

*Supplementary Material for*  
**Topology-Driven Extraordinary Damping in  
Nature-Inspired Architected Interpenetrating Phase  
Composites**

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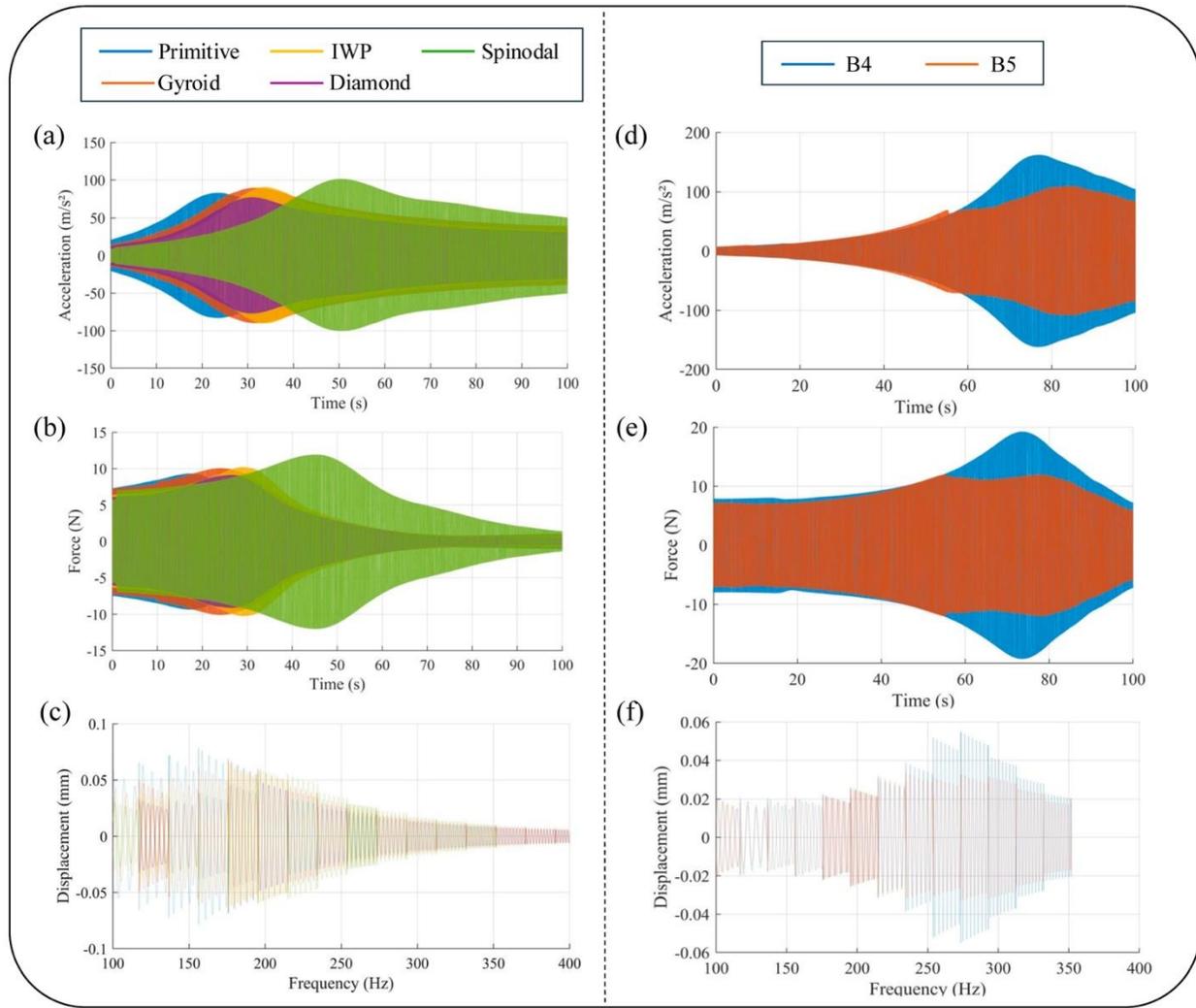
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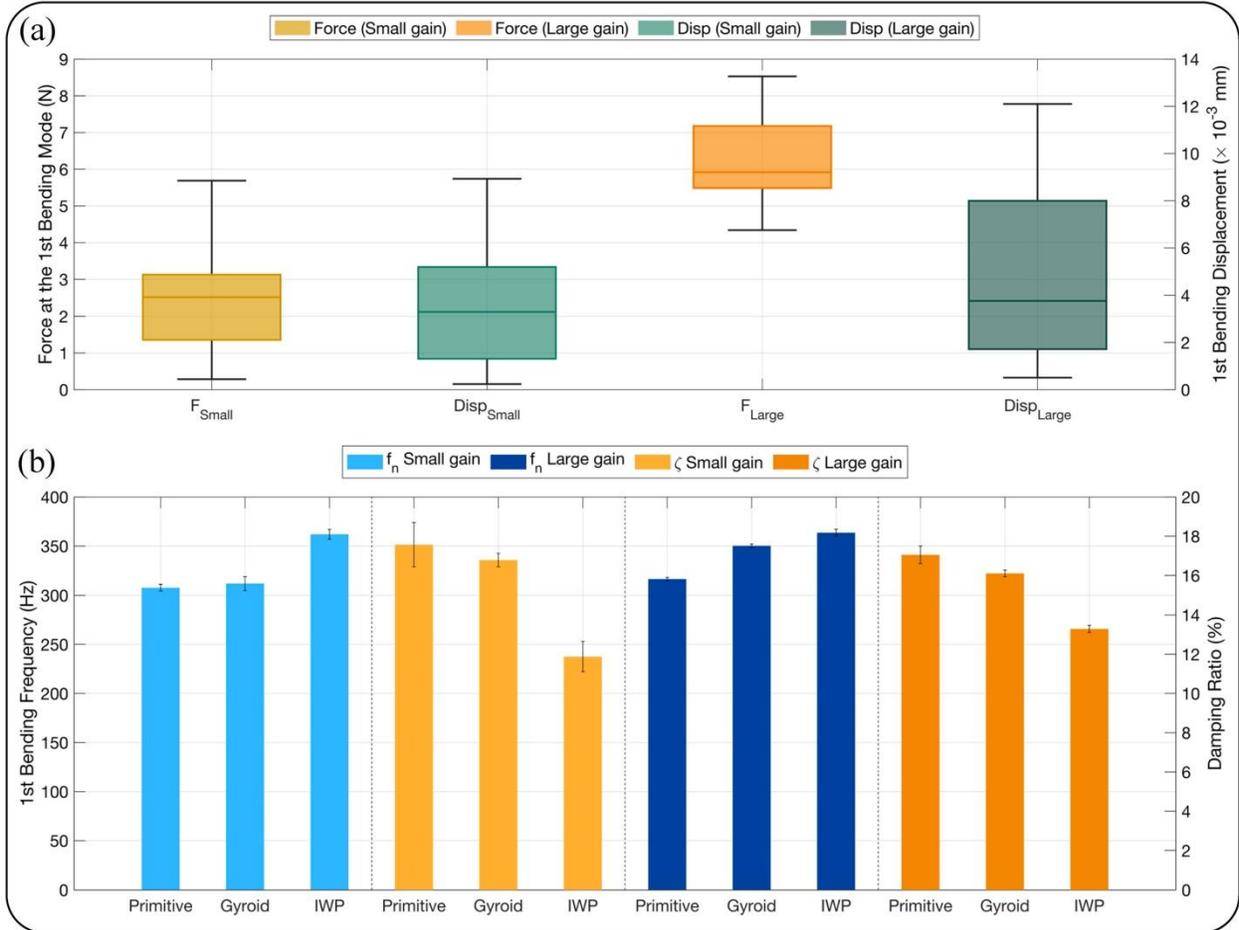
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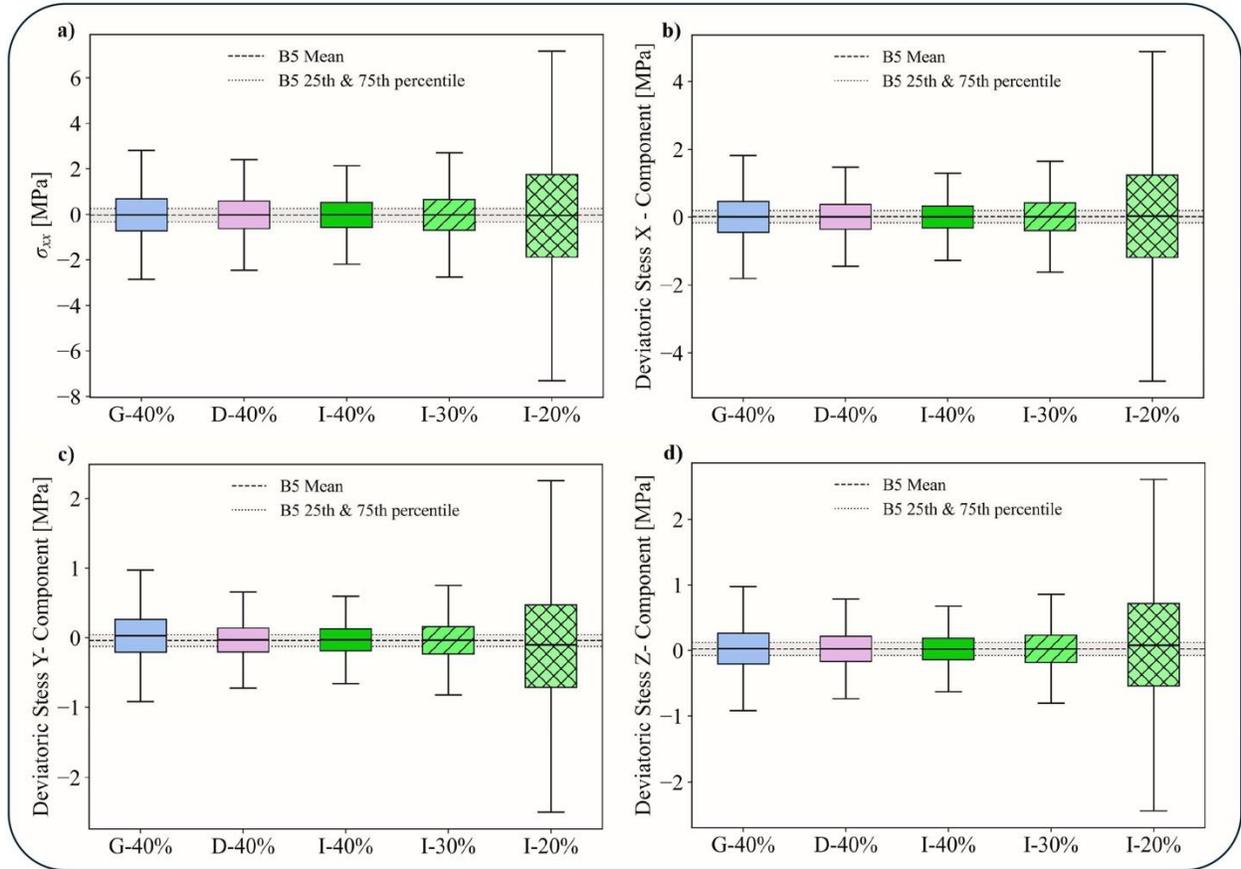
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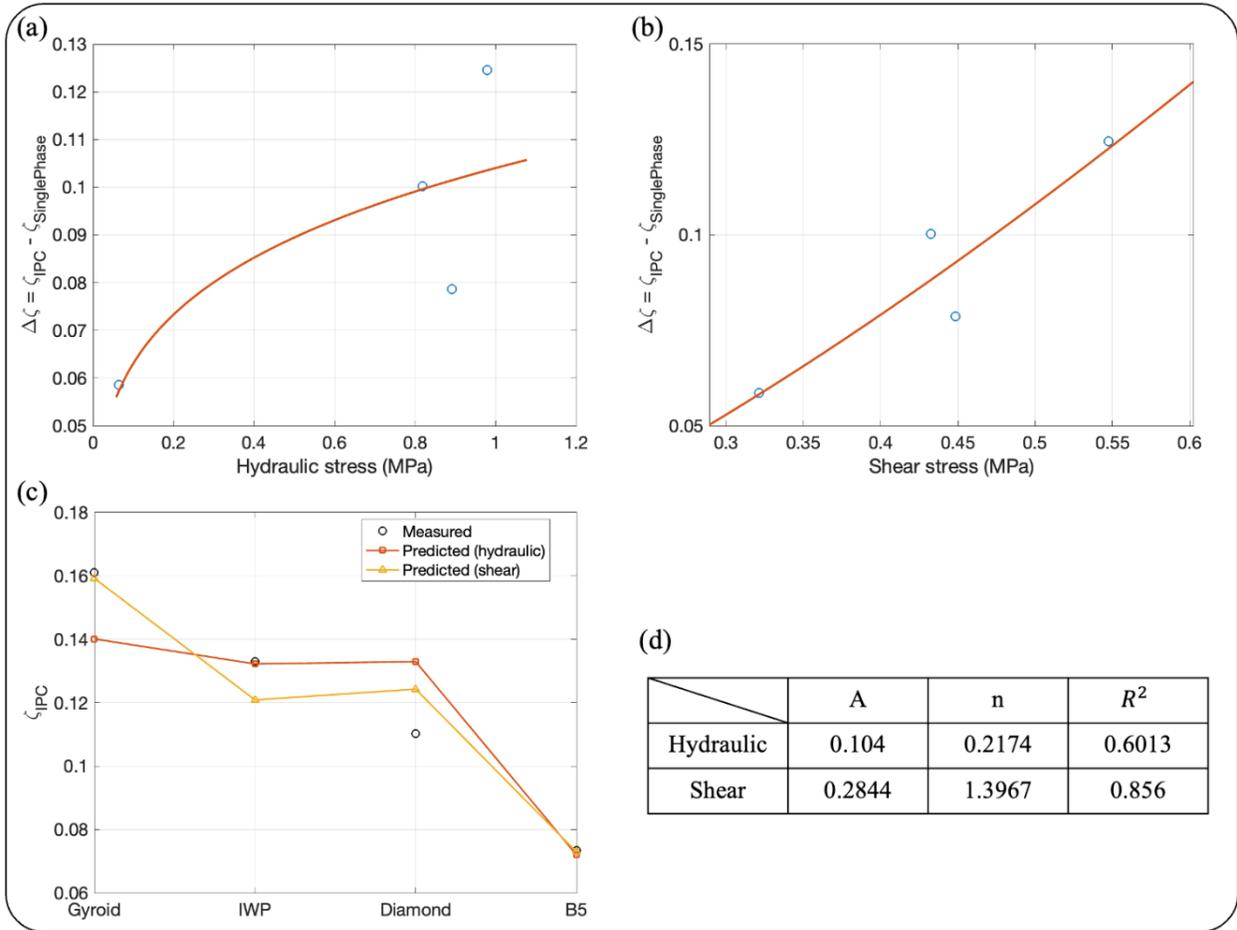
**Figure S1.** Acceleration ( $m/s^2$ ) (a, d) and force ( $N$ ) (b, e) responses at the beam midpoint in the large-gain tests, recorded by the PCB impedance head. The corresponding displacement spectra (mm) versus frequency are shown in (c, f). Results for the TPMS and stochastic designs are presented in the left column (a-c), while those for the B4 and B5 patterns are shown in the right column (d-f).



**Figure S2.** (a) Averaged force and displacement responses at the first bending mode across all IPC structural designs. (b) First bending frequencies and corresponding damping ratios obtained under low- and high-input force amplitudes for the Primitive, Gyroid, and IWP IPC designs. Frequencies from the small- and high-gain tests are denoted by light and dark blue bars, respectively, while the damping ratios from the small- and high-gain tests are denoted by light and dark orange bars, respectively.



**Figure S3.** The normal stress distribution (a) and the deviatoric stress components in the X (b), Y (c), and Z (d) directions are shown for the IPC topologies viz Gyroid (G), Diamond (D), and IWP (I) at a relative density of 40% and a slenderness ratio of 8. Comparative results for the B5 architecture at the same slenderness ratio, together with the IWP topology at reduced relative densities of 20% and 30%, are additionally provided.



**Figure S4.** Damping ratio enhancement  $\Delta\zeta$  as a function of the Hydraulic (a) and shear (b) stresses, using a power-law relationship  $\Delta\zeta = A * \sigma^n$ . Comparison between measured damping ratios  $\zeta_{IPC}$  and values predicted by the additive phenomenological model  $\zeta_{IPC} = \zeta_{SP} + A * \sigma^n$ , demonstrating improved predictive capability when shear stress is used as the governing parameter. Summary table of fitted parameters (A, n) and goodness-of-fit metrics for both hydraulic- and shear-stress-based phenomenological models are provided in (d).