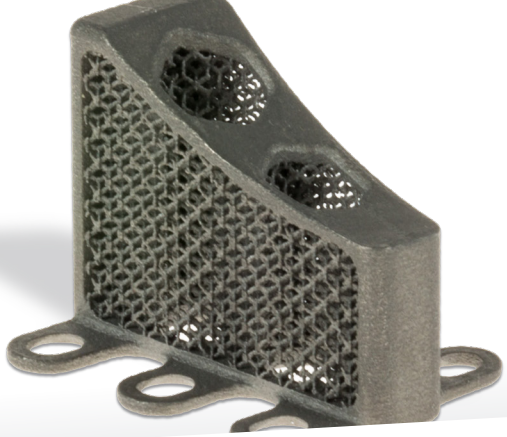


LaserForm® Ti Gr1 (A)

Commercially pure titanium fine-tuned for use with ProX® DMP 320 and DMP 350 printers; metal powder perfectly suited for medical applications and implants as LaserForm Ti Gr1 (A) is the purest Ti grade, known for its excellent biocompatibility and high ductility.

LaserForm Ti Gr1 (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

Commercially pure titanium is perfectly suited for medical applications because of its low stiffness and excellent biocompatibility. Grade 1 titanium is the most ductile medical titanium grade, rendering it ideal for implants, such as bone plates and other fixation devices, which need to be molded manually during surgery to fit the patient. Similar to other titanium grades, Grade 1 titanium has excellent corrosion resistance, including chloride and cavitation corrosion resistance.

Classification

Parts built with LaserForm Ti Gr1 Alloy have a chemical composition that complies with ASTM F3302, ASTM F67, ASTM B265, ASTM B348 (grade 1), ISO 5832-2, ISO 13782 and Werkstoff Nr. 3.7025 standards.

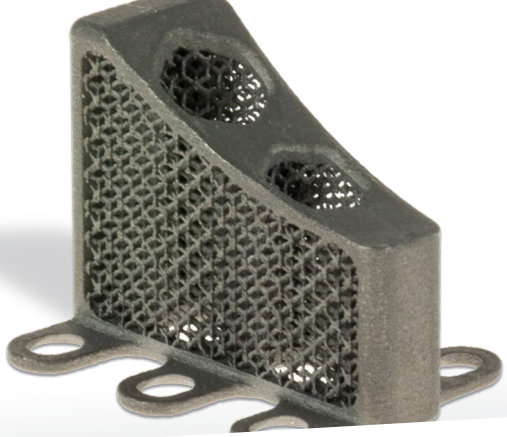
Mechanical Properties [1,2,3]

MEASUREMENT	CONDITION	METRIC		U.S.	
		AFTER STRESS RELIEF 1	AFTER HIP	AFTER STRESS RELIEF 1	AFTER HIP
Youngs modulus (GPa | ksi)	ASTM E8M	105-120	105-120	15000-17500	15000-17500
Ultimate Strength (MPa | ksi)	ASTM E8M				
Horizontal direction — XY Vertical direction — Z		500 ± 30 500 ± 30	460 ± 30 460 ± 30	73 ± 4 73 ± 4	67 ± 4 67 ± 4
Yield strength Rp0.2% (MPa | ksi)	ASTM E8M				
Horizontal direction — XY Vertical direction — Z		380 ± 30 380 ± 30	340 ± 20 340 ± 20	55 ± 4 55 ± 4	49 ± 3 49 ± 3
Elongation at break (%)	ASTM E8M				
Horizontal direction — XY Vertical direction — Z		29 ± 5 30 ± 5	36 ± 5 36 ± 5	29 ± 5 30 ± 5	36 ± 5 36 ± 5
Reduction of area (%)	ASTM E8M				
Horizontal direction — XY Vertical direction — Z		53 ± 5 53 ± 6	58 ± 10 60 ± 10	53 ± 5 53 ± 6	58 ± 10 60 ± 10
Hardness, Rockwell B (HRB)	ASTM E18	85 ± 5	80 ± 5	85 ± 5	80 ± 5

Thermal Properties[4]

MEASUREMENT	CONDITION	METRIC	U.S.
Thermal conductivity (W/(m.K) | btu.in/(h.ft.°F))	At 50 °C / 120 °F	16	9.25
Coefficient of Thermal Expansion (µm/m.°C | µin/(in.°F))	In the range of 20 to 600 °C	7.17	3.98
Melting point (°C | °F)		1668	3070

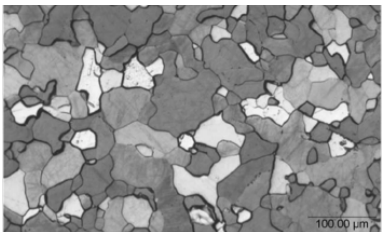
[1] Parts manufactured with standard parameters on a ProX DMP 320, Config A
[2] Values based on average and double standard deviation
[3] Surface condition of test samples: Horizontal samples (XY) tested in machined surface condition only, vertical (Z) tested in as-printed and machined surface condition
[4] Values based on literature



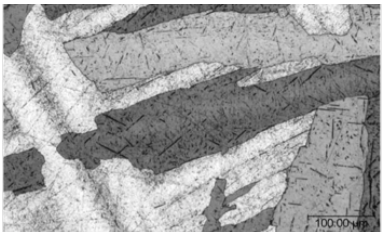
LaserForm® Ti Gr1 (A)

Physical Properties

MEASUREMENT	CONDITION	METRIC		U.S.	
		AS BUILT AND AFTER STRESS RELIEF	AFTER HIP	AS BUILT AND AFTER STRESS RELIEF	AFTER HIP
Density — Relative, based on pixelcount (%)[1,2]	Optical method	> 99.6 typical 99.8		> 99.6 typical 99.8	
Density — Absolute theoretical[3] (g/cm³ | lb/in³)		4.51		0.163	



Microstructure after stress relief 1



Microstructure after HIP

Surface Quality[4,5]

MEASUREMENT	CONDITION	METRIC	U.S.
		SANDBLASTED	SANDBLASTED
Surface Roughness Ra Top surface[6] (µm | µin) Vertical side surface[7] (µm | µin)	ISO 25178	 4-8 4-8	 160-310 160-310

Chemical Composition

Ti	Bal.
N	≤0.03
C	≤0.08
H	≤0.015
Fe	≤0.20
O	≤0.18
Residuals (each)	≤0.1
Residuals (total)	≤0.4

[1] Minimum value based on 95% confidence interval
Tested on typical density test shapes
[2] May deviate depending on specific part geometry
[3] Values based on literature
[4] Parts manufactured with standard parameters on a ProX DMP 320, Config A
[5] Sand blasting performed with zirconia blasting medium at 2 bar
[6] Top surface measurements along the 2 perpendicular axes of the reference square geometry
[7] Vertical side surface measurement along the building direction

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