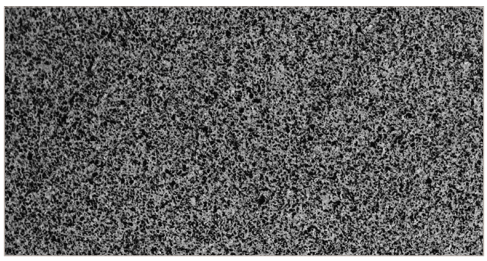
GF Graphite Materials

Premium graphite for glass forming applications

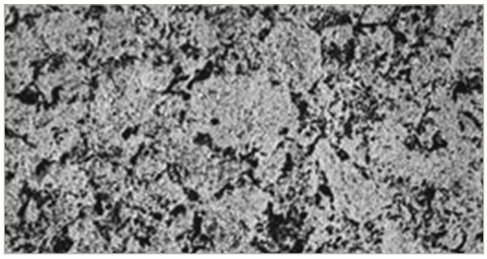
With the variety of materials available in today's market, using a graphite material developed for a specific application ensures optimum performance, increased throughput, and improved cost of ownership. Entegris produces a line of materials specifically intended for glass forming applications. GF and GF-LT graphite materials are produced using a proprietary process that allows differentiation over conventional graphite materials. This process differentiation leads to:

- World-class microstructure
- Higher level of interconnected porosity
- Tighter correlation between particle and pore
- Improved purity levels
- Isotropic mechanical properties
- Increased machining capabilities
- Higher physical strength
- Unique coefficient of thermal expansion (CTE)

3D formed glass for smartphones



GF microstructure



Conventional graphite microstructure

ATTRIBUTES

- Improved surface finish on glass
- Non-wetting to glass
- Reduced glass stress and less thermal checking
- Increased mold life
- Uniform oxidation resistance
- Improved machinability
- Improved wear/erosion resistance
- Higher product yield rates
- Minimal production downtime
- CTE match to popular high CTE glass
- Process consistency for improved cost of ownership

QUALITY

Our quality program assures that each person has the opportunity to perform a quality job in a safe environment. Quality is built into each Entegris product as it progresses through the plant. We are an ISO:9008 and AS:9100 registered company.

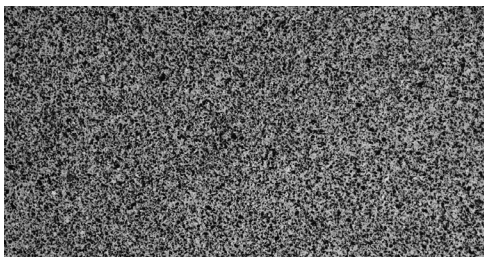
GRAPHITE GRADES

GF Graphite

This is our base grade of graphite material with high strength and durability for glass forming applications. GF materials provide higher product yield through improved glass surface finishes and a match to high CTE glass products.

GF-LT Graphite

This material offers the same attributes as GF graphite in addition to improved wear and erosion resistance. The higher hardness of this material provides superior polishing capabilities to a very high gloss surface finish.



GF and GF-LT graphite microstructure

POST-PROCESSING

We offer purification of each GF graphite material to allow for increased oxidation resistance through the elimination of metallic contaminates that react to oxygen present in the glass forming process.

Our purification process reduces impurities to 5 ppm (99.9995%) or less as determined by ash analysis.

Targeted Purified Graphite GDMS Elemental Data Analysis

ELEMENT	CONCENTRATION
Na	<0.005 ppm*
Mg	<0.005 ppm*
Al	0.09 ppm
K	<0.005 ppm*
Ca	<0.005 ppm*
Ti	0.02 ppm
V	0.002 ppm
Mn	<0.001 ppm*
Fe	0.03 ppm
Ni	0.01 ppm
Cu	<0.001 ppm*
Zn	<0.005 ppm*
Si	Trace to 5 ppm
S	Trace to 5 ppm
B	Trace to 5 ppm
P	Trace
Mo	Trace

** Denotes value below detection limits*

COST OF OWNERSHIP

The use of GF materials provides a positive cost of ownership when taking the following into consideration:

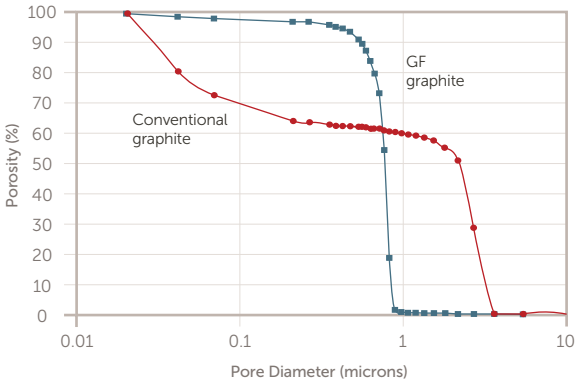
- Enhanced machinability
- Excellent mold finish minimizing cost for hand polishing
- Extended mold life
- Minimal downtime for mold set change
- Increased product yield per run
- Reduced glass polishing requirements
- Superior product quality
- Improved ability to meet consumer product demand

TYPICAL MATERIAL PROPERTIES

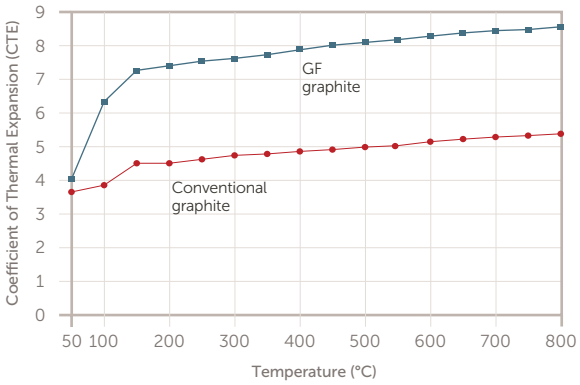
PROPERTY	GF	GF-1	GF-LT	GF-LT-1	GF-XL	GF-XL-1
Particle size	<3 µm (120 µin)	<3 µm (120 µin)	<3 µm (120 µin)	<3 µm (120 µin)	<1 µm (40 µin)	<1 µm (40 µin)
Pore size	0.8 µm (32 µin)	0.8 µm (32 µin)	0.8 µm (32 µin)	0.8 µm (32 µin)	0.2 µm (8 µin)	0.2 µm (8 µin)
Apparent density	1.74 g/cm³ (0.063 lb/in³)	1.74 g/cm³ (0.063 lb/in³)	1.77 g/cm³ (0.064 lb/in³)	1.77 g/cm³ (0.064 lb/in³)	1.74 g/cm³ (0.063 lb/in³)	1.74 g/cm³ (0.063 lb/in³)
Compressive strength	130 MPa (18,800 psi)	130 MPa (18,800 psi)	155 MPa (22,500 psi)	155 MPa (22,500 psi)	162 MPa (23,500 psi)	162 MPa (23,500 psi)
Flexural strength[1]	92 MPa (13,350 psi)	92 MPa (13,350 psi)	97 MPa (14,100 psi)	97 MPa (14,100 psi)	95 MPa (13,800 psi)	95 MPa (13,800 psi)
Shore hardness	74	74	96	96	88	88
Coefficient of thermal expansion	8.1 µm/m °C (4.5 µm/in °F)	8.1 µm/m °C (4.5 µm/in °F)	8.5 µm/m °C (4.7 µm/in °F)	8.5 µm/m °C (4.7 µm/in °F)	8.1 µm/m °C (4.5 µm/in °F)	8.1 µm/m °C (4.5 µm/in °F)
Thermal conductivity[2]	85 W/m-K (50 BTU-ft/hr/ft² °F)	85 W/m-K (50 BTU-ft/hr/ft² °F)	60 W/m-K (35 BTU-ft/hr/ft² °F)	60 W/m-K (35 BTU-ft/hr/ft² °F)	77 W/m-K (45 BTU-ft/hr/ft² °F)	77 W/m-K (45 BTU-ft/hr/ft² °F)
Purity (ash)	<3000 ppm	<5 ppm	<3000 ppm	<5 ppm	<3000 ppm	<5 ppm
Oxidation threshold[3]	450°C (842°F)	560°C (1040°F)	470°C (878°F)	580°C (1076°F)	450°C (842°F)	560°C (1040°F)

[1] Measured using 3-point bend method.
[2] Approximate values taken at room temperature; as temperature increases, thermal conductivity decreases.
[3] Oxidation threshold defined as temperature at which oxidation weight loss after 24 hrs is approximately 1% (size 0.5" × 0.5" × 1").

Pore Distribution



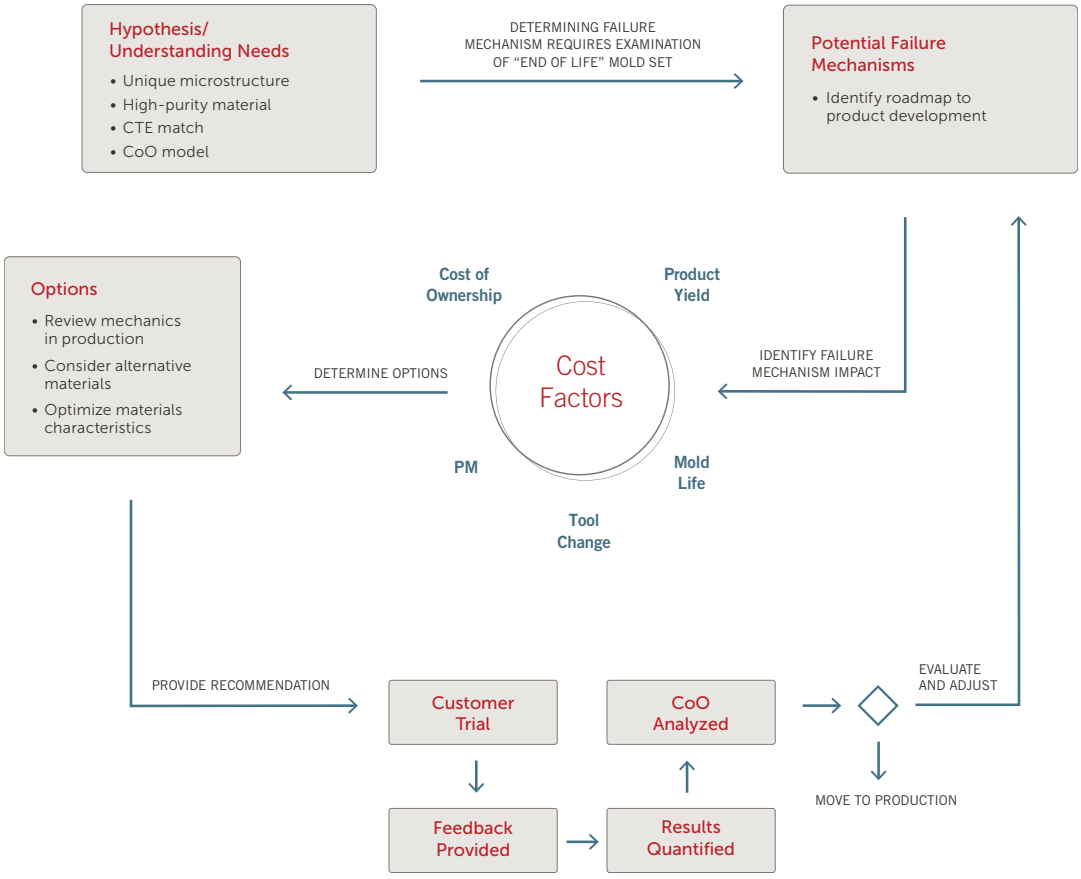
Coefficient of Thermal Expansion



TECHNICAL SOLUTIONS PROVIDER

- Committed participant to major industries
- Material development road mapping
- High temperature technical/application expertise
- Carbon expertise
- Solutions development for specific applications
- Vertical integration
- World-class material analysis capability
- Global reach with market leadership customer focused
- History of customized differentiated solutions
- Experienced and dedicated support team
- Proven cost of ownership record

Material Development and Partnering Philosophy



FOR MORE INFORMATION

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