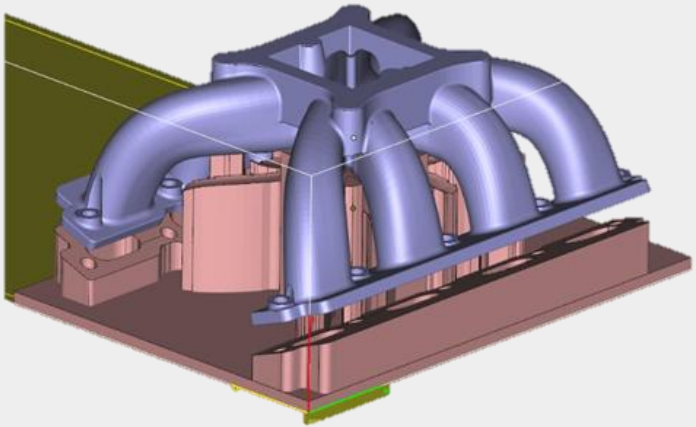
Evaluation of resolution

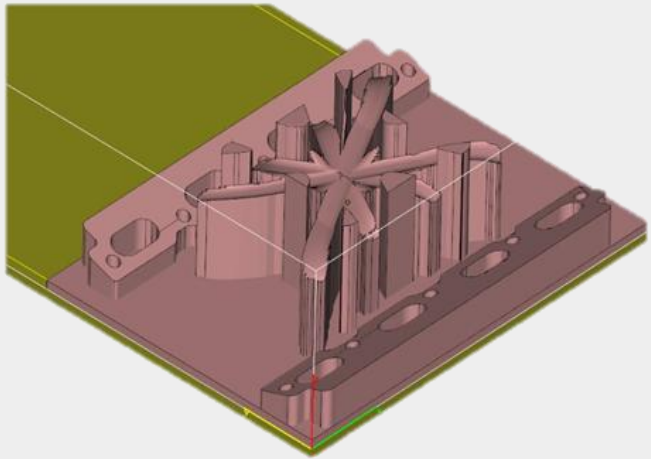
- Comparison of original STL to sintered component



Printing of Sintering Support

Design and printing of sintering support possible in single step





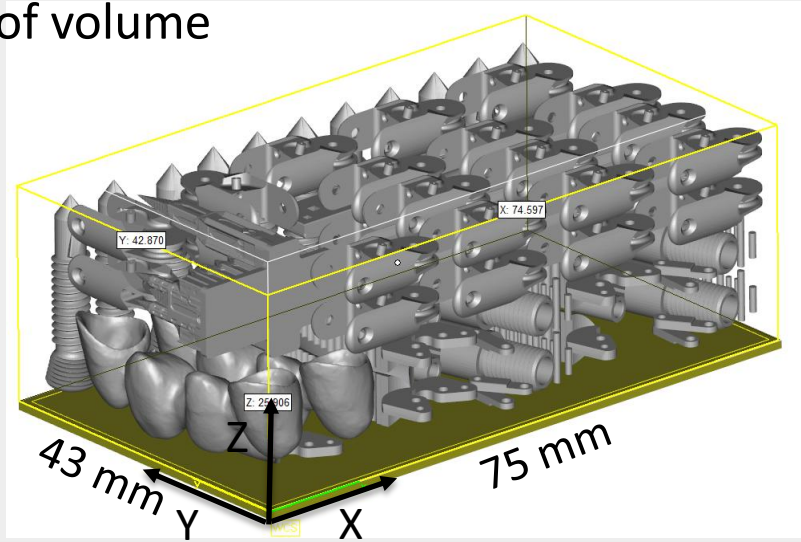
LMM of Ti6Al4V

First results

Introduction

Detail of Run

- Placement on building platform without support structures
- 26 mm building height (Z direction) = 520 layers
- Volume nesting with software, 18% usage of volume
- 1 scaled by factor 1,2
- Shrinkage due to sintering only estimated!



Placement of parts on building platform

Results

Selection of Green Parts after Printing

- Cleaning needs to be improved to avoid small surface defects
- Selection of proper solvents
- 4,4 g/cm³ (98% rel.)

Conclusion

Conclusion

What is LMM?

- MIM-like AM Process based on stereolithography
  - Same metal powder & and furnace equipment for debinding/sintering
- Robust AM process
  - Easy handling of machine and preparation of printing jobs
  - Easy material change
- No danger to the operator (no metal dust or high-power laser)
- Proof of Concept for 316L stainless steel
  - Highest surface quality achievable compared to other AM processes
  - Known material properties
  - Good accuracy and resolution
- Material development focus on Ti6Al4V
- First trials WC/Co, Cu, SiC, W, Mo

Acknowledgements

Nick Cruchley

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