

# App. Note

## Electro-Graph = Graphite

- High Purity, Isotropic, Graphite
- Replacement Components for all OEM materials
- Complete Configuration support

Electro-Graph has the advantage of nearly 30 years experience with graphite materials for semiconductor processes. That knowledge provides us with the ability to pinpoint the ideal material for each specific application, setting us apart from the OEMs and other second source competitors. Our product management, engineering, and procurement teams take a collaborative approach with our customers and suppliers, keeping us on the leading edge in developing premier graphite.

There is no single material that is ideal for every customer's needs. That is why at Electro-Graph we first understand the application and then provide the best performing and most cost effective solutions.

Consider the following examples:

- Many graphite components have purely structural applications and limited requirements
- Beamline apertures typically require a higher end material
- Some apertures or applications require specialty materials to mitigate arcing or particles

Electro-Graph is uniquely equipped to provide the ideal graphite for each of the above scenarios. All our graphite is purified to less than 5 PPM of total impurities, which is the best of any industry, including: aerospace, fuel cell, medical, and nuclear applications. We offer the hardest, densest, and purest graphite materials available.

Only through offering a wide gamut of materials can Electro-Graph guarantee optimum performance and cost of ownership to our customers. These options and our attention to detail is why we are the premier supplier of graphite and refractory metals to nearly every fab in the semiconductor industry.

The following pages show data comparing Electro-Graph materials to those of our competition.

Let us show you how to improve your process, increase your up-time, and reduce your cost of ownership. We will exceed your expectations...



# App. Note

## Electro-Graph = Graphite

- Guaranteed Supply
- Lowest Cost
- High Performance
- Low Contamination

**Purified Structural Graphite** = This material class includes 9 different grades of graphite from a select group of qualified raw material suppliers. This specification is recommended for almost all non-aperture applications, where direct beam strike is not a factor. Specifying Purified Structural Graphite allows us to provide the most cost effective graphite. The characteristics remain high, but this designation provides the most opportunity for cost savings.

The benefits:

- Guaranteed supply line – Multiple suppliers ensures raw material availability
- Cost – This designation includes our lowest cost graphite materials. We can continually optimize material selection for cost
- Performance – The graphite grades in this class are extremely controlled. In fact, all of these materials are proven in ion implant and in many cases, are used by our competitors for aperture applications.
- Consistency – Contamination levels remain extremely low for this designation (<5 ppm), while hardness, density, and strength are controlled to provide durability and performance.

PROPERTIES	TYPICAL PROPERTY RANGE
Particle Size ( $\mu$ )	4-6
Apparent Density (g/cc)	1.76-1.83
Flexural Strength (psi)	10,900-13,500
Compressive Strength (psi)	20,000-26,300
Tensile Strength (psi)	7,630-9,500
Electrical Resistance ( $\mu$ -ohm-cm)	1,295-2,438
Hardness (shore)	74-91
CTE ( $\mu$ -in/in/C)	5.0-8.1
Thermal Conductivity (watts/m K)	60-95
Purity (% carbon)	99.9995



# App. Note

## Electro-Graph = Graphite

- Stable Supply
- Lower Cost
- Consistency
- Higher Particle Performance
- Higher Wear Performance
- Low Contamination

**Aperture Graphite =** This material class includes 3 different specific grades of graphite from a select group of qualified raw material suppliers. This specification is recommended for all high wear applications, where erosion and particles are factors due to beam strike. Out of the 9 materials included in the Purified Structural Graphite class, these materials have been proven to compare favorably to our competitors' materials. Typically harder and more dense than most other graphite. Non-coated materials will allow consistent performance throughout the thickness of the part, unlike other coated parts which performance will degrade over time.

The Benefits:

- Guaranteed Supply Line
- Cost
- Consistency
- Particle Performance
- Wear

PROPERTIES	TYPICAL PROPERTY RANGE
Partical Size ( $\mu$ )	3-6
Apparent Density (g/cc)	1.77-1.88
Flexural Strength (psi)	12,000-13,500
Compressive Strength (psi)	20,000-34,800
Tensile Strength (psi)	8,500-9,500
Electrical Resistivity ( $\mu$ -ohm-cm)	1,295-2,438
Hardness (shore)	74-91
CTE ( $\mu$ -in/in/C)	5.1-8.1
Thermal Conductivity (watts/m K)	60-100
Purity (% carbon)	99.9995



# App. Note

## Electro-Graph = Graphite

- Application Specific Performance
- Particle
- Arcing
- Wear

### Specialty Graphite =

Hardest and smallest particle size material available. Designed for specialty and low energy extraction applications that are most prone to arcing. Specialty graphite is most commonly used on items that have been identified as critical components where offering improved arcing control, particle reduction and wear performance is needed to outperform one of our other class of graphite's. If indeed this type of analysis is necessary, EG engineering and product management will review with the end user and identify the most appropriate material for a specific application.

#### The Benefits:

- Application Specific Performance
- Particle
- Arcing
- Wear

#### Disadvantage:

- Supply Line
- Cost

PROPERTIES	TYPICAL PROPERTY RANGE
Partical Size ( $\mu$ )	1-3
Apparent Density (g/cc)	1.76-1.88
Flexural Strength (psi)	12,300-15,000
Compressive Strength (psi)	26832-34,800
Tensile Strength (psi)	8,600-10,500
Electrical Resistivity ( $\mu$ -ohm-cm)	1,295-3,200
Hardness (shore)	80-100
CTE ( $\mu$ -in/in/C)	5.1-8.4
Thermal Conductivity (watts/m K)	100
Purity (% carbon)	99.9995



# App. Note Electro-Graph = Graphite

Although several physical forms occur only polycrystalline, pyrolytic, and vitreous graphite play a roll in semiconductor manufacturing. To form the most common of these types, polycrystalline graphite, raw material manufacturers blend, crush, and mill raw coke to sizes required for various bulk material properties. Once packed and pressed the raw coke billet is baked to form a carbon billet. The carbon billet is then graphitized in a high temperature environment to form a basic raw graphite form. The material can then be post processed to improve specific material characteristics such as surface hardness.

As with alumina oxide, graphite is available in many raw forms and grades of which the best are not readily specified by AMS, ASTM, or other associations generating material specifications. Electro-Graph supplies components from bare polycrystalline, pyrolytic infiltrated, solid pyrolytic, vitreous impregnated, and glassy (vitreous) coated graphite. In turn, each of these materials can be supplied in two-to-five basic grades that meet a broad range of applications within the semiconductor manufacturing environment. As a result, the raw material for each graphite component supplied by Electro-Graph is specified by the raw material grade and any required post process. Most graphite considered to be pure has less than 5ppm total ash. Listed below is a typical GDMS purity analysis for bulk polycrystalline graphite. Contact our engineering staff for a more detailed review of individual needs.

Element	[ ppm wt ]	Element	[ ppm wt ]	Element	[ ppm wt ]	Element	[ ppm wt ]
Li	< 0.01	Mn	< 0.001	Ag	< 0.05	Tm	< 0.01
Be	< 0.01	Fe	0.03	Cd	< 0.05	Yb	< 0.01
B	0.7	Co	0.008	In	< 0.1	Lu	< 0.01
C	MATRIX	Ni	0.01	Sn	< 0.05	Hf	< 0.01
N	NM	Cu	< 0.01	Sb	< 0.01	Ta	< 5
O	NM	Zn	< 0.05	Te	< 0.01	W	0.08
F	0.07	Ga	< 0.01	I	< 0.05	Re	< 0.05
Na	< 0.005	Ge	< 0.05	Cs	< 0.01	Os	< 0.01
Mg	< 0.005	As	< 0.01	Ba	< 0.01	Ir	< 0.01
Al	0.09	Se	< 0.01	La	< 0.01	Pt	< 0.1
Si	0.05	Br	< 0.01	Ce	< 0.01	Au	< 0.05
P	0.02	Rb	< 0.005	Pr	< 0.01	Hg	< 0.1
S	0.18	Sr	< 0.005	Nd	< 0.01	Tl	< 0.005
Cl	0.38	Y	< 0.005	Sm	< 0.01	Pb	< 0.01
K	< 0.05	Zr	< 0.005	Eu	< 0.01	Bi	< 0.01
Ca	< 0.05	Nb	< 0.005	Gd	< 0.01	Th	< 0.005
Sc	< 0.005	Mo	< 0.05	Tb	< 0.01	U	< 0.005
Ti	0.02	Ru	< 0.01	Dy	< 0.01		
V	0.002	Rh	< 0.005	Ho	< 0.01		
Cr	0.18	Pd	< 0.01	Er	< 0.01		

Total 1.82