M3DP: PARTS AND DEMONSTRATORS BY PLASMA METAL DEPOSITION

SBI INTERNATIONAL

CONTENT

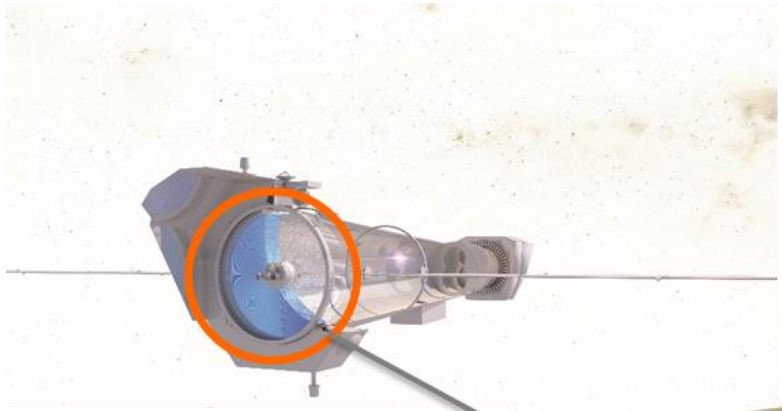
AM APPLICATIONS BY PMD®

TECHNOLOGY & SBI ADDITIVE MANUFACTURING SYSTEMS

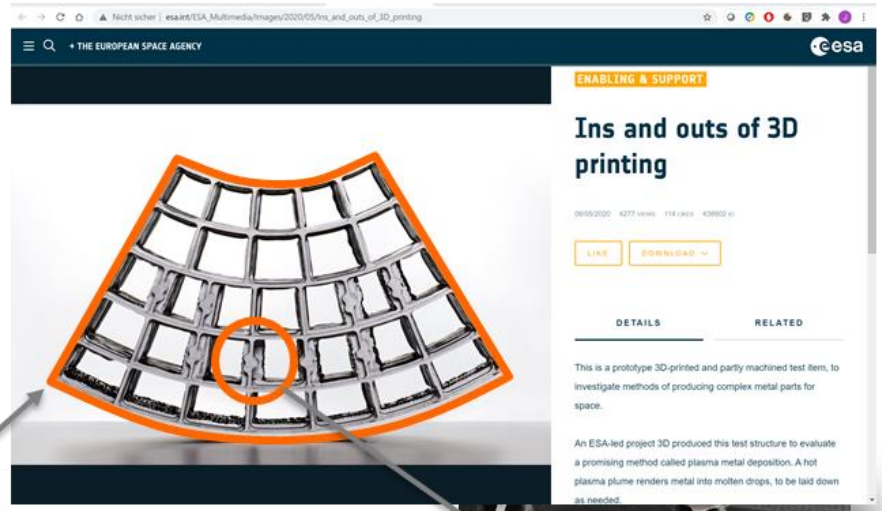
TITANIUM 64 – PMD POWDER & PMD WIRE

Feasiblity study for 3m diameter X-ray Eye structure in Ti64.
Processed with powder and wire options - fully inspected.

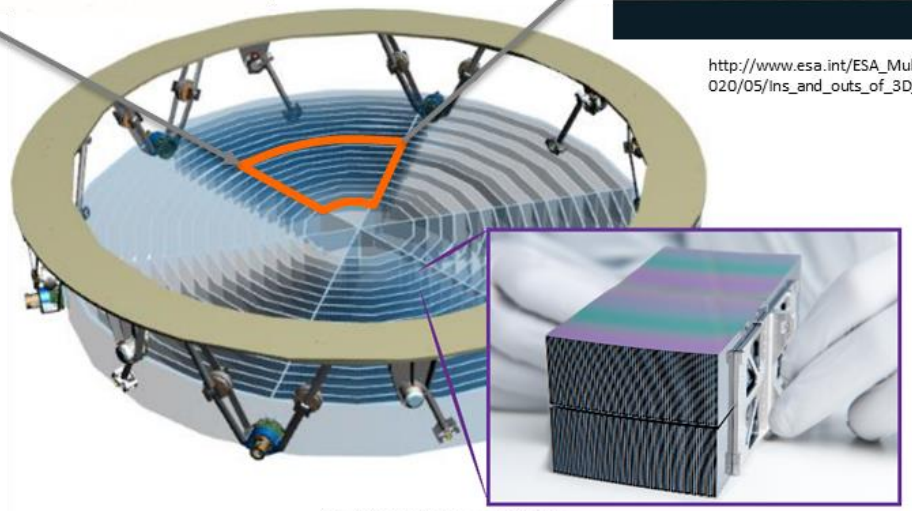
STUDY: ATHENA SPACE TELESCOPE PART



https://www.the-athena-x-ray-observatory.eu/media/rokgallery/f/f853731b-aa06-4967-e9aa-a9c23c19ecab/InsideAthena_XIFU_movie.jpg



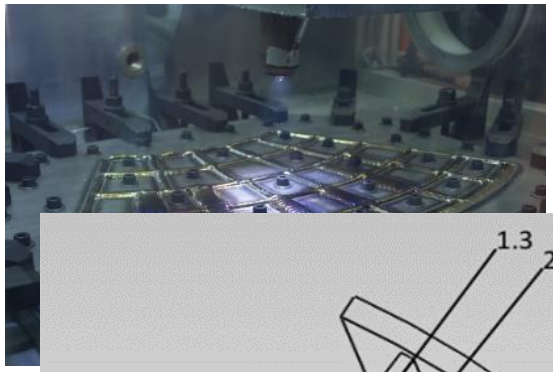
http://www.esa.int/ESA_Multimedia/Images/2020/05/Ins_and_outs_of_3D_printing

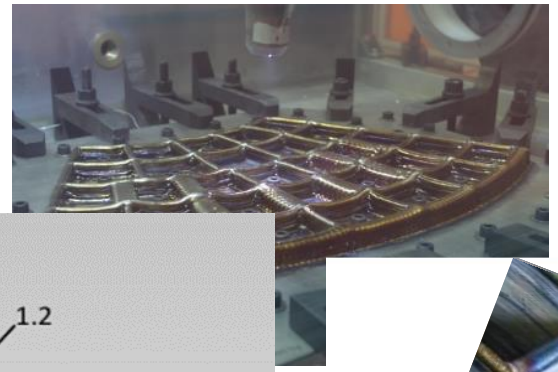


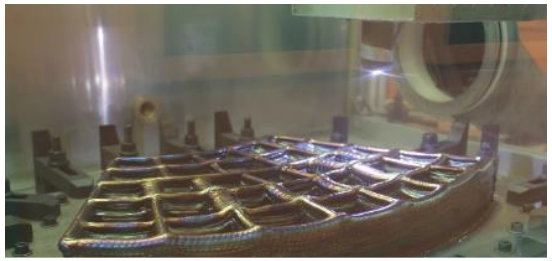
Credit: ESA. Cosine and ACO Team

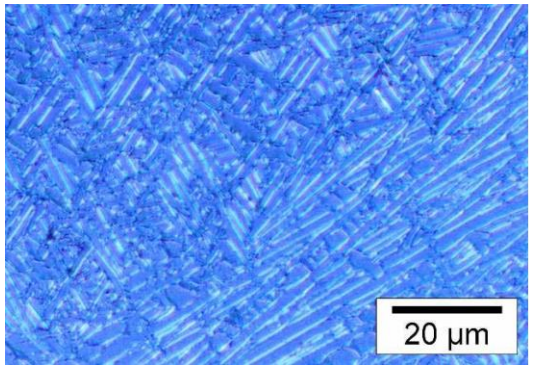
https://www.the-athena-x-ray-observatory.eu/images/Nuggets/AN08_ima.gif

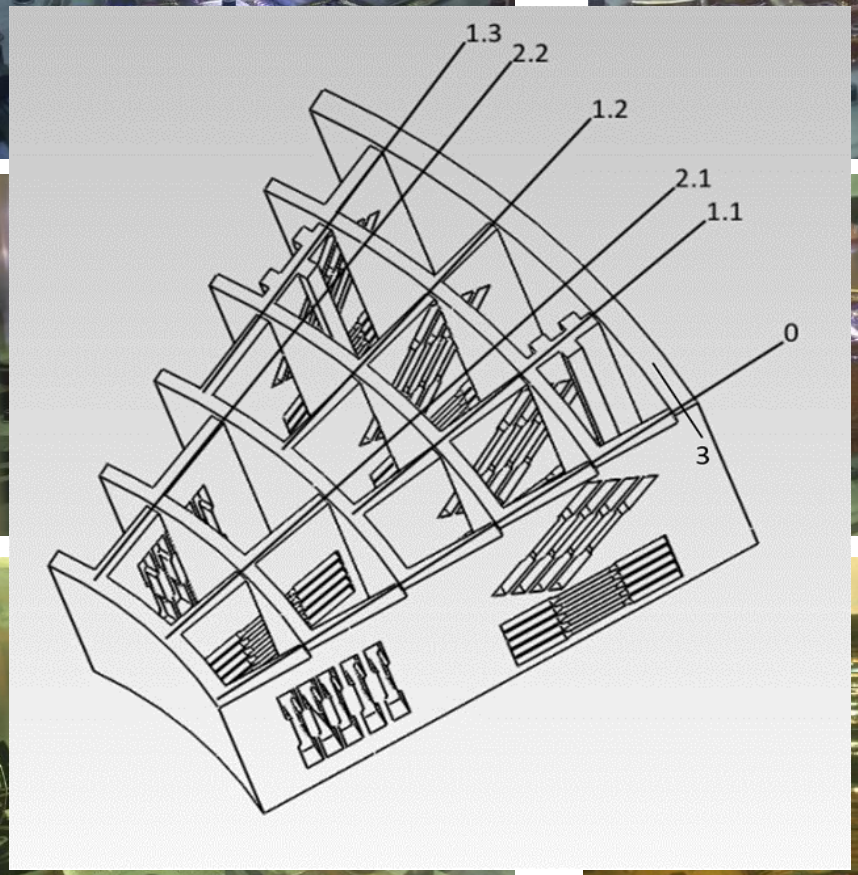
STUDY: ATHENA SPACE TELESCOPE PART

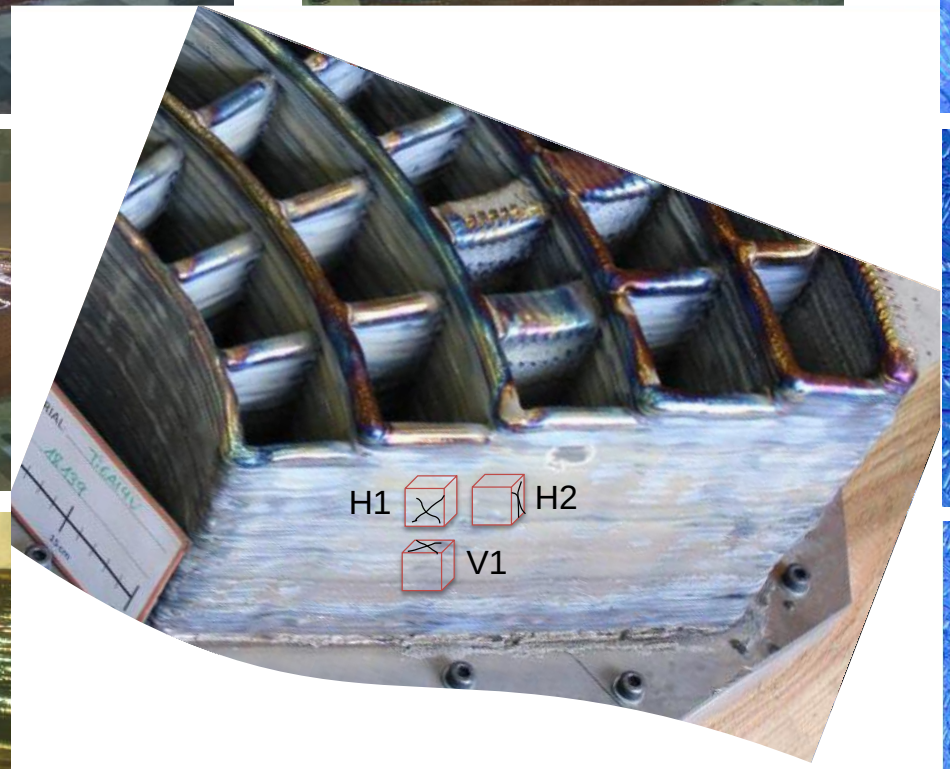


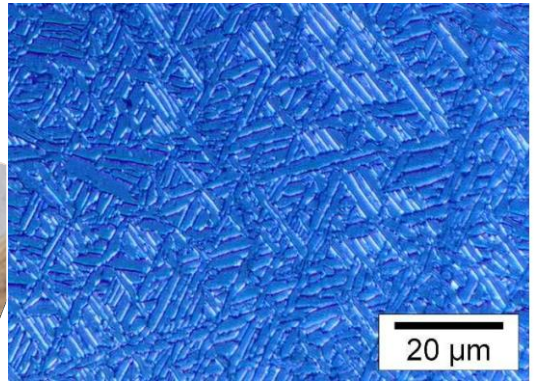


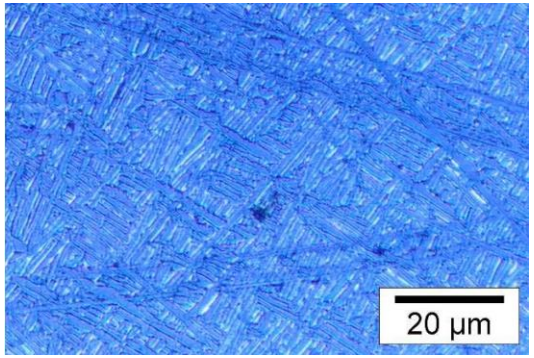


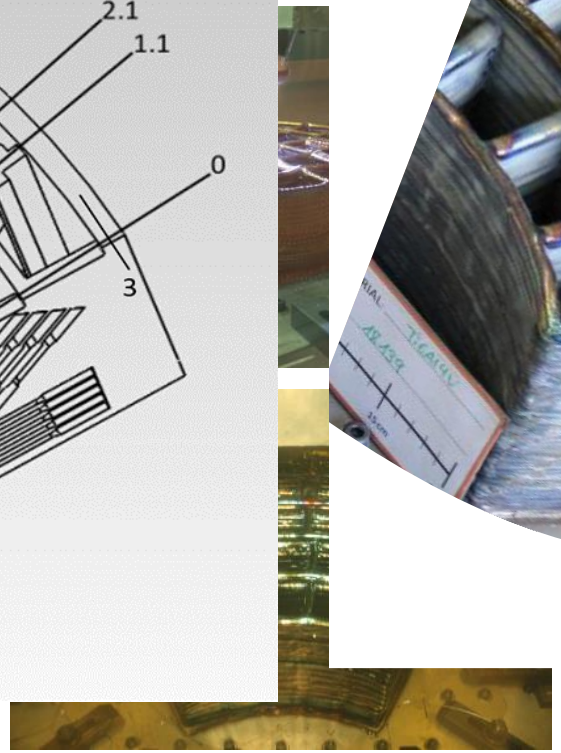




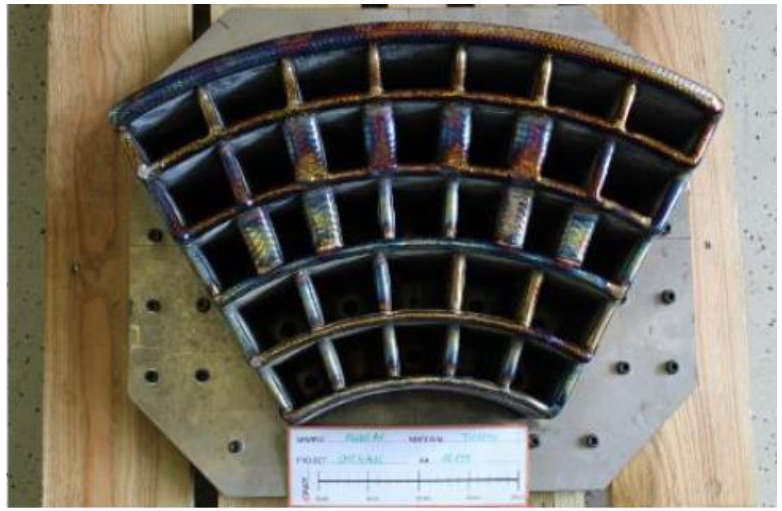




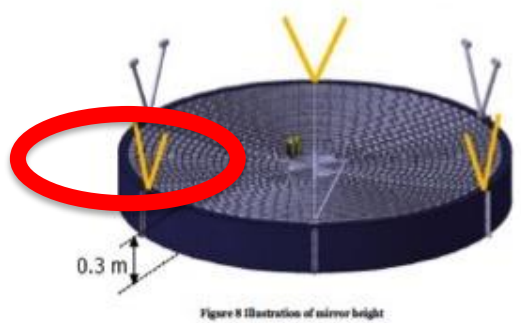


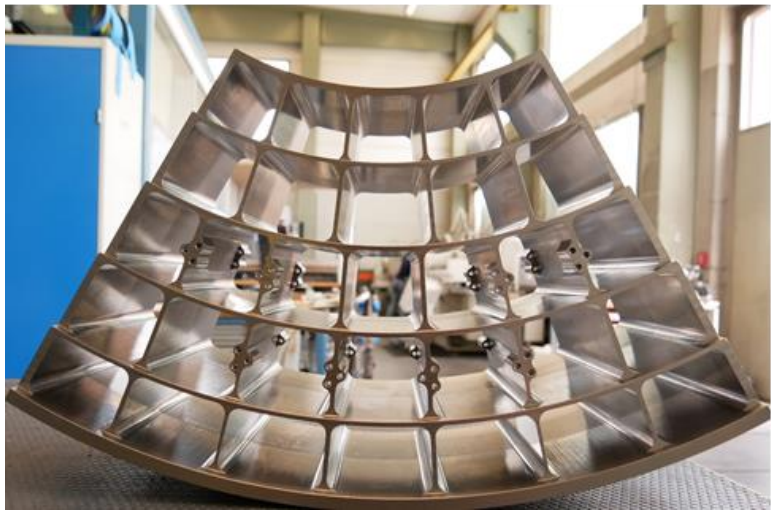


STUDY: ATHENA SPACE TELESCOPE PART



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 !



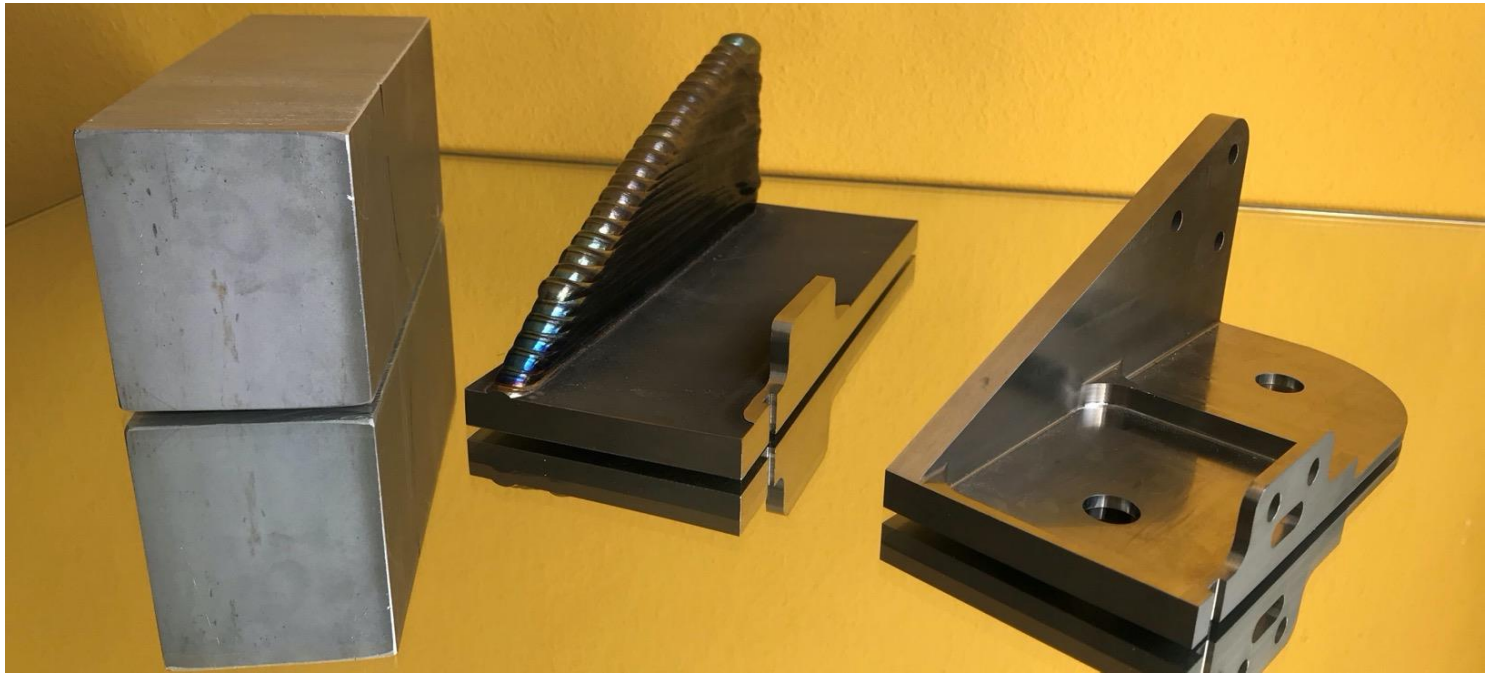


Demonstrator	PMD®-ALM	Machining
Raw Material need	45 kg	205 kg
Final Part weight	ca. 25 kg	ca. 25 kg
Buy to Fly (BTF)	ca. 1,8:1	~ 8,4: 1!
Material Waste	ca. 20 kg	180 kg !

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

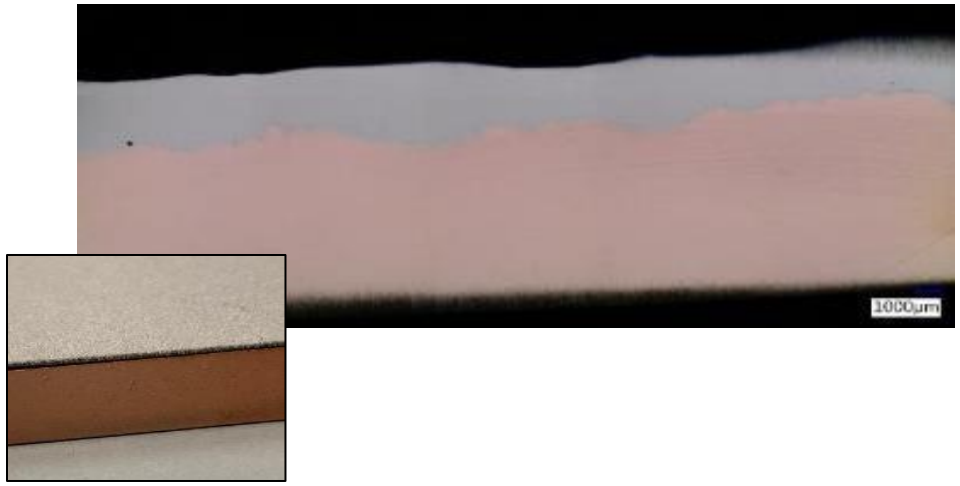
TI64 – PMD WIRE

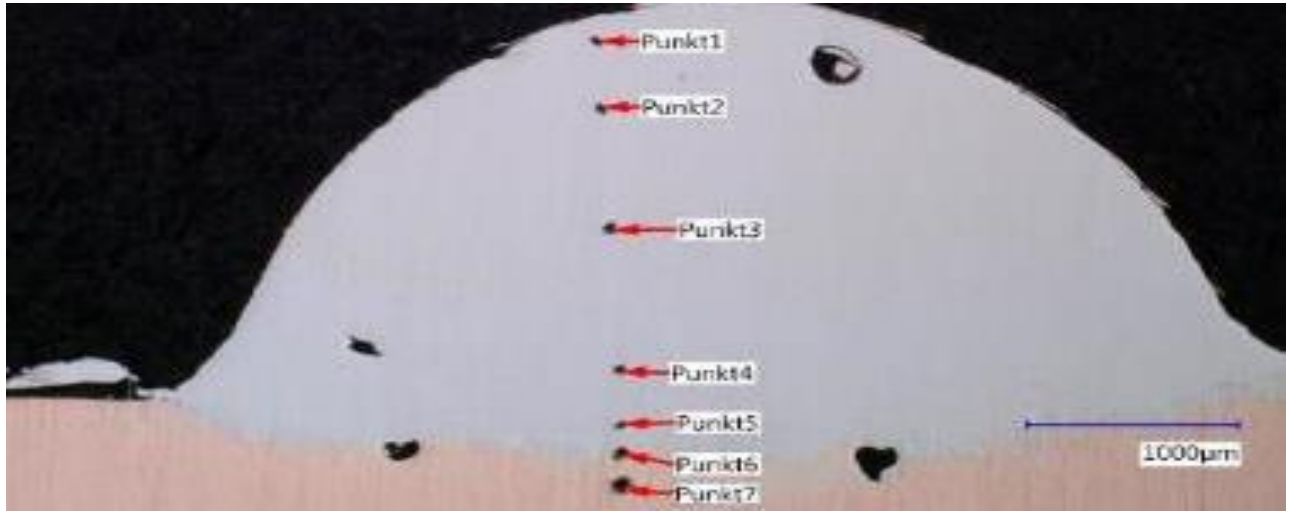
Hinge structures often lead to a high buy-2-fly ratio. This is an example for an aeronautic application with Titanium grade 5 alloy, manufactured by PMD® from high grade Ti AM wire.



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
RHP	Ti-6Al-4V	PMD	895-930	825-865	10-13

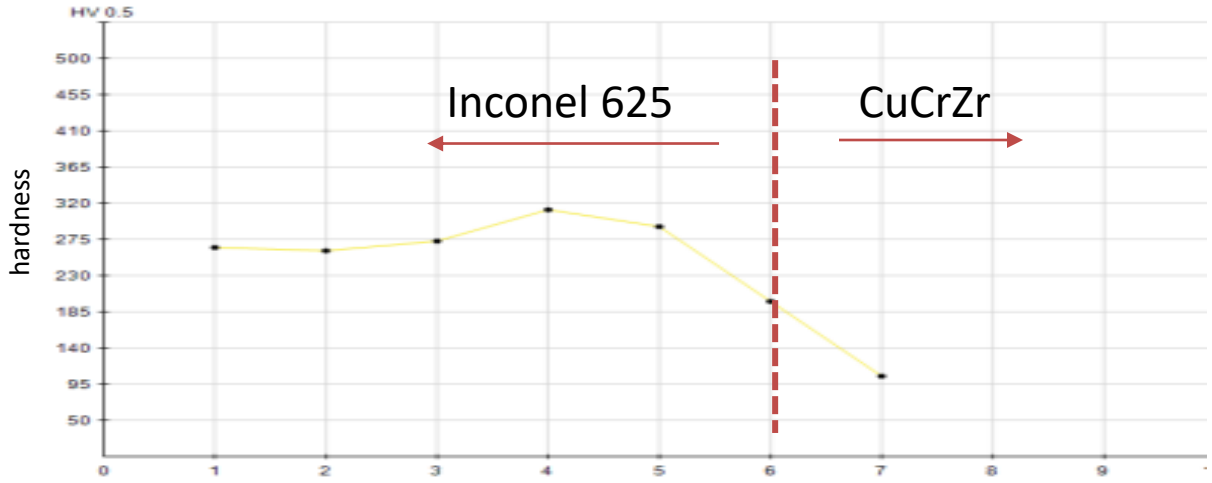
INCONEL 625 CLADDING ON COPPER ALLOY



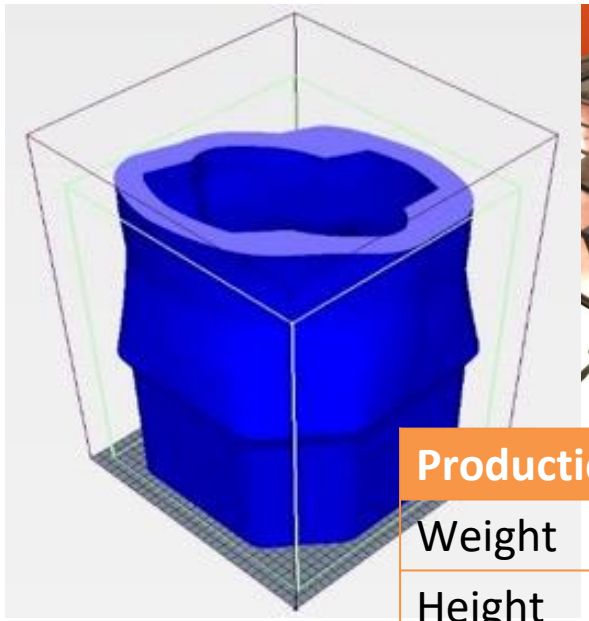


Base Material is a copper alloy (CuCrZr) plate to be cladded by a layer of Inconel 625 with a cladding thickness of 100-150µm

Due to very low thermal impact into the substrate, a sharp interface can be formed. Hardness values are measured.



STUDY: INVAR TOOLS BY ADDITIVE MANUFACTURING



Production data	
Weight	67 kg
Height	Ca. 450 mm

Invar is not easy to mill, so AM near netshape geometries are of high interest.
Second, the thermomechanical properties of INVAR need to survive the AM processing.
This was confirmed by the study.

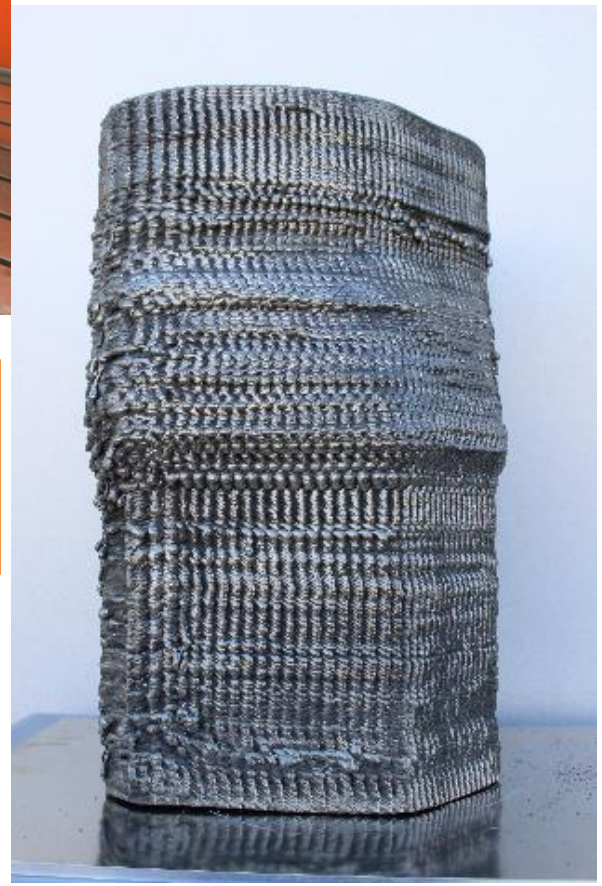


Foto: Alpex, “Addi©tive Tooling”

MULTI-MATERIAL GUIDE

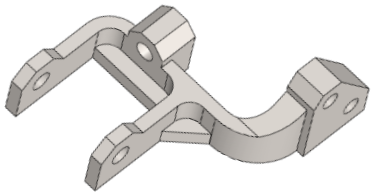
EXAMPLE STEEL

courtesy RHP

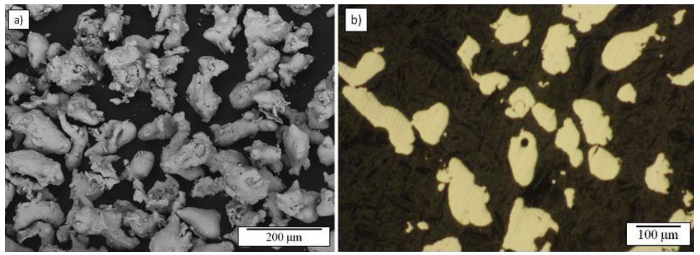
Material properties

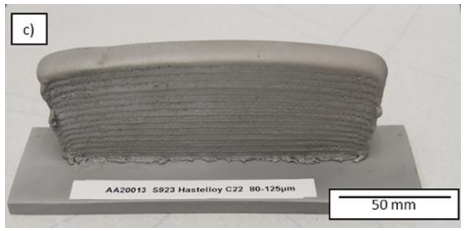
Standard	Material	Origin	Mechanical properties		
			UTS MPa	YS MPa	A %
ASTM A693	17-4PH	Sheet	1103	793	5
DIN 10088-3	1.4542	Billet	1070-1270	1000	10
RHP	**1.4542**	**PMD + PH**	**1075-1140**	**995-1095**	**10-11**

APPLICATION STUDIES

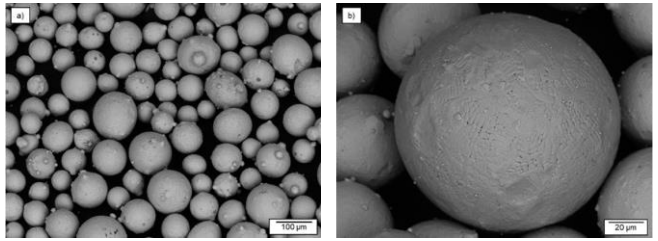


- **Gearfork Bracket**
- 17-4 PH powder

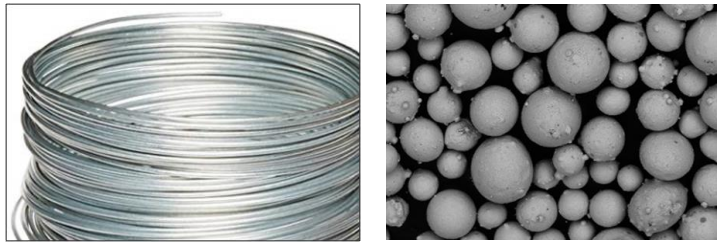




- **Material Influence Test**
- Hastalloy C-22 powder



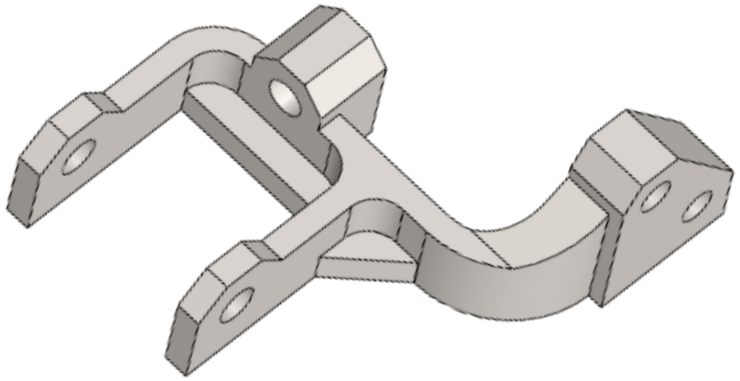
- **Space Telescope part**
- Ti Alloy powder + wire

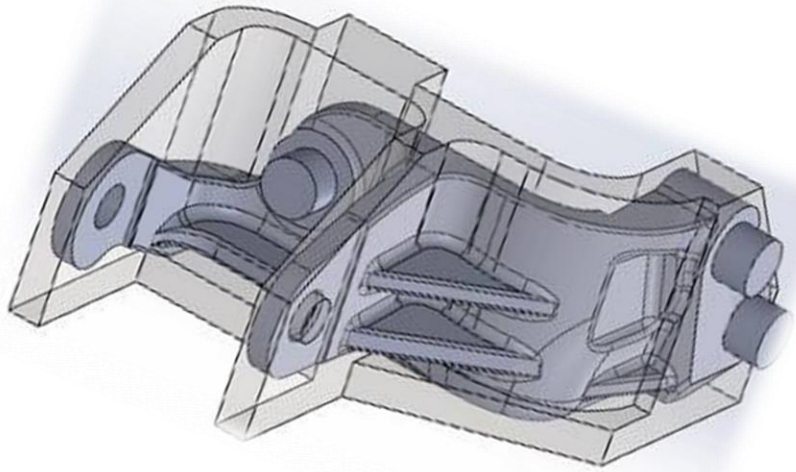


STUDY: GEARFORK BRACKET

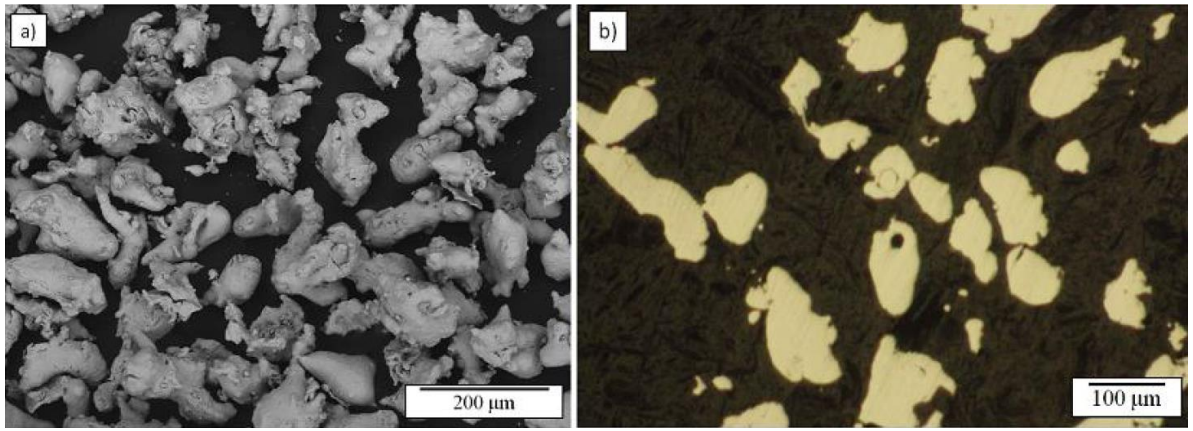
SUPREME

- ✓ 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)

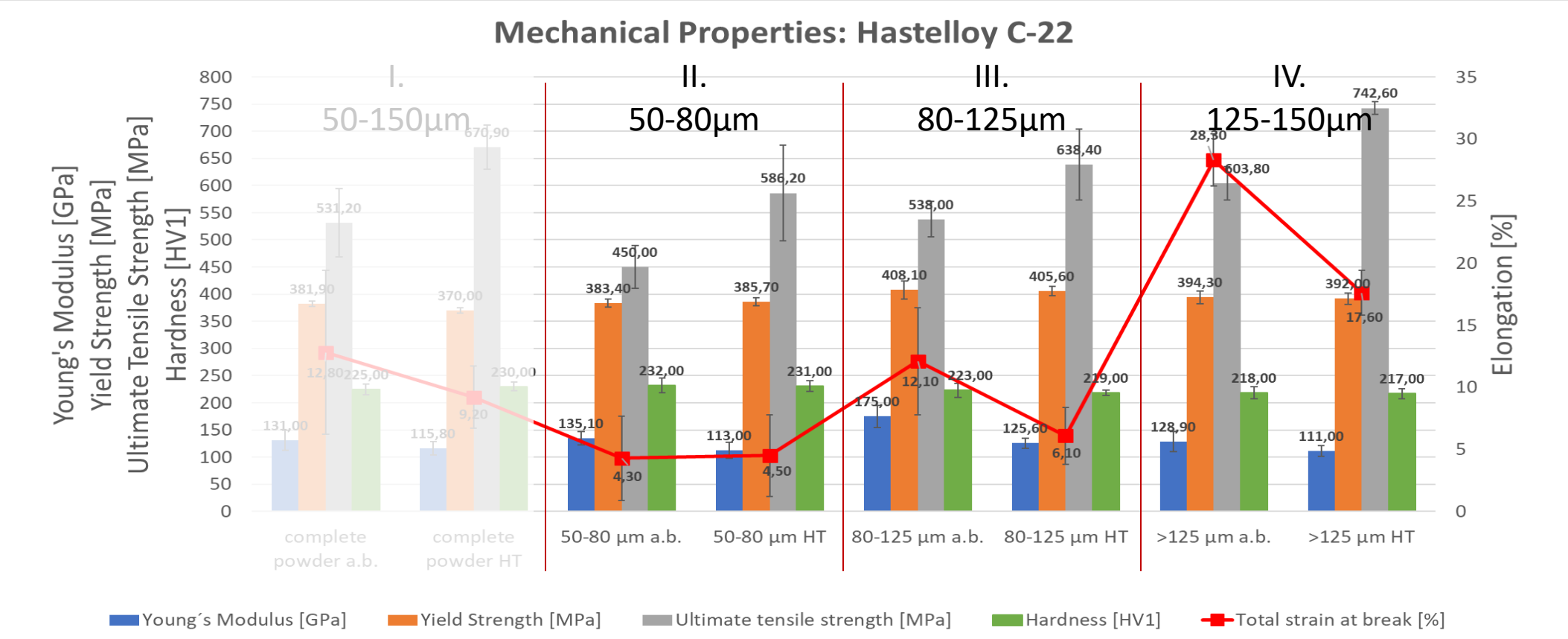


STUDY: GEARFORK BRACKET

Factor	1 part / batch		9 part / batch		160 part / batch	
	Amount/ part	Cost/unit	Amount/ unit	Cost/unit	Amount/ part	Cost/unit
Powder	941 g	-	941 g	-	941 g	+
Base plate	2.2 kg	-	2.2 kg	-	1.4 kg	o
Scrap material	2.1 kg	o	2.0 kg	o	1.4 kg	+
Argon	7124 l	-	792 l	o	128 l	+
Building time	4 h	-	0.7 h	o	0.5 h	+
Parts/year	200	-	1,800	o	>12,000	+

The authors warmly thank the EU H2020 and the "Sustainable Process Industry through Resource and Energy Efficiency" (SPIRE) programs, who fund the SUPREME project under grant agreement n° 768612.

STUDY: HASTALLOY MATERIAL TEST



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Material	Density [g/cm³]	Melting point range [°C]	Young´s Modulus [GPa]	Yield Strength [MPa]	Ultimate Tensile Strength [MPa]	Elongation at breaks [%]	Hardness Vickers [HV1]
Hastelloy C-22 [10]	8.69	1357-1399	209	372	786	62	213

STUDY: HASTALLOY MATERIAL TEST

RESULTS

Appearence of precipitates rich in Mo

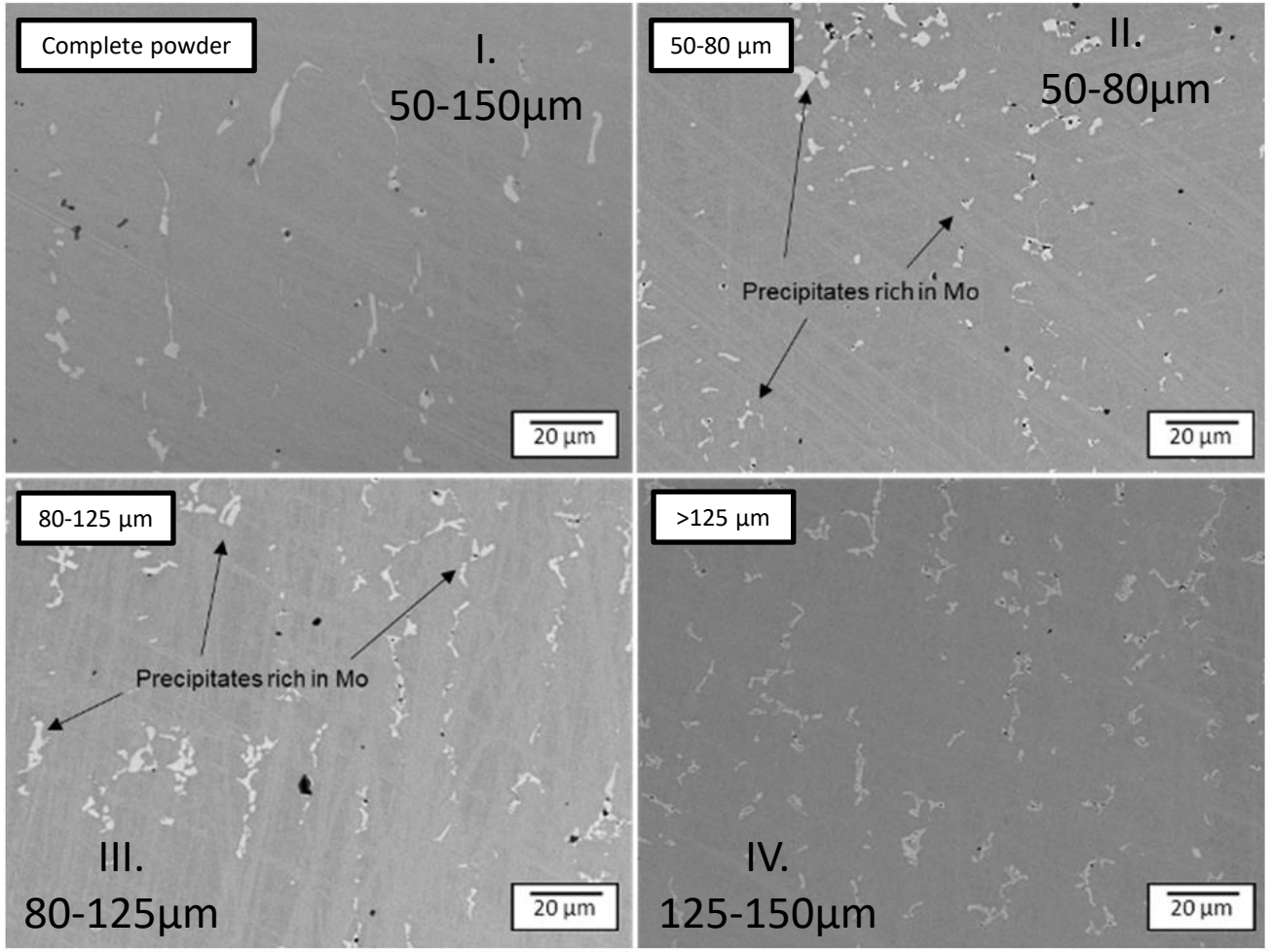
Precipitates grow in a preferential direction that coincides with the building direction

Micro-porosity:

Densification with no trend of dependence on the powder size:

As built: 98.1 ± 0.3% TD
HT: 98.7 ± 0.2% TD

- Particle size ↑ ➔ UTS↑ and ε↑
- micro-porosity for walls built with 50-80µm and 80-125µm
- Particle size ↑ ➔ Hardness ↓



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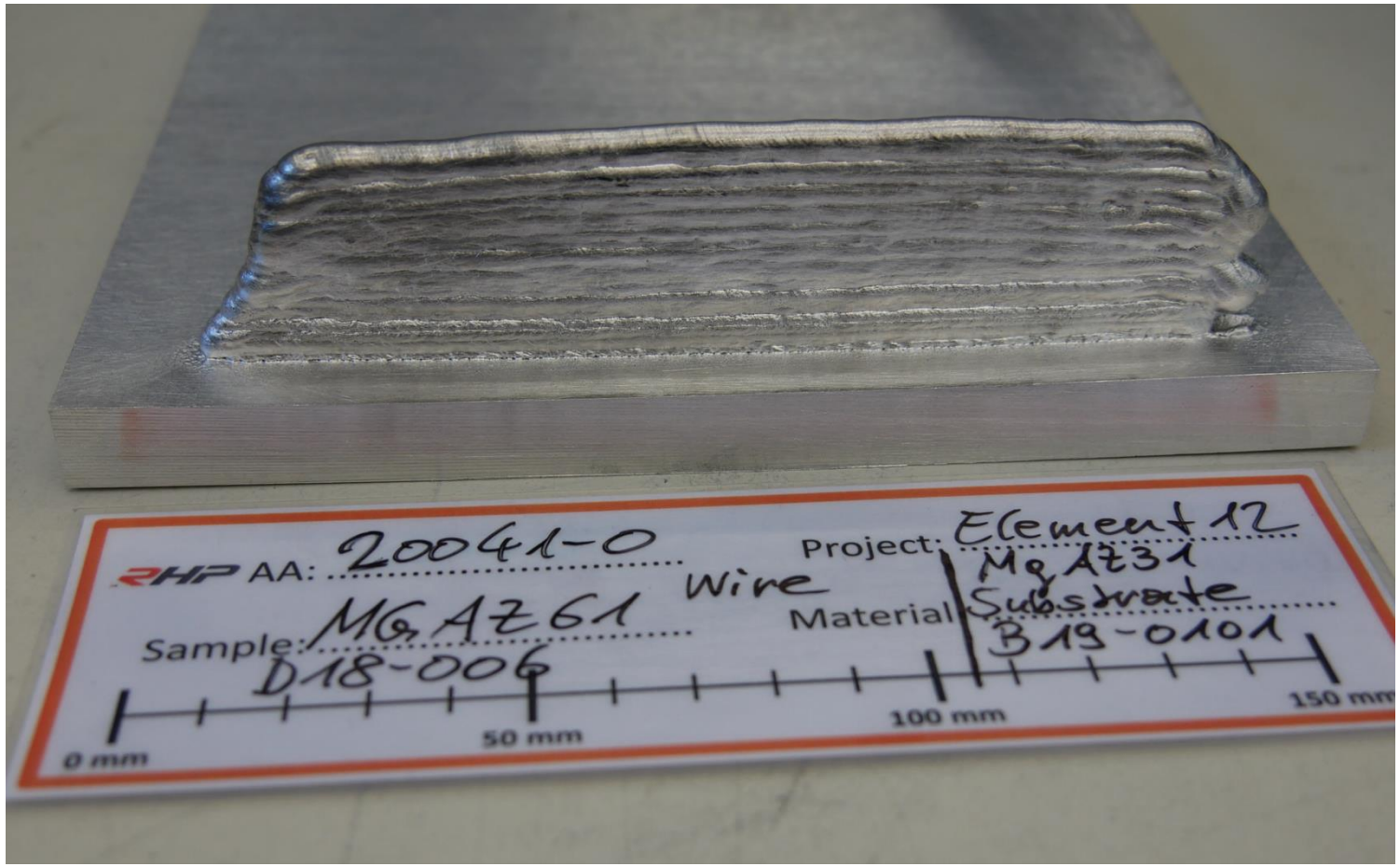
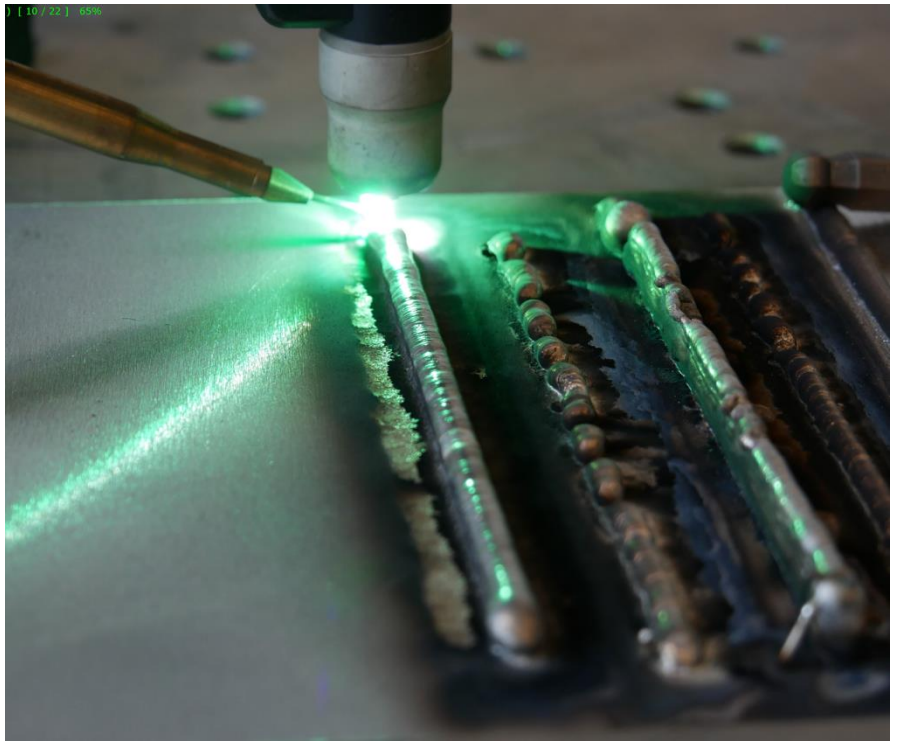
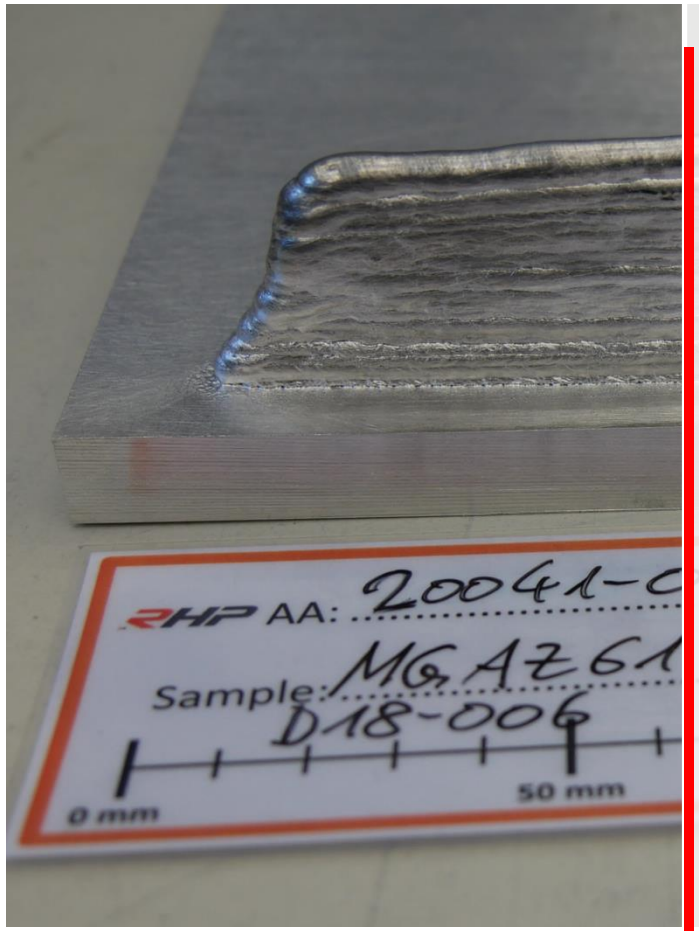
EXAMPLE MAGNESIUM ALLOYS





courtesy RHP

EXAMPLE MAGNESIUM ALLOYS



Material properties

Mg-AZ91						
Source	**Treatment**	**Orientation**	**Young's modulus [GPa]**	**$Rp_{0.2}$ [MPa]**	**UTS [MPa]**	**A [%]**
Dynacast	Casting		45	148	248	6.6
RHP wire based	As built	Horizontal	56±4	99±3	268±23	13±4
		Vertical	54±2	101±5	272±14	13±3
	HT 150°C	Horizontal	41±10	103±4	280±3	17±2
		Vertical	36±1	110±5	269±14	13±3
	HT 415°C	Horizontal	43±1	96±2	274±21	14±6
		Vertical	39±2	75±8	197±32	7±2

EXAMPLE ALUMINIUM ALLOY

Light weight arm from AlMg5Cr

Bearing bracket made of AW 5356

EXAMPLE ALUMINIUM ALLOYS

Material properties

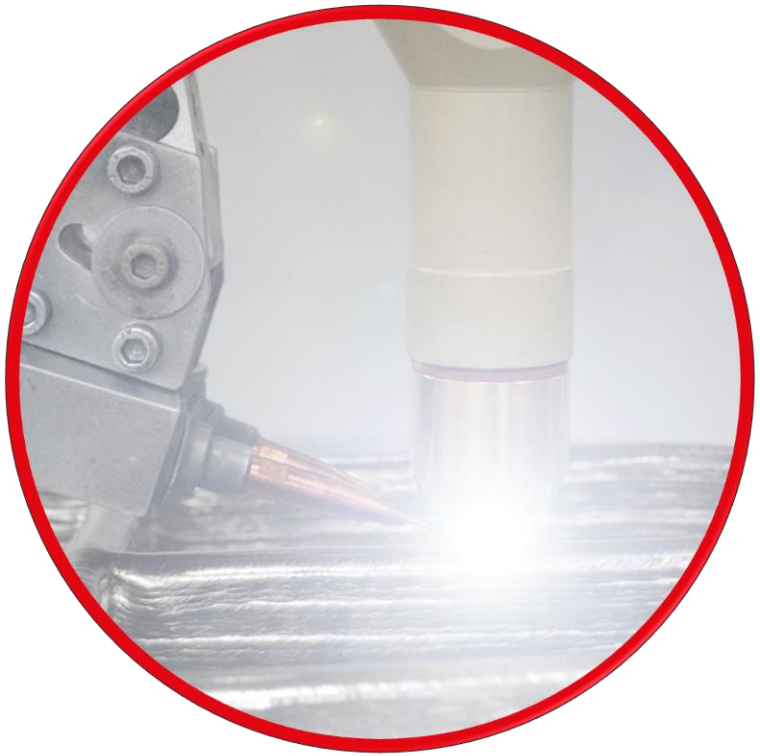
Standard	Material	Origin	Mechanical properties		
			UTS MPa	YS MPa	A %
ISO 18273	S Al 5356	GMAW	250	110	25
RHP	**AlMg5Cr**	**PMD**	**272**	**125**	**10-12**

CONTENT

AM APPLICATIONS BY PMD®

TECHNOLOGY & SBI ADDITIVE MANUFACTURING SYSTEMS

PMD® – PLASMA METAL DEPOSITION TECHNOLOGY



+

AND / OR

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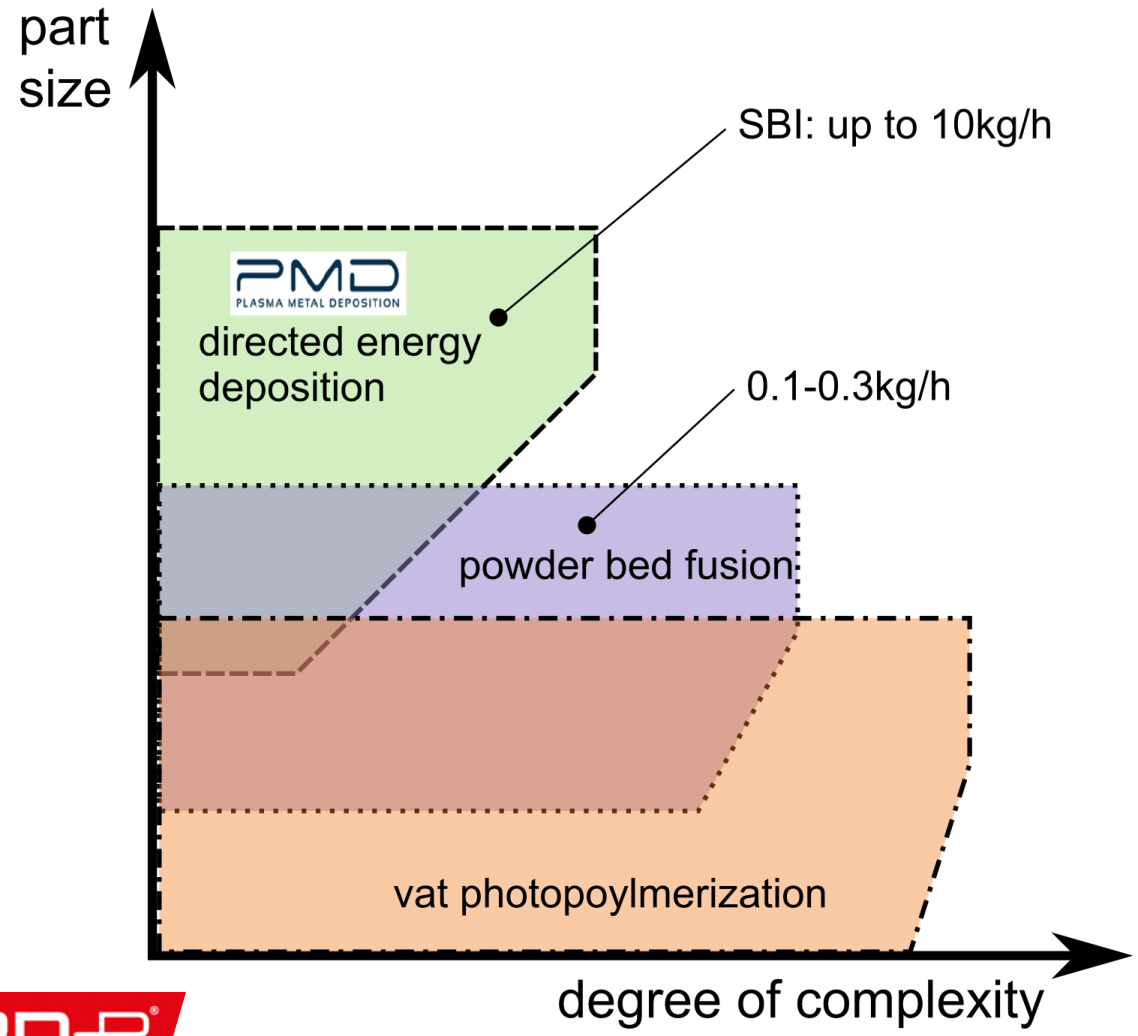
PMD®
PLASMA METAL DEPOSITION

M3DP®

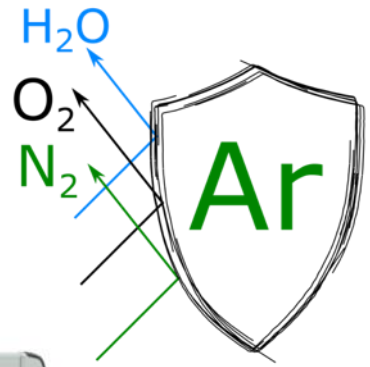
M3DP COMPARED WITH OTHER AM TECHNOLOGIES



PMD®
PLASMA METAL DEPOSITION

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

M3DP - OUR ADDITIVE MANUFACTURING SYSTEM

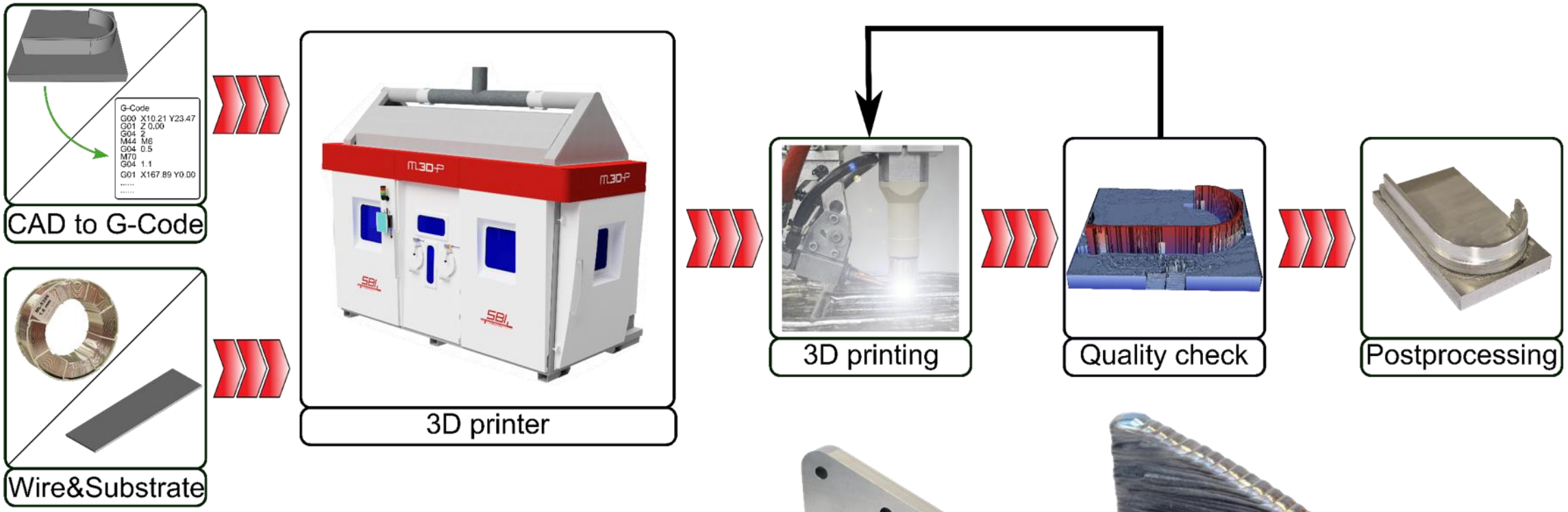


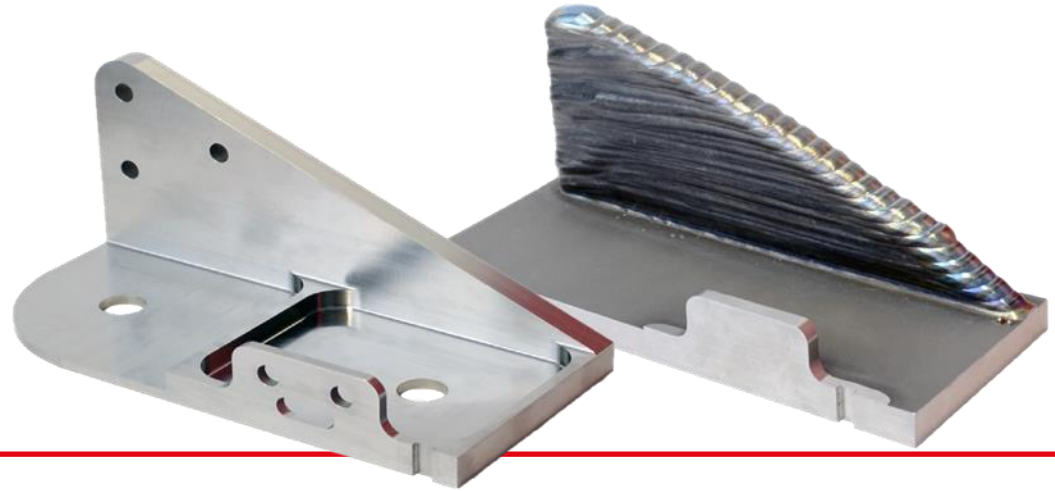
SBI ACTIVE GAS SHIELD TECHNOLOGY*

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

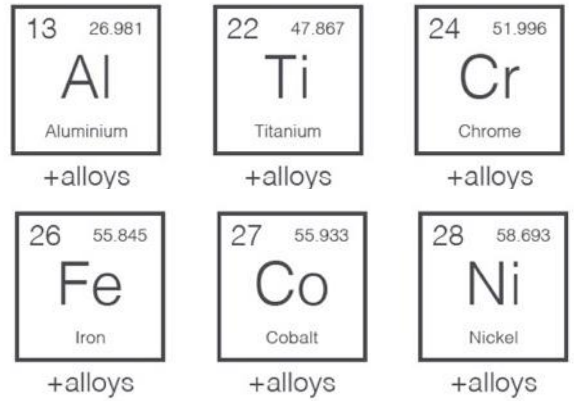
*optional available for inert gas atmosphere

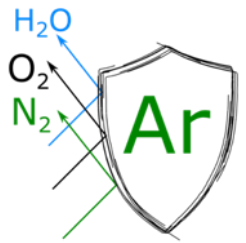
SBI - PLASMA ARC ADDITIVE MANUFACTURING





M3DP-SL: SCIENTIFIC LINE FOR ADDITIVE RESEARCH





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

incl. SBI Active Gas Shield Technology

M3DP & M3DP-SL ADDITIVE MANUFACTURING SYSTEMS

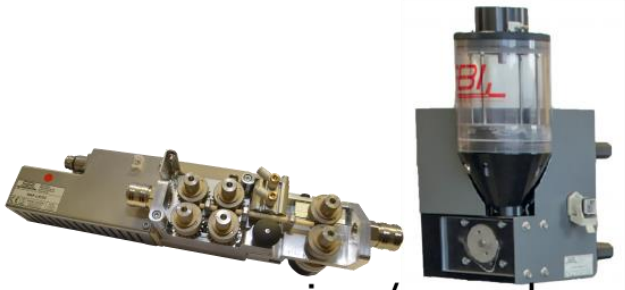
M3DP

M3DP-SL

	M3DP	M3DP-SL
Dimensions	5000 x 2400 x 4200 mm (X-Y-Z)	1700 x 1400 x 2600 mm (X-Y-Z)
Buildvolume	max. 2000 x 600 x 600 mm (X-Y-Z)	Ø400 x 500 mm (Ø-Z)
Mass	6,500 kg	3,500 kg
max. payload	650 kg	250 kg
Airtight system	Yes - optional available	Yes
Feedstock	Metal wire & powder	Metal wire & powder
Energy source	Plasma arc	Plasma arc
Deposition rate	max. 10kg/h for nickel-base-alloys 4kg/h for titanium	Max. 10kg/h for nickel-base-alloys 4kg/h for titanium

PMD ROBOTIC LINE

material feeding systems



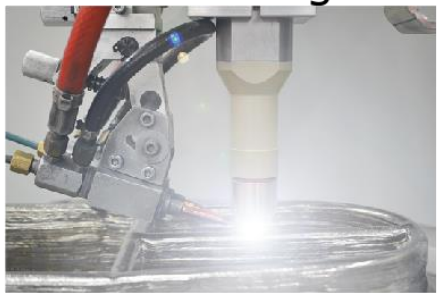
wire / powder

camera monitoring

power source

custom / standard

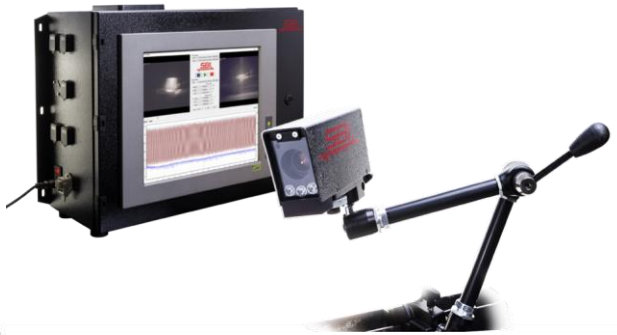
torch & wire guide

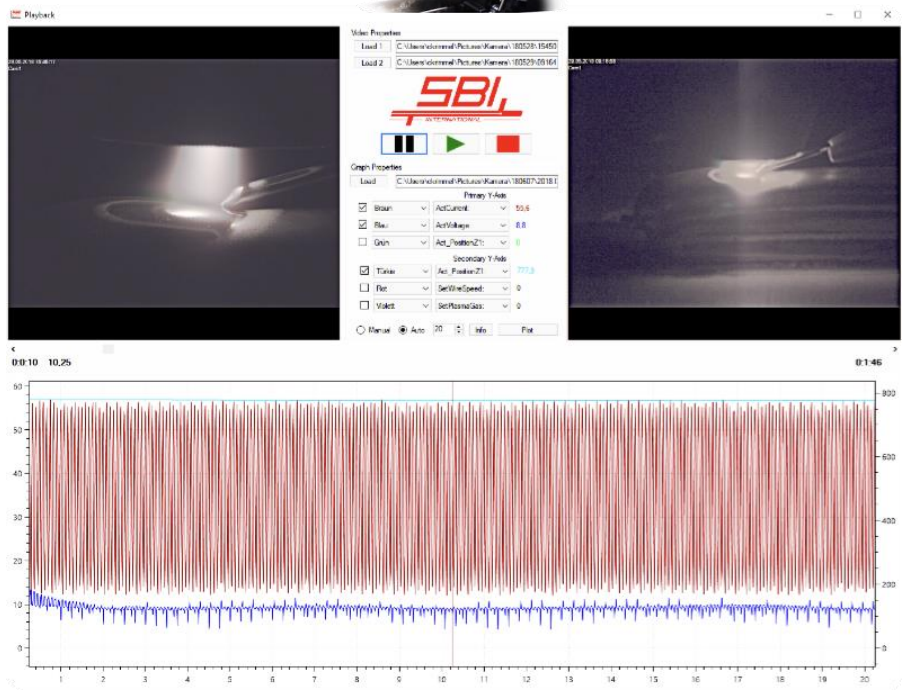


QUALITY MANAGEMENT

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 paramters)**
  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





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In our joint Application Center with RHP-Technology you can follow your own AM part grow from wire or powder.

M3DP®

PMD® PLASMA METAL DEPOSITION

RHP TECHNOLOGY

PMD ROBOTIC

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WE OFFER OUR EXPERTISE:

- ✓ AM part planning
- ✓ AM material selection
- ✓ AM manufacturing
- ✓ Posttreatments
- ✓ Final machining
- ✓ Process optimizations
- ✓ Material testing & analysis
- ✓ Demonstrator delivery
- ✓ Technology consulting

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SBI – THE SPIRT OF TOMORROW!

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