

GLASSMATE® GF MATERIALS

Premium graphite for glass forming applications

Overview

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. Poco Graphite produces a line of materials specifically intended for Glass Forming applications. POCO's GLASSMATE® materials are produced using a proprietary process which allows differentiation over conventional graphite materials. This process differentiation leads to:

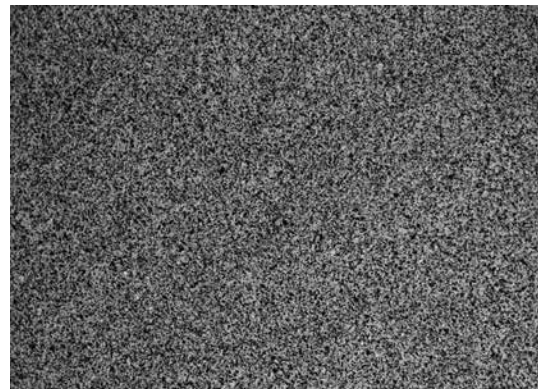
- World class microstructure
- Higher level of interconnected porosity
- Tighter correlation between particle and pore
- Improved purity levels
- Isotropic mechanical properties
- Increased machining capabilities
- Higher physical strength
- Unique coefficient of thermal expansion (CTE)

Attributes

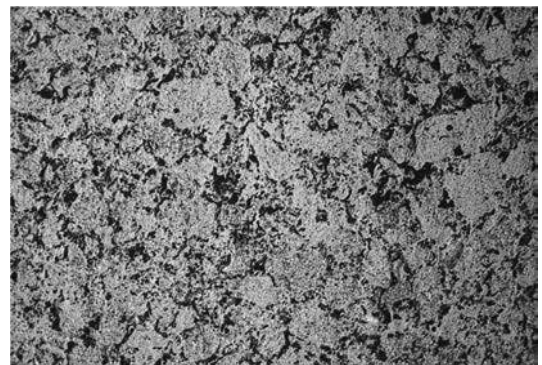
- Improved surface finish on glass
- Non-wetting to glass
- Reduced glass stress and less thermal checking
- Increased mold life
- Uniform oxidation resistance
- Improved machinability
- Improved wear/erosion resistance
- Higher product yield rates
- Minimal production downtime
- CTE match to popular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



3D Formed Glass for Smartphones



GF Microstructure



Conventional Graphite Microstructure

GLASSMATE Grades

GF

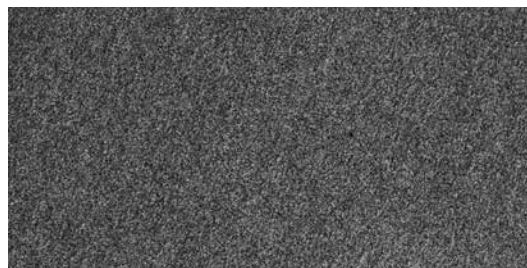
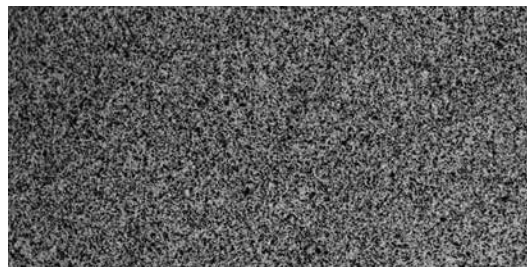
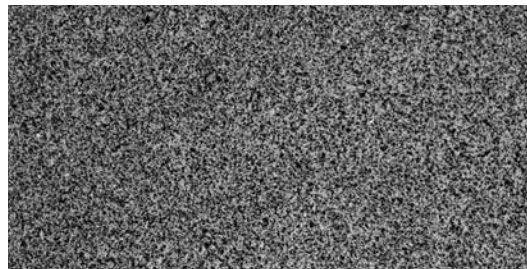
This is the base grade of POCO's GLASSMATE Glass Forming materials with high strength and durability for glass forming applications. GF materials provide higher product yield through improved glass surface finishes and a match to high CTE glass products.

GF-LT

This material offers the same attributes as GF 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-XL

POCO's GF-XL material offers a tighter microstructure and higher hardness over GF to improve wear resistance and provide improved glass surface quality. The smaller particle size of GF-XL allows for increased material strength and reduced porosity.



Post-Processing

POCO offers purification of each GM-GF material to allow for increased oxidation resistance through the elimination of metallic contaminants that react to oxygen present in the glass forming process. POCO's purification process reduces impurities to 5 ppm (99.9995%) or less as determined by ash analysis.

Quality

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

Targeted Purified POCO Graphite GDMS Elemental Data Analysis

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

* Denotes value below detection limits

Cost of Ownership

The use of POCO 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

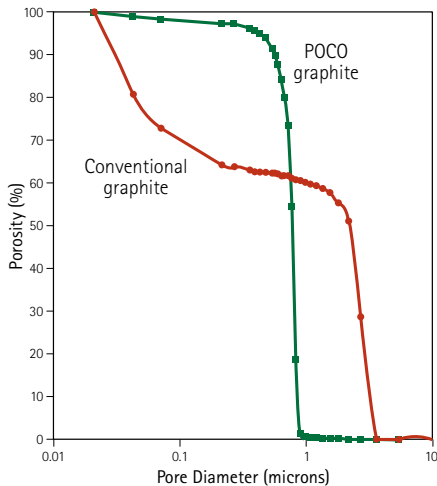
Property	GF	GF-1	GF-LT	GF-LT-1	GF-XL	GF-XL-1
Particle size: μm (μin)	<3 (120)	<3 (120)	<3 (120)	<3 (120)	<1 (40)	<1 (40)
Pore size: μm (μin)	0.8 (32)	0.8 (32)	0.8 (32)	0.8 (32)	0.2 (8)	0.2 (8)
Apparent density: g/cm^3 (lb/in^3)	1.74 (0.063)	1.74 (0.063)	1.77 (0.064)	1.77 (0.064)	1.74 (0.063)	1.74 (0.063)
Compressive strength: MPa (psi)	130 (18,800)	130 (18,800)	155 (22,500)	155 (22,500)	162 (23,500)	162 (23,500)
Flexural strength ¹ : MPa (psi)	92 (13,350)	92 (13,350)	97 (14,150)	97 (14,150)	95 (15,250)	95 (15,250)
Shore hardness:	74	74	96	96	88	88
Coefficient of thermal expansion: $\mu\text{m}/\text{m } ^\circ\text{C}$ ($\mu\text{in}/\text{in } ^\circ\text{F}$)	8.1 (4.5)	8.1 (4.5)	8.5 (4.7)	8.5 (4.7)	8.1 (4.5)	8.1 (4.5)
Thermal conductivity ² : $\text{W}/\text{m-K}$ ($\text{BTU-ft}/\text{hr}/\text{ft}^2 \text{ } ^\circ\text{F}$)	85 (50)	85 (50)	60 (35)	60 (35)	77 (45)	77 (45)
Purity: ppm ash	<3000	<5	<3000	<5	<3000	<5
Oxidation threshold ³ : $^\circ\text{C}$ ($^\circ\text{F}$)	450 (842)	560 (1040)	470 (878)	580 (1076)	450 (842)	560 (1040)

¹ Measured using 3-point bend method.

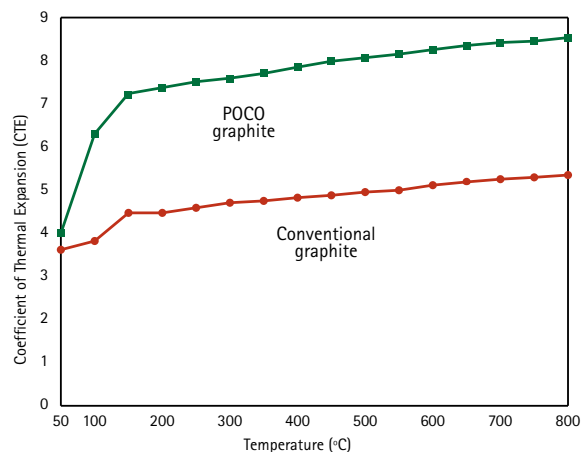
² Approximate values taken at room temperature; as temperature increases, thermal conductivity decreases.

³ Oxidation threshold defined as temperature at which oxidation weight loss after 24 hrs is approximately 1% (Size $0.5'' \times 0.5'' \times 1''$).

Performance Data Comparison



Pore distribution

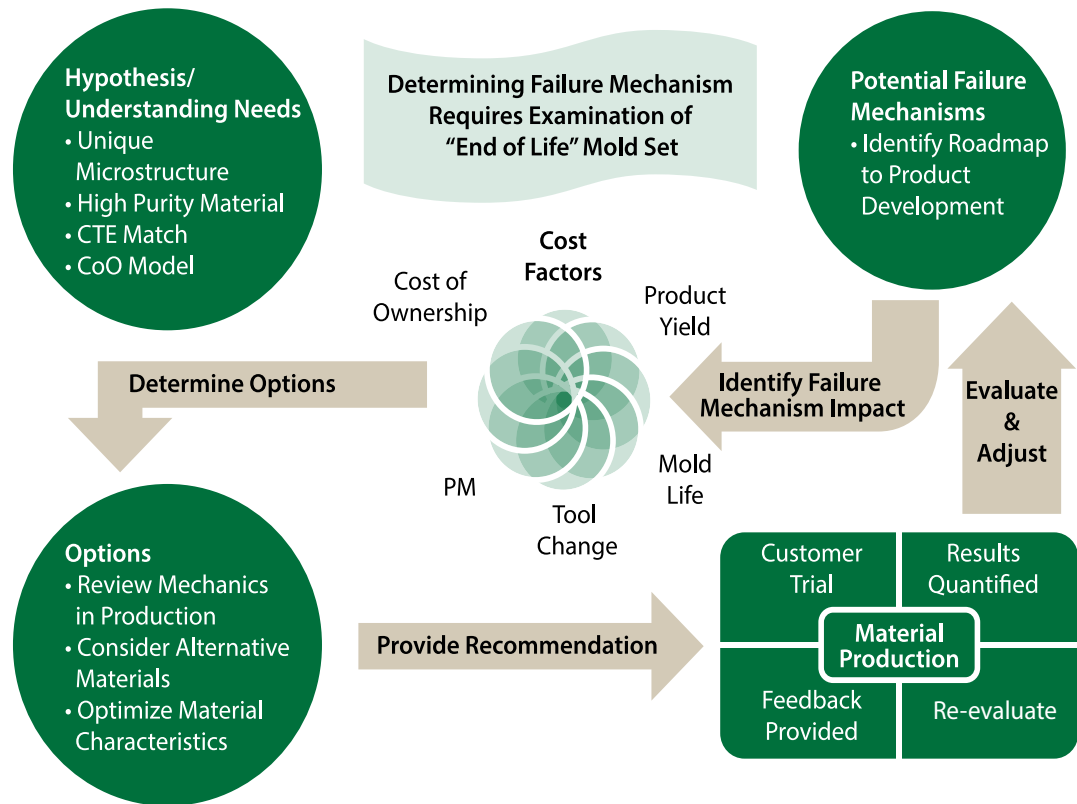


Coefficient of thermal expansion

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 & Partnering Philosophy



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POCO GRAPHITE, INC.

Corporate Headquarters | 300 Old Greenwood Rd. | Decatur, Texas 76234 USA
 Telephone: 1.940.627.2121 | Facsimile: 1.940.393.8366
www.poco.com