Morgan
Advanced Materials

Morgan Advanced Materials (Group)

Founded in 1856
A global advanced materials company
Based in Windsor. United Kingdom
Listed on the London Stock Exchange

Shanghai Morgan Advanced Materials & Technology Co., Ltd.

Founded in 2006
A wholly-owned subsidiary of
Morgan Advanced Materials Co., Ltd.
Based in Shanghai

What differentiates us?

Advanced materials science and processing capacity
Rich experience in application engineering
Stable product performance
Continuous innovation for a century
Global operation network

You may reach us through:

SPECIALTY GRAPHITE PRODUCTS CUSTOMER SERVICE:

021-64343350 Extension: 206
chinasales@morganplc.com

OTHER COMMENTS OR SUGGESTIONS:

ecchina.suggestions@morganplc.com

MORGAN'S OFFICIAL WECHAT ACCOUNT:

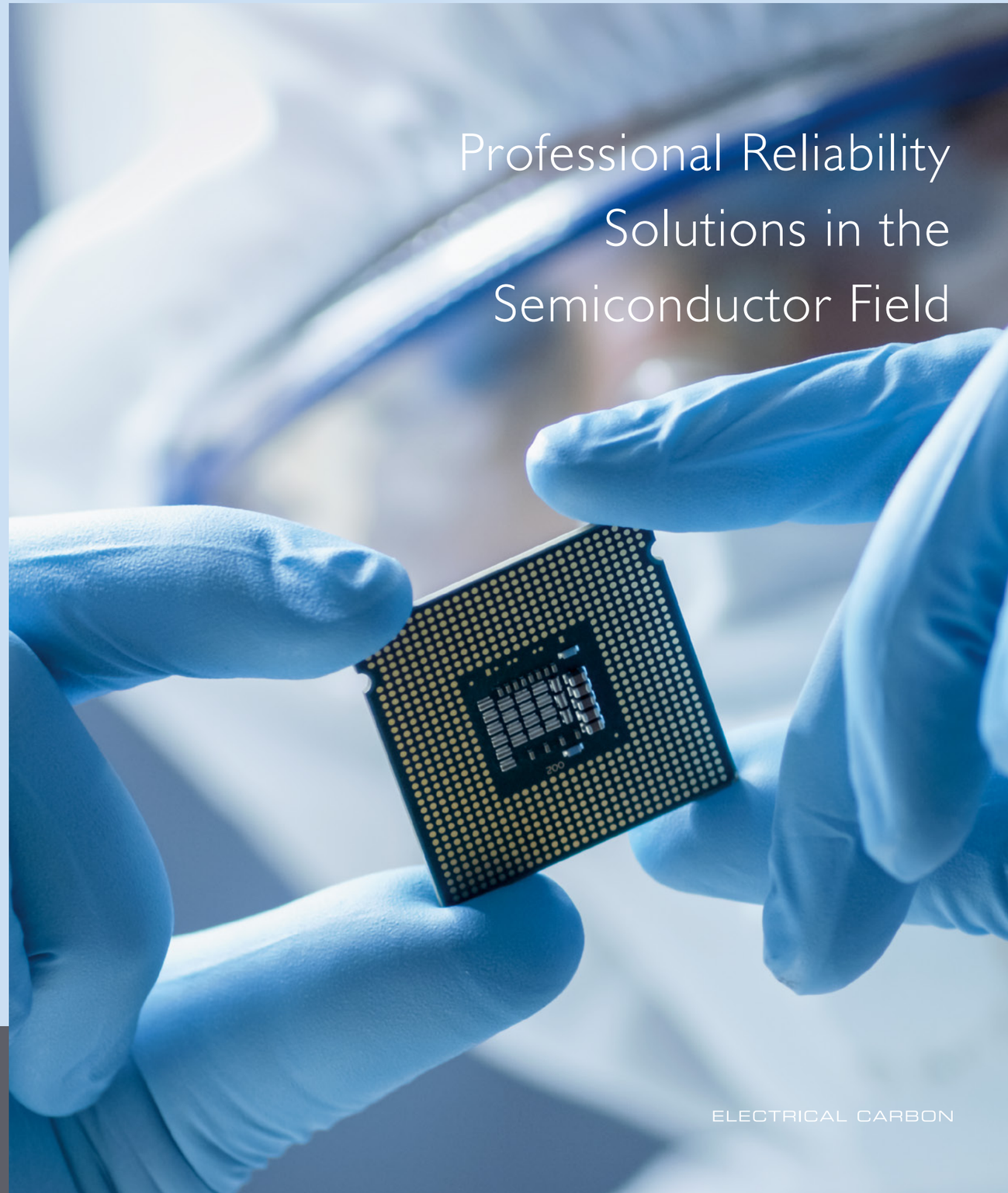
Morgan1856

Shanghai Morgan Advanced Material & Technology Co., Ltd.
No. 4250, Longwu Road, Minhang District, Shanghai, China

www.morganelectricalmaterials.com
www.morganadvancedmaterials.com

Morgan
Advanced Materials

Professional Reliability Solutions in the Semiconductor Field



ELECTRICAL CARBON

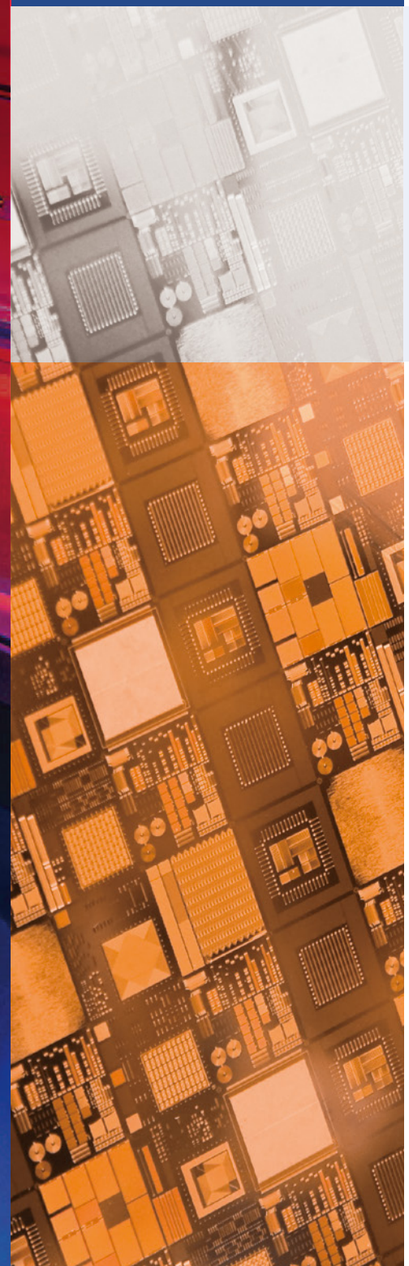
Morgan
Advanced Materials

Professional Reliability Solutions Centenary Material Research and Application Experience in Serving Global Customers

Table of Contents

Morgan boasts over 100 years of expertise and application experience in providing specialty graphite and insulation products.

With the help of rich experience in material research and application, we provide customers with comprehensive solutions to meet a variety of challenges.



More prominent technical advantages

- Advanced Production R&D
- 3,4 and 7-axis, manual Graphite Machining
- Ultrasonic Cleaning
- Advanced Purification
- Impregnation
- Glassy Carbon Coating
- Operational Excellence

Product portfolio of higher performance

- Fine-grained and high-purity graphite, used in ion implanter equipment for semiconductor production
- Porous carbon and porous graphite, widely used for the production of third-generation semiconductor silicon carbide (SiC) wafers
- Graphite powder for engineering with controlled particle morphology and composition, used for the production of synthetic diamond
- High-purity soft felt with low thermal conductivity and thermal insulation, used for high-temperature furnaces in vacuum or inert gas environments at up to 3000°C in solar energy and other fields
- High-purity Graphitic rigid boards with low thermal conductivity, used for improving thermal efficiency in vacuum or inert gas environments at below 3000°C

Machined Graphite

Felt Insulation

Rigid Boards

Stitched/Rigidized Cylinders

Graphite Powders

Porous Graphite

Wider application market

- Semiconductor
- Solar
- Industrial Furnace
- Optical Fibre
- Industrial
- Glass
- Automotive
- Aerospace
- Metallurgical & Aluminium

Graphitic Soft Felt Insulation Products

Morgan offers a range of high purity soft felts with low thermal conductivity and thermal insulation, used for high-temperature furnaces in vacuum or inert gas environments at up to **3000°C** in solar energy and other fields.

General material characteristics include:

- High-purity soft felts with low thermal conductivity and thermal insulation
- **100%** graphite fiber strands
- **VDG** carbon content > **99%**, **WDF** carbon content > **99.9%**
- Low shrinkage and low volatile release
- A purity of up to < **20 ppm**

Four specifications are available, each of which can be supplied in rolls, parts or pre-rolled soft felt drum:

- **VDG:** High-purity graphite felt, better thermal conductivity, heat treatment temperature above 1900°C
- **VDG-P:** Ultra high purity **VDG** graphite felt
- **WDF:** High purity graphite felt, heat treatment temperature above **2650°C**, low thermal conductivity
- **WDF-P:** · Ultra-high purity **WDF** graphite felt

Value proposition:

High-quality raw materials, refined product development and proprietary preparation processes ensure uniform production, help save energy and reduce consumption, to promote the performance of high-temperature furnaces, lower operating costs and maintain the stability of high-purity products.

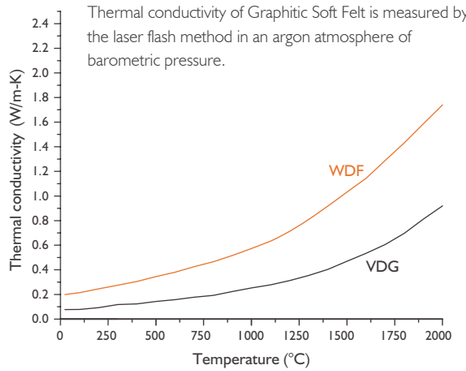
Typical parameters of thermal insulation soft felt

	Measured Temperature (°C)	VDG	WDF
Density, g/cc	20	0.09	0.08
Linear shrink [1] %	20	1	Negligible
Water absorption%	20	1	Negligible
Minimum carbon content %		99.0	99.9
Emissivity		0.99	0.99
Sublimation temperature °C		3600	3600
Surface area (nitrogen) m^2/g	20	0.6	0.7
Vapor pressure um	2270 2440 2620	1 10 100	1 10 100
Minimum heat treatment temperature°C		1900	2650

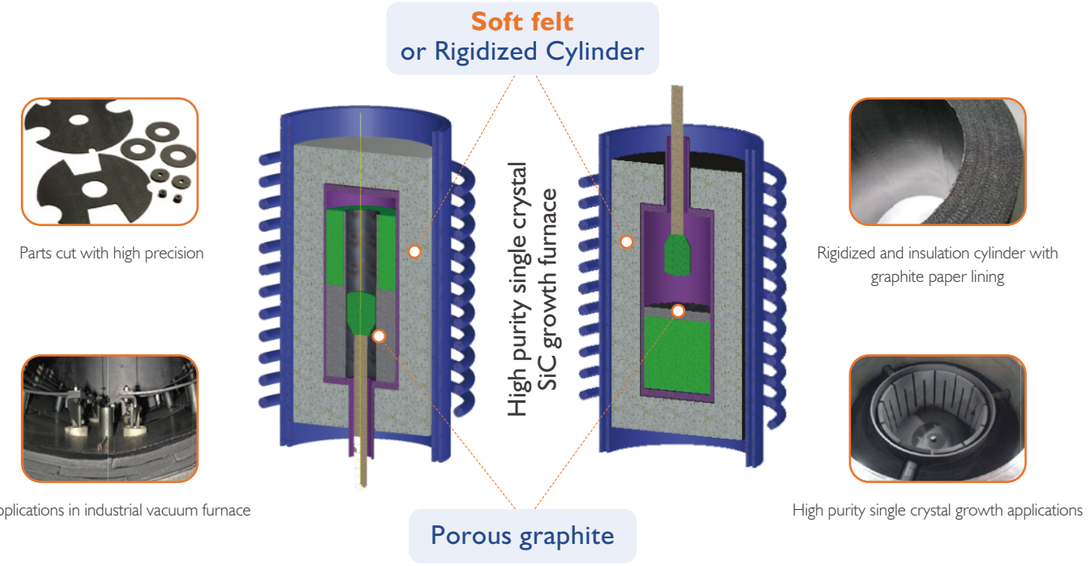
[1] Measure after heating to 3000°C

Thermal Conductivity Coefficient

Thermal conductivity of Graphitic Soft Felt is measured by the laser flash method in an argon atmosphere of barometric pressure.



Curve of Thermal Conductivity Versus Temperature



Product Specification Sheet

	Thickness (in/mm)				Width	Width (in/cm)			Length (yd/m)			Weight Per Unit Area (lb/yd² kg/yd²)		Typical Roll Weight (lb/kg)	
Thickness Specification	Typical Value		Minimum Value		Grade	Typical Value	Minimum Value	Maximum Value	Typical Value	Minimum Value	Maximum Value	VDG Typical Value	WDF Typical Value	VDG Typical Value	WDF Typical Value
1/8"	0.11	2.8	0.09	2.2	0.13 3.4	Standard	41 104.1	40 101.6	44 111.8	52 47.6	16 14.6	52 47.6	0.50 0.23	0.47 0.21	29.61 13.46	27.83 12.65
5mm	0.20	5.1	0.18	4.5	0.22 5.6	Standard	42 106.7	41 104.1	46 116.8	34 31.1	16 14.6	34 31.1	0.97 0.44	0.93 0.42	38.48 17.49	36.89 16.77
						Widened	47 119.4	46 116.8	48 121.9	34 31.1	16 14.6	34 31.1	0.97 0.44	0.93 0.42	43.06 19.57	41.28 18.76
1/4"	0.22	5.6	0.20	5.1	0.25 6.4	Standard	42 106.7	41 104.1	46 116.8	34 31.1	16 14.6	34 31.1	1.04 0.47	0.99 0.45	41.25 18.75	39.27 17.85
						Widened	47 119.4	46 116.8	48 121.9	34 31.1	16 14.6	34 31.1	1.04 0.47	0.99 0.45	46.16 20.98	43.95 19.98
10mm	0.41	10.3	0.36	9.0	0.44 11.2	Standard	42 106.7	41 104.1	46 116.8	17 15.5	8 7.3	17 15.5	1.96 0.89	1.87 0.85	38.87 17.67	37.09 16.86
						Widened	47 119.4	46 116.8	48 121.9	17 15.5	8 7.3	17 15.5	1.96 0.89	1.87 0.85	43.50 19.77	41.50 18.87
1/2"	0.44	11.1	0.40	10.2	0.48 12.3	Standard	42 106.7	41 104.1	46 116.8	17 15.5	8 7.3	17 15.5	2.03 0.92	1.93 0.88	40.26 18.30	38.28 17.40
						Widened	47 119.4	46 116.8	48 121.9	17 15.5	8 7.3	17 15.5	2.03 0.92	1.93 0.88	45.05 20.48	42.84 19.47
1"	0.88	22.4	0.80	20.3	0.97 24.6	Standard	42 106.7	41 104.1	44 111.8	8 7.3	4 3.7	8 7.3	3.54 1.61	3.83 1.74	33.04 15.02	35.75 16.25

Morgan Advanced Materials

Graphitic Rigid Board Insulation Products

Morgan Advanced Materials offers a line of premium Rigid Board Insulation products developed for optimal performance at temperatures up to **3000°C** in vacuum or inert atmospheres.

General material characteristics include:

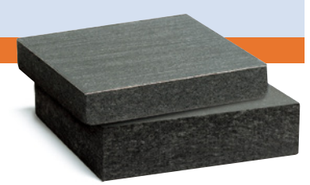
- High purity and low thermal conductivity
- **100%** Rayon-based fiber precursor
- Carbon content **> 99%**
- Low shrinkage and low volatile release
- Can be purified to **< 20 ppm**

Four grades are available, which can be supplied in bulk block or machined to print:

- **RGB:** A high purity carbon-bonded carbon fiber rigid board, heat treated to a minimum of **1900°C**
- **RGB-P:** An ultra-high purity **RGB**
- **RGB-LTC:** A high punity carbon-bonded carbon fiber rigid board, heat treated to a minimum of **1900 °c**, with improved insulation properties
- **RGB-LTC-P:** An ultra-high purity **RGB-LTC**

Value proposition:

High quality raw materials and well controlled, highly capable, proprietary manufacturing processes ensure a consistent high purity product with uniform insulation properties.This will help minimize energy consumption, maximize fumace performance, and minimize total cost of ownership.

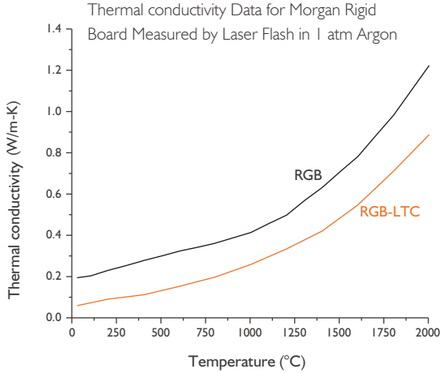


Rigid Borad Insulation Typical Properties

	Units/Direction		RGB	RGB-LTC
Density	g/cc		0.16	0.10
Flexural Strength	MPa	w/g	1.0	0.30
		a/g	1.0	0.28
Compressive Strength	MPa	w/g	0.62	0.13
		a/g	0.36	0.12
Carbon Content	%		> 99	> 99
Ash	%		< 0.1	0.04
CTE(@1000°C)	$(x10^{-6})/°C$		2.6	2.7
Thermal Conductivity(W/mk)	1000°C (Ar) 1500°C (Ar) 2000°C (Ar)		0.42 0.71 1.22	0.25 0.48 0.88
Min Process Temp,°C			1900	1900

Thermal Conductivity Coefficient

Thermal conductivity Data for Morgan Rigid Board Measured by Laser Flash in 1 atm Argon



Thermal Conductivity vs.Temperature

Furnace door with Graphite Foiled **RGB** after fiveThermal Cycles to **1500°C** in Nitrogen

Highly Engineered and Customized **RGB** Insulation Pack for polycrystalline Silicon Production

Enhanced Surface Treatments:

Graphite foil or graphitic coatings can be applied to exposed surfaces of the Rigid Board insulation to prevent erosion and oxidation during exposure to or inert atmosphere environments at high temperatures.

Application of the graphite foil to the surface of Rigid Board has been shown to significantly extend the life time of the Rigid Board insulation during in-house testing.

The excellent bond strength and mechanical integrity of the graphite foil to the rigid board surface has been validated by repeated testing and thermal cycling in these harsh environments.

Extended life time and reduced particle generation can lead to improve product quality and lower cost of ownership.

Engineered Solutions:

The excellent machinability of our Rigid Board Insulation is combined with our world-class 5-axis CNC machining capabilities to give us the ability to produce highly customized, complex, engineering solutions.

Our engineering staff is ready to work with you to design a complete insulation package for your application. A wide range of sizes and thicknesses are available which affords design flexibility.

Custom sizes can also be supplied to the customer's specification. Current maximum dimensions are 8"x 40" x 60" block.

Morgan Advanced Materials

Porous carbon and porous graphite

The porous carbon and porous graphite materials from Morgan are widely used in the furnace for the single crystal growing of SiC in vacuum or inert gas atmospheres at up to **2650°C** or higher.

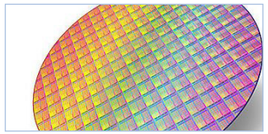
General material characteristics include:

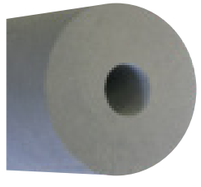
- ·A high purity of up to **< 5 ppm**
- Uniform pore size distribution

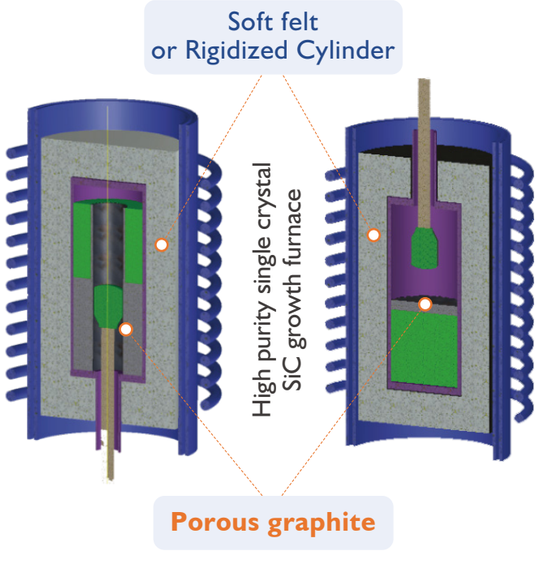
Eight specifications are available, each of which is customizable according to the characteristics of the customer's single crystal growth furnace.

Value proposition:

The purification and preparation processes of high-quality graphite and carbon materials ensure high purities and pore size consistency of the products, to help to reduce the defects of the single crystal growth of SiC and improve the uniformity of single crystal growth.



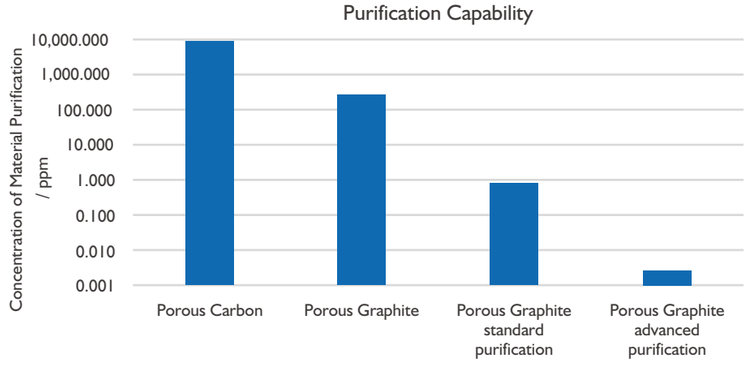




Morgan Advanced Materials

Product Specification Sheet

Typical Parameters	Unit	PC25	PG25	PC45	PG45	PC60	PG60	PC70	PG70
Bulk density	g/cc	1.05	1.08	1.08	1.1	1.1	1.13	1.12	1.16
Compressive strength	lb/in2	800	800	900	900	1000	1000	1000	1000
Bending strength	lb/in2	300	400	500	600	6000	8000	900	1000
Tensile strength	lb/in2				150		200		250
Specific resistance	Ω-in * 10-5	450	150	450	130	450	200	450	120
Permeability									
Air	Ft3/ft2 /min	10	10	3	3	1	1	2	2
Water	Gal/ft2 /min	90	90	30	30	10	10	20	20
Porosity	%	48	58	50	50	47	47	40	40
Average pore size	um	0.0047 in	0.0047 in	70	70	40	40	55	55
Thermal conductivity	W/M°K	1	10	2	18	2	18	3	30



PPB level purification is critical for single crystal silicon carbide growth applications.

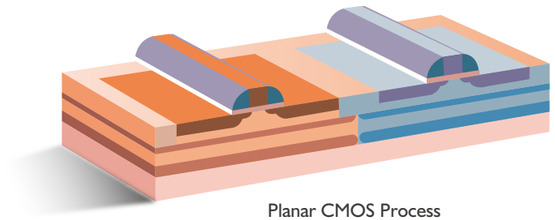
High purity graphite in ion implanter

Morgan's high purity graphite is widely used in ion implantation equipment, which is extremely critical in semiconductor manufacturing, and can be used for conductive electrodes, metal protective layers, ion adsorption layers, and particulate protection layers, etc.

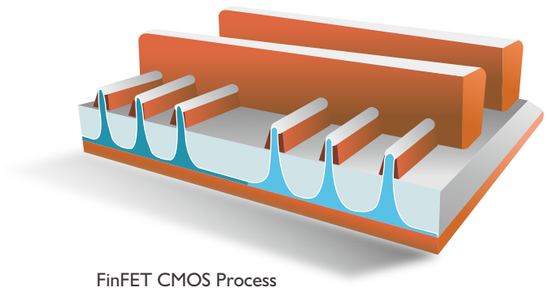
General material characteristics include:

- High purification, with total metal content < **2 ppm**.
- Advanced impregnation, which can fill and seal the graphite surface to a depth of **6.35 mm**, reduce particle generation, and extend product life time.
- Ultimate glassy carbon coating, which can fill the graphite surface voids to an ultra-low level, eliminate surface particles and outgassing, reduce the surface charge effect, and prolong the life time of graphite

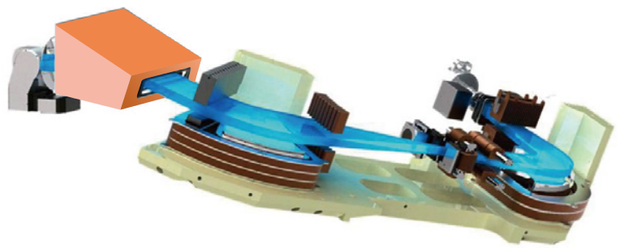
Graphite in a variety of specifications and grades is available and customizable according to ion implantation equipment



Planar CMOS Process



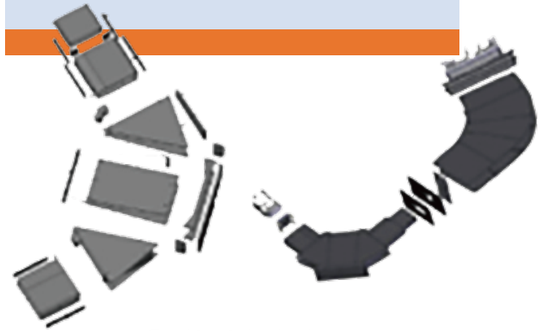
FinFET CMOS Process



Ion Implanter

Value proposition:

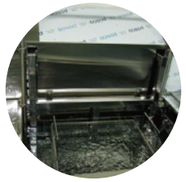
High quality graphite of superb purification, impregnation and glassy carbon coating capabilities are widely applied in key areas of ion implantation equipment to standard up to the stringent requirements of ion implantation processes such as ultra-low metal pollution and particle pollution. It can promote the yield and stability of process devices, prolong the service life of the product, and minimize the operation and maintenance cost of the production line.



Graphites in Ion Implanter

Machining

Purification



Ultrasonic cleaning

Impregnation

Glassy Carbon Coating

Morgan Advanced Materials