Carbon nanotubes, graphite nanoplatelets and nano-sized core shell rubber particles have all been extensively researched for their capability to improve mechanical properties of thermoset resins. However, there has been a lack of research on their evaluation for energy absorption in high velocity impact scenarios, and the fundamental mechanics of their failure mechanisms during highly dynamic stress transfer through the matrix. This study is essential for laying the foundation for improvement in ballistic performance in composite armor. In hard armor applications, energy absorption is largely accomplished through the delamination between plies of the composite laminate. Such energy absorption is accomplished through two mechanisms. The first being the elongation of the fiber reinforcement contained in the resin matrix, and the second is the propagation of the crack in between the discreet fabric plies.

This study aims to fundamentally study the energy absorption characteristics of various nano-particles as reinforcements in thermoset resin for high velocity impact applications. Multiple morphologies are evaluated through the use of platelet, tubular and spherical shaped nano-particles. Evaluations of the effect on stress transfer through the matrix due to the combination of nano-sized and micro scale particles of milled fiber is conducted. Three different nano-particles are utilized, specifically, multi-walled carbon nanotubes, graphite nanoplatelets, and core shell rubber particles. The difference in surface area, aspect ratio and molecular structure between the tube, platelet and spherical nano-particles causes energy absorption through different failure mechanisms, which changes the impact performance of composite panels enhanced with these nano-particle fillers. Composite panels made through the use of dispersing various nano-particles in a non-contact planetary mixer, are evaluated through various dynamic and static testing, including un-notched cantilever beam impact, mixed mode fracture toughness, Split-Hopkinson bar, and ballistic V50 testing. The failure mechanism of various nano-particle enhanced resin matrices during the ballistic event is discussed through the use of scanning electron microscope images, X-ray photoelectron spectroscopy (XPS), and Raman spectroscopy of the panels after failure. The Raman spectroscopy data shows a Raman shift for the fibers that had an enhancement in the V50 performance through the use of nano-particles.

Major: Mechanical Engineering

Educational Career:
Bachelor’s of Aeronautical and Astronautical Engineering, BS, 1994, The Ohio State University
Master's of Mechanical Engineering, MS, 1996, The Ohio State University

Committee in Charge:
Dr. Jihua Gou, Chair, MAE
Dr. Seetha Raghavan, MAE
Yuanli Bai, MAE
Lei Zhai, Nanoscience Technology Center

Approved for distribution by Dr. Jihua Gou, Committee Chair, on June 20, 2013.

The public is welcome to attend.