Sierpinski–Knopp Fractal Based Architected Composite for Improved Competing Mechanical properties

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Architected composites are materials in which the mechanical performance is governed by the deliberate design of internal geometry and spatial arrangement of constituent phases. The designed materials allow tailorability in mechanical properties as well as combine otherwise competing mechanical properties. Stiffness and damping are competing mechanical properties in engineering materials. In this work, a planar design, based on Sierpinski-Knopp (SK) curve, for architected composite is presented for simultaneous stiffness, toughness and damping. SK space filling curve is a fractal curve generated by recursive sub-structuring based on right, isosceles triangle. To achieve planar isotropy, SK curve is implemented over equilateral triangles maintaining hexagonal symmetry (Fig. 1). Owing to interlocking nature and ease of fabrication (3D printing) 6th iteration of SK curve is used. The constituents are considered to be stiffer polylactic acid (PLA) and a compliant polyurethane (PU). The dimensions of the geometry are chosen considering fabrication by 3D printing and experimental characterization. Finite element simulations are performed to evaluate the effective elastic modulus and damping characteristics. The stiff PLA has elastic modulus of 1210 MPa and zero damping capacity, whereas PU has high damping of 0.6 and low stiffness. The results demonstrate nearly isotropic elastic behaviour with an effective modulus of 124 MPa. Furthermore, a significant increase in stiffness (up to 190 MPa) can be obtained with reduced compliant layer thickness. Simultaneous stiffness-damping is found to be enhanced in the proposed architected composite. These findings highlight the potential of fractal-inspired architected composites for applications requiring simultaneous mechanical robustness and vibration damping. This paper will present the salient results of a numerical and experimental study through mechanical testing, deformation analysis using Digital Image Correlation (DIC) to assess the performance of the proposed design.

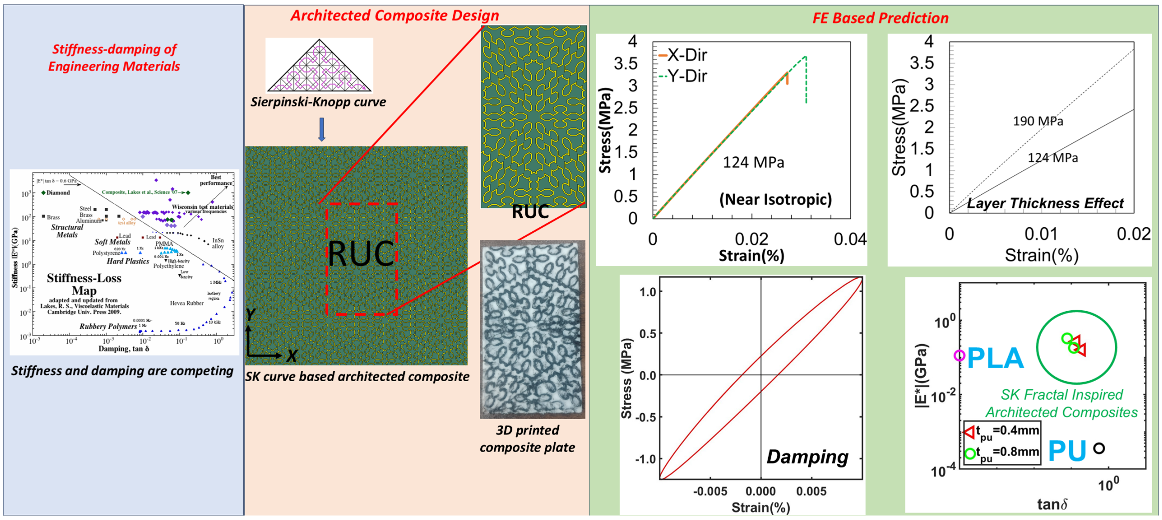

Figure 1. Architected composite using Sierpinski-Knopp fractal for simultaneous stiffness-damping performance.