Interface Thickness and Orientation in 3D Printed Fiber-Reinforced Composites

T. Volders[1], M. Contino[2], F. Passoni[2], L. Andena[2], D. Ruffoni[1]

[1]Mechanics of Biological and Bioinspired Materials Laboratory, University of Liege, Belgium.

[2]Department of Chemistry, Materials and Chemical Engineering, Politecnico di Milano, Italy.

Biological materials offer valuable insights into nature's strategies for the development of high performance fiber-reinforced systems. Plywood structures in the cuticle and lamellar organization in osteonal bone are typical examples where the arrangement of fibres in multiple layers enhance toughness [1]. In fibrous composites the interface between matrix and fiber plays a crucial role in the mechanical behaviour. PolyJet multi-material printing, a technique where liquid photopolymers are deposited and cured by UV light, allows to build composites with fiber arrangements not accessible by traditional manufacturing routes. However, this process presents challenges related to material mixing at the interfaces [2]. Our study focuses on the role of the interface gluing stiff elements. We fabricated and tested dumbbell samples featuring stiff fibers (manufactured using a rigid glassy polymer) separated by compliant layers (fabricated with a soft rubbery polymer). Firstly, we considered only a single layer, and we investigated the impact of layer thickness and orientation. Samples were tested in tension and the interpretation of results supported by finite element analysis. Changing interface orientation w.r.t. the applied load switches the deformation mode allowing to tune the mechanical behavior of the resulting composite. However, when interface thickness approaches the size of the material mixing region (about 150 μm in this study), the behavior of the composites becomes less predictable and the impact of the interface is much reduced. Multilayer systems are currently investigated. These findings shall provide guidelines to fabricate advanced composites using polymer-based additive manufacturing.

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