VRIJE UNIVERSITEIT BRUSSEL

The faculty of Engineering of the Vrije Universiteit Brussel invites you to attend the public defense leading to the degree of

DOCTOR OF ENGINEERING SCIENCES

of **Ahmad Shawki Charkieh**

The public defense will take place on **Monday 6th July 2026 at 5pm** in room **D.2.01** (Building D, VUB Main Campus)

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STUDY OF THE MECHANICAL PERFORMANCE OF FIBRE-REINFORCED POLYMER MATRIX COMPOSITES PRODUCED USING 3D-PRINTING TECHNIQUES

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Abstract of the PhD research

This doctoral thesis addresses critical challenges at the intersection of sustainable manufacturing, advanced materials, and intelligent structural design. Driven by the global imperatives for a circular economy and high-performance engineering, this research presents a comprehensive workflow for the development of lightweight, functional "smart" composite structures using Additive Manufacturing (AM). The study begins by tackling the significant hurdles in utilizing recycled Polyethylene Terephthalate (rPET) for Fused Filament Fabrication (FFF), developing a highperformance rPET-carbon fibre composite filament through optimized material formulation and processing. Building upon this sustainable feedstock, the thesis explores the mechanical behaviour of both foundational and advanced architected metamaterials. Initially, it characterizes uniform lattice structures and the benefits of foam infill, revealing limitations in design control. Subsequently, it investigates novel, bio-inspired, and functionally graded core architectures, including intersecting spherical shells, gradient Triply Periodic Minimal Surfaces (TPMS), and origami-inspired patterns, demonstrating unprecedented control over tailorable mechanical responses. Critically, this work pioneers a robust methodology for integrating fibre optic sensors (FOS) directly into 3D-printed composite structures during fabrication. This integration transforms passive metamaterials into multi-functional "smart" components capable of real-time, in-situ Structural Health Monitoring (SHM). The culmination of this research is the design, fabrication, and validation of a high-end, sensor-embedded component, showcasing the practical realization of a sustainable, intelligent, and highperformance structural solution. This thesis contributes a complete, experimentally-validated pipeline that bridges the gap between recycled materials and advanced smart structures, paving the way for a new generation of sustainable, responsive engineered products.