Multi-functional composites – materials in which additional functions exist beyond a primary structural function – offer the promise of improved system performance through the reduction of redundancies and reduced safety factors. In this seminar talk, the potential of self-healing, thermal regulation, integrated structural fluid storage, and localized interlaminar reinforcement are discussed in the context of initial prototyping work, as well as with regards to design for automated and scalable manufacture.

Microvascular materials offer a route to achieve repeated self-healing of a fracture location, thermoregulation, and other fluid transport-mediated functions. These functions rely on the mass transport of reactive chemistries or thermal fluids through pre-embedded micro channels. These microvascular geometries are defined by sacrificial thermoplastic filaments that are catalyzed to rapidly depolymerize at elevated temperatures to define porous features. The chemistry is scaled via melt extrusion of filaments that are co-spoooled onto pre-preg tapes suitable for automated fiber placement or 3-D printed onto composite plates. The resulting channels are critical to enhance self-healing functions, embedded heat exchangers, and to enable structural storage of liquids. Finally, vertically aligned CNTs (carbon nanotubes) and microvascular features are integrated in tandem within the laminate in order to retain the initial material strength that is typically compromised due to the presence of the hollow microvascular channels. The self-healing polymerization reaction can be accelerated through targeted use of resistive heating within the CNT-reinforced composite.