Manufacturing Challenges for BOP & Graphite Stack Components

Feb 28, 2014

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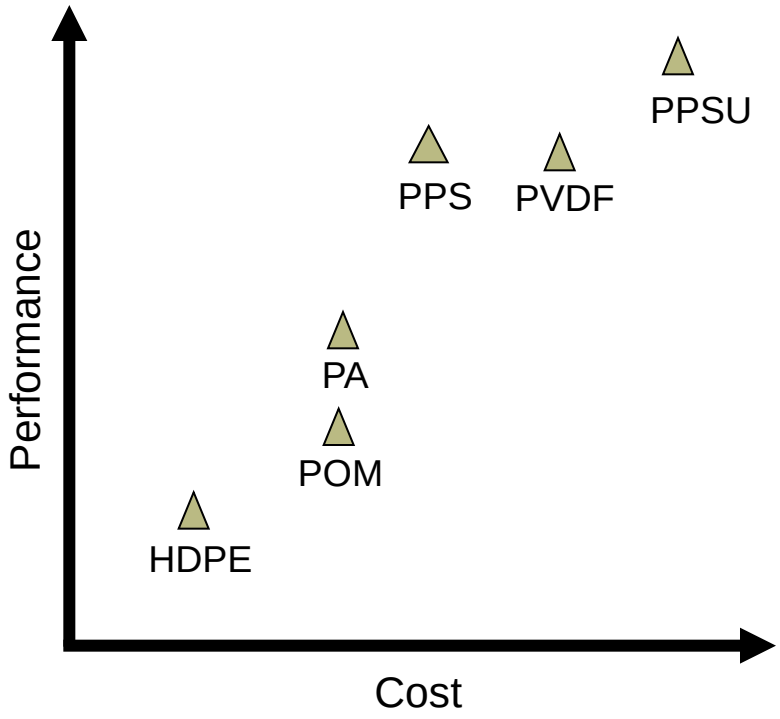
creating a material advantage

Areas of Development

- C.T.E
- Semi Dissipative Materials
- Impregnation of Metal into Graphite - Titanium
- Chemical Vapor Deposition/Physical Vapor Deposition
- Silicon Carbide
- Graphene

Balance of Plant Manifold Assembly

- Material selection process
  - High-density Polyethylene (HDPE)
  - Polyoxymethylene (POM)
  - Polyamide (PA)
  - Polyvinylidene Fluoride (PVDF)
  - Polyphenylene Sulfide (PPS)
  - Polyphenylsulfone (PPSU)



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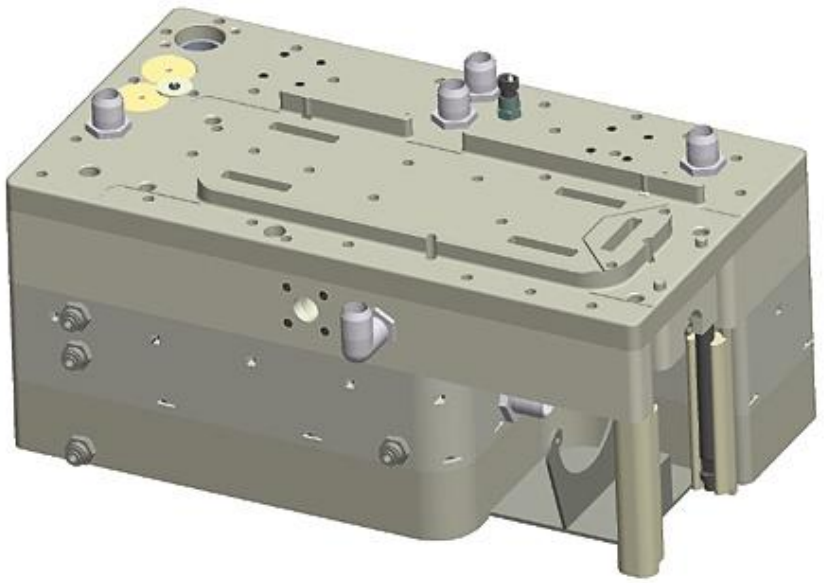
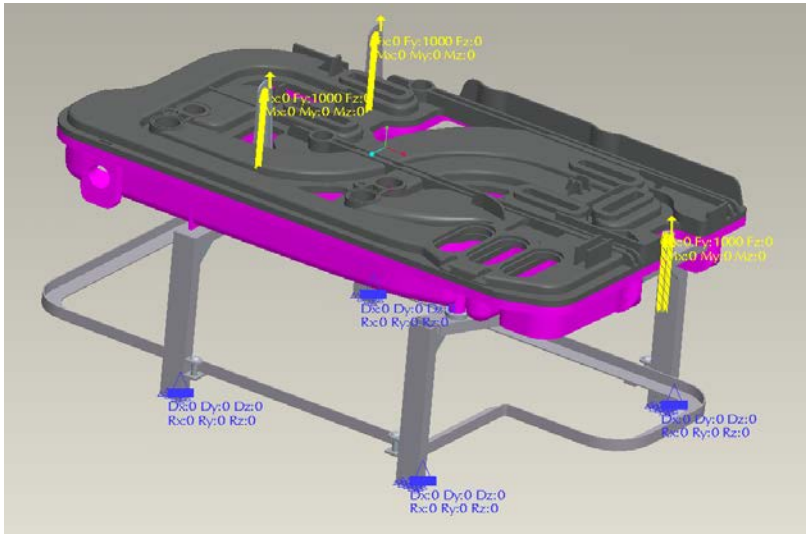
Generation II to Generation III Manifold Assembly

- Generation II
  - Four-layer, machined PVDF assembly
  - Chemically compatible
  - Good structural performance (Heavy)
  - Built for function (form and fit to follow)



- Generation III
  - Good structural performance
    - Steel tubular frame to support loads
    - Static & Dynamic FEA completed
  - Lighter weight
    - Extra material removed
  - Fewer parts



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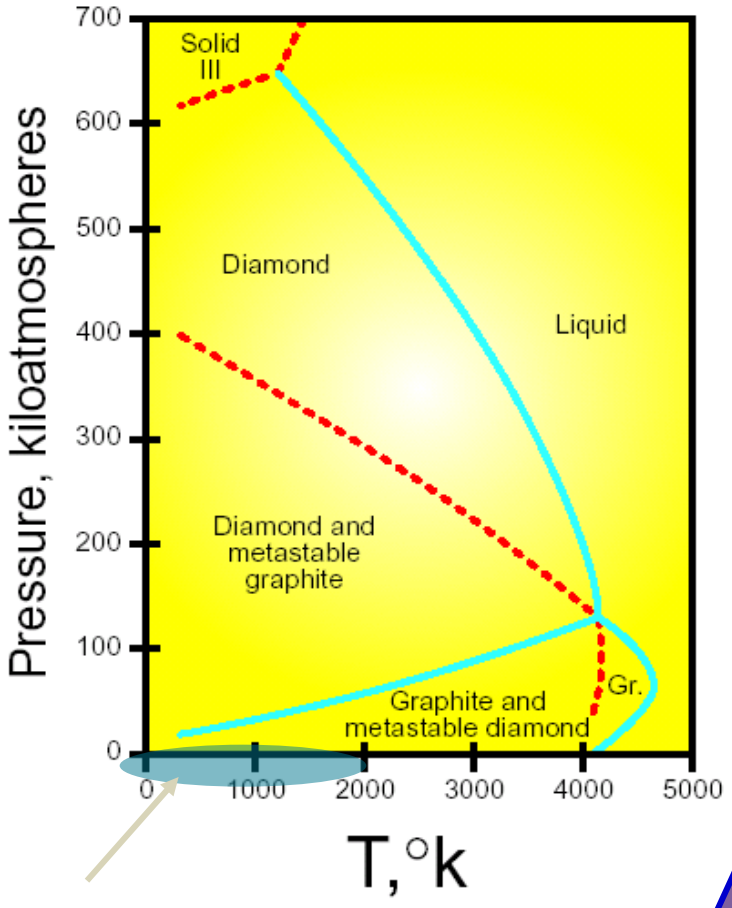
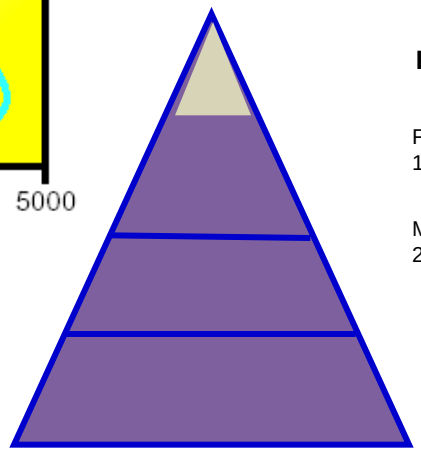
Graphite is a form of Carbon



Area of interest

Forms of Carbon

- Amorphous carbon
- Graphite
- Diamond
- Fullerenes
  - Buckyballs
- Nanotubes
- Graphene



Poco Main Market Areas

1 and 5 Micron sizes

Fine grain graphites, very few suppliers
1 to 20 micron particle size

Many manufacturers in the mid range
25 to 200 micron particle size

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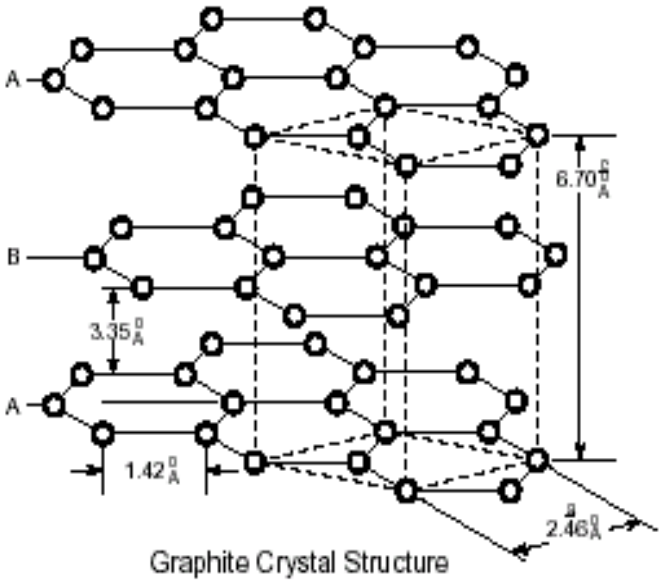
Advantages of POCO Graphite

- Proven in many demanding plasma & CVD applications
- High purity material
- Electrically conductive
- High strength
- Uniform microstructure
- Unique cleaning solutions to prevent particulation
- Proven Cost of Ownership advantages over other materials



Graphite Crystal Structure

Very unique structure

Strong bonds within the crystal plane

Weak bonds between the planes

Everyone's Ideal Structure

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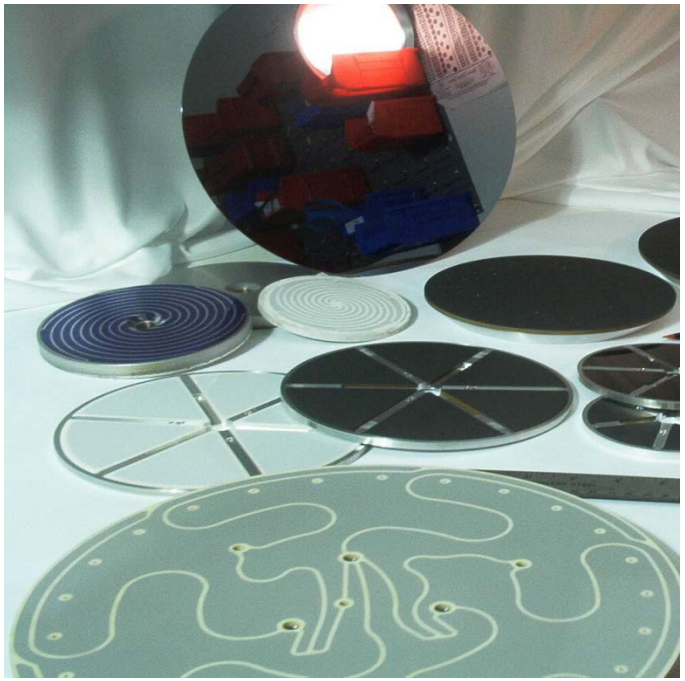
Specialty Coating Technology

- Proprietary CVD and PVD processes at low temperatures with concentrated precursors
- Low temperature allows use on materials that cannot withstand high temperatures
  - Coatings can be applied to polymers, metals, ceramics
  - Produces high quality coatings (less cracking and pinholes)
- Concentrated precursors produce very high purity coatings



E-Chucks

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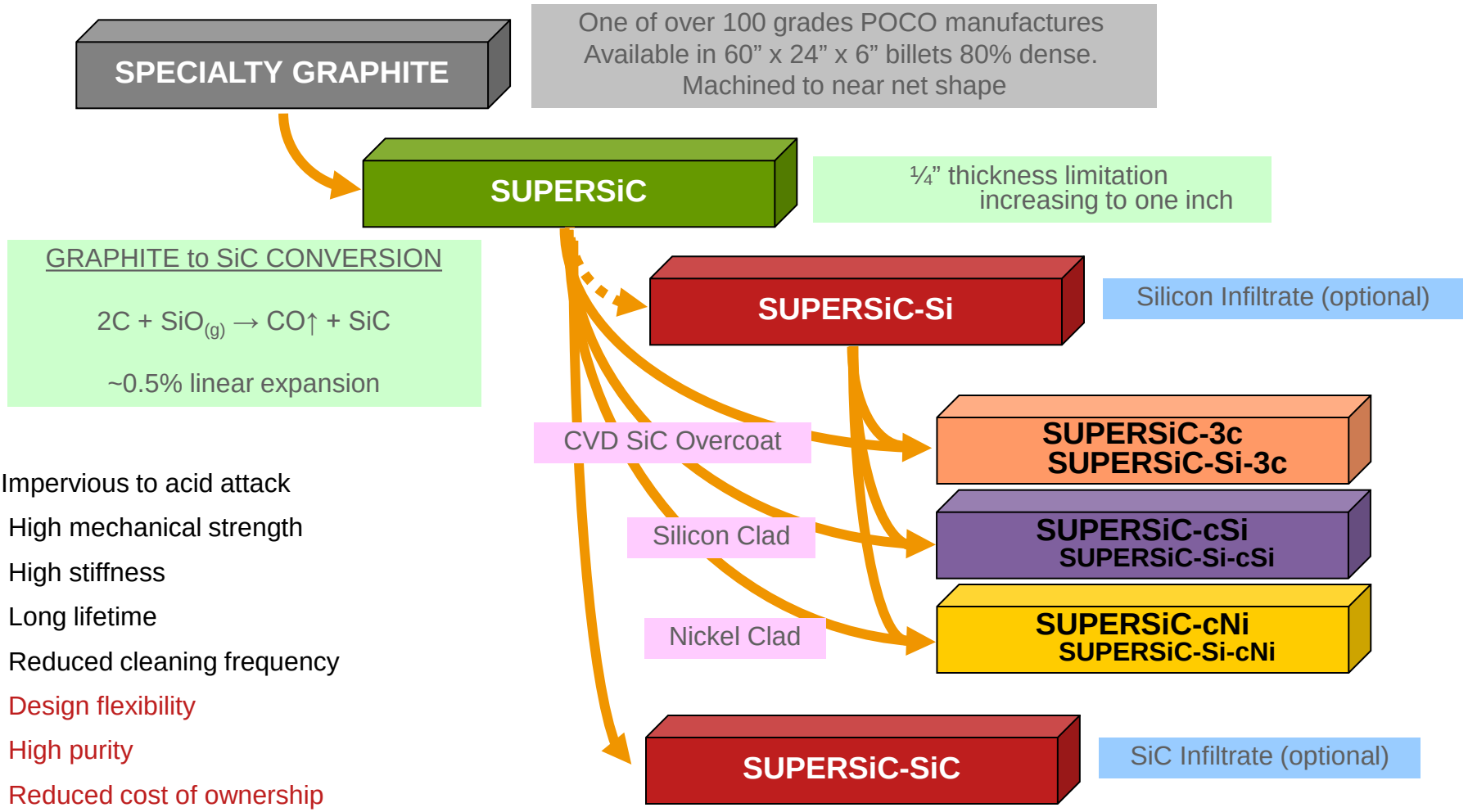
POCO SUPERSiC®



- Impervious to acid attack
- High mechanical strength
- High stiffness
- Long lifetime
- Reduced cleaning frequency
- Design flexibility
- High purity
- Reduced cost of ownership

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Appendix

Graphite Property Trends

For increase in ➔	AD	Process Temp	Particle Size	Comments
Strength	↑	↓	↓	*Flaw Size*
Electrical Resistivity	↓	↓	↓	*Microstructure*
Hardness	↑	↓	↓	*Surface Finish*
Thermal Conductivity	↑	↑	↑	*Surface Finish*
CTE	↑	↑	↓	*Microstructure*

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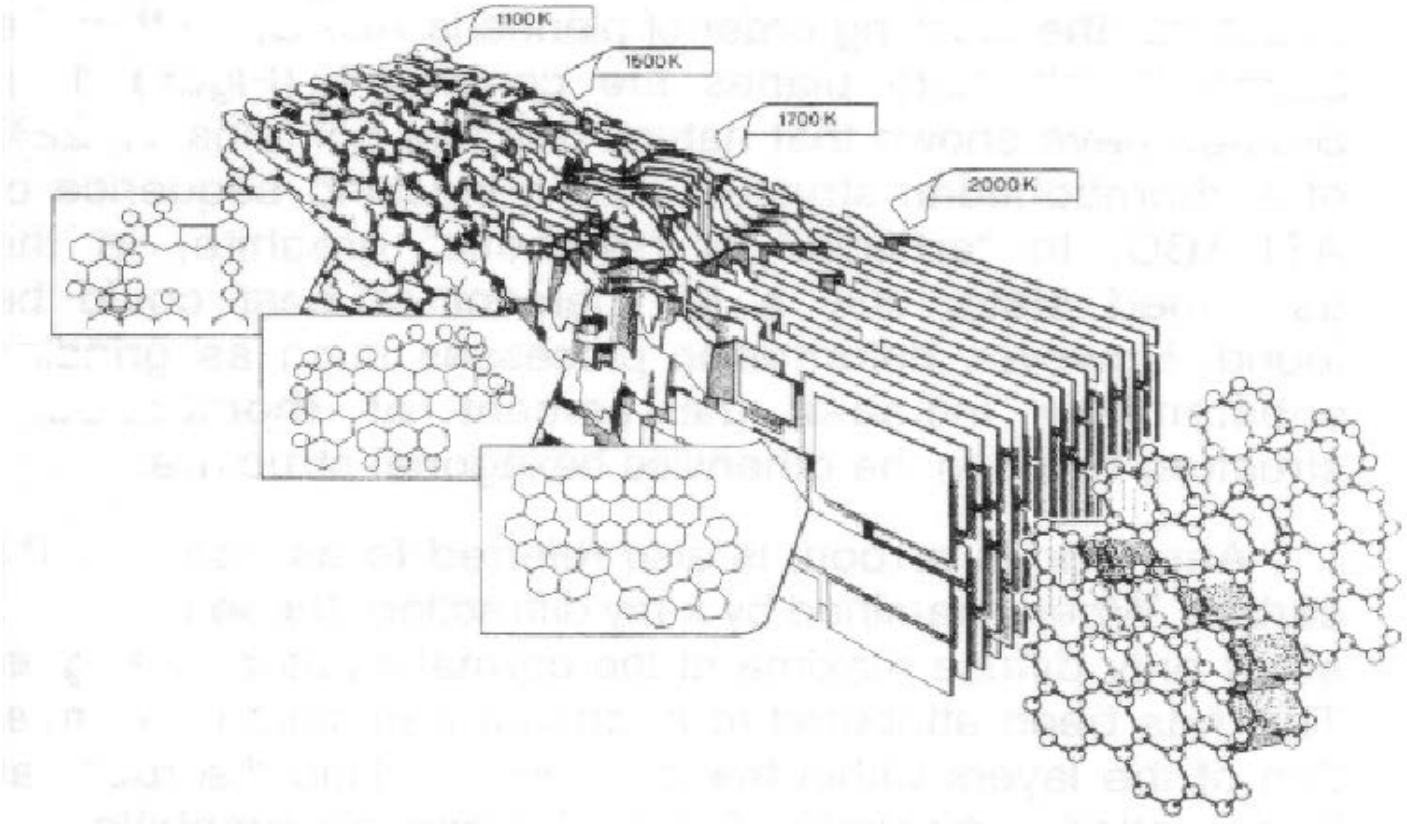
Development of Crystalline Alignment during Graphitization



A model of changes from mesophase to graphite during heat treatment

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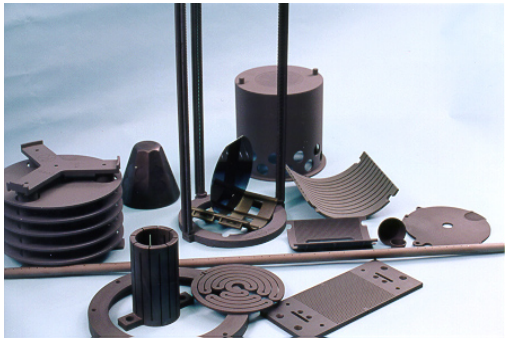
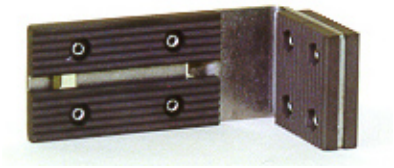
Primary Market Areas

Semiconductor



Glass



EDM

Optics

Industrial/Biomedical Products

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