Additive Manufacturing of Nanomaterial Based Hierarchical Structures

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Abstract

Aerospace systems demand high performance materials that minimize weight while functioning under extreme environmental conditions. One way to meet these requirements is by incorporating hierarchical structures into part design. These structures are known to impart unique mechanical properties not characteristic of the bulk material such as high strength and toughness. It is difficult, however, to manufacture these structures due to the inherent trade-off between part size and feature resolution in traditional manufacturing processes. Additive manufacturing offers a potential solution to these issues by allowing material placement directly at desired locations. This loosens geometric constraints and allows for multiple contiguous materials in a single part. Despite these advantages, additive manufacturing still suffers from part size/feature resolution and repeatability issues. The goal of this work is to develop capabilities for additive manufacturing of hierarchical structures with features from the nano- to macroscale. First, we will study existing additive manufacturing techniques for aerospace grade parts and develop improved systems to mitigate repeatability issues. Then, we will use carbon nanotubes as a basis for manufacturing multifunctional systems with material hierarchy. Finally, we will study biostructures as basis of new additive manufacturing techniques for geometric hierarchy. This includes diatomite composite printing and growth and manipulation of live diatoms on macroscale parts.