

PROCEEDINGS

Manufacturing Science for Green Lightweight Composites: Interface Healing, Voids, and Mechanical Reliability in Extrusion-Based 3D Printing

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ABSTRACT

Green lightweight composites demand manufacturing routes that combine structural efficiency, material efficiency and compatibility with recyclable polymer systems. Extrusion-based 3D printing, particularly fused filament fabrication of thermoplastics and fiber-reinforced thermoplastic composites, offers an attractive route through flexible deposition, reduced tooling and local tailoring of reinforcement. However, translating printable feedstocks into reliable load-bearing structures remains constrained by process-induced interfaces and defects. This study discusses process-structure-property relationships in 3D printed short-fiber reinforced thermoplastics and continuous fiber-reinforced thermoplastic composites, with a focus on interface healing, void formation and mechanical reliability. The central message is that printed performance is governed by the coupled evolution of thermal history, intimate contact, molecular interdiffusion/autohesion, fiber orientation or impregnation, and mesostructural voids during deposition. Representative studies will illustrate how fracture-based characterization, thermal measurement and microstructural/mesostructural analysis can quantify the extent and consistency of fusion bonding between deposited filaments, and how insufficient healing or void-rich regions lead to anisotropic and defect-controlled failure. The discussion will further connect short-fiber and continuous-fiber reinforcement strategies to the manufacturing challenges of stiffness enhancement, interlayer reliability and lightweight structural performance. By linking interface healing and void-controlled failure to practical process windows, these investigations aim to provide a manufacturing-science perspective for sustainable additive manufacturing of lightweight thermoplastic composite structures.

KEYWORDS

Additive manufacturing; fused filament fabrication; fiber-reinforced thermoplastic composites; interface healing; void formation; mechanical reliability

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