How We Fit

Materials-by-Design Process

Key Goals

- Establish high strain rate mixed mode traction separation laws for glass fiber/epoxy interphases
- Design interphase for maximum energy absorption from both resin plasticity and interphase debonding mechanisms

Mechanism-based Approach

MD simulation:
- Force
- Stress
- Strain
- Deflection
- Frictional

- Velocity
- Impact
- Energy absorption

Design process:
- UD
- Resin
- Fiber

UDel composite models

Input to unit cell

Impregnated tow models

Input to fiber-level

Key Accomplishments

- Developed HSR Kolsky bar experimental technique for composite interphase characterization at the micromechanical length scale: measure traction separation laws
- Modeling methodology to determine interfacial traction separation laws
- Carbon nanotubes (CNTs) as non-invasive sensor for crack monitoring

Technical Approach

Novel Kolsky Bar Techniques at the Nanometer to Micron Scale With Real Time Sensing and Visualization

S-glass/epoxy microdroplet

S-Glass/Epoxy Interphase

S-glass/epoxy cruciform

Visualization of damage in interphase

Major Results

- HSR S-glass/epoxy interphase characterization covering six decades of loading (up to 1.5x10^3 s^-1)
- Stress rate dependent traction-separation laws
- FE modeling of the QS and HSR microdroplet test method
- Cohesive zone modeling of the interphase between fiber/matrix

Mechanisms

- Mixed mode damage initiation followed by mode II dominated crack propagation
- Progressive interfacial debonding, frictional sliding

Impact

- Improved understanding of energy absorbing mechanisms will have broad applications in composites
- Critical element of materials-by-design framework for composite materials under high rate loading
- Will lead to improved protection materials while decreasing the cost and time for development of new lightweight energy absorbing composite materials