Manufacturing Challenges for BOP & Graphite Stack Components

Feb 28, 2014
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)
### 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
Graphite is a form of Carbon

Forms of Carbon
- Amorphous carbon
- Graphite
- Diamond
- Fullerenes
  - Buckyballs
- Nanotubes
- Graphene

Area of interest

Poco Main Market Areas
- 1 and 5 Micron sizes
  - Fine grain graphites, very few suppliers
  - 1 to 20 micron particle size
- 25 to 200 micron particle size

Many manufacturers in the mid range
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

Very unique structure

Strong bonds within the crystal plane

Weak bonds between the planes

*Everyone’s Ideal Structure*
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
POCO SUPERSiC®

One of over 100 grades POCO manufactures
Available in 60” x 24” x 6” billets 80% dense.
Machined to near net shape

SUPERSiC

GRAPHITE to SiC CONVERSION

\[ 2C + SiO_{(g)} \rightarrow CO↑ + SiC \]

~0.5% linear expansion

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

SUPERSiC-Si

1/4” thickness limitation increasing to one inch

Silicon Infiltrate (optional)

CVD SiC Overcoat

SUPERSiC-Si-3c

SUPERSiC-cSi

SUPERSiC-cNi

SiC Infiltrate (optional)

Silicon Clad

Nickel Clad

SUPERSiC-SiC

Impervious to acid attack
High mechanical strength
High stiffness
Long lifetime
Reduced cleaning frequency
Design flexibility
High purity
Reduced cost of ownership
### Graphite Property Trends

<table>
<thead>
<tr>
<th>Property</th>
<th>AD</th>
<th>Process Temp</th>
<th>Particle Size</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strength</td>
<td>↑</td>
<td>↓</td>
<td>↓</td>
<td>Flaw Size</td>
</tr>
<tr>
<td>Electrical Resistivity</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
<td>Microstructure</td>
</tr>
<tr>
<td>Hardness</td>
<td>↑</td>
<td>↓</td>
<td>↓</td>
<td>Surface Finish</td>
</tr>
<tr>
<td>Thermal Conductivity</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
<td>Surface Finish</td>
</tr>
<tr>
<td>CTE</td>
<td>↑</td>
<td>↑</td>
<td>↓</td>
<td>Microstructure</td>
</tr>
</tbody>
</table>
Developed of Crystalline Alignment during Graphitization

A model of changes from mesophase to graphite during heat treatment
Primary Market Areas

- Semiconductor
- Glass
- EDM
- Optics
- Industrial/Biomedical Products