Study of Fiber-Loaded Slurries for Oxide-Oxide Composite Fabrication by Additive Manufacturing

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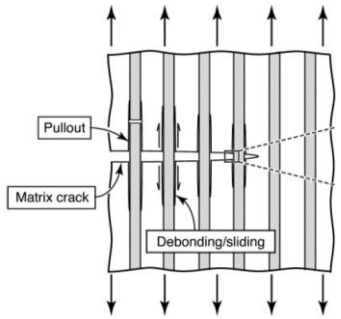
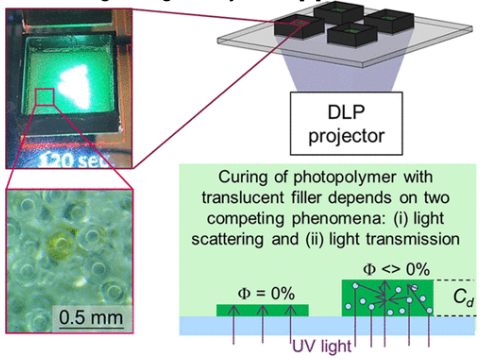
BRITTLE CERAMICS CAN BE TOUGHENED THROUGH FIBER ADDITIONS

Traditionally, ceramics are known for their high hardness, strength and performance as an engineering material at high temperatures. However, they are brittle and fracture easily. Ceramic-matrix composites address this issue by mitigating fracture [1][2][4]

Ceramic Matrix Composite Structure [5]



Additive Manufacturing of CMC Through Digital Light Projection [3]



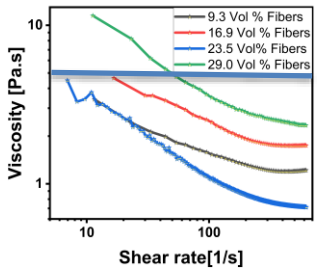
Crack Energy Dissipation : Crack deflection; Fiber debonding and Sliding; Fiber breakage and pull-out [5]

WE STUDY FIBER ADDITIONS TO ALUMINA INKS FOR ADMATEC 3D PRINTING SYSTEMS

The effects of Nextel 610 alumina fiber additions to commercial Admatec alumina nanoparticulate slurries under different fiber loading , milling , thermal debinding and sintering conditions.

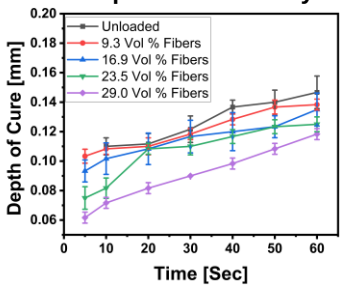
RHEOLOGY IS CRITICAL FOR PRINTABILITY

Slurries with viscosity **< 5 Pa.S are printable**

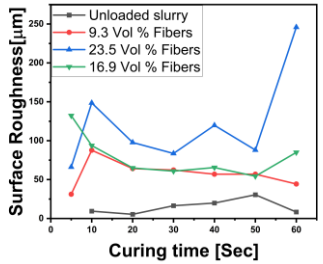


DEVELOPING PRINTABLE COMPOSITE INKS TARGET 100um DEPTH OF CURE AND LOW ROUGHNESS

Depth of Cure Study

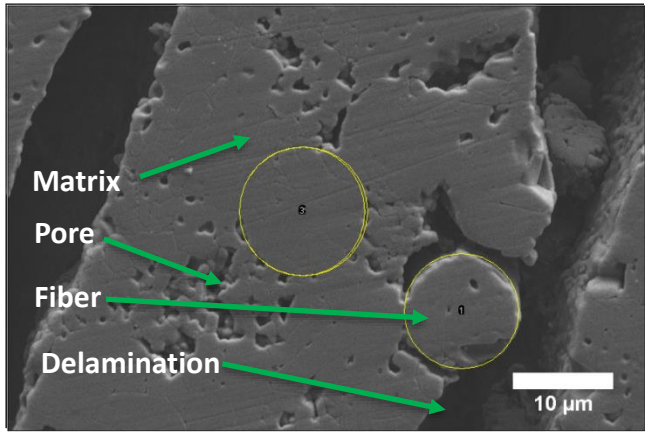


Surface Roughness

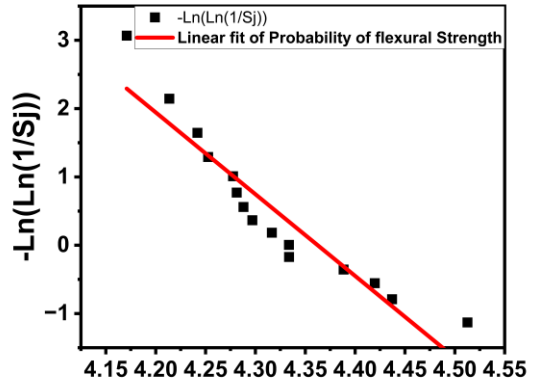


132-LAYER BARS PRINTED MAINTAINED STRUCTURE THROUGH SINTERING DENSE MATRIX WITH DEFECTS EVIDENT

Additively manufactured Sintered bars, 23.5 vol.% fiber



LOW FLEXURAL STRENGTH DUE TO DELAMINATIONS HIGH REPEATABILITY



Weibull Modulus m= 11.9

Characteristic Flexural Strength σ_0=78.5 MPa

Fiber Directionality: Modal angle 85.9°

True Density: ρ =(81.7±3.1)% TD

SUMMARY

- Fiber loadings up to 23.5% can be printed with adequate cure depth and surface resolution for flexural bars up to 132-layers
- After sintering bars have 81.7% theoretical density with average delamination spacing of 8um
- Unpolished, low density bars led to reduced fracture strength of 78.5 MPa with high repeatability (Weibull modulus >10)

FUTURE WORK

- Understand printing and sintering behavior of parts printed with lower fiber fractions
- Quantify microstructure and mechanical performance as a function of fiber loading
- Optimize printing and sintering parameters to reduce delamination defects

REFERENCES

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