How We Fit

Technical Approach & Major Results

Key Accomplishments

Materials-by-Design Process

Mechanism-based Approach

• Establish distribution of fiber defect sizes and their spatial location as physical basis for mapping defects for dynamic modeling of micromechanical tensile failure
• New test methods required for extending to lower length scales and for model validation
• Experimental validation of the model using single and multi-fiber model micro-composites

Key Goals

- Developed and validated a fiber-level FE modeling framework to capture the dynamic effects of a single fiber break while relaxing the inherent assumptions in theoretical shear lag models
- Identified influential non-dimensional parameter, \( R_{\text{shear}} \), which gives insights into micromechanical damage mechanisms and demonstrated the need to tailor the matrix and interphase as a system
- Extended the scope of SFFT using in-situ visualization of fiber break progression
- LabView script to track the locations of each fiber break in SFFT and index them
- In-situ observation of interfacial debond growth accompanying fiber breaks
- Developed novel experimental method (Continuous Fiber Bending Experiment) to characterize spatial distribution of critical defects in the fiber
- Designed and manufactured precision fiber-placement fixture(a) to create precisely controlled multi-fiber microcomposites(b) for FE model validation

Interaction with composites CMRG tasks

• Brittle S-glass fibers, have gage-length dependent stochastic distribution of strength
  (Depends on size and spatial distribution of critical defects)
• Dynamic Localization and clustering of fiber breaks leads to catastrophic failure
• Cannot be modeled using RVEs

To experimentally determine the statistical distribution (size and spatial) of Critical surface defects in S-glass fibers

- Brittle S-glass fibers, have gage-length dependent stochastic distribution of strength
- Dynamic Localization and clustering of fiber breaks leads to catastrophic failure
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Major Sources of Stochasticity

- Brittle S-glass fibers, have gage-length dependent stochastic distribution of strength
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OBJECTIVE FUNCTION

To experimentally determine the statistical distribution (size and spatial) of Critical surface defects in S-glass fibers

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Measuring Critical Defect Distribution : Continuous Fiber Bending Experiment

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Impact

• Generation of a defect-distribution based model capable of predicting progression of fiber breaks under a range of applied strain rates
• Framework for tailoring interface and matrix to enhance tensile properties and energy absorption in the composite
• Study the interaction of micromechanical damage mechanisms inside a realistic composite system
• Generate inputs for homogenized models at higher length scales : MAT-162 (ARL), PHCDM-RVE (Dr. Ghosh, Hopkins), Meso-scale woven fabric model (Chris, ARL)
• Will also provide direct input to dynamic Punch-shear models (Dr. Haque, UDel)