MATERIAL DATASHEET

Composites

Markforged

Composite Base	Test (ASTM)	Onyx	Onyx FR	Onyx ESD	Nylon
Tensile Modulus (GPa)	D638	2.4	3.0	4.2	1.7
Tensile Stress at Yield (MPa)	D638	40	41	52	51
Tensile Stress at Break (MPa)	D638	37	40	50	36
Tensile Strain at Break (%)	D638	25	18	25	150
Flexural Strength (MPa)	D790[1]	71	71	83	50
Flexural Modulus (GPa)	D790[1]	3.0	3.6	3.7	1.4
Heat Deflection Temp (°C)	D648 B	145	145	138	41
Flame Resistance	UL94	—	V-0[2]	—	—
Izod Impact - notched (J/m)	D256-10 A	330	—	44	110
Surface Resistance (Ω)	ANSI/ESD STM11.11[3]	—	—	10^5 - 10^7	—
Density (g/cm^3)	—	1.2	1.2	1.2	1.1

Markforged parts are primarily composed of Composite Base materials. Users may reinforce parts with one type of Continuous Fiber.

Dimensions and construction of test specimens:

- Tensile: ASTM D638 type IV beams
- Flexural: 3-pt. Bending, 4.5 in (L) x 0.4 in (W) x 0.12 in (H)
- Heat-deflection temperature at 0.45 MPa, 66 psi (ASTM D648-07 Method B)

1. Measured by a method similar to ASTM D790. Composite Base -only parts do not break before end of flexural test.

2. Onyx FR is UL 94 V-0 Blue Card certified down to a thickness of 3mm.

3. Surface resistance measured on multiple part surfaces using recommended print settings by an accredited third party test facility. See Onyx ESD technical data sheet for more details.

Continuous Fiber	Test (ASTM)	Carbon	Kevlar®	Fiberglass	HSHT FG
Tensile Strength (MPa)	D3039	800	610	590	600
Tensile Modulus (GPa)	D3039	60	27	21	21
Tensile Strain at Break (%)	D3039	1.5	2.7	3.8	3.9
Flexural Strength (MPa)	D790[1]	540	240	200	420
Flexural Modulus (GPa)	D790[1]	51	26	22	21
Flexural Strain at Break (%)	D790[1]	1.2	2.1	1.1	2.2
Compressive Strength (MPa)	D6641	320	97	140	192
Compressive Modulus (MPa)	D6641	54	28	21	21
Compressive Strain at Break (%)	D6641	0.7	1.5	—	—
Heat Deflection Temp (°C)	D648 B	105	105	105	150
Izod Impact - notched (J/m)	D256-10 A	960	2000	2600	3100
Density (g/cm^3)	—	1.4	1.2	1.5	1.5

Dimensions and Construction of Fiber Composite Test Specimens:

- Test plaques used in these data are fiber reinforced unidirectionally (0° Plies)
- Tensile test specimens: 9.8 in (L) x 0.5 in (H) x 0.048 in (W) (CF composites), 9.8 in (L) x 0.5 in (H) x 0.08 in (W) (GF and Kevlar® composites)
- Compressive test specimens: 5.5 in (L) x 0.5 in (H) x 0.085 in (W) (CF composites), 5.5 in (L) x 0.5 in (H) x 0.12 in (W) (Kevlar® and FG composites)
- Flexural test specimens: 3-pt. Bending, 4.5 in (L) x 0.4 in (W) x 0.12 in (H)
- Heat-deflection temperature at 0.45 MPa, 66 psi (ASTM D648-07 Method B)

Tensile, Compressive, Strain at Break, and Heat Deflection Temperature data were provided by an accredited 3rd party test facility. Flexural data was prepared by Markforged. Inc. These represent typical values.

Markforged tests plaques are uniquely designed to maximize test performance. Fiber test plaques are fully filled with unidirectional fiber and printed without walls. Plastic test plaques are printed with full infill. To learn more about specific testing conditions or to request test parts for internal testing, contact a Markforged representative. All customer parts should be tested in accordance to customer's specifications.

Part and material performance will vary by fiber layout design, part design, specific load conditions, test conditions, build conditions, and the like.

This representative data were tested, measured, or calculated using standard methods and are subject to change without notice. Markforged makes no warranties of any kind, express or implied, including, but not limited to, the warranties of merchantability, fitness for a particular use, or warranty against patent infringement; and assumes no liability in connection with the use of this information. The data listed here should not be used to establish design, quality control, or specification limits, and are not intended to substitute for your own testing to determine suitability for your particular application. Nothing in this sheet is to be construed as a license to operate under or a recommendation to infringe upon any intellectual property right.

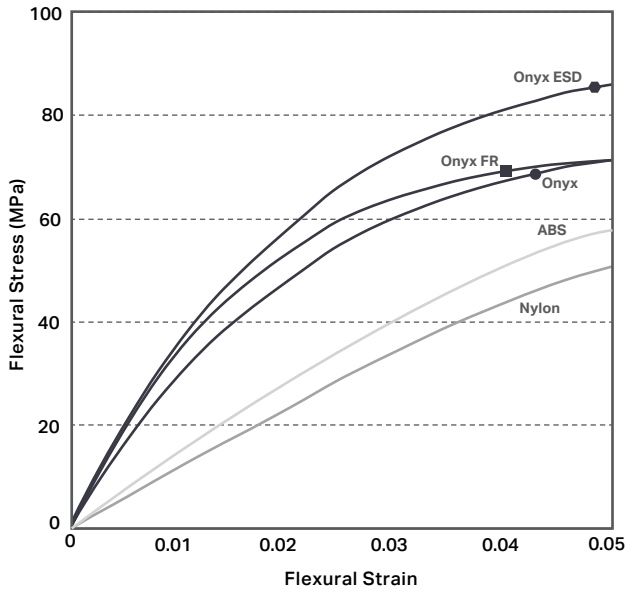
MATERIAL DESCRIPTIONS

Composites

Markforged composite printers are capable of Continuous Fiber Reinforcement (CFR) — a unique process that reinforces FFF parts with high-strength continuous fibers. A CFR capable machine uses two extrusion systems: one that extrudes Composite Base material in a standard FFF process, and a second for long strand continuous fibers that are laid down in-layer, replacing FFF infill.

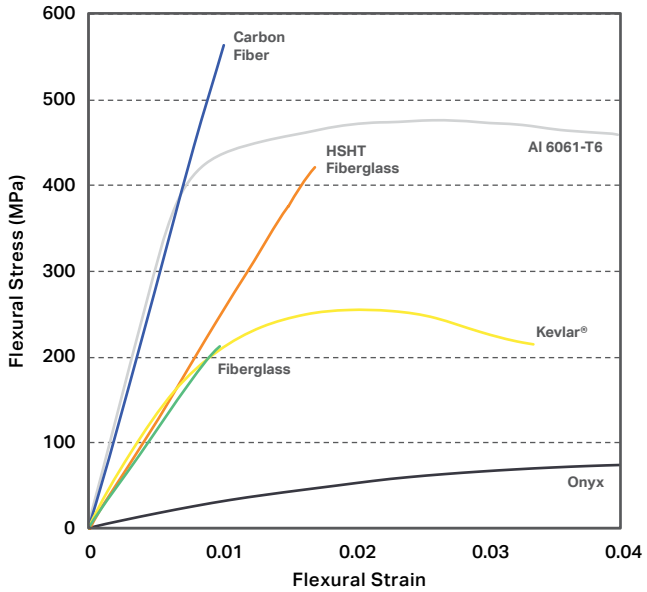
Composite Base

Markforged Composite Base materials print like conventional FFF thermoplastics. They can be printed by themselves, or reinforced with any of our continuous fibers, including Carbon Fiber, Kevlar, and Fiberglass.



Continuous Fiber

Continuous Fibers are laid down on the inside of parts through a second fiber nozzle. They cannot be printed by themselves — instead, they are used to reinforce parts printed out of a composite base material like Onyx.



● Onyx **Flexural Strength: 71 MPa**

Onyx is a micro carbon fiber filled nylon. It's 1.4 times stronger and stiffer than ABS and can be reinforced with any continuous fiber. Onyx sets the bar for surface finish, chemical resistivity, and heat tolerance.

■ Onyx FR **Flexural Strength: 71 MPa**

Onyx FR is a Blue Card certified UL94 V-0 material that possesses similar mechanical properties to Onyx. It's best for applications in which flame retardancy, light weight, and strength are required.

⬢ Onyx ESD **Flexural Strength: 83 MPa**

Onyx ESD is a static dissipative safe variant of Onyx — meeting stringent ESD safety requirements while offering excellent strength, stiffness, and surface finish. It's best used in applications that require ESD safe materials.

● Nylon **Flexural Strength: 50 MPa**

Nylon White parts are smooth, non-abrasive, and easily painted. They can be reinforced with any continuous fiber and work best for non-marring work holding, repeated handling, and cosmetic parts.

● Carbon Fiber **Flexural Strength: 540 MPa**

Carbon Fiber has the highest strength-to-weight ratio of our reinforcing fibers. Six times stronger and eighteen times stiffer than Onyx, Carbon Fiber reinforcement is commonly used for parts that replace machined aluminum.

● Fiberglass **Flexural Strength: 200 MPa**

Fiberglass is our entry level continuous fiber, providing high strength at an accessible price. 2.5 times stronger and eight times stiffer than Onyx, Fiberglass reinforcement results in strong, robust tools.

● Kevlar® **Flexural Strength: 240 MPa**

Kevlar® possesses excellent durability, making it optimal for parts that experience repeated and sudden loading. As stiff as fiberglass and much more ductile, it can be used for a wide variety of applications.

● HSHT Fiberglass **Flexural Strength: 420 MPa**

High Strength High Temperature (HSHT) Fiberglass exhibits aluminum strength and high heat tolerance. Five times as strong and seven times as stiff as Onyx, it's best used for parts loaded in high operating temperatures.