Additive Manufacturing of Polymer Derived Ceramics

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Research Project Goals:
- The goal of this project is to, for the first time, enable 3D printing of ceramics from thermally cross-linked preceramic polymers.

Research Project Overview:
- Motivation:
  - Revolutionize ceramic applications
  - Faster and cheaper ceramic manufacturing
  - New complex shapes
- Polyramic SPR 036 [3]
  - Vinyl substituted polycarbosiloxane resin
  - Cured with dicumyl peroxide
  - High ceramic yield, low viscosity, excellent oxidation resistance
  - Pyrolyzed to yield Silicon Oxycarbide

<table>
<thead>
<tr>
<th>State</th>
<th>Mass (g)</th>
<th>Length (mm)</th>
<th>Thickness (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before Pyrolysis</td>
<td>0.4838</td>
<td>23.42</td>
<td>4.92</td>
</tr>
<tr>
<td>After Pyrolysis</td>
<td>0.2610</td>
<td>17.32</td>
<td>1.01</td>
</tr>
</tbody>
</table>

- Successful suspended resin solution
- Pyrolyzed state:
  - 60% mass lost
  - 30% smaller

Project Conclusions/Outcomes/Next Steps:
- Crosslinked precursor to ceramic SiOC
- Next Steps:
  - More complicated shapes
  - Coil, Lego
  - Polymer Precursor for SiC
  - Reduce product size
    - To micro, then nano
  - CMCs
    - Particles, Fibers

References
3. Starfire Systems, “Polyramic Resins Brochure”
4. RunTide. “Production Process of industrial ceramics”