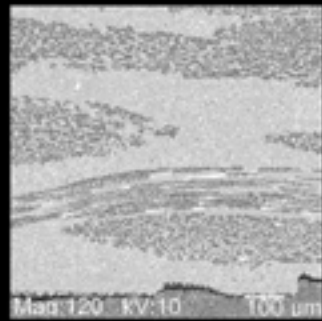


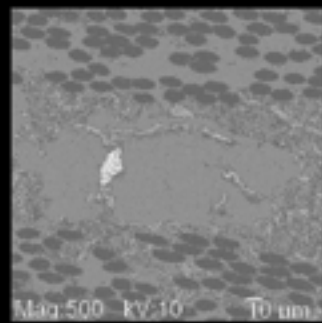
Polymer-to-Ceramic Technology™ from Starfire Systems

Processing

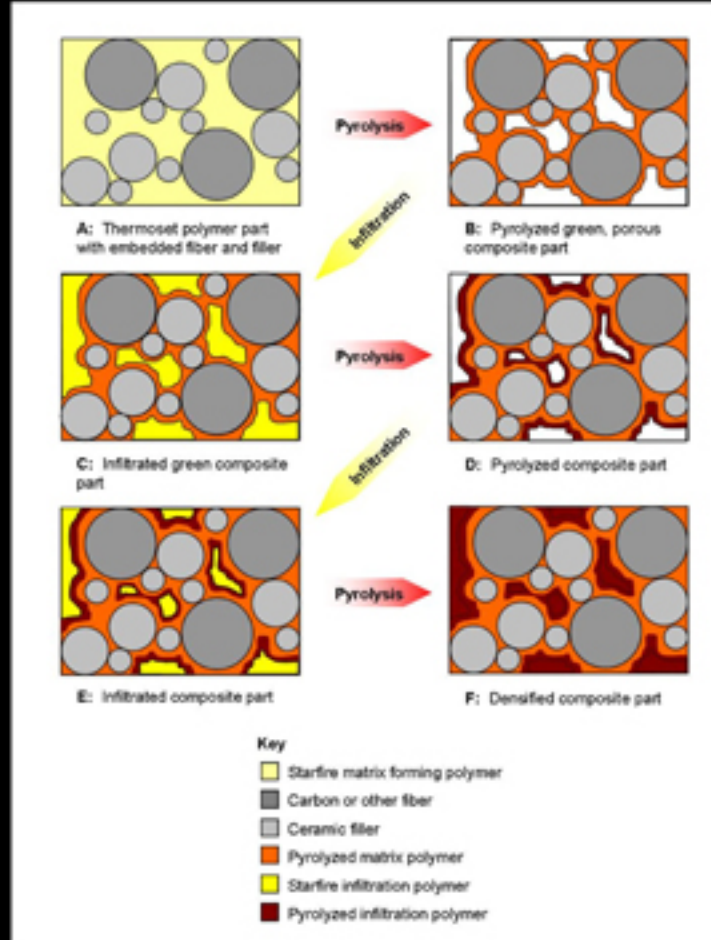
- Polymers are liquids or low melting point solids.
- Form parts using conventional polymer processing.
- Use polymer infiltration and pyrolysis (PIP) to densify.



C/SiC laminate



C/SiC laminate showing filling of porosity through PIP



Ceramic Composite Properties

Matrix resin	Infiltration resin	Flexural strength (MPa)	Flexural modulus (GPa)
SMP-10	SMP-10	249	73.0
RD-688a	SPR-212	240	81.1
SPR-212	SPR-212	255	78.2

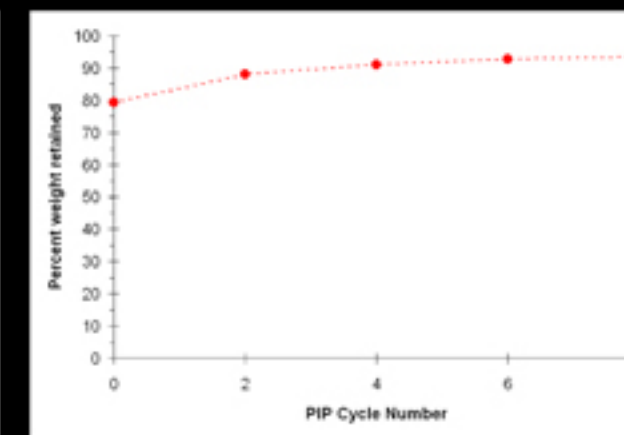
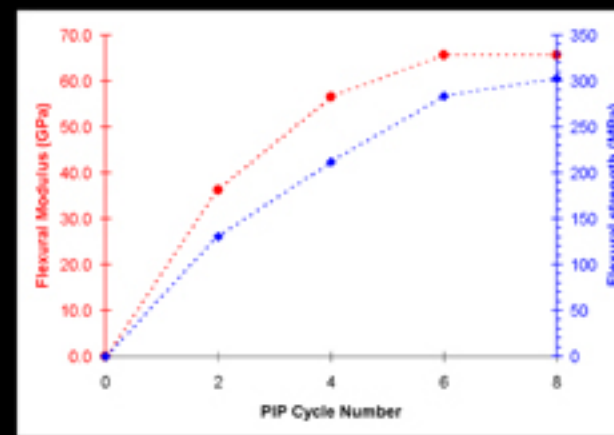
Mechanical properties for polymer derived ceramic matrix composites consist of T-300 6K, 5HS carbon fabric, 0,90 orientation, 6mm thick.

Matrix resin	Infiltration resin	CTE (ppm/°C)	Thermal conductivity 300 °C (W/m²K)
SMP-10	SMP-10	6 _Z 1.0 _{X-Y}	1.5
RD-688a	SPR-212	6 _Z 1.2 _{X-Y}	2.0
SPR-212	SPR-212	7 _Z 1.7 _{X-Y}	2.5

Thermal properties for polymer derived ceramic matrix composites consist of T-300 6K, 5HS carbon fabric, 0,90 orientation, 6mm thick.



Chopped fiber C/SiC Polymer-to-Ceramic Composite (PTCC) automotive brake rotor

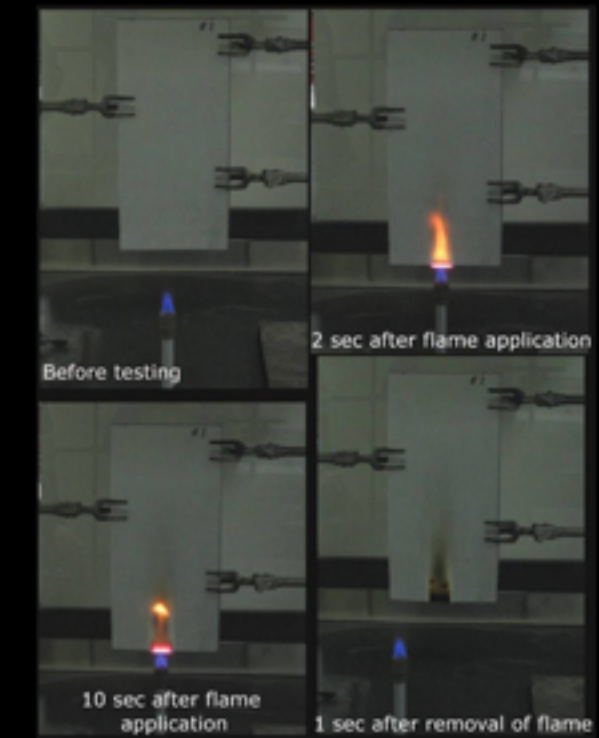


Flexural modulus and flexural strength (left) and percent weight retained after 1 hour at 850 °C (right) for SPR-212 derived ceramic matrix composites consisting of T-300 6K, 5HS carbon fabric, 0,90 orientation, 6mm thick as a function of number of infiltration (PIP) cycles.

Polymer Composite Properties

Test	Results
60 sec Vertical Ignition	<1 sec extinguish 2.4" burned No drip
12 sec Vertical Ignition	8.9 sec extinguish 2.4" burned No drip
45° Ignition	2.1 sec extinguish 0 sec glow after flame No flame penetration
Heat release	45.0 kW/m² peak rate 29 seconds to peak 31.1 kW-min/m² total over two minutes
Smoke emission density	D _s = 2 after 4 minutes
Toxic Gas Emission (ppm) [Not detected = ND]	HF= ND HCl = 1 HCN = ND SO ₂ = ND NO _x = 1 CO = 90

Flame, smoke and toxicity testing results for glass fiber reinforced Polyaramic® resin laminates.



Vertical burn test on glass-reinforced Polyaramic® resin laminate.



Other Forms

- Variety of slurries for ceramic matrix composites with fillers of desirable properties.
- Bulk molding compounds with discontinuous carbon fibers.
- Polymers can be used to produce protective coatings for high temperature oxidizing environments.

Resin	Viscosity (cP)	Pyrolysis yield (%)	Density (g/cm³)
SMP-10	40 - 100	72 - 78	1.0
RD-730	Solid	65 - 67	1.0
SPR-212	12 - 26	60 - 65	1.0
RD-688a	300 - 2,000	65 - 68	1.1

Properties of preceramic polymer resins from Starfire Systems.