

# Polymer-to-Ceramic™ Composite (PTCC) Properties



POLYMER-TO-CERAMIC™ TECHNOLOGY

## Polymer-to-Ceramic™ Composite Properties: Carbon Fiber Reinforced

Starfire Polymer-to-Ceramic Composite (PTCC) materials are fiber reinforced ceramic composites which utilize Starfire Polymer-to-Ceramic™ technology and produce tough, high thermally stable composites for numerous applications. When reinforced with medium to high modulus carbon fiber, these PTCCs can create low weight, high strength, oxidation stable composites suitable for a wide variety of environments and markets.

Starfire's silicon carbide (SiC) forming poly-carbosilane polymers and the silicon-oxycarbide (SiOC) forming Polyamic® polymers can be used to form robust ceramic matrix composites (CMCs). Table 1 shows some properties of the starting polymers typically used for CMC manufacture.

| Property  | SMP-10 | SPR-688   | SPR-212 |
|---|--------|-----------|---------|
| Ceramic Formed                                    | SiC    | SiOC      | SiOC    |
| Viscosity (cP)                                    | 40-100 | 300-2,000 | 12-26   |
| Pyrolysis Yield (%)                               | 72-78  | 65-68     | 60-65   |
| Liquid Density (g/cm <sup>3</sup> )               | 1.0    | 1.1       | 1.0     |
| Ceramic Density <sup>1</sup> (g/cm <sup>3</sup> ) | 2.20   | 1.99      | 1.95    |

**Table 1: Some typical Starfire Polymer Properties used to manufacture CMCs.**

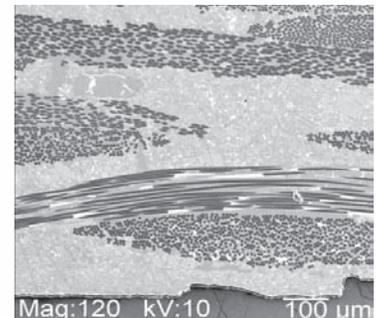
Table 2 shows mechanical and thermal properties of typical 6mm 2-D carbon fiber reinforced laminates comprised of 6k carbon fiber 5HS fabric, and layed up to a 0,90° orientation layup.

The matrix ceramic is SiC for SMP-10 derived composites and SiOC for SPR-688 and SPR-212 derived composites, and all laminates are processed utilizing Starfire's polymer infiltration and pyrolysis (PIP) technique.

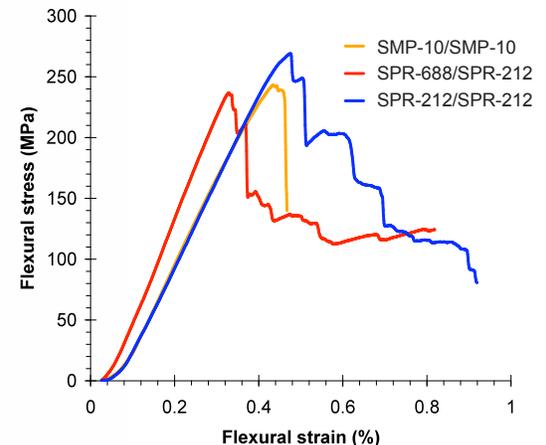
| Detail                                 | Composition                          |                                      |                                      |
|--|--------------------------------------|--------------------------------------|--------------------------------------|
| Molding Polymer                        | <b>SMP-10</b>                        | <b>SPR-688</b>                       | <b>SPR-212</b>                       |
| Infiltration Polymer                   | <b>SMP-10</b>                        | <b>SPR-212</b>                       | <b>SPR-212</b>                       |
| Flexural Strength (MPa)                | 249                                  | 240                                  | 255                                  |
| Flexural Modulus (GPa)                 | 73.0                                 | 81.1                                 | 78.3                                 |
| CTE (ppm/°C)                           | 6 <sub>z</sub><br>1.0 <sub>x-y</sub> | 6 <sub>z</sub><br>1.2 <sub>x-y</sub> | 7 <sub>z</sub><br>1.7 <sub>x-y</sub> |
| Thermal Conductivity at 300°C (W/m*°K) | 1.5 <sub>z</sub>                     | 2.0 <sub>z</sub>                     | 2.5 <sub>z</sub>                     |

**Table 2: Some typical Starfire Polymer-to-Ceramic Composite (PTCC) Properties**

<sup>1</sup>Pyrolyzed to 850°C



**Microstructure of a fully densified C/SiC Polymer-to-Ceramic™ Composite**



### Warranty

No analysis of this product is permitted. The data provided relates only to the material identified above, as supplied by Starfire Systems®, Inc. (SSI). Because conditions and methods of use of our products are beyond our control, this information should not be used as a substitution for customer's tests to ensure that SSI's products are safe, effective, and fully satisfactory for the intended end use. SSI's sole warranty is that the product will meet sales specifications in effect at the time of shipment.