Booth
3A49

Constellium Aheadd® Aluminium alloys designed specifically for laser powder bed additive manufacturing

Aluminium 2022, Düsseldorf

Dr. Ravi SHAHANI
C-TEC Constellium Technology Center, France

Constellium

Constellium – a world leader in value-added aluminium solutions

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Company Statements

Who We Are

We are a **global leader** in innovative and high value-added aluminium products and solutions dedicated primarily to aerospace, automotive and packaging markets.

Our Commitment

Minimize the impact of our operations on the environment, and work to improve the footprint of the aluminum life cycle throughout the value chain.

Our Ambition

Innovate beyond the material to bring our customers complete, sustainable solutions and endless possibilities.

Key Figures

100+ years of experience	**~12k** employees	**27** production facilities	**€6.2 Bn** 2021 revenue	**3** R&D Centers

- **Voreppe, France**
- Brunel Univ, UK
- **Plymouth MI, US**

Geographical footprint

Largest plants

- Ravenswood, VW (Aero)
- Muscle Shoals, AL (Pack., Auto)
- Van Buren, MI (Auto)

- Issoire, F (Aero)
- Neuf-Brisach, F (Pack., Auto)
- Singen, D (Pack., Auto)
- Decin, CZ (Auto)

Constellium core markets : lightweighting and/or recycling are key

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- Car body closures
- Body-in-White
- Structural Components
- Crash Management Systems
- Battery Enclosures
- Chassis and mechanical parts
- Decorative parts and equipment
- Heat exchangers

Some of our customers

Audi, BMW Group, Daimler, Fiat Chrysler Automobiles, Ford, General Motors, Honda, Porsche, Stellantis, Subaru, Volkswagen

- Outer wing
- Center wing box
- Fuselage and nose fuselage
- Engine (incl. gear boxes)
- Landing gear

Some of our customers

Airbus, ATR, Boeing, Bombardier, Dassault Aviation, Embraer, Gulfstream, Lockheed Martin, Pilatus, SpaceX

- Beverage cans
- Food cans
- Closures
- Aerosols
- Cosmetics packaging
- Foil stock

Some of our customers

AB InBev, Amcor, Ardagh Group, Ball, Can-Pack, Crown, Coke

But also...

Defense

Constellium's lightweight alloys offer outstanding impact resistance for armored vehicles and military bridges.

Transportation

We offer a wide range of lightweight and high performance solutions for vehicles such as commercial trucks and trailers, boats and ships, trains and buses.

Industry

We have more than 100 years of experience in industrial applications, from precision plates to semiconductor equipment to architecture.

Constellium – track record of aluminium innovation

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Aerospace

Automotive

Packaging

Airware®
Plate, sheet, extrusions

Large sand castings

Surfalex®
Formalex®
Securalex®

Automotive body sheet

HSA6™
Automotive extrusions

Multilayer sheet for brazed heat exchangers

Aeral™
Sheet for low environmental footprint aerosol packaging

Capability to recycle ~ 32 billion cans a year

Cosmetic packaging sheet

Constellium innovation – alloy design

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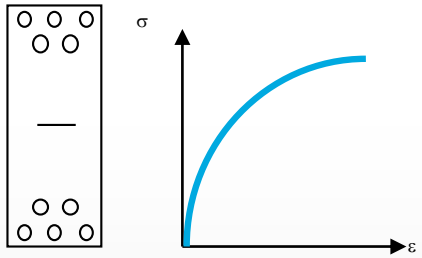
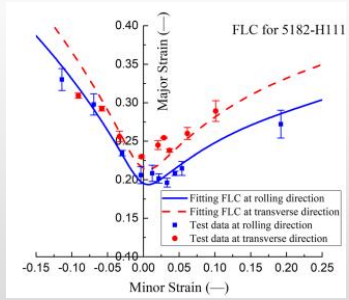
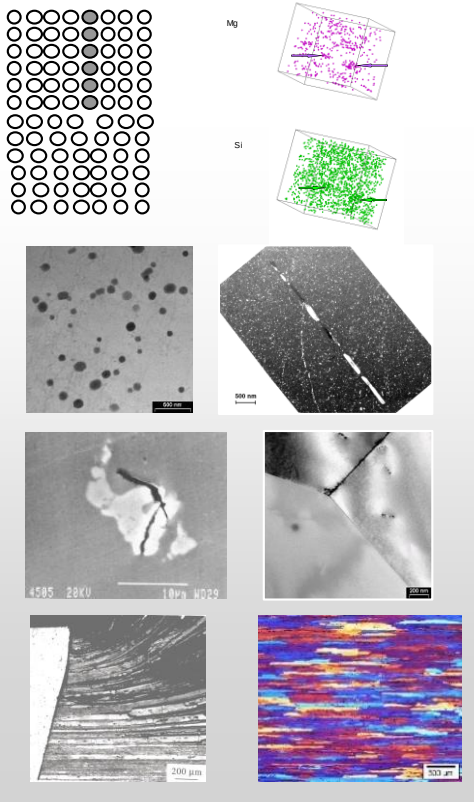
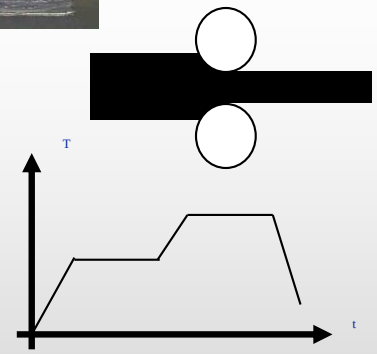
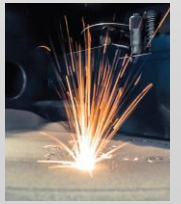
APPLICATION	TARGETED PROPERTIES	REQUIRED MICROSTRUCTURE	COMPOSITION & PROCESS









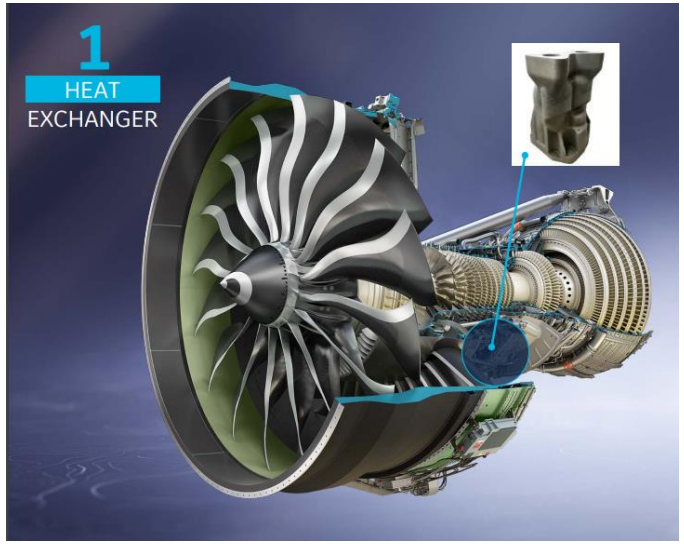


Optimised & sustainable alloy solutions consider the whole process chain

Laser powder bed fusion (LPBF) : scope for « rapid solidification » alloys

Aluminium additive manufacturing by laser powder bed fusion (LPBF)

Single parts replacing complex assemblies, short lead times, no tooling



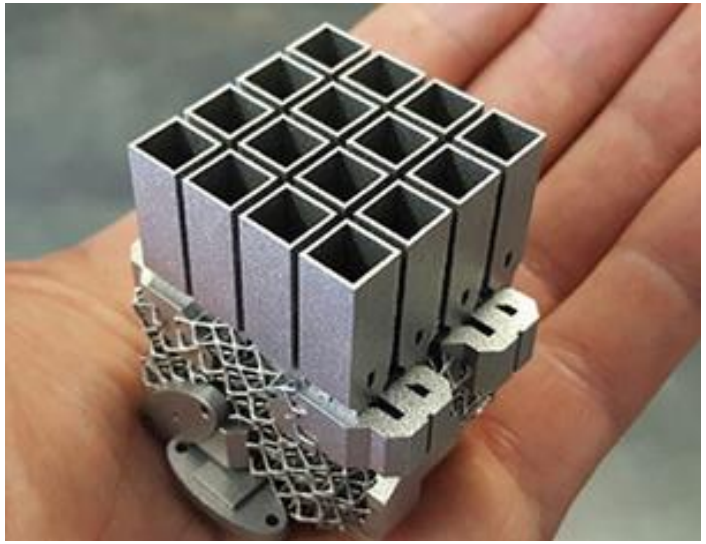
GE 9X heat exchanger

Civil aviation

Traditional manufacturing : 163 parts

40% lighter
25% lower cost

Aluminium F357 (AlSi7Mg0,6)



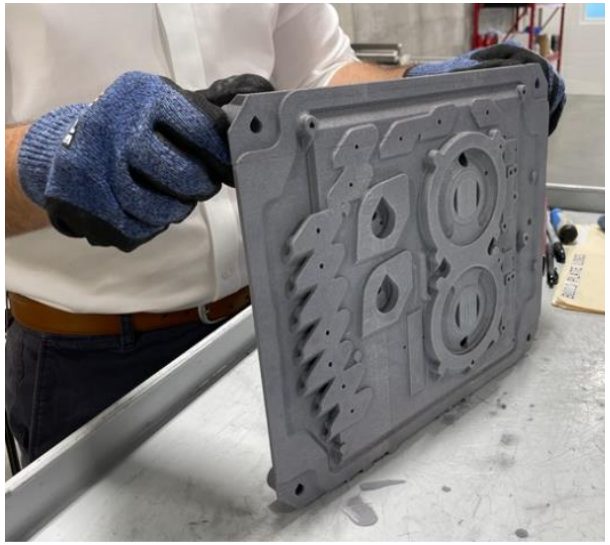
Optisys RF Antenna

Telecommunication satellites

Traditional manufacturing : 100 parts

95% lighter
20-25% lower production cost,
75% lower non-recurring cost
Lead time reduced from 11 to 2 months

Aluminium AlSi10Mg



Wabtec brake control panel

Rail industry

Traditional manufacturing : 32 parts

> 65% weight saving

Lead time reduction

Aluminium AlSi10Mg

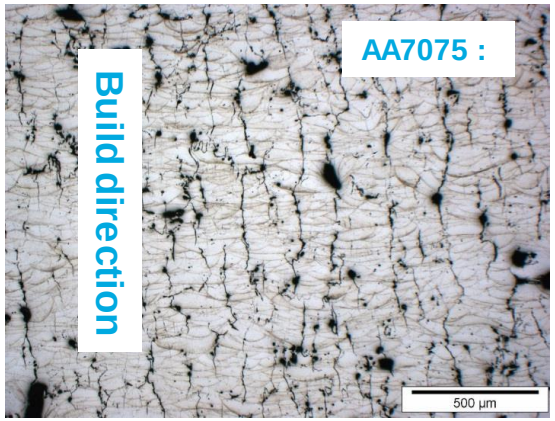
Additive manufacturing by LPBF : parts are built in layers 30-150 µm at a time : new opportunities for aluminium designs and applications, little threat to traditional high-volume aluminium manufacturing

Why new aluminium alloys for laser powder bed AM?

High performance conventional alloys are difficult to process

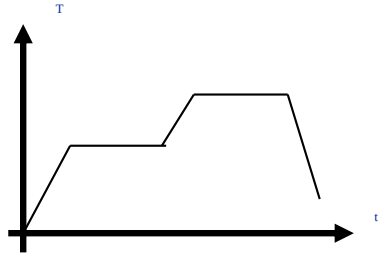
PRINT → SOLUTION HEAT TREAT → QUENCH → AGE HARDEN (<200°C)

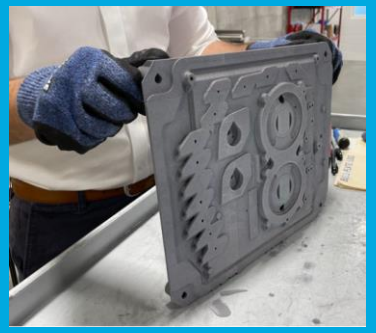
Hot cracks
Zn, Mg evaporation

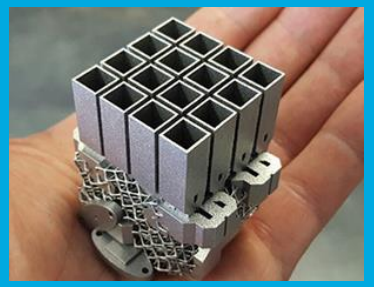


Porosity risk

Distortion risk







Most printed aluminium parts use Al-Si alloys developed for castings which print well

Mechanical performance is moderate, various « compromise » heat treatments used

Surface finishing by polishing, anodizing etc. is difficult

Constellium Aheadd®

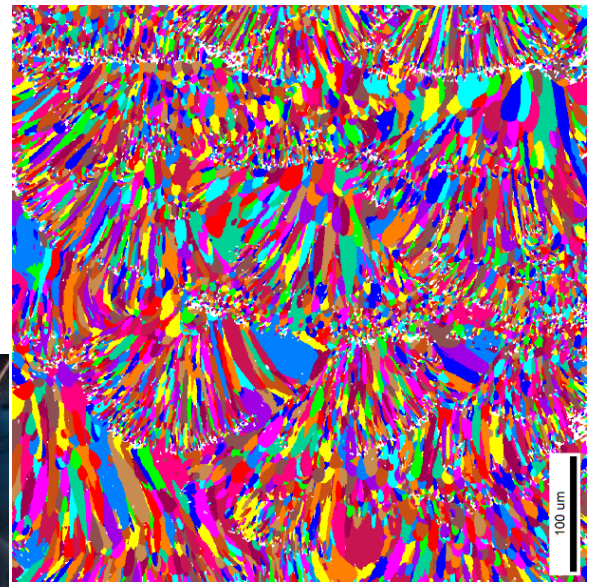
« Rapid solidification » aluminium alloys designed for laser powder bed AM

PRINT → **AGE HARDEN 400°C**

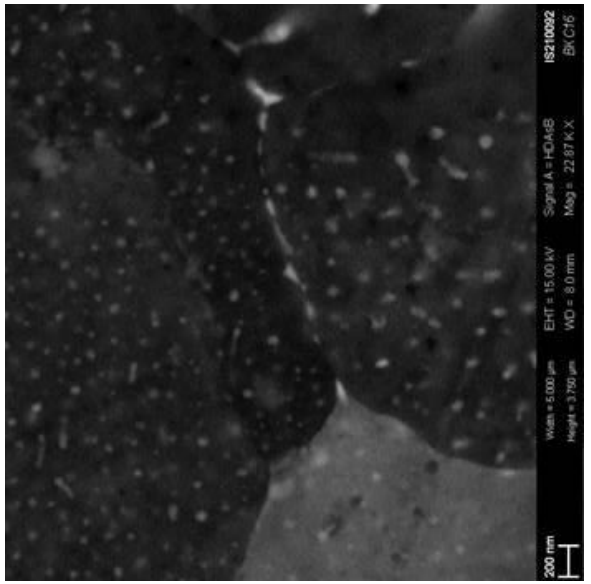
No volatile magnesium or zinc for better printing

No quench => better geometry
Thermal stability at 300°C

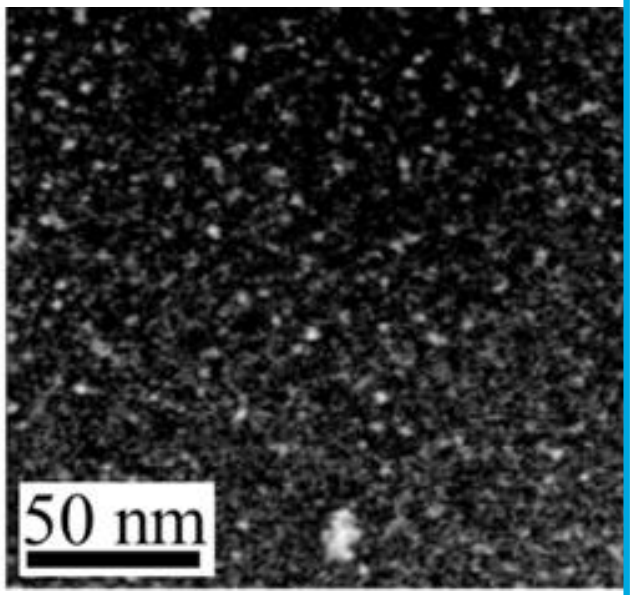
Aheadd® CP1 (AA8A61 Al-Zr-Fe)



Fine grain structure



Very fine Al-Fe phases

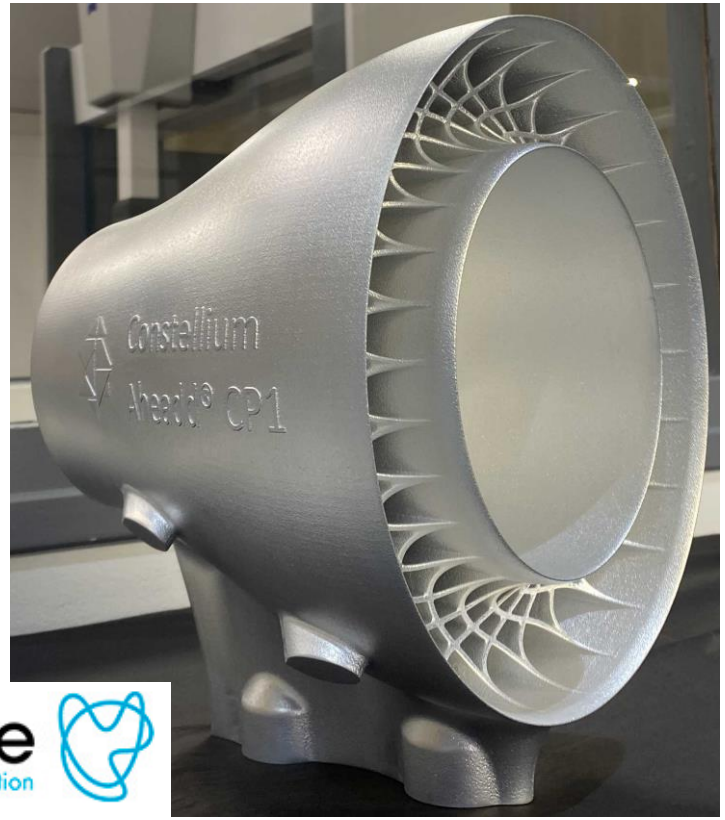


Nanoscale Al3Zr

Constellium Aheadd®

High performance aluminium alloys designed for laser powder bed AM

Aheadd® CP1 (Al-Zr-Fe)
Optimized solution for most aluminum AM applications



VOLUM-E 3DComplexProduction

Heat exchanger demonstrator, 250mm diameter
Chemical polish

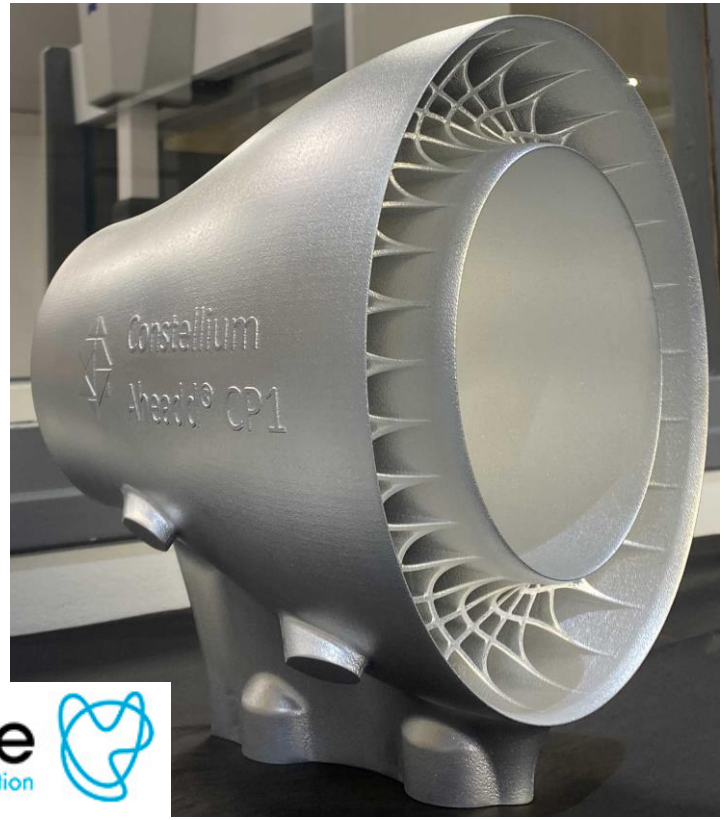
Aheadd® HT1 (Al-Mn-Ni-Cu-Zr)
High temperature alloy - could replace selected titanium or steel components

Aerospace bleed valve regulator body

Constellium Aheadd®

High performance aluminium alloys designed for laser powder bed AM

Aheadd® CP1 (Al-Zr-Fe)
Optimized solution for most aluminium AM applications



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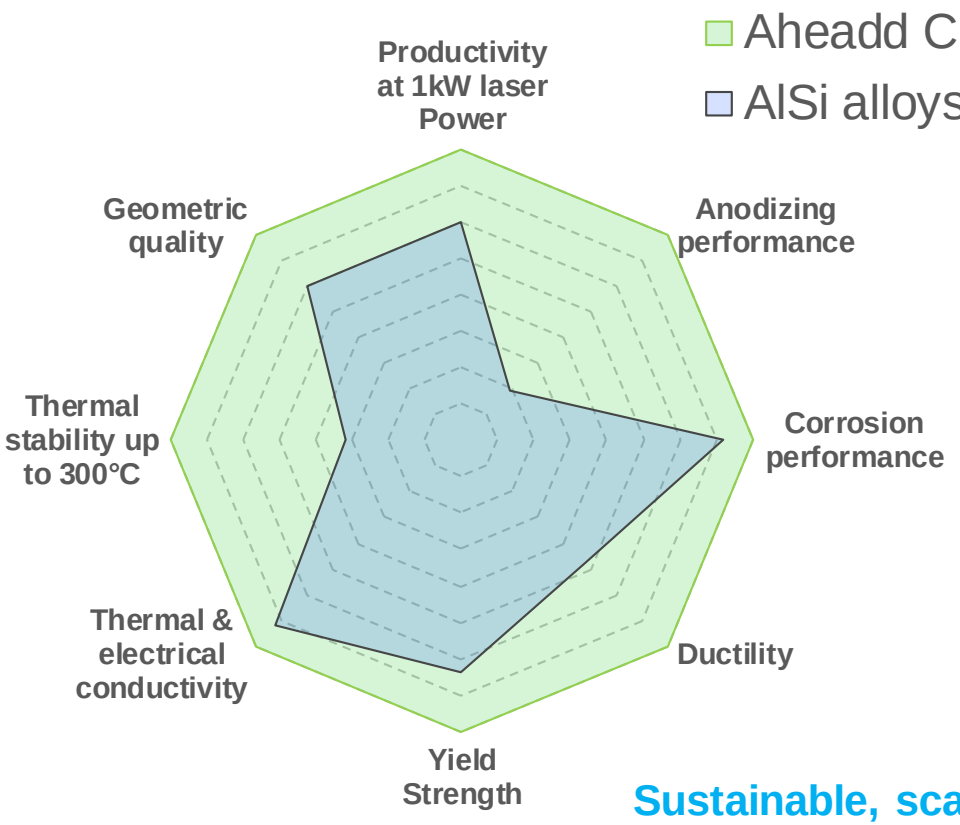
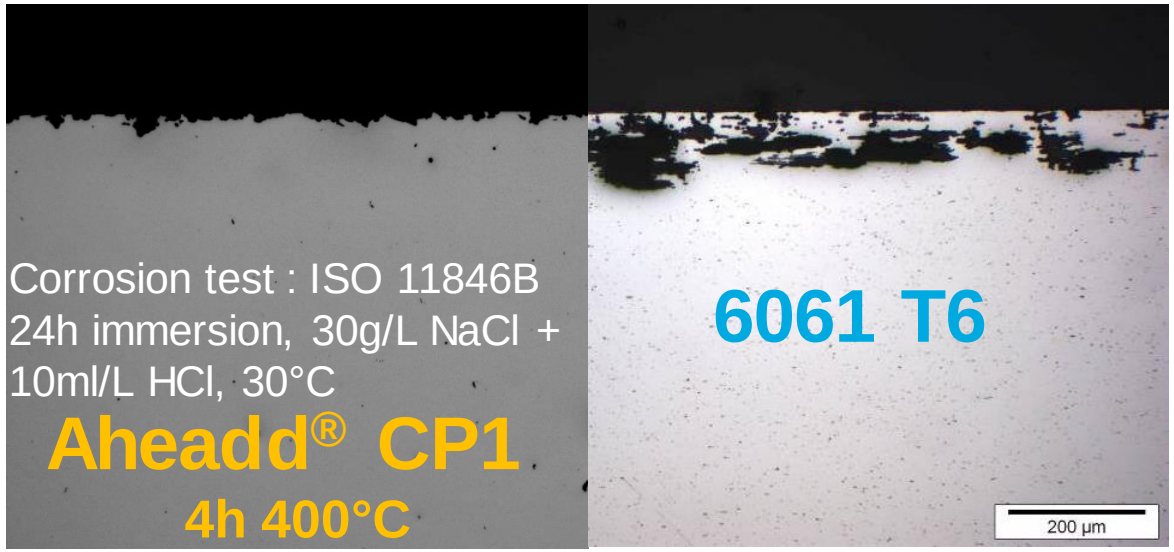


Sustainable, scalable alloy system

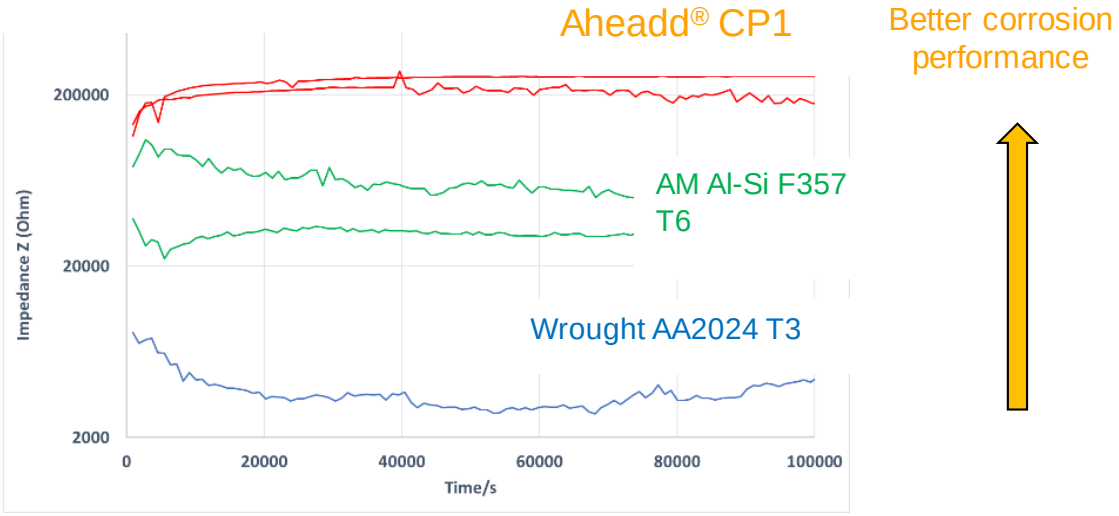
Al	Zr	Fe
Aluminum	Zirconium	Iron

Constellium Aheadd® CP1
Excellent corrosion resistance

Aggressive intergranular corrosion test in acidified salt water : no localized attack for Aheadd CP1



Electrochemical test in salt water: kinetics of corrosion of Aheadd CP1 are very low



Electrochemical tests in aerated 0.1M NaCl. Corrosion kinetics of Aheadd CP1 are much lower than AM Al-Si or wrought 2024 T3

AHEADD CP1 outperforms conventional high performance alloy systems in corrosion resistance. Corrosion rate is very low with no signs of localized attack. Longer term testing in progress

Constellium Aheadd® CP1

No quench, low residual stress, excellent geometric control

Burloak Technologies antenna demonstrator

- Consolidated space component
- Antenna with intricate features which is highly likely to deform during traditional T6 treatment

Burloak Technologies
a division of SAMUEL

Constellium Aheadd® CP1

Printing performance demonstrated on multiple platforms – 400W to 1kW lasers

EOS
SLM Solutions
GE Additive
Renishaw

Addup
Aconity
3DS
More coming…

Constellium can recommend process windows for efficient parameter setup depending on laser power, layer thickness and quality targets

Case Study with the AMRC, Boeing, Constellium and GE Additive

"Machine learning has the potential to be a key technology in accelerating further development and adoption of AM"

Lukas Jiranek, Boeing

Constellium Aheadd® CP1

Faster printing for lower part costs

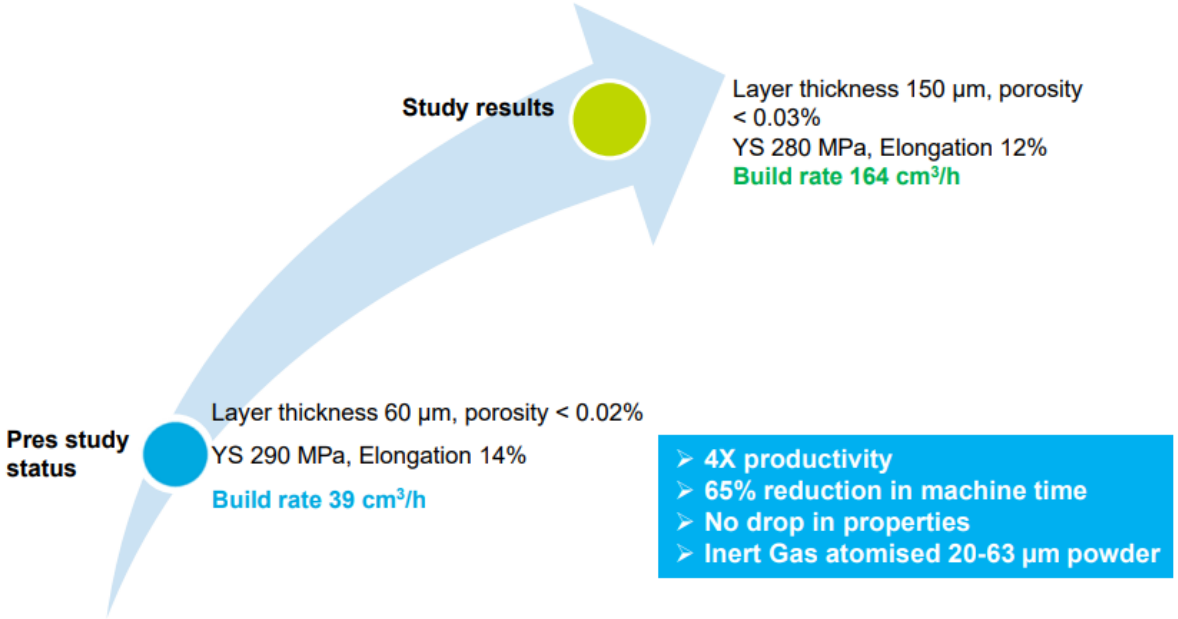


Fig. 1 The study provides an opportunity to develop cost-efficient and high-performance aluminium Laser Beam Powder Bed Fusion (LBF-PB) components in series production

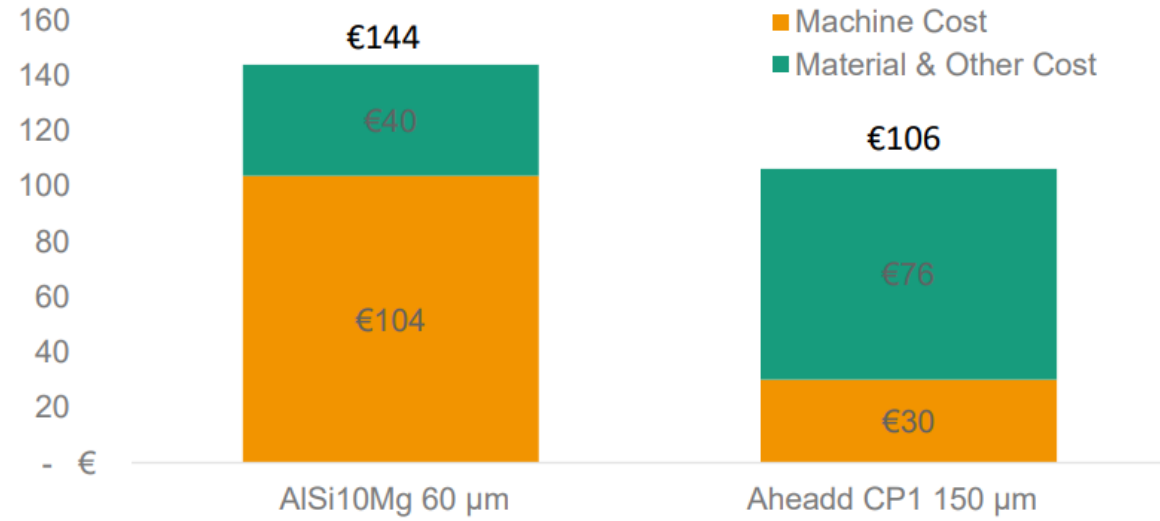


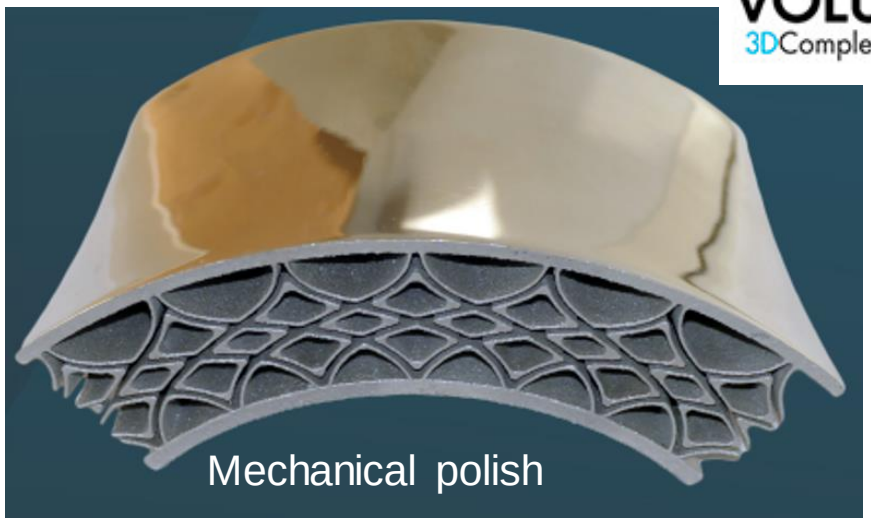
Fig. 2 Built component cost assessment (Data courtesy – Fraunhofer IAPT)

Fraunhöfer IAPT data on an SLM Solutions platform at 1kW laser power.
Very high LPBF productivity levels without loss of mechanical properties

Constellium Aheadd® CP1

Excellent finishing performance

Aheadd® CP1
No Si or ceramic phase for better machining and polishing by mechanical, chemical or electrochemical processes



VOLUM-e 3DComplexProduction

10mm

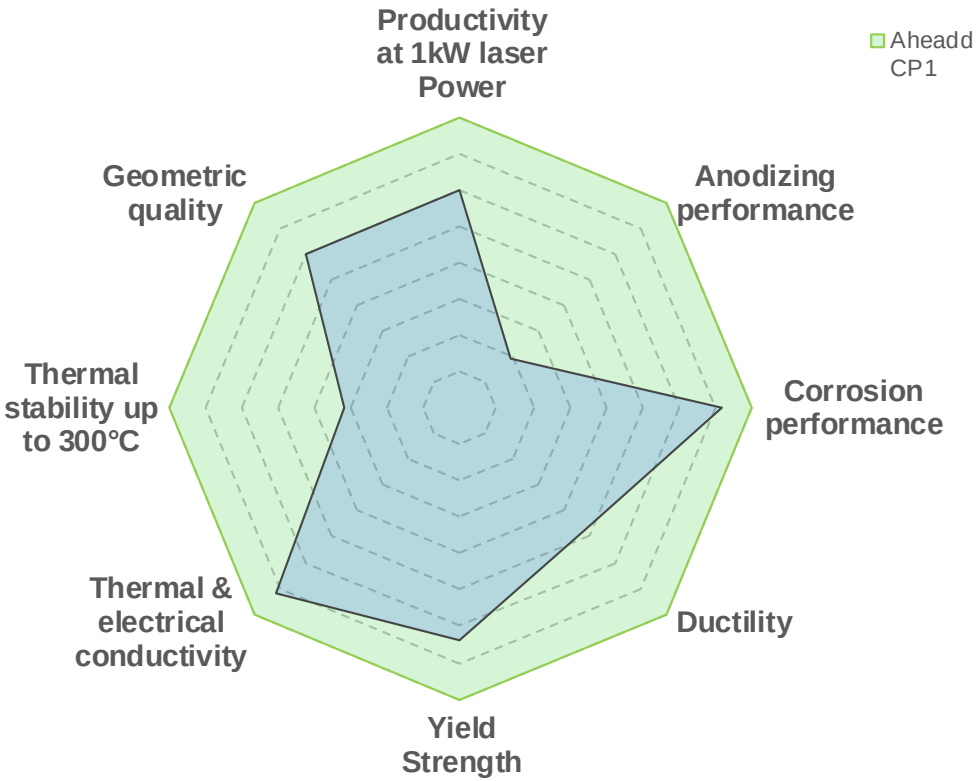
Preliminary electropolish and colour anodizing trials on as-built surfaces

250mm diameter demonstrator chemical polish on industrial line

Constellium Aheadd® CP1 Al-Zr-Fe alloy (AA8A61)

Setting the new standard for aluminum LPBF component production

Processing advantages	Design advantages
• High productivity • Wide processing window • No volatiles (Mg, Zn) : low smoke, stable chemistry • Properties are stable during the build • Simple heat treatment, no quench • Excellent surface finishing • Good machinability (no ceramics)	• Low residual stress • Excellent performance for thin walls • Heat treat can be tuned to very high thermal/electrical conductivity (e.g. for heat exchange or RF components) • Si-free for semiconductor equipment • Joining options include brazing
Robust properties	**Standardisation, Sustainability & scale-up**
• 300 MPa YS (43 ksi) and >10% elongation, isotropic properties • High thermal & electrical conductivity • Thermally stable up to 300°C (572°F) • Very good cryogenic properties • Excellent corrosion performance	• Replace multiple tempers of AlSi10Mg, F357& 6061 derivatives • Sustainable alloy system (Al-Zr-Fe) • No rare earth/expensive elements • Inert gas-atomized powder (not a blend), facilitating recycling



Constellium Aheadd® CP1 Al-Zr-Fe (AA8A61)

Setting the new standard for aluminum LPBF component production

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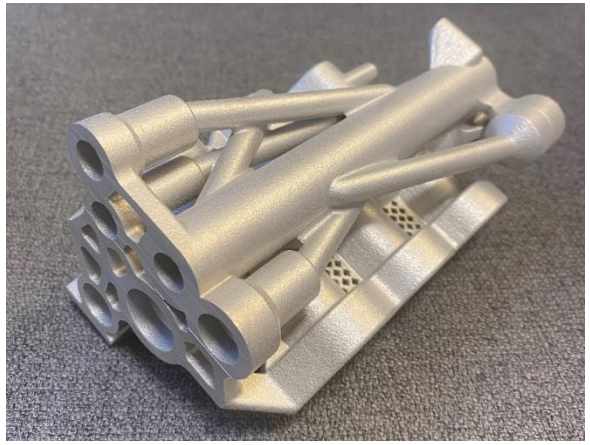
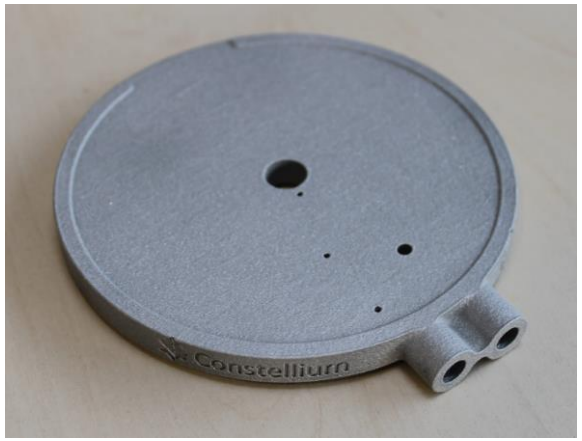
VOLUM-e 3DComplexProduction

Burloak Technologies a division of SAMUEL



GMP Group Designed & made by GMP Group



Heat exchangers

- *Fast printing*
- *Corrosion resistance*
- *Very high thermal conductivity*
- *Low roughness*
- *Chemical polish*

RF components

- *Excellent geometry (no quench)*
- *Low roughness*
- *Very high electrical conductivity*

Complex mechanical parts, on-demand spare parts

- *Fast printing*
- *Robust mechanical properties*
- *Low roughness*
- *Corrosion resistance*

Semiconductor fabrication equipment

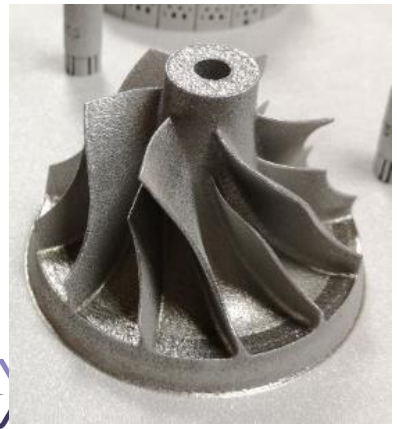
- *No chamber pollution*
- *Thermal stability*
- *Anodizing performance*
- *Corrosion resistance*

Aheadd CP1 can replace current AlSi10Mg, F357 or 6061 solutions for aluminium LPBF with better geometries, surface quality, mechanical performance and corrosion resistance. Solutions are cost-competitive through faster printing and simplified post-processing.

Constellium Aheadd® HT1 (Al-Mn-Ni-Cu-Zr) for high temperature strength

Demonstrator studies

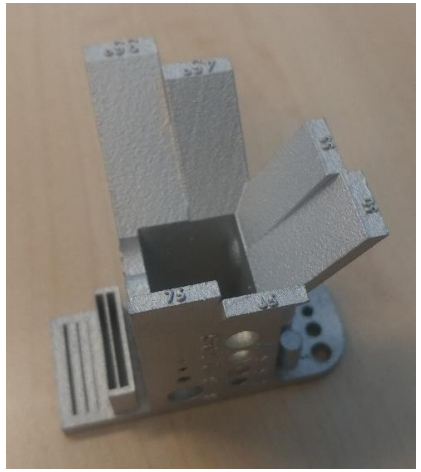
Thin-walled heat exchanger



Impeller

Hydraulic manifolds

Automotive exhaust valve support



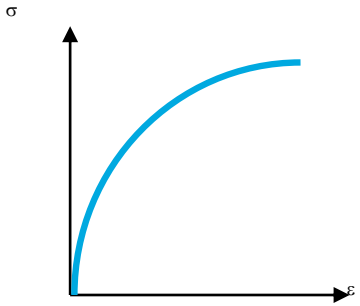
Parameter optimisation

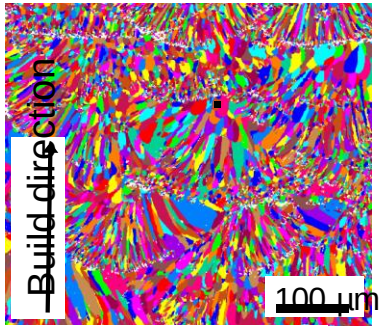
Aerospace bleed valve regulator body

Constellium Aheadd®

Collaboration example : aerospace

APPLICATION	TARGETED PROPERTIES	REQUIRED MICROSTRUCTURE	COMPOSITION & PROCESS





SAFRAN

Constellium

cetim

MORF3D AEROSPACE

AIRBUS HELICOPTERS

LIEBHERR

AddUp GLOBAL ADDITIVE SOLUTIONS

AddUp | Poly-Shape | BeAM

AddUp, a Fives & Michelin joint-venture.

THALES

Initiative 3D
Institut multi-sites fabrication additive Auvergne Rhône-Alpes

DLR

APWORKS

DASSAULT AVIATION

ONERA
THE FRENCH AEROSPACE LAB

VOLUM-e 3DComplexProduction

GMP Group

Application development projects in aerospace, automotive, semiconductor, defense, rail industries in Europe, North America and Asia

Constellium Aheadd®

Powder supply chain and quality

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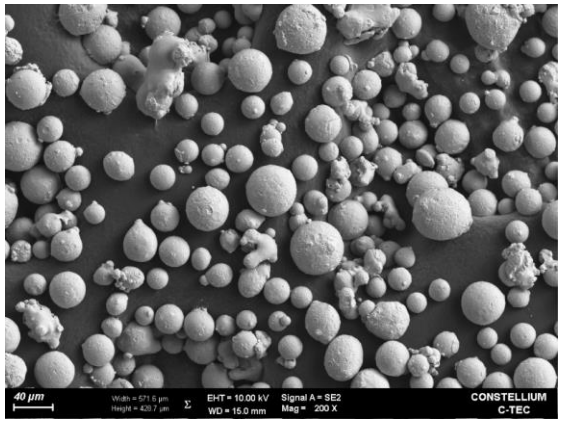
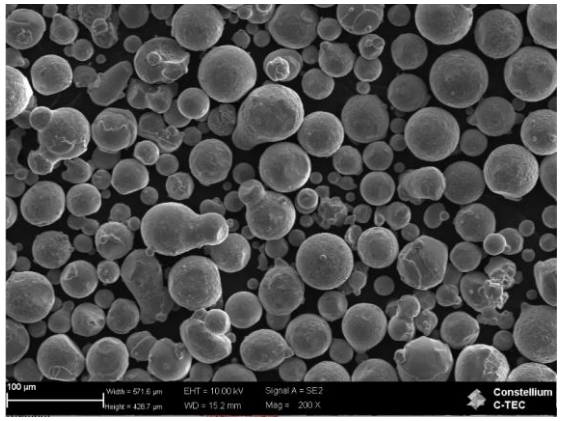
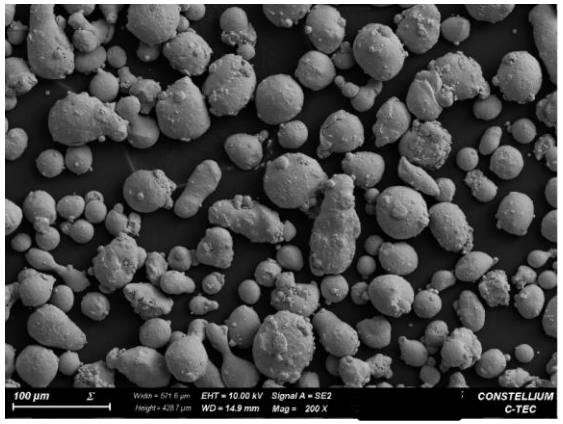
Production route #1



Production route #2



Production route #3



Process : Inert gas atomization

Standard particle size distribution : 20-63µm

Custom PSDs available on request

Certifications :

- ISO-9001: 2015 quality certification
- ISO-14001: 2015 environmental certification
- ISO-45001: 2018 safety certification
- Cofrac 17025 for chemical analysis and mechanical tests

afaq
AFNOR CERTIFICATION

Certificat
Certificate

N° 2017/73968.4 Page 1 / 1

AFNOR Certification certifie que le système de management mis en place par :
AFNOR Certification certifies that the management system implemented by:

C-TEC
CONSTELLIUM TECHNOLOGY CENTER

pour les activités suivantes :
for the following activities:

RECHERCHE, DEVELOPPEMENT, ASSISTANCE TECHNIQUE ET REALISATION DE PRESTATIONS POUR LE COMPTE DES SOCIETES DU GROUPE ET DES CLIENTS EXTERNES. PRODUCTION ET VENTE D'ALLIAGES D'ALUMINIUM. RECHERCHE, DEVELOPPEMENT ET GESTION DE LA FABRICATION DE POUDRE D'ALUMINIUM.

RESEARCH, DEVELOPMENT, TECHNICAL SUPPORT AND PROVISION OF SERVICE FOR THE GROUP'S COMPANIES AND FOR EXTERNAL CUSTOMERS. PRODUCTION AND SALE OF ALUMINUM ALLOYS. RESEARCH, DEVELOPMENT AND MANUFACTURING MANAGEMENT OF ALUMINUM POWDER.

a été évalué et jugé conforme aux exigences requises par :
has been assessed and found to meet the requirements of:

ISO 9001 : 2015 - ISO 14001 : 2015 - ISO 45001 : 2018

et est déployé sur les sites suivants :
and is developed on the following locations:

725 rue Aristide Bergès Paro Economique Centr'Alp 38341 VOREPPE CEDEX France

Le détail des activités et sites certifiés par norme est mentionné sur les certificats suivants :
The description of certified activities and locations per standard is mentioned on the following certificates:

Certificat ISO 9001 : 2015 n° 73988
Certificat ISO 14001 : 2015 n° 73987
Certificat ISO 45001 : 2018 n° 73988

Certificats ISO 9001 et ISO 14001 délivrés sous accréditation n° 4-0001
Certificates ISO 9001 and ISO 14001 issued under accreditation n°4-0001

Ce certificat est valable à compter du (année/mois/jour) 2021-03-15 Jusqu'au 2023-01-29
This certificate is valid from (year/month/day) Until

Julien NIZRI
Directeur Général d'AFNOR Certification
Managing Director of AFNOR Certification

afnor CERTIFICATION

Constellium Aheadd®

Aluminium Alloys Designed for Laser Powder Bed AM - Summary

Booth 3A49

- Laser powder bed fusion L-PBF brings new opportunities for aluminium, and little threat to traditional high volume manufacturing. Drivers include massive part count reduction, geometries impossible to produce conventionally, no tooling costs & lead time reduction

- All conventional aluminium alloy systems show significant limitations in use for L-PBF. Constellium has developed rapid solidification aluminium alloys designed specifically for L-PBF for better AM processing, post-processing and component properties. Sustainable raw materials are used to bring competitive, scalable solutions

- **Aheadd ® HT1** (Al-Mn-Ni-Cu-Zr, AA8A81.50) targets structural applications with service temperatures beyond the capabilities of current aluminium solutions, saving weight over titanium or steel solutions

- **Aheadd ® CP1** (Al-Zr-Fe, AA8A61.50) brings multiple advantages over AlSi10Mg, F357 or 6061-based solutions. **Aheadd ® CP1** delivers robust, isotropic properties, simplified post-processing and compatibility with multiple surface finishing processes. High LPBF productivity levels will broaden the range of cost-effective component designs to mainstream applications including on-demand spare parts in multiple industries and automotive functional prototypes.

- Go **Aheadd ®** - talk to us about your aluminium LPBF application! In addition to powder supply, Constellium can support with printing and post-processing recommendations, printed samples or demonstrator parts, and metallurgical support.

Constellium

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To learn more please visit our booth 3A49

www.constellium.com

Constellium Aheadd® CP1

Robust properties outperforming AlSi10Mg, AlSi7Mg and 6061
Straightforward post-build heat treatment

GMP Group

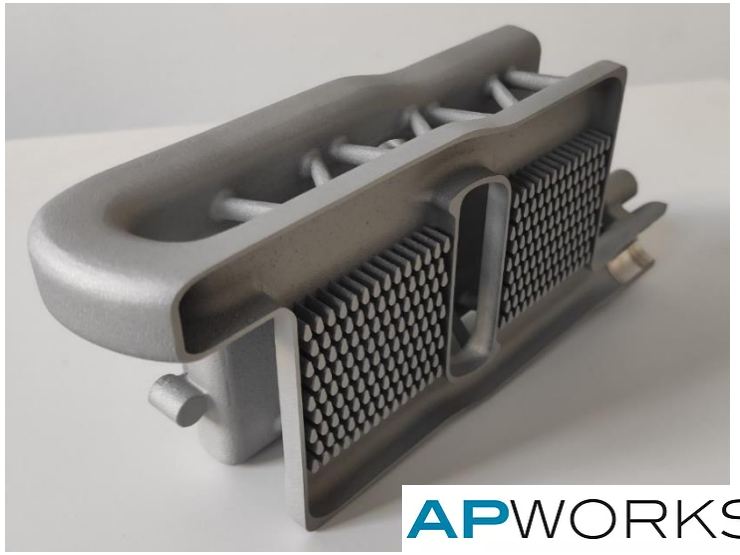
Designed & made by GMP Group

Aheadd CP1 heat sink demonstrator

	Typical properties, room temperature (vertical direction)			Thermal Conductivity W/mK	Electrical Conductivity MS/m (%IACS)
	YS (MPa)	UTS (MPa)	A%		
As-built	137	203	22.8	124	18.1 (31.2)
4h 400°C heat treat	323	342	12.8	187	28.4 (49.0)

Data from builds using 60µm layers, EOS M290

4h 400°C is a peak age heat treatment (zirconium precipitation hardening) Overaging can be used for even higher conductivities e.g. thermal management systems and radio frequency components



APWORKS

Target demonstrator : Flow-optimized AM cooler Designed and manufactured by APWORKS

Constellium Aheadd® HT1

High strength from room temperature to above 250°C

Heat Treatment	Test Temperature (°C)	Typical Properties (vertical direction)		
		YS (MPa)	UTS (MPa)	A%
#1 For high strength at lower temperatures	25	425	445	6
#2 For high temperature applications	250	216	265	5

Tensile tests at 250°C vertical direction	Thermal stability : pre-exposure time, temperature	
	0	2 h 350°C + 50h 250°C
Aheadd® HT1 heat treatment #2	216 MPa	216MPa

AddUp
GLOBAL ADDITIVE SOLUTIONS
AddUp I Poly-Shape I BeAM
AddUp, a Fives & Michelin joint-venture.

Game-changing thermal stability. Property control through adjustment of stress relief heat treatment in range 300 – 400°C