LaserForm® Ti Gr23 (A)

Titanium alloy fine-tuned for use with ProX® DMP 320 and DMP 350 metal printers. Metal powder producing technical and medical parts with a combination of high specific strength and excellent biocompatibility. LaserForm Ti Gr23 (A) is ELI (Extra Low Interstitial) grade with lower iron, carbon, and oxygen content and is known for higher purity than LaserForm Ti Gr5 (A) resulting in improved ductility and fracture toughness.

LaserForm Ti Gr23 (A) is formulated and fine-tuned specifically for 3D Systems' ProX DMP 320 and DMP 350 metal 3D printers to deliver highest part quality and best part properties. The print parameter database that 3D Systems provides together with the material has been extensively developed, tested and optimized in 3D Systems' part production facilities that hold the unique expertise of printing 500,000 challenging production parts year over year. Based on over 1000 test samples the below listed part quality data and mechanical properties give you high planning security. And for a 24/7 production 3D Systems' thorough Supplier Quality Management System guarantees consistent, monitored material quality for reliable process results.

Material Description

This titanium alloy is commonly used in aerospace and medical applications because of its high strength, low weight and excellent biocompatibility. The essential difference between Ti6Al4V ELI (grade 23) and Ti6Al4V (grade 5) is the reduction of oxygen content to 0.13% (maximum) in grade 23. This confers improved ductility and fracture toughness, with some reduction in strength.

These benefits make LaserForm Ti Gr23 (A) the most used medical and aerospace titanium grade. It can be used in biomedical applications such as surgical implants, orthodontic appliances or in-joint replacements due to its biocompatibility, good fatigue strength and low modulus.

Classification

Parts built with LaserForm Ti Gr23 (A) Alloy have a chemical composition that complies with ASTM F3001, ASTM F3302, ISO 5832-3, ASTM F136 and ASTM B348 standards.

Mechanical Properties [1,2,3]

MEASUREMENT	CONDITION	METRIC			U.S.		
		AFTER STRESS RELIEF 1	AFTER STRESS RELIEF 2	AFTER HIP	AFTER STRESS RELIEF 1	AFTER STRESS RELIEF 2	AFTER HIP
Youngs modulus (GPa | ksi) Horizontal direction — XY Vertical direction — Z	ASTM E1876	119 ± 3 120 ± 1	119 ± 3 120 ± 1	122 ± 2 NA	17300 ± 730 17400 ± 300	17300 ± 730 17400 ± 300	17700 ± 300 NA
Ultimate Strength (MPa | ksi)	ASTM E8M						
Horizontal direction — XY Vertical direction — Z		1160 ± 20 1170 ± 50	1070 ± 30 1070 ± 30	980 ± 50 980 ± 70	168 ± 3 170 ± 7	155 ± 4 155 ± 4	142 ± 7 142 ± 10
Yield strength Rp0.2% (MPa | ksi)	ASTM E8M						
Horizontal direction — XY Vertical direction — Z		1060 ± 30 1100 ± 60	970 ± 30 1000 ± 60	890 ± 50 890 ± 90	154 ± 4 160 ± 9	141 ± 4 145 ± 9	129 ± 7 129 ± 13
Plastic elongation (%)	ASTM E8M						
Horizontal direction — XY Vertical direction — Z		10 ± 2 10 ± 3	13 ± 2 13 ± 3	14 ± 2 14 ± 2	10 ± 2 10 ± 3	13 ± 2 13 ± 3	14 ± 2 14 ± 2
Reduction of area (%)	ASTM E8M						
Horizontal direction — XY Vertical direction — Z		35 ± 10 40 ± 10	45 ± 10 45 ± 15	45 ± 5 45 ± 5	35 ± 10 40 ± 10	45 ± 10 45 ± 15	45 ± 5 45 ± 5
Hardness, Rockwell C	ASTM E18	37 ± 2	37 ± 4	34 ± 1	37 ± 2	37 ± 4	34 ± 1
Fatigue[4,5] (MPa | ksi)	ASTM E466	NA	typical 637	NA	NA	typical 92	NA

Thermal Properties

MEASUREMENT	CONDITION	METRIC	U.S.
Thermal conductivity[6] (W/(m.K) | Btu in/(h.ft.°F))	At 20 °C/ 68 °F	4.2 ± 0.1	29 ± 1
Coefficient of thermal expansion[7] (µm/(m.°C) | µ inch/(inch.°F))	In the range of 20 to 600 °C	8.6	4.8
Melting range[7] (°C | °F)		1692-1698	3046-3056

[1] Parts manufactured with standard parameters on a ProX DMP 320, Config A
[2] Values based on average and double standard deviation
[3] Surface condition of test samples: Horizontal samples (XY) tested in machined surface condition only, vertical (Z) tested in as-printed and machined surface condition
[4] Force-controlled axial fatigue testing (R=0.1). Endurance limit at 5 x 10^6 cycles Fatigue samples with machined surface
[5] Results are based on limited sample size, not statistically representative
[6] Thermal conductivity values are calculated by the Wiedemann-Franz law using the respective electrical resistivity values
[7] Values based on literature

Electrical Properties

MEASUREMENT	CONDITION	METRIC	U.S.
Electrical conductivity[1,2] (10^5 S/m)	ASTM B193 at 20°C / 68°F	5.9 ± 0.1	5.9 ± 0.1

Physical Properties

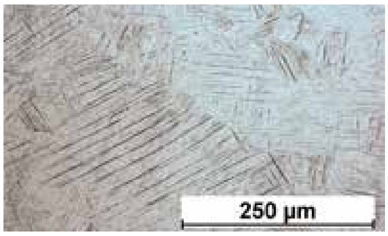
MEASUREMENT	CONDITION	METRIC	U.S.
		AS BUILT	AS BUILT
Density — Relative, based on pixel count[3,4] (%)	Optical method	> 99.6 typical 99.8	> 99.6 typical 99.8
Density — Absolute theoretical[5] (g/cm^3 | lb/in^3)		4.42	0.16

Surface Quality[6,7,8]

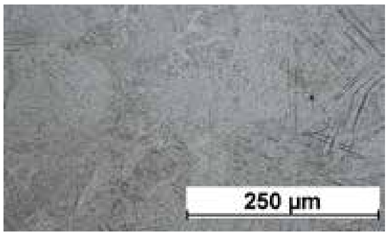
MEASUREMENT	CONDITION	METRIC	U.S.
		SANDBLASTED	SANDBLASTED
Surface Roughness R_a	ISO 25178		
Layer thickness 30µm and 60µm Top surface[9] (µm | µin) Vertical side surface[10] (µm | µin)		typical 3-8 typical 5-7	typical 120-320 typical 200-280
Layer thickness 90µm Top surface[9] (µm | µin) Vertical side surface[10] (µm | µin)		typical 13-19 typical 6-12	typical 500-750 typical 240-480

Chemical Composition

ELEMENT	% OF WEIGHT
Ti	Bal.
N	≤0.03
C	≤0.08
H	≤0.012
Fe	≤0.25
O	≤0.13
Al	5.5 - 6.5
V	3.5 - 4.5
Y	≤0.005
Residuals (each)	≤0.1
Residuals (total)	≤0.4

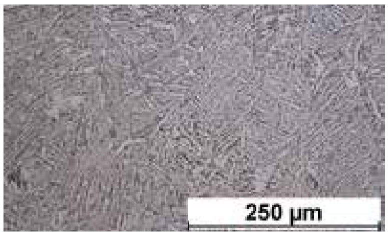


Microstructure as built



Microstructure after stress relief 1

Microstructure after stress relief 2



Microstructure after HIP

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