Hybrid carbon fiber reinforced polymer (HCFRP) composites with alumina nanoparticles reinforcement display improved material properties such as fracture toughness, resistance to crack propagation and improved fatigue life. However, homogeneous dispersion of nanoscale materials in the matrix is important for even distribution of the improved properties. This research is aimed at quantifying the improvement in dispersion of nanoparticles and elucidating the effects on the mechanical property of HCFRP samples through the novel use of photoluminescent characteristic peaks emitted by the alumina reinforcement particles. Photo-luminescence emission from secondary reinforcement particles of alumina embedded within the hybrid carbon fiber composites is leveraged to reveal microstructural effects of functionalization and particle weight fraction as it relates to overall composite mechanics.

6, 9 and 12 weight percentage of alumina particle loading with Reactive Silane Coupling Agents, Non-reactive Silane Coupling Agent and untreated surface treatment are investigated in this research. Uniaxial tensile tests were conducted with measurements using piezospectroscopy (PS) and concurrent digital image correlation (DIC) to quantify the mechanical property and load distribution between the carbon fiber/epoxy and the reinforcing nanoparticles. Photoluminescence results show the dispersion and sedimentation behavior of the nanoparticles in the material for different surface treatment and weight percentage of the alumina nanoparticles. The piezospectroscopic maps capture and track the residual stress and its change under applied load. This work extends the capability of spectroscopy as an effective non-invasive method to study, at the microstructural level, the material and manufacturing effects on the development of advanced composites for applications in aerospace structures and beyond.

Major: Aerospace Engineering

Educational Career:
Bachelor’s of Aeronautical Engineering, BS, 2013, Military Institute of Science and Technology

Committee in Charge:
Dr. Seetha Raghavan, Chair, Mechanical & Aerospace Engineering
Yuanli Bai, Mechanical & Aerospace Engineering
Jihua Jan Gou, Mechanical & Aerospace Engineering

Approved for distribution by Dr. Seetha Raghavan, Committee Chair, on October 16, 2017.

The public is welcome to attend.