

Hybrid Additive Wing Structures with Integrated Metallic Lattices for Impact Resistance

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Abstract. Low velocity impacts represent a critical threat for lightweight aerostructures, potentially causing internal damage and loss of structural integrity. This work investigates hybrid additive design strategies for improving the impact resistance of an unmanned aerial vehicle wing section through the integration of metallic lattice domains within a composite additively manufactured structure.

A parametric design tool was developed to generate lattice architectures and enable automated integration with finite element analyses. The wing section features an external skin manufacturable in carbon fiber reinforced polyamide through fused filament fabrication, while the internal architecture is subdivided into three reinforced regions incorporating metallic lattice domains designed for metal laser sintering in AlSi10Mg. One lattice domain is positioned within the leading edge, while two additional reinforcement regions are embedded in specifically designed dorsal and ventral pockets, where localized sandwich panels are integrated to enhance resistance to impact loads. The lattice geometries are parametrically controlled and optimized to improve energy absorption and damage tolerance under LVI conditions, enabling the systematic exploration of different unit-cell topologies. The hybrid configurations were first investigated through numerical simulations, allowing the identification of the most effective lattice architectures in terms of impact energy dissipation and structural response. The optimized designs were subsequently manufactured by combining polymer composite and metal additive manufacturing, resulting in multi-material hybrid wing structures with tailored internal reinforcement.

Finally, experimental Low Velocity Impact tests were conducted to validate the numerical predictions and assess the structural effectiveness of the proposed solutions.