COLIBRIUM ADDITIVE
a GE Aerospace company

13 Al

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

L-PBF Nickel X

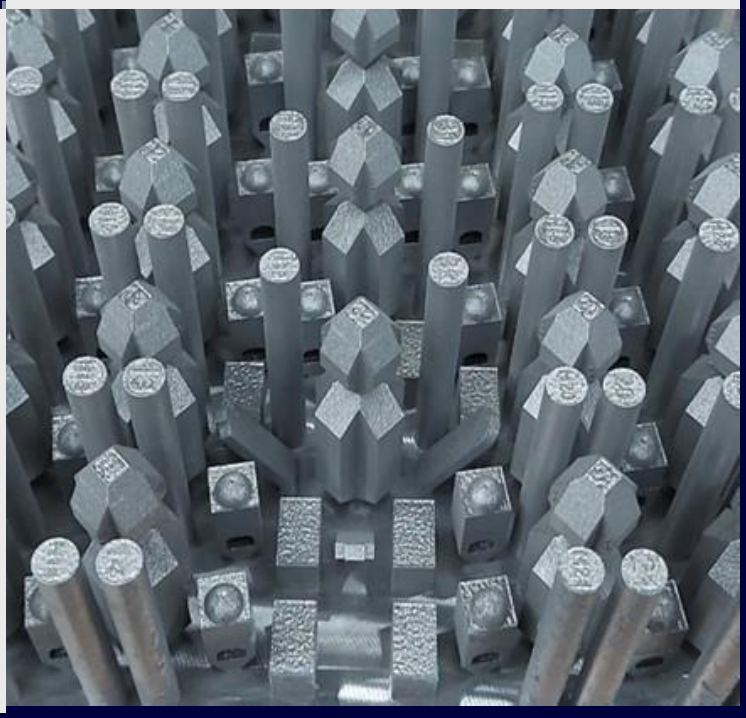
Parameters for Colibrium Additive's M2 Series 5

Nickel X

Nickel-Chromium-Iron-Molybdenum based superalloys like Nickel X (UNS N06002) have an exceptional combination of oxidation resistance, fabricability and high-temperature strength. The outstanding resistance to oxidizing, reducing, and neutral atmospheres up to 1200 °C makes Nickel X an ideal candidate for high temperature applications across different industries. Typical applications include gas turbine combustion zone components, aircraft parts, industrial furnace systems, chemical process industry and petrochemical process equipment.

M2 Series 5 Nickel X

The Nickel X parameters for the Colibrium Additive M2 Series 5 are developed leveraging the performance of the previous M2 generations. This balanced parameter utilizes 50 µm layer thickness and produces surface roughness less than 10 µm without bead blast or shot peening for most surfaces, while delivering good productivity with dual lasers. Parameter 226 has been optimized for use of steel blade recoater. Moreover, the mechanical properties for both parameters exceed the limits specified in ASTM B572 in the heat treated state.



M2 Series 5 Nickel X

Machine Configuration

M2 Series 5

Single- or dual-laser architecture

Nitrogen gas

Powder Chemistry*

Nickel X powder chemical composition according to AMS7008.

Particle size: 15-45 µm

* In general Nickel X is known to be susceptible to the formation of microcracks. The occurrence of microcracks is highly dependent on the microstructural evolution during solidification and thus on the local cooling rate and may occur in dependence of part & print layout.

Thermal States

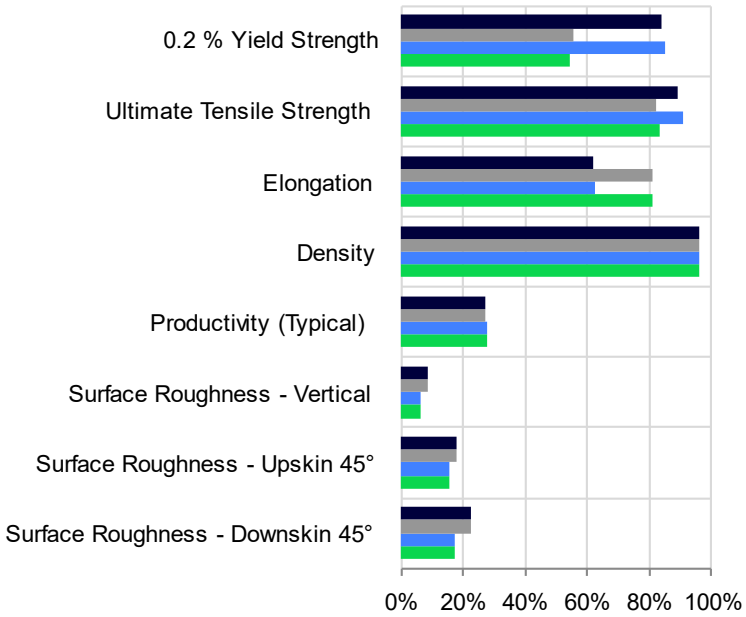
As-Built (AB)

Solution Anneal (SOLN)

1177 °C for 1 hour; air cooling

Parameter Availability and Thermal State Comparison

- Balanced Parameter 224 As-Built
- Balanced Parameter 224 SOLN
  400 W, 50 µm layer thickness, rubber recoater
- Balanced Parameter 226 As-Built
- Balanced Parameter 226 SOLN
  400 W, 50 µm layer thickness, steel 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 this Nickel alloy, the ranges are as follows: 0.2%YS: 0-700 MPa UTS: 0-900 MPa, Elongation: 0-20%, Density: 99-100% (As-Built), Productivity: 5-60 cm^3/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 224 - 400 W / 50 µm

Typical Build Rate

	(cm^3/h)
Typical build rate with coating[1]	19.8
Theoretical melting rate bulk per laser[2]	18.0

[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	183	166	615	555	840	755
SOLN	191	184	385	385	765	715

Thermal State	Elongation (%)	
	H	V
As-Built	33.5	40.0
SOLN	46.5	50.0

Physical Properties at Room Temperature

Parameter 224

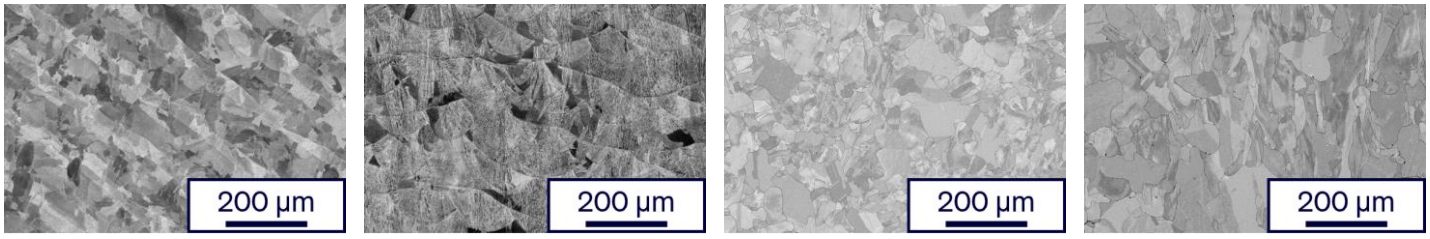
	Overhang Surface Roughness, Ra (µm)		
	45°	60°	75°
Upskin	12	9	4
Downskin	13	9	3

Surface Roughness, Ra (µm)	
H	7
V	9

Thermal State	Relative Density (%)		Hardness (HV10)
	H	V	H
As-Built	99.9	99.9	242
SOLN	---	---	190

Microstructure

As-Built		SOLN	
H	V	H	V



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

Balanced Parameter 226 - 400 W / 50 µm

Typical Build Rate

	(cm^3/h)
Typical build rate with coating[1]	20.2
Theoretical melting rate bulk per laser[2]	18.4

[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	188	170	625	560	855	780
SOLN	189	191	380	380	765	730

Thermal State	Elongation (%)	
	H	V
As-Built	34.5	40.0
SOLN	47.5	49.0

Physical Properties at Room Temperature

Parameter 226

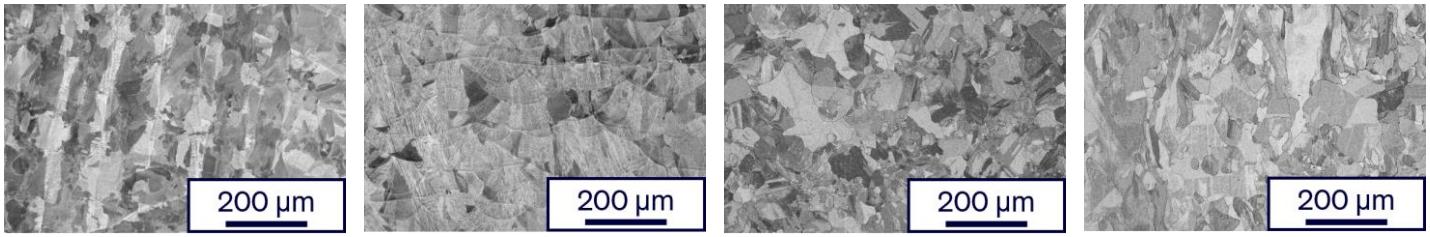
	Overhang Surface Roughness, Ra (µm)		
	45°	60°	75°
Upskin	11	8	6
Downskin	12	8	6

Surface Roughness, Ra (µm)	
H	17
V	8

Thermal State	Relative Density (%)		Hardness (HV10)
	H	V	H
As-Built	99.9	99.9	241
SOLN	---	---	191

Microstructure

As-Built		SOLN	
H	V	H	V



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

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.