

**Johannes  
Niedermayer**

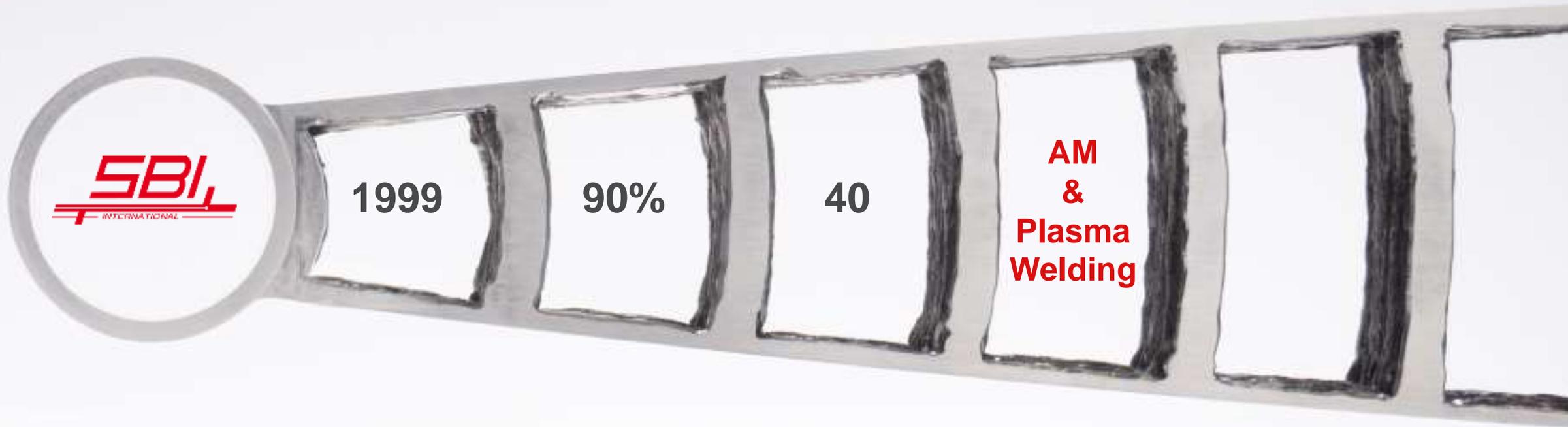


**Michael  
Kitzmantel**

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**M3DP – WHEN 3D COMPONENTS GROW  
BEYOND THE POWDER BED!**

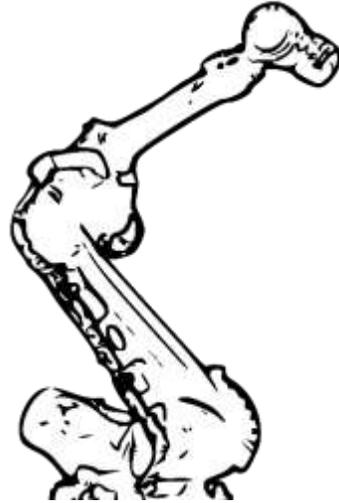




**ADDITIVE MANUFACTURING  
WITH HIGH EFFICIENCY**

credit: Syrovatka  
courtesy RHP





**M30P**

**PMD**<sup>®</sup>  
PLASMA METAL DEPOSITION  
R o b o t i c

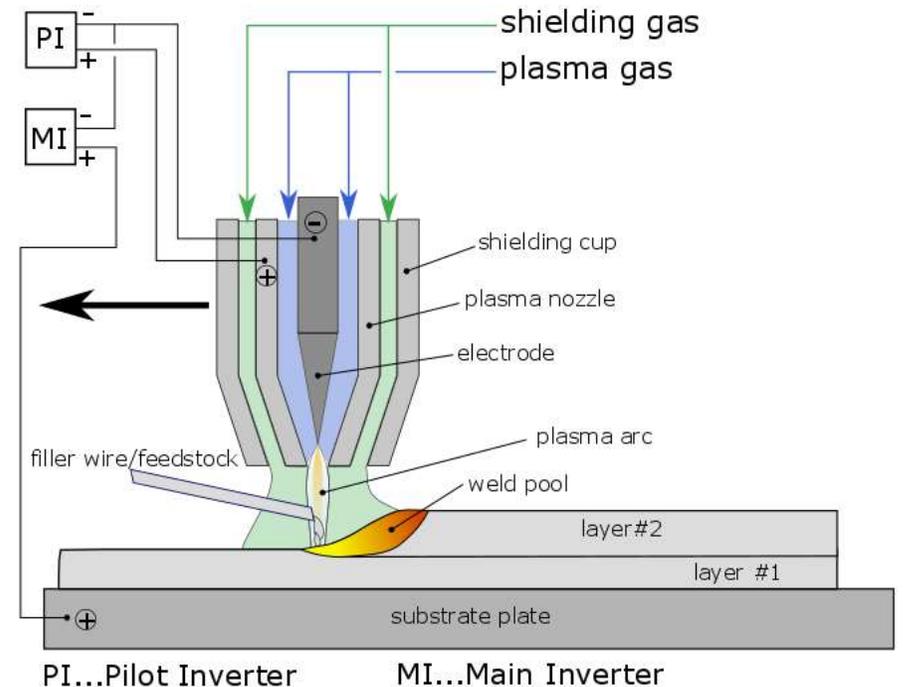
**M30P SL**

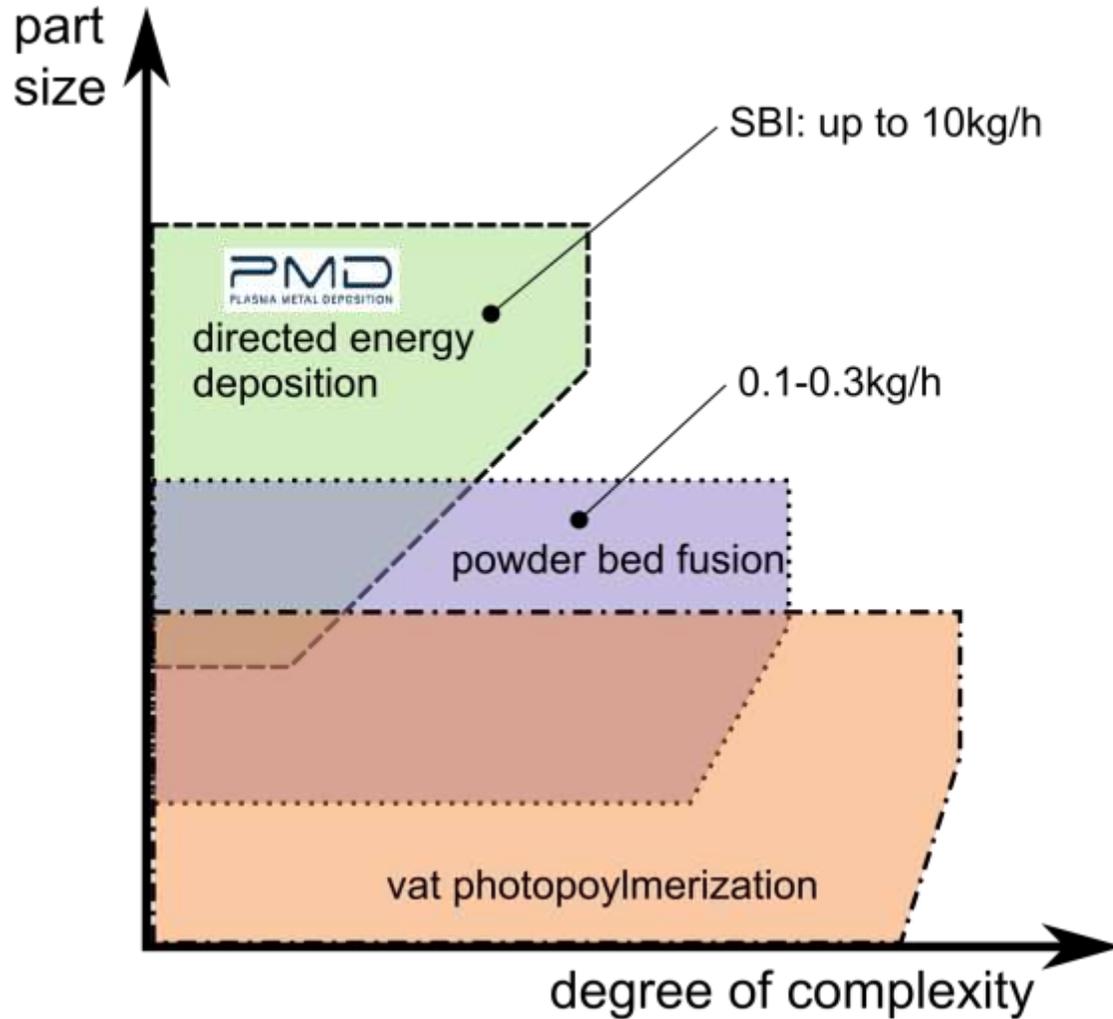
# AM – A SHORT OVERVIEW

							
	<b>MATERIAL JETTING</b>	<b>BINDER JETTING</b>	<b>MATERIAL EXTRUSION</b>	<b>POWDER BED FUSION</b>	<b>DIRECTED ENERGY DEPOSITION</b>	<b>SHEET LAMINATION</b>	<b>VAT PHOTO POYLMERI-SATION</b>
<b>FUSION THROUGH</b>	UV LIGHT	BONDING AGENT	HEATED PRINTHEAD	LASER BEAM; ELECTRON BEAM	ELECTRIC ARC; LASER & ELECTRON BEAM;	MICROWAVES; BONDING AGENT	UV LIGHT
<b>MATERIALS</b>	PLASTIC	PLASTIC; CERAMIC; METAL; SAND	PLASTIC; PLASTIC EMBEDDED METALS	METAL; CERAMIC	METAL	METAL; PAPER	PHOTO-POYLMERS
<b>EXAMPLES</b>	DOD	N.A.	FDM, FFF	SLM, SLS, DMP	RPD, EBAM	LOM	SLA, DLP

Classification of AM-processes according to ASTM F-42

- The plasma torch is moved by a CNC gantry system along an arbitrary path and creates a weld pool on a substrate plate.
- By adding wire into the weld pool material deposition is achieved. Putting one deposition over the previous a desired part can be generated.
- **PMD** is a “**near net shape**” process and means that post processing like lathing and milling are almost always necessary.
- The process works with all fusion weldable metals like steel, nickle-base alloys, titanium, aluminium,...
- The **M3DP** is a pure AM-system and therefore has no subtractive function





- ✓ XL Parts
- ✓ Deposition Rate
- ✓ Flexibility
- ✓ Scalability
- ✓ Economy friendly



+



AND / OR



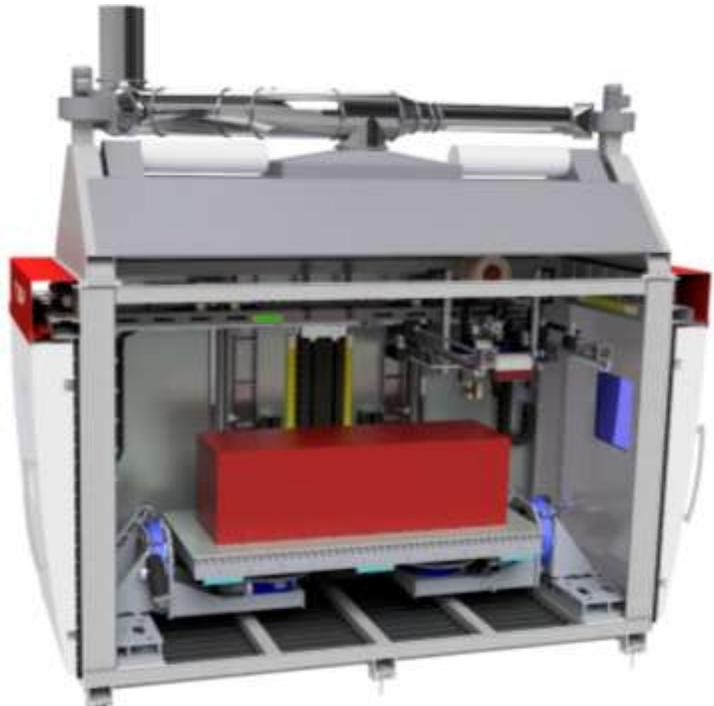
- ✓ Multiple wires
- ✓ Wire preheating

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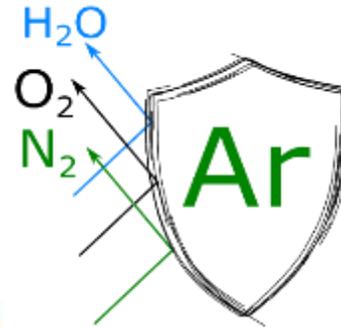
- ✓ Multiple powders



**PMD<sup>®</sup>**  
PLASMA METAL DEPOSITION



Buildvolume 2000 x 600mm x 600mm  
5-Axis-System for 2.5D build-up



Buildvolume Ø1000mm x 800mm  
8-Axis-System for 3D build-up

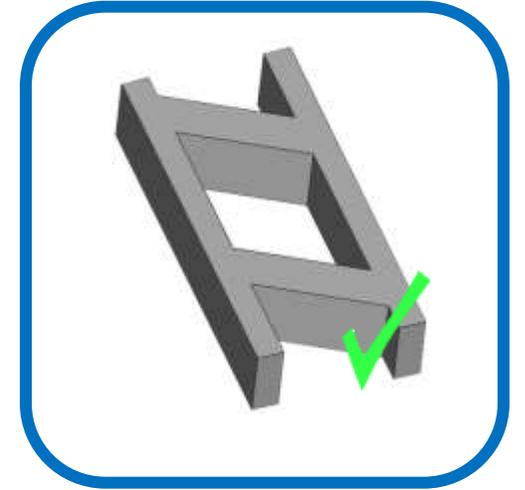
- **Cylindric**

- tubes
- pipes



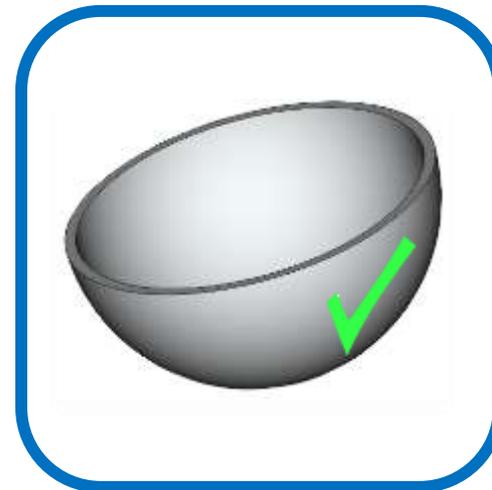
- **2.5D & 3D parts**

- Structural parts
- consoles
- Print2Forge



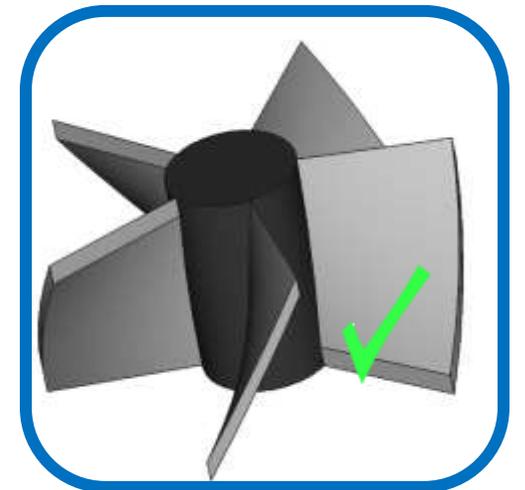
- **Spherical**

- Domes
- Tanks



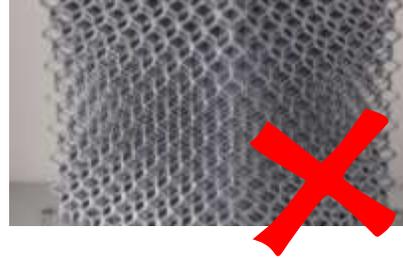
- **Hybrid**

- turbines
- bliscs
- repair
- Forge2Print



- **High complexity**

- Lattice structures
- Cooling channels



- **Topological optimized structures**



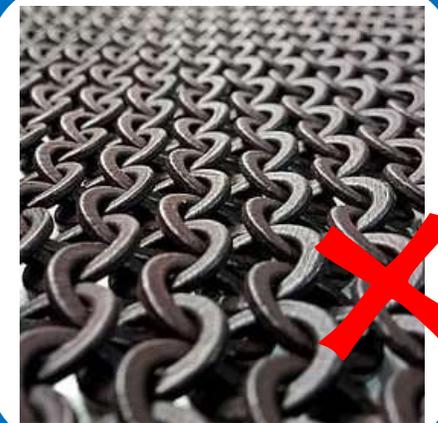
- **High resolution / Net-shape**

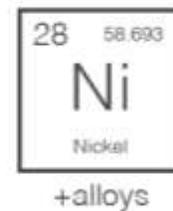
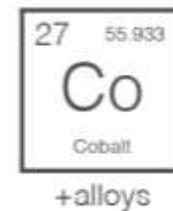
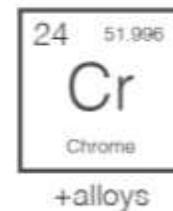
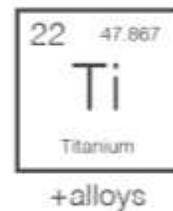
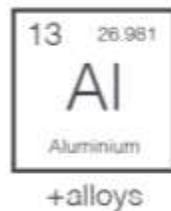
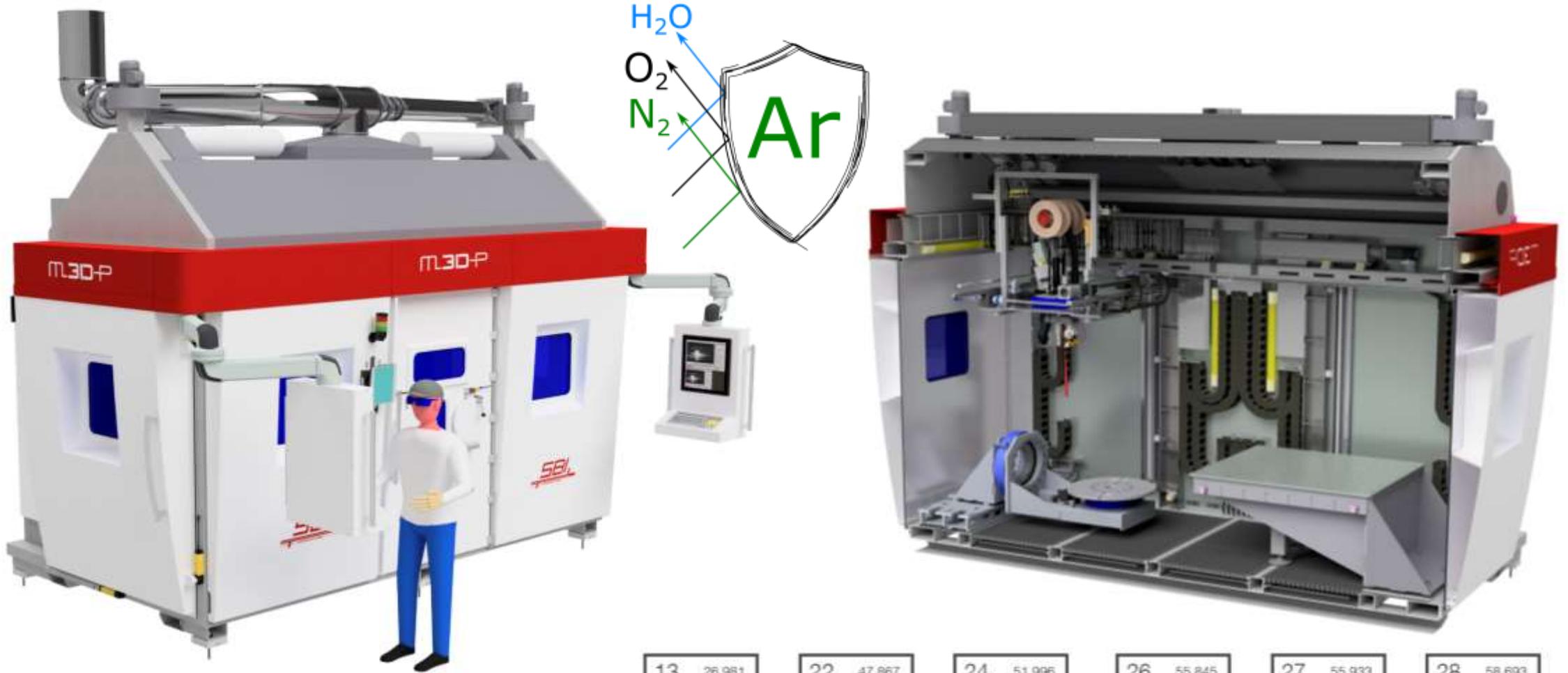
- Screws

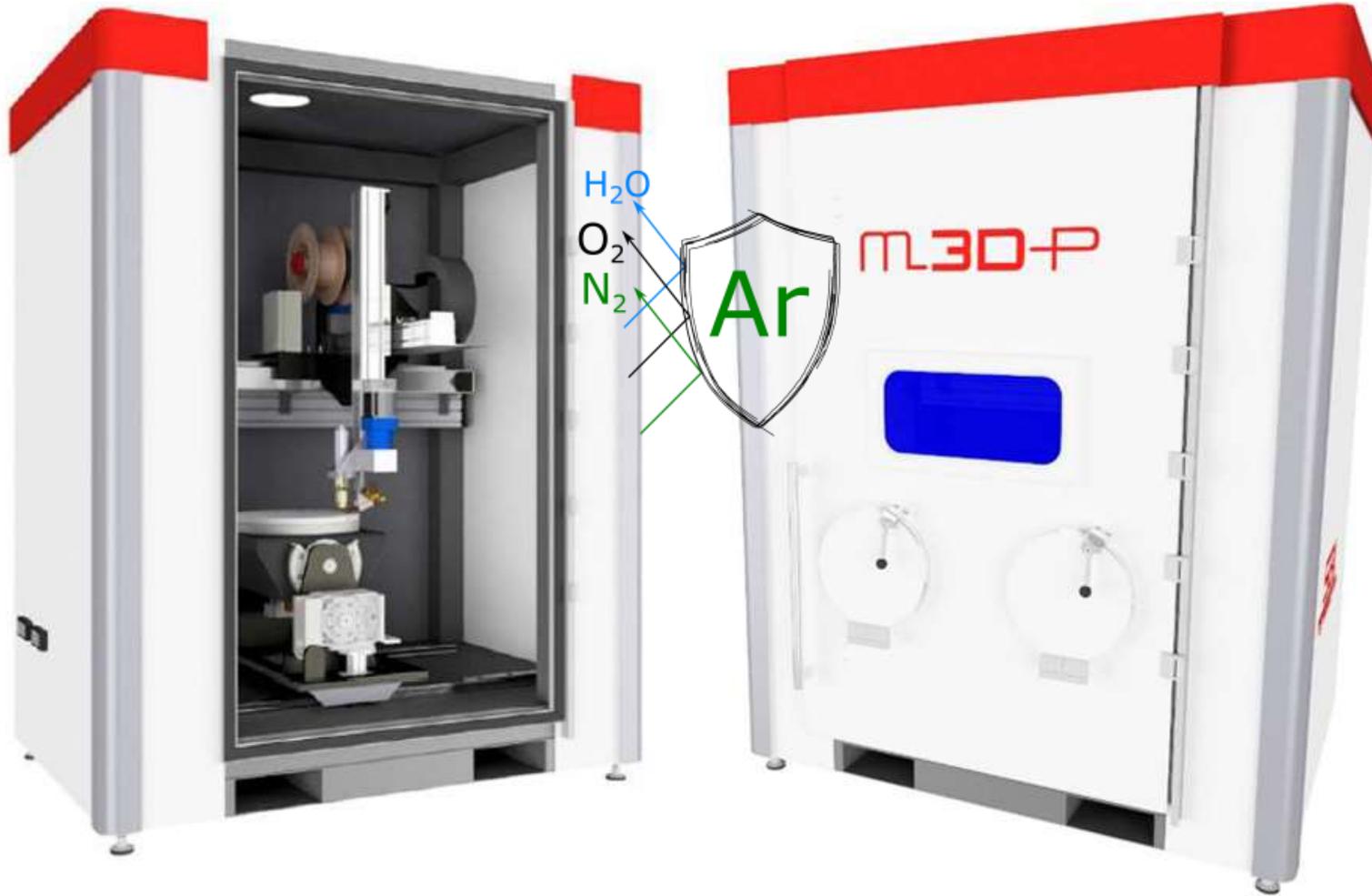


- **Consolidated parts**

- Chainmail

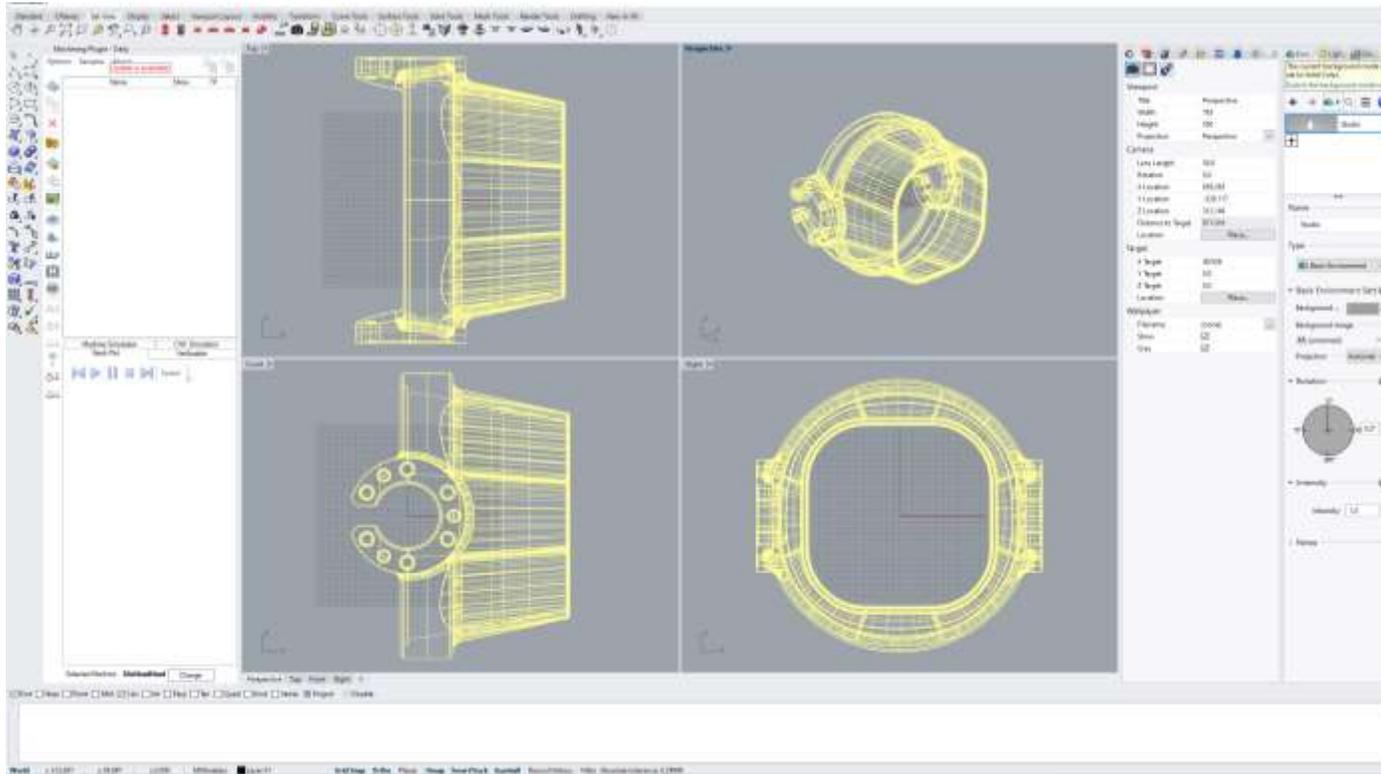




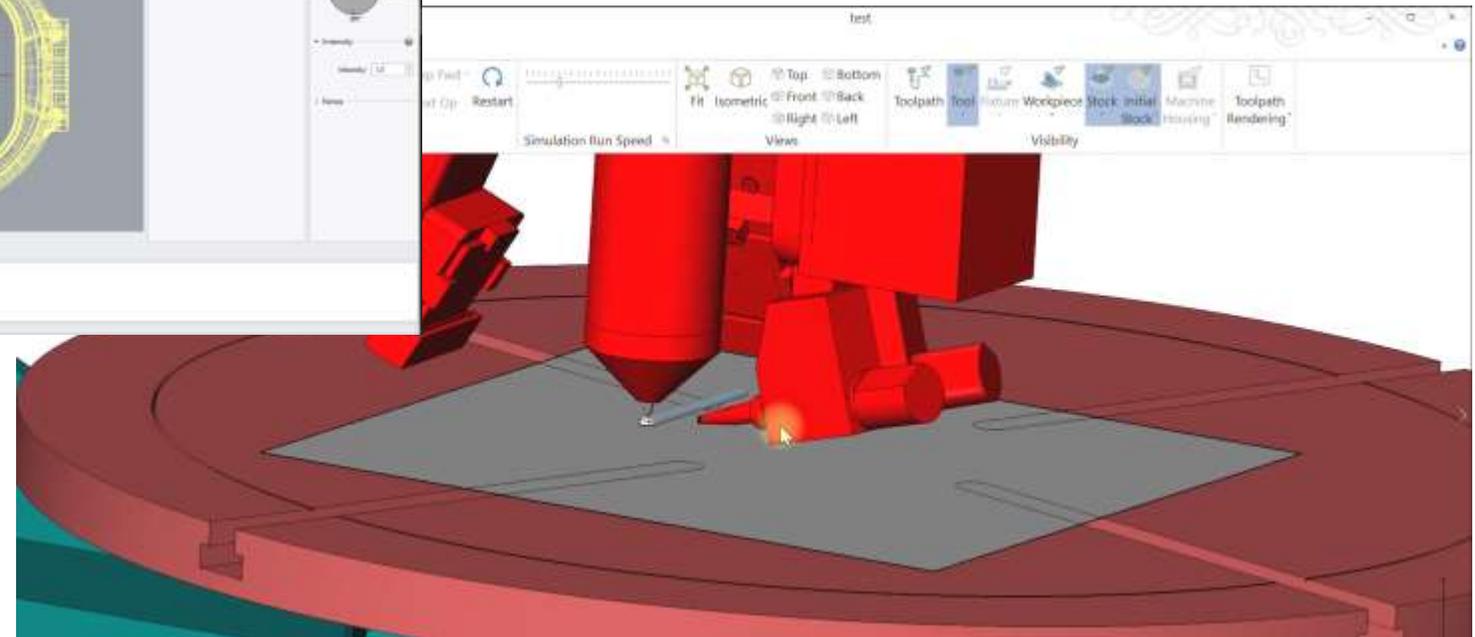


13 26.981 <b>Al</b> Aluminium +alloys	22 47.867 <b>Ti</b> Titanium +alloys	24 51.996 <b>Cr</b> Chrome +alloys
26 55.845 <b>Fe</b> Iron +alloys	27 55.933 <b>Co</b> Cobalt +alloys	28 58.693 <b>Ni</b> Nickel +alloys

Fully functional M3DP System with smaller footprint and many options for R&D



- ✓ G-Code Generation
- ✓ Offline & (Online)
- ✓ Full process control
- ✓ Automatic Collision Warnings
- ✓ Feature recognition





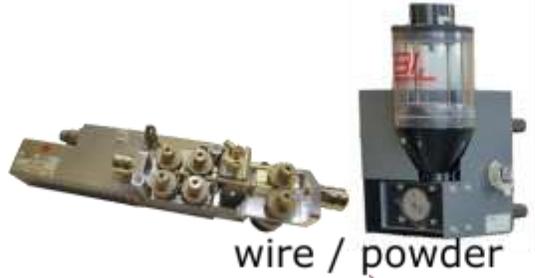
**M3DP**



**M3DP-SL**

<b>Dimensions</b>	5000 x 2400 x 4200 mm (X-Y-Z)	1700 x 1400 x 2600 mm (X-Y-Z)
<b>Buildvolume</b>	2000mm x 600mm x 600mm	Ø400 mm x 500 mm
<b>Mass</b>	7.000kg	3.000kg
<b>max. payload</b>	650kg	250kg
<b>Airtight system</b>	Yes - optional	Yes - optional
<b>Feedstock</b>	Metal <b>wire &amp; powder</b>	Metal <b>wire &amp; powder</b>
<b>Energy source</b>	Plasma arc	Plasma arc
<b>Deposition rate</b>	max. 10 kg/h for nickel-base-alloys 4,5 kg/h for titanium	max. 10 kg/h for nickel-base-alloys 4,5 kg/h for titanium

material feeding systems



camera monitoring



power source



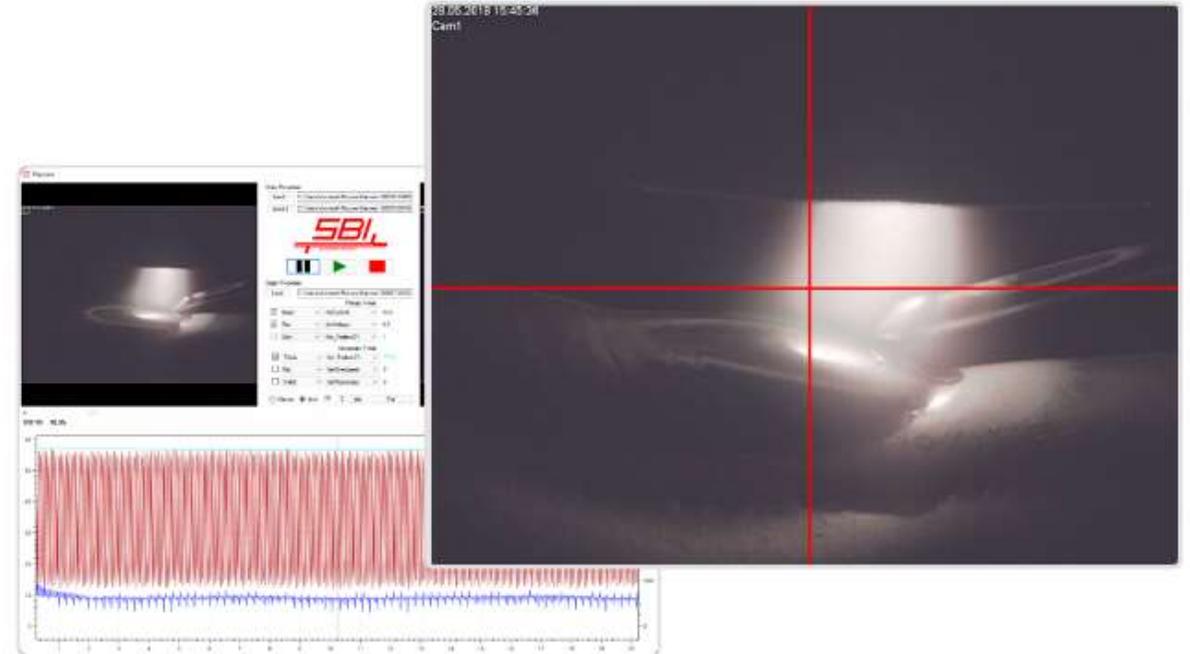
custom / standard

torch & wire guide

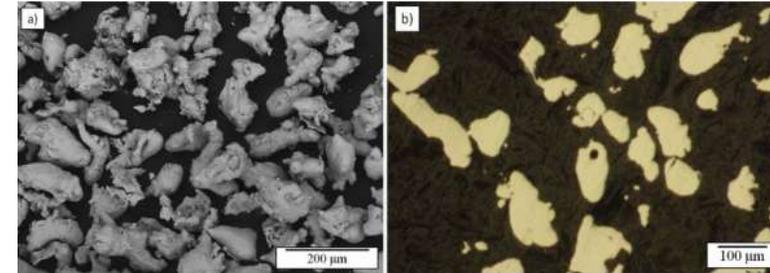
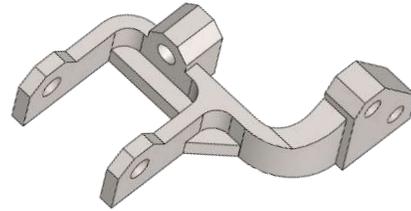


The AM process is supervised and controlled throughout the whole build up:

- ✓ **SBI Camera system**  
process recording and visual supervision by operator
- ✓ **SBI Datalogger (for all process parameters)**  
coordinates, process parameters, errors,... which are connected to the video by timestamp
- ✓ **3D scanner implementation**  
3D scan of the deposited material after each layer and matching of the deposited structure with a should-be 3D model; adaptive Z-offset control
- ✓ **Pyrometer implementation**  
For checking interlayer temperature and temperature in general



- **Gearfork Bracket**
- 17-4 PH powder



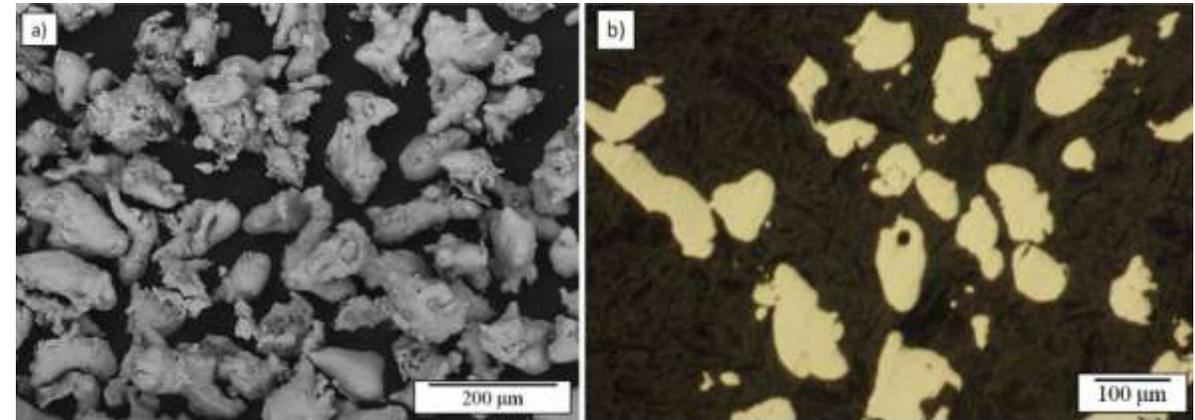
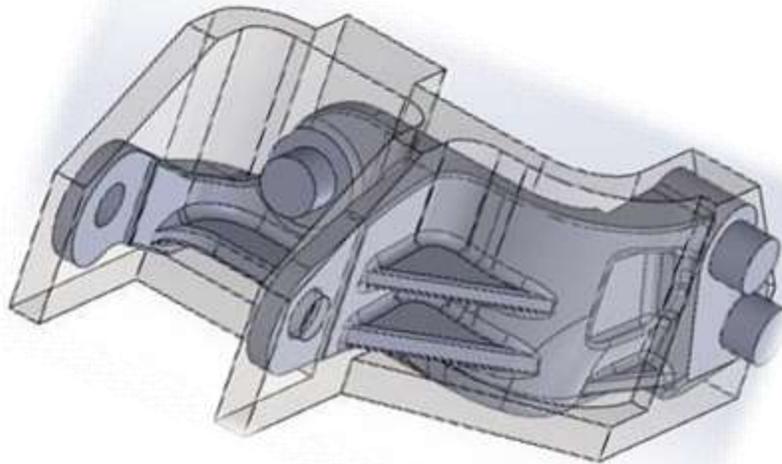
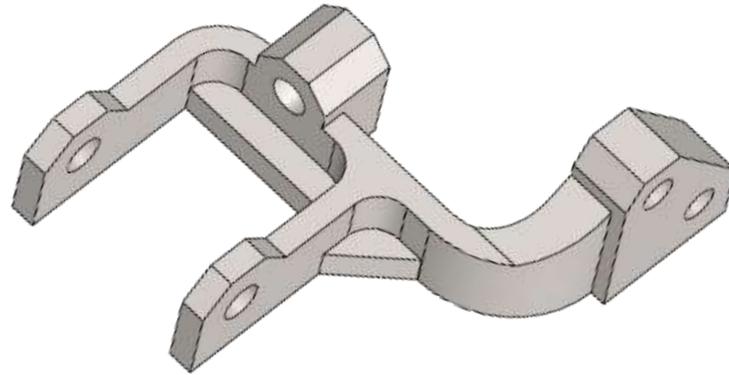
- **Space Telescope part**
- Ti Alloy powder + wire



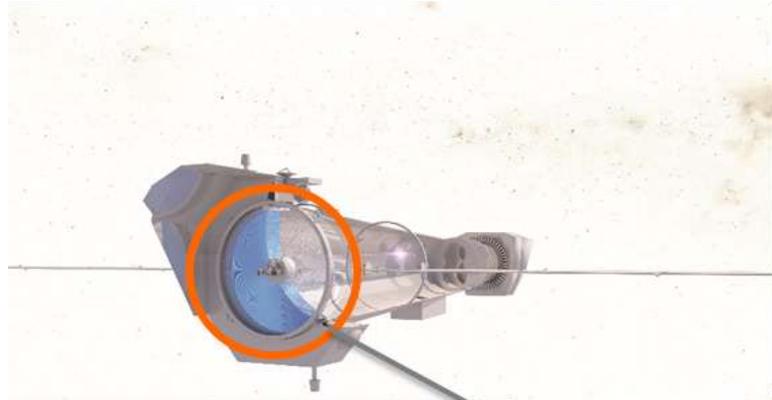


- ✓ Batch process
- ✓ Economic production
- ✓ Reduced post processing
- ✓ Reduced resources

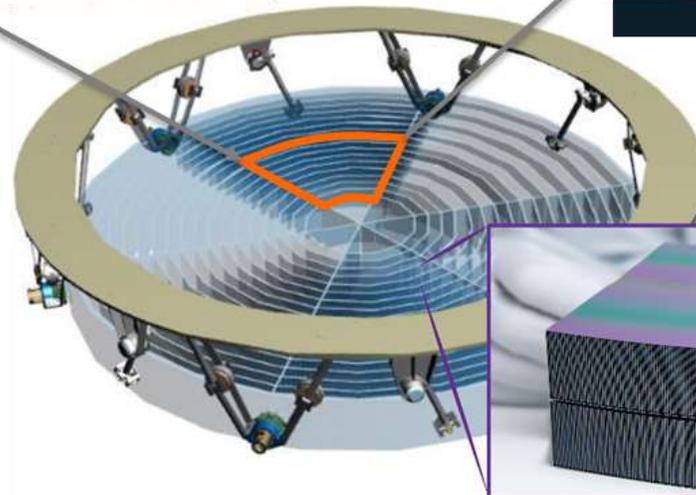
- 2.5 D production
- Use of base plate
- Water jet cutting + machining of holes / functional surfaces
- Argon box to save Argon (and keep fumes, residual powder)



# STUDY: ATHENA SPACE TELESCOPE PART

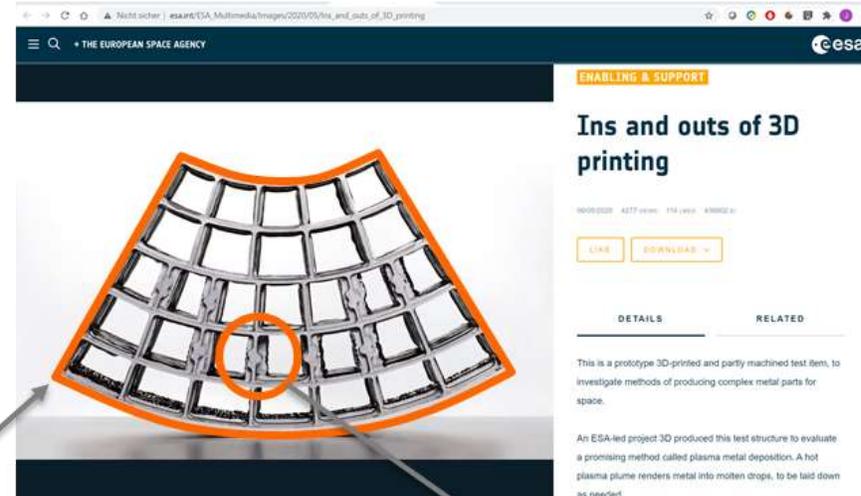


[https://www.the-athena-x-ray-observatory.eu/media/rokgallery/f/f853731b-aa06-4967-e9aa-a9c23c19ecab/InsideAthena\\_XIFU\\_movie.jpg](https://www.the-athena-x-ray-observatory.eu/media/rokgallery/f/f853731b-aa06-4967-e9aa-a9c23c19ecab/InsideAthena_XIFU_movie.jpg)

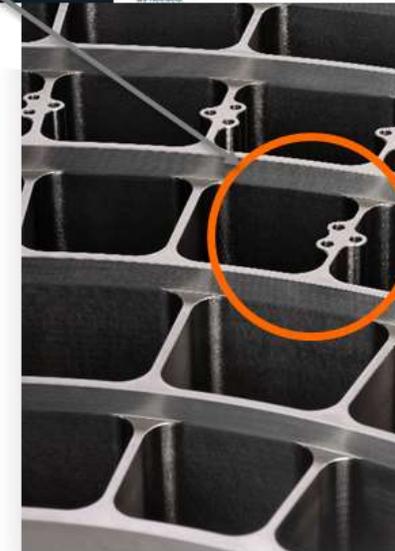


Credit: ESA, Cosine and ACO Team

[https://www.the-athena-x-ray-observatory.eu/images/Nuggets/AN08\\_ima.gif](https://www.the-athena-x-ray-observatory.eu/images/Nuggets/AN08_ima.gif)



[http://www.esa.int/ESA\\_Multimedia/Images/2020/05/Ins\\_and\\_outs\\_of\\_3D\\_printing](http://www.esa.int/ESA_Multimedia/Images/2020/05/Ins_and_outs_of_3D_printing)



# STUDY: ATHENA SPACE TELESCOPE PART



1 Segment	PMD®-ALM	Machining
Raw Material need	290 kg	1.600 kg
Final Part weight	ca. 160 kg	ca. 160 kg
Buy to Fly (BTF)	ca. 1,8: 1	~ 10: 1!
Material Waste	130 kg	1.440 kg !

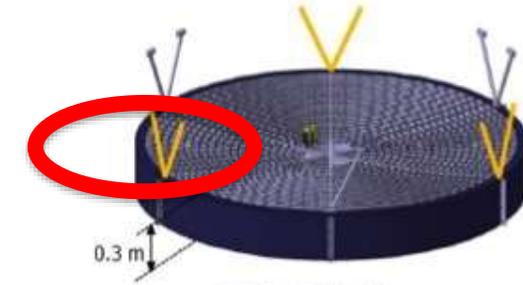
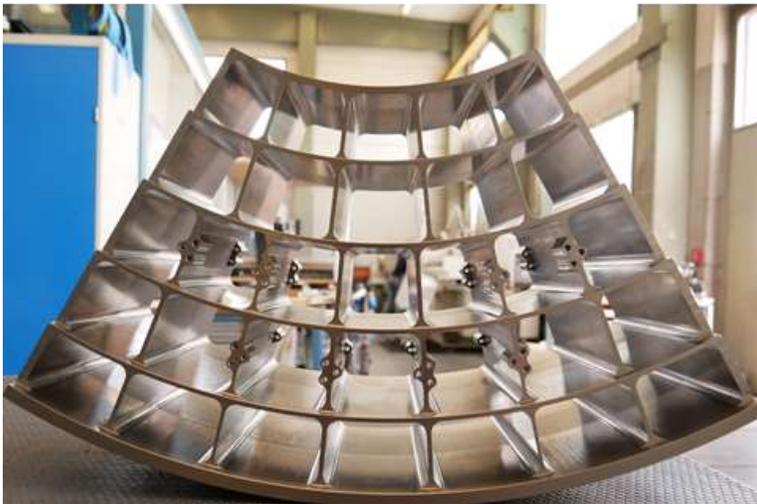


Figure 8 Illustration of mirror height



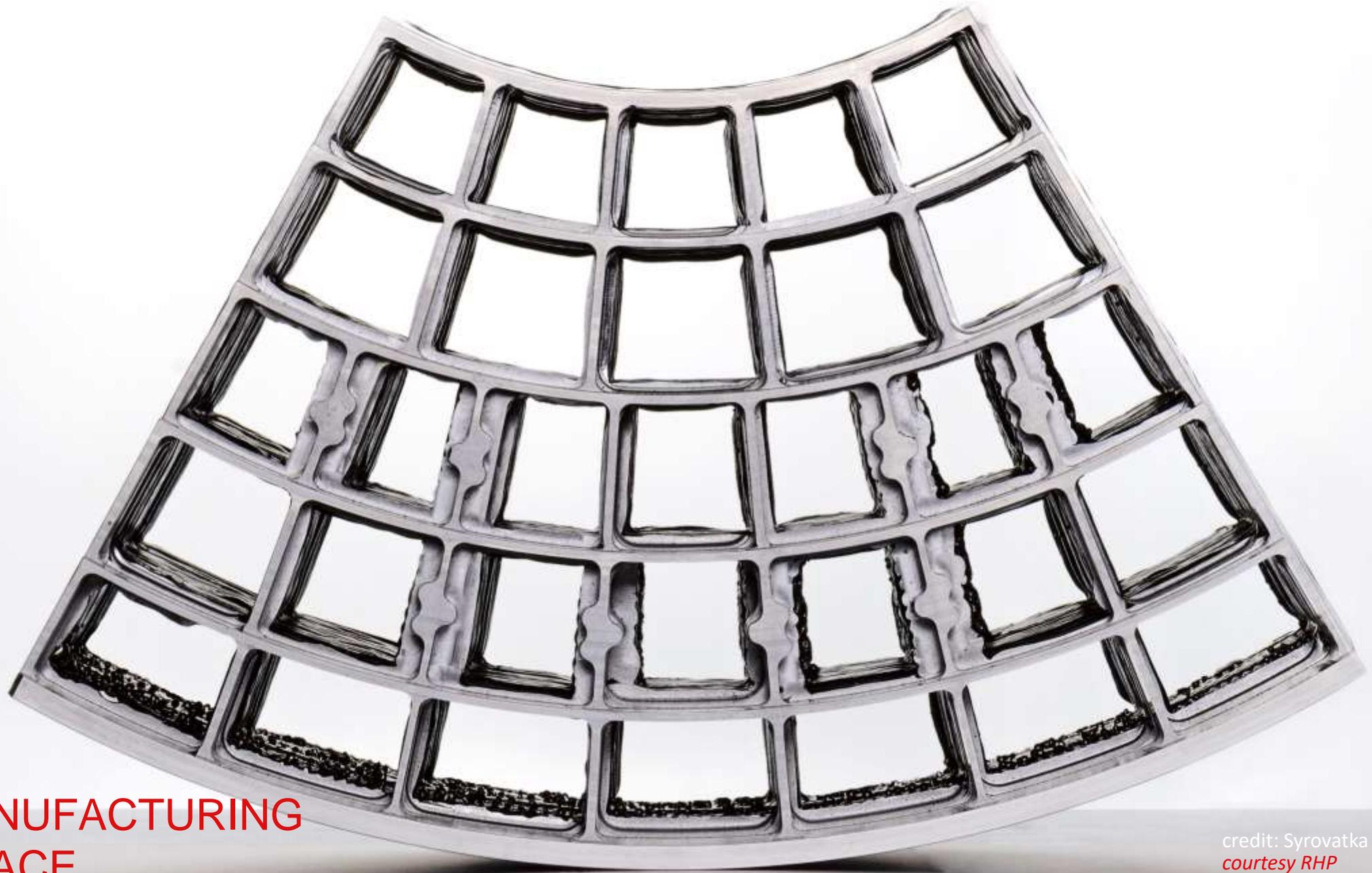
Demonstrator	PMD®-ALM	Machining
Raw Material need	45 kg	205 kg
Final Part weight	ca. 25 kg	ca. 25 kg
Buy to Fly (BTF)	ca. 1,8:1	~ 8,4: 1!
Material Waste	ca. 20 kg	180 kg !

**6 Segments -> 8,6 tons of waste vs. 800kg of waste**



## Material properties

Standard	Material	Origin	Mechanical properties		
			UTS MPa	YS MPa	A %
ASTM B348	Grade 5	Billet	895-1000	828-910	10-18
ASTM B367	Grade 5-C	Casted	895	825	5
<b>RHP</b>	<b>Ti-6Al-4V</b>	<b>PMD</b>	<b>895-930</b>	<b>825-865</b>	<b>10-13</b>



ADVANCED MANUFACTURING  
FOR USE IN SPACE

credit: Syrovatka  
courtesy RHP



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***WE DO IT PLASMA!***