Hierarchical Carbon Nanotube Carbon Fiber Unidirectional Composites with Preserved Tensile and Interfacial Properties

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Abstract: Hybrid hierarchical carbon-nanotube (CNT)-based composites, such as radially-aligned CNT arrays grown onto microfiber filaments, have significant potential to expand the performance and functionality of fiber reinforced composites. Here, a novel method for high-yield growth of aligned CNTs on aerospace-grade carbon fibers (CFs) is demonstrated at the composite level for the first time. Fuzzy carbon fiber reinforced plastics (fuzzy CFRP) unidirectional composites with >60% microfiber volume fraction are fabricated via vacuum-assisted resin infusion of CNT-grafted tows using an unmodified aerospace-grade epoxy. Preservation of microfiber tensile modulus and strength are demonstrated by longitudinal composite tensile testing, consistent with single-fiber tensile tests. Fiber-matrix interface strength is also unchanged by the CNT growth as revealed through continuously-monitored fiber fragmentation tests. Taken together, the results provide needed new composite-level understanding of hierarchical structural composite laminates and motivate future work on structural CF composite laminates with integrated multifunctionality and improved interlaminar and intralaminar performance.