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

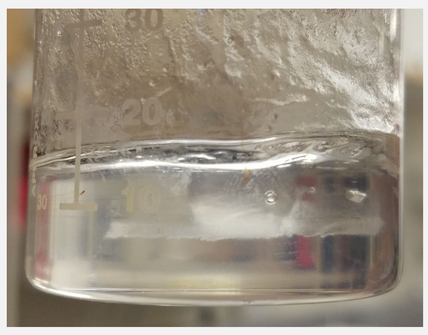
Research Project Overview:

- 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

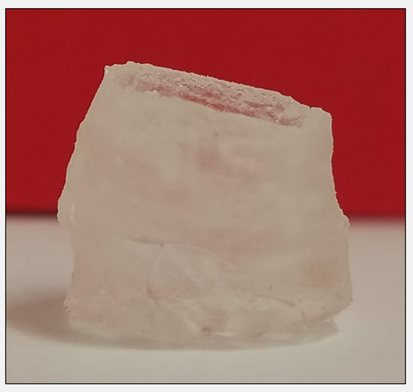
Classic ceramic processing [4] vs. additive manufacturing method

Raw Materials	
Powder, Additives, Plasticizer	SPR 036 Solution, catalyst
↓	
Forming	
Shaping, Carving, Extruding	Additive Manufacturing
↓	
‘Green’ State	
Green Machining	Cross-linking
↓	
Sinter	
Ceramic	SiOC
↓	
Finish	
Grinding, Polishing, Glazing	×

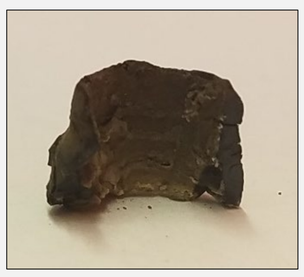
Research Project Results:



Pyrolysis

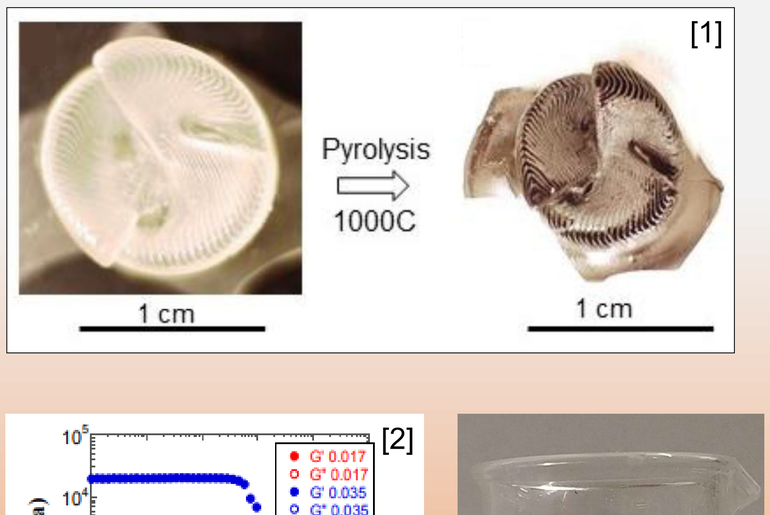


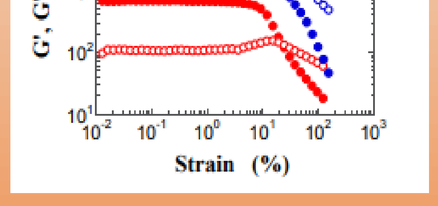
Pyrolysis

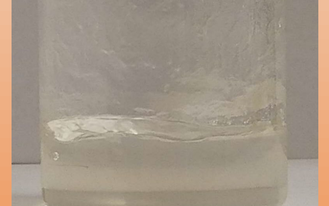


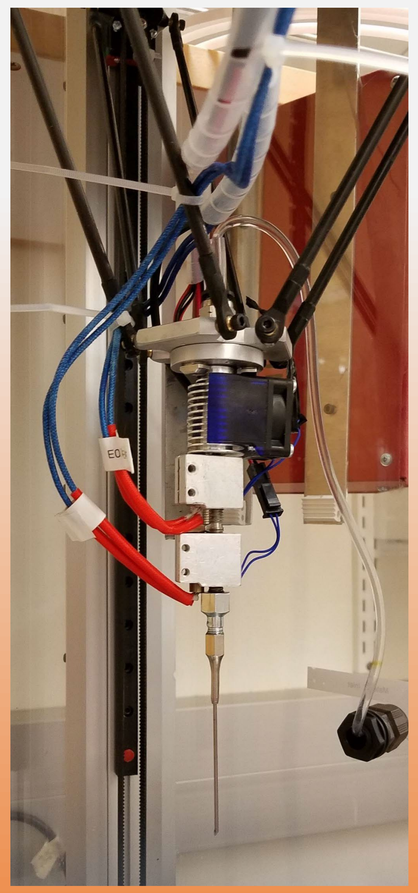
State	Mass (g)	Length (mm)	Thickness (mm)
Before Pyrolysis	0.4838	23.42	4.92
After Pyrolysis	0.2610	17.32	1.01

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



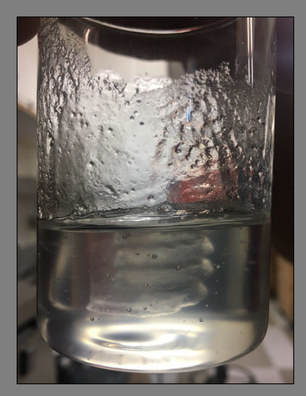






Project Conclusions/Outcomes/Next Steps:

- 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

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2. Sugino, Y.; Kawaguchi, M. Fumed and Precipitated Hydrophilic Silica Suspension Gels in Mineral Oil: Stability and Rheological Properties. Gels 2017, 3, 32.
3. Starfire Systems, "Polyramic Resins Brochure"
4. RunTide. “Production Process of industrial ceramics”