Cameron Abrams and Giuseppe Palmese (Drexel); Sanjib Chowdhury, Bazle Haque and Jack Gillespie (UDel); Tim Sirk, Jan Andzelm, Robert Elder, Tanya Chantawansri, Joe Lenhart, Danny O’Brien (Army Research Laboratory)

Goals and Motivation

• Model and control high strain rate mixed-mode traction-separation laws for glass fiber/epoxy interphases
• Develop a ‘Materials-By-Design’ methodology to bridge length scales from Molecular Dynamics (MD) into finite element (FE) (potential based cohesive modeling)
• Advance basic understanding of:
  • load transfer within interphase under HSR
  • role of sizing and resin chemistry
  • energy absorbing mechanisms from nanometer to micron length scales

Mechanism-based Approach

Materials-by-Design Process

How We Fit

Technical Approach

• New Energy Absorbing Epoxies
• MD Prediction of Interphase Traction laws for Bridging Length Scales
• Prediction of Glass Fiber HSR Properties
• Materials by Design Framework Established

Key Accomplishments

Future Directions

• Advance MD models for three constituents
• Optimize interphase properties
• Validate predictions through canonical testing

Impact

• New energy absorbing mechanisms
• New light weight protection materials
• Validated multi-scale models for Design of Next Generation Soldier Systems

Major Results

Materials-by-Design Process

MD Epoxy: New Energy Absorption Mechanisms

MD Glass Fiber: Prediction of High Strain Rate Properties

Interphase Design Improves Strength and Energy Absorption in Composition

MD simulations of coarse-grained PRS systems

Synthesis of New Epoxy Networks and Interphases Partially Reacted Substructures (PRS)

Interphase Composition

Interphase Design Improves Strength and Energy Absorption in Composition

Code implementation include load/unloading capability