COLIBRIUM ADDITIVE
a GE Aerospace company

13 Al					
22 Ti	24 Cr	26 Fe	27 Co	28 Ni	29 Cu

L-PBF Aluminum Al-Si10-Mg

Parameters for Colibrium Additive's M2 Series 5

Aluminum Al-Si10-Mg

Al-Si10-Mg has a chemical composition according to ASTM F3318 and is an essential Aluminum alloy in the world of additive manufacturing. As good casting alloy for complex geometries, it combines light weight and excellent thermal conductivity. The alloy is ideally suited for part designs with thin walls such as ductwork or heat exchangers. Once post-processed, parts offer good strength and hardness superior to conventionally cast material, as well as good dynamic properties for industries in the aerospace, automotive, automation and tooling sectors. In summary this aluminum alloy holds great promises to bring additive manufacturing to high volume consumer applications.

M2 Series 5 Aluminum Al-Si10-Mg

The Al-Si10-Mg parameter for the Colibrium Additive M2 Series 5 are developed leveraging the performance of the previous M2 generations. The balanced parameter is a 40 µm parameter that produces surface roughness less than 10 µm without bead blast or shot peening, while delivering good productivity with dual lasers. In particular the down- and upskin areas were further improved to ensure consistent high surface quality across different angles. Moreover, the mechanical properties succeed the limits specified in ASTM F3318 for additive manufactured parts in the as-built and stress relieved (SR1) state.


Design by TUfast

M2 Series 5 Aluminum Al-Si10-Mg

Machine Configuration

M2 Series 5

Single- or dual-laser architecture

Nitrogen gas

Powder Chemistry

Aluminum Al-Si10-Mg powder chemical composition according to ASTM F3318 / AMS7018.

Particle size: 15-63 µm

Thermal States

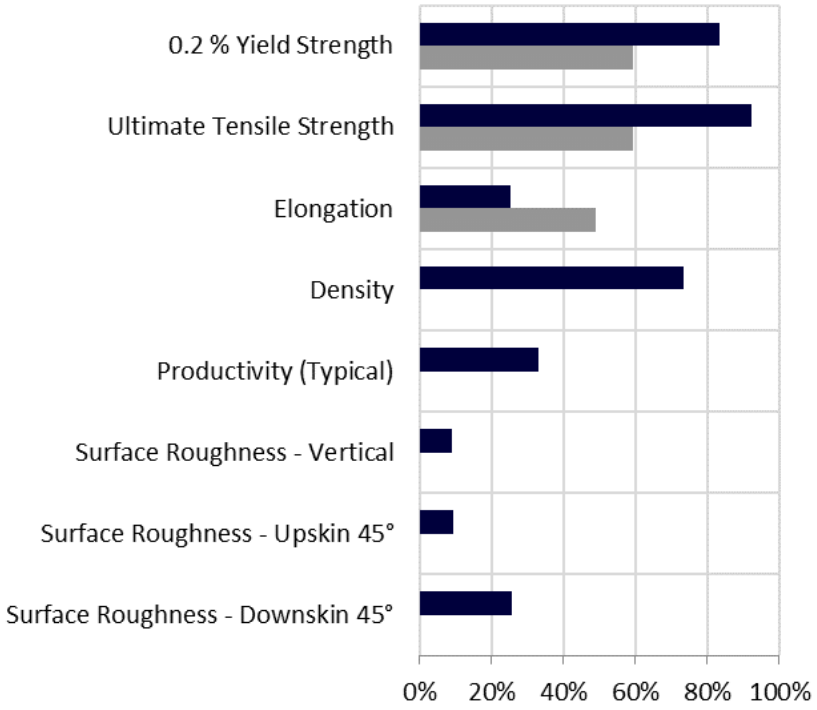
As-Built (AB)

Stress relief (SR1)

295°C for 2 hours, air cooling

Parameter Availability and Thermal State Comparison

- Balanced Parameter 389 AB
  400 W, 40 µm layer thickness, rubber recoater
- Balanced Parameter 389 SR1
  400 W, 40 µm layer thickness, rubber recoater



Bar plot is generated by normalizing typical material data (containing both horizontal and vertical data) against a range defined for each material family. For titanium-based alloys, the ranges are as follows: 0.2%YS: 0-300 MPa UTS: 0-500 MPa, Elongation: 0-30%, Density: 99-100%, Productivity: 5-60 cm³/h, Surface Quality (all): 5-40 µm. 0% in the bar plot indicates the lower range value, 100% indicates the upper range value

Balanced Parameter 389 - 400 W / 40 µm

Typical Build Rate

	(cm^3/h)
Typical build rate with coating[1]	23.2
Theoretical melting rate bulk per laser[2]	28.1

[1] Using standard Factory Acceptance Test layout and 2 lasers
[2] Calculated (layer thickness × scan velocity × hatch distance)

Tensile Performance at Room Temperature

Thermal State	Modulus of Elasticity (GPa)		0.2% Yield Strength (MPa)		Ultimate Tensile Strength (MPa)	
	H	V	H	V	H	V
As-Built	70	68	260	235	455	460
SR1	71	71	175	175	290	295

Thermal State	Elongation (%)		Area Reduction (%)	
	H	V	H	V
As-Built	9.0	6.0	8	6
SR1	16.0	13.0	35	31

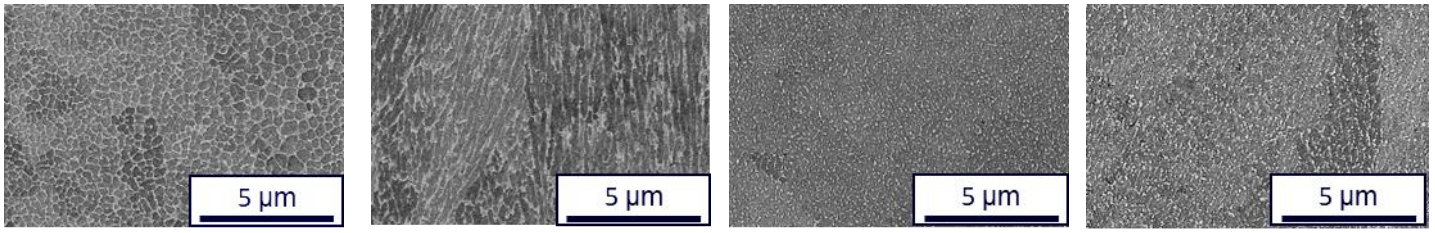
	Overhang Surface Roughness, Ra (µm)		
	45°	60°	75°
Upskin	9	7	7
Downskin	14	10	9

Surface Roughness, Ra (µm)	
H	22
V	9

Thermal State	Relative Density (%)		Hardness (HV5)
	H	V	H
As-Built	99.7	99.7	121
SR1	---	---	90

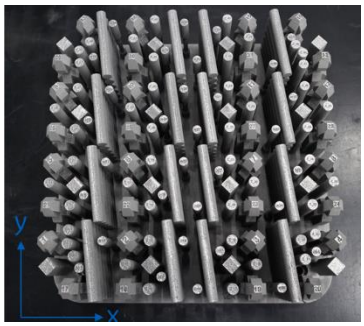
Microstructure

As-Built		SR1	
H	V	H	V



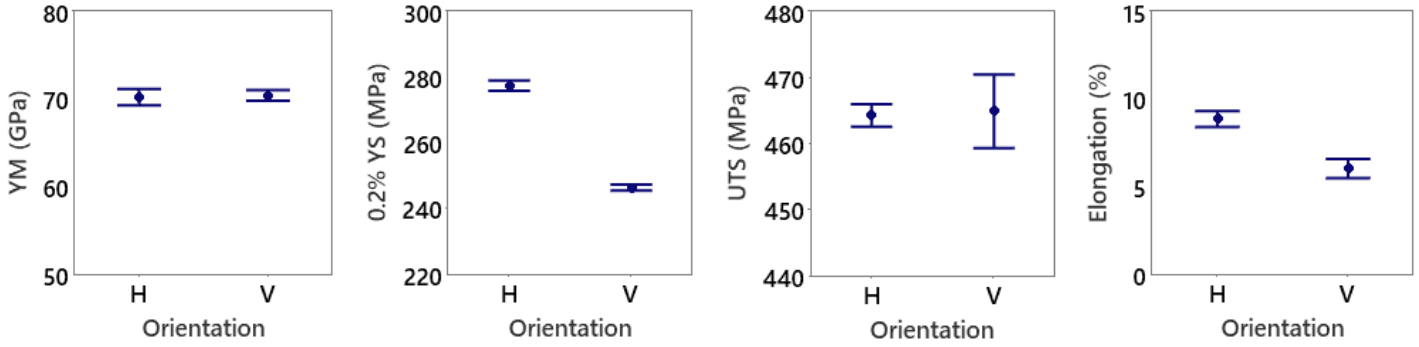
Scanning electron microscope images in As-Built and SR1 condition as defined previously.

The platform stability build evaluates relative density, roughness and tensile properties across different positions and orientations. To illustrate the position dependency of the M2 Series 5, the samples were homogenously distributed across the platform on 16 different positions. Regarding surface quality all sides of the specimen, so all orientations with respect to gas flow and optical system, are included in the analysis. Data shown below are dependent on part & print layout as well as batch chemistry variations and thus might deviate from “typical values” given on previous pages.

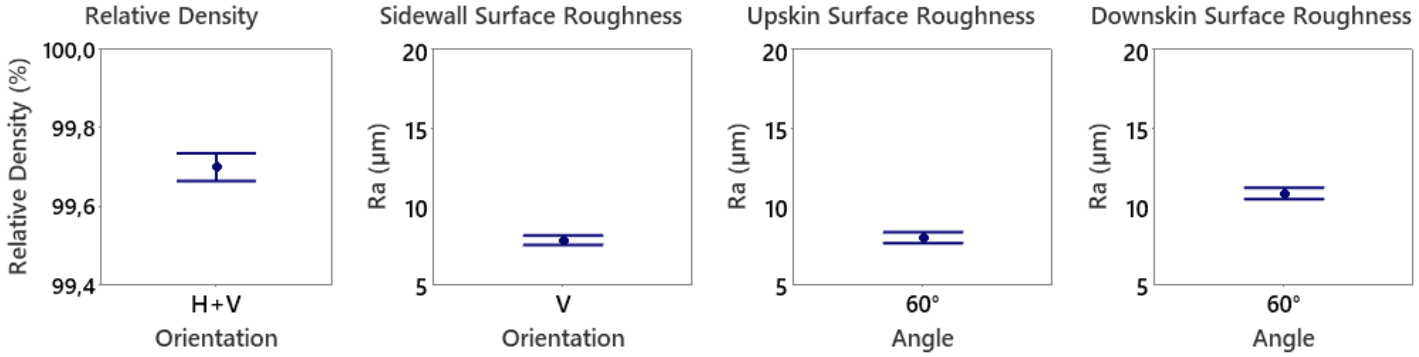


	Sample Size	Mean	Std. Dev.		Sample Size	Mean	Std. Dev.
YM (GPa) H/V - AB	16/16	70/70	2/1	Rel. Density (%)	32	99.70	0.02
0.2% YS (MPa) H/V - AB	16/16	277/246	3/2	Sidewall Roughness Ra (µm)	64	7.8	1.2
UTS (MPa) H/V - AB	16/16	464/465	3/11	60° Upskin Roughness Ra (µm)	64	8.0	1.4
Elongation (%) H/V - AB	16/16	8.9/6.0	0.2/0.3	60° Downskin Roughness Ra (µm)	64	10.8	1.5

Results Platform Stability: Mechanical properties in AB condition



Results Platform Stability: Relative Density and Surface Quality



Data Sheet Nomenclature and Notation

H: Horizontal, perpendicular to build direction.
V: Vertical, parallel to build direction.
Other angles are measured from horizontal.

Roughness measurements have been performed according to DIN EN ISO 4287 and DIN EN ISO 4288. In general analysis of the surface quality is strongly dependent on the methodology used and therefore deviations might be observed depending on methodology used. Vertical and horizontal sidewalls have been characterized using a tactile system, overhangs using an optical system.

Tensile evaluations were performed according to ASTM E8 or E21, depending on test temperature.