Supporting Information

Hierarchical bioinspired architected materials and structures

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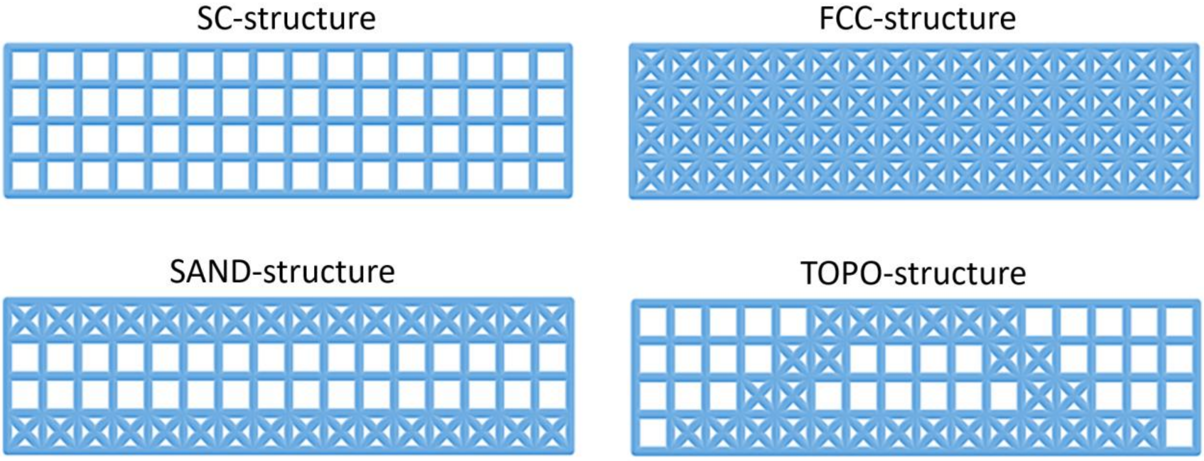

Figure S1 - Representation of the four different population strategies of the on-hierarchical lattice structures. In the SC-structure the whole design space is populated with stretching dominated SC unit cells. In the FC-structure all the design space is filled with stretching dominated FCC unit cells. In the SAND-structure SC and FCC unit cell are combined together in a "sandwich" like structure (lightweight core with load bearing skins. Finally, the TOPO-structure is obtained by performing a topology optimization on the design space and replacing the zones where material is left with FCC unit cells and zones where material is removed with SC unit cells.

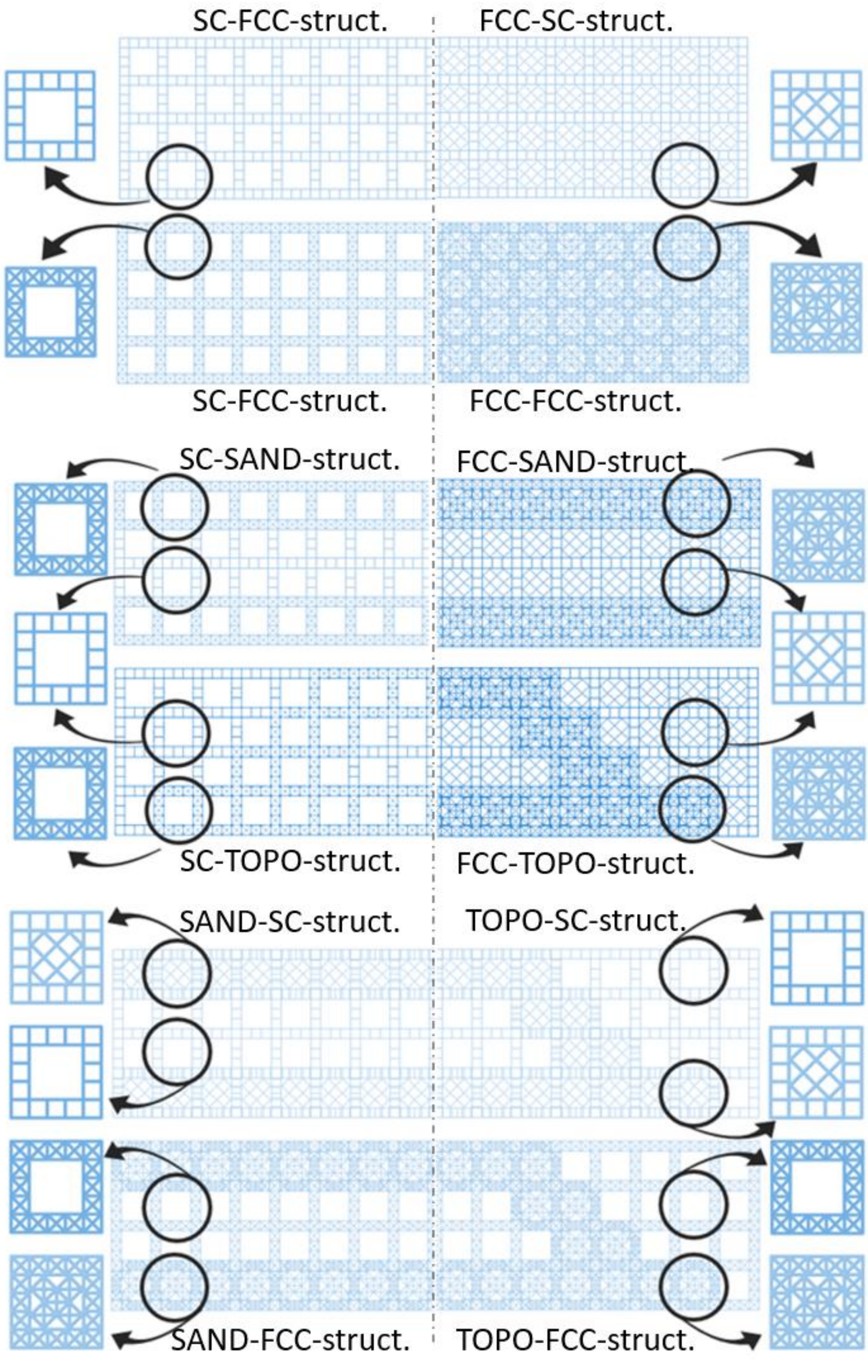

Figure S2 - Representation of the twelve different population strategies of hierarchical lattice structures, with zooms on their substructures. Given the symmetry with respect to the mean plane of the structures, only half of the beam for each model is shown in the figure.

	Non - Hierarchical			
	SC	FCC	SAND	TOPO
n	1.7	1.1	1.4	1.2
	Hierarchical			
	SC-SC	SC-FCC	SC-SAND	SC-TOPO
n	1.67	1.73	2.01	1.83
	FCC-SC	FCC-FCC	FCC-SAND	FCC-TOPO
n	1.30	1.13	1.21	1.14
	SAND-SC	SAND-FCC	-	-
n	1.28	1.12	-	-
	TOPO-SC	TOPO-FCC	-	-
n	1.32	1.12	-	-

Table S1 - Non-hierarchical and hierarchical lattice structures scaling law exponents. Ideally bending dominated lattice structures has an exponent equal to 2, while stretching dominated ones has an exponent equal to 1.

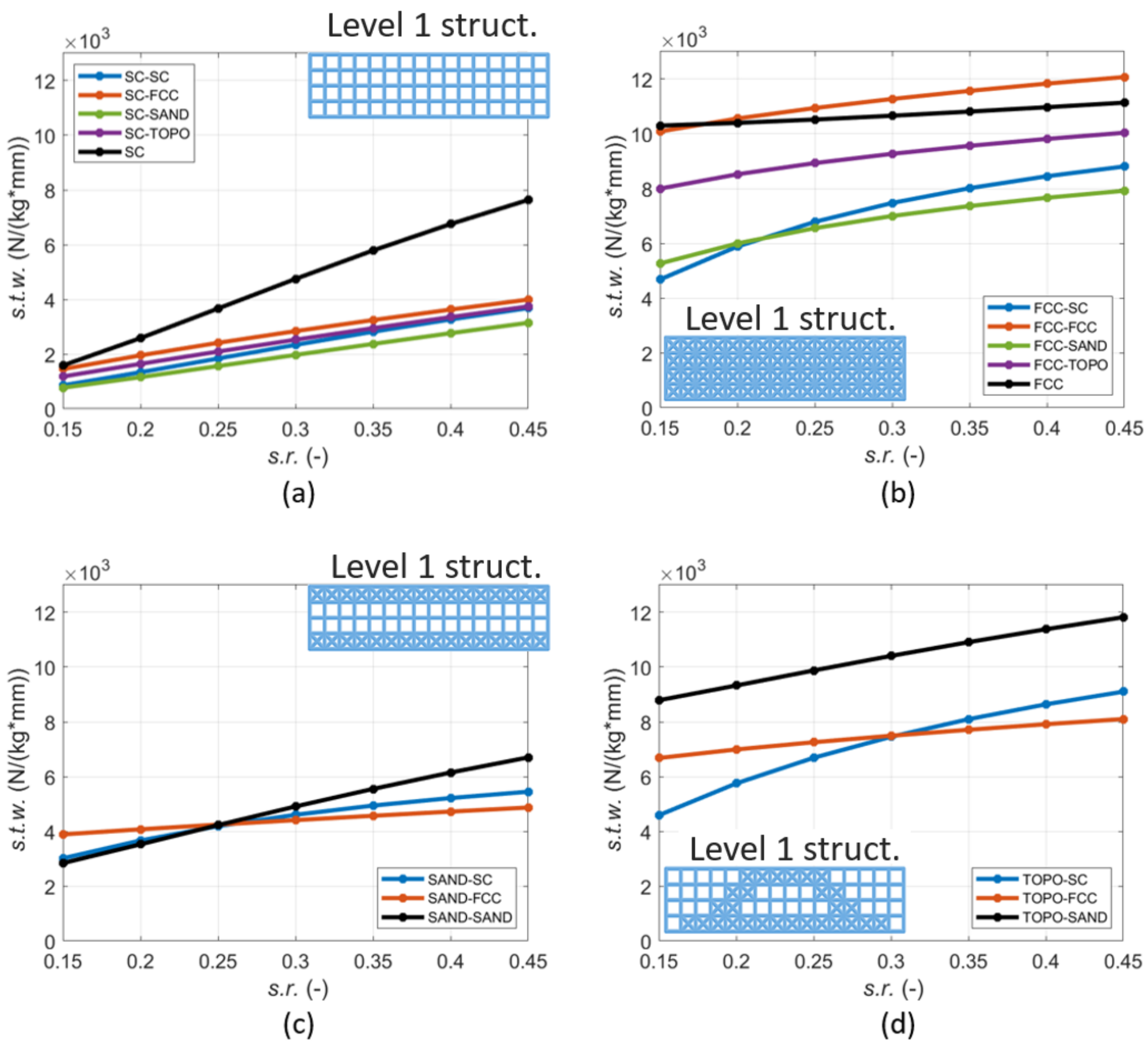

Figure S3 – Hierarchical lattice structure Stiffness-to-weight ratio vs Slenderness ratio: (a) SC HL-structures; (b) FCC HL-structures; (c) SAND HL-structures; (d) TOPO HL-structures.

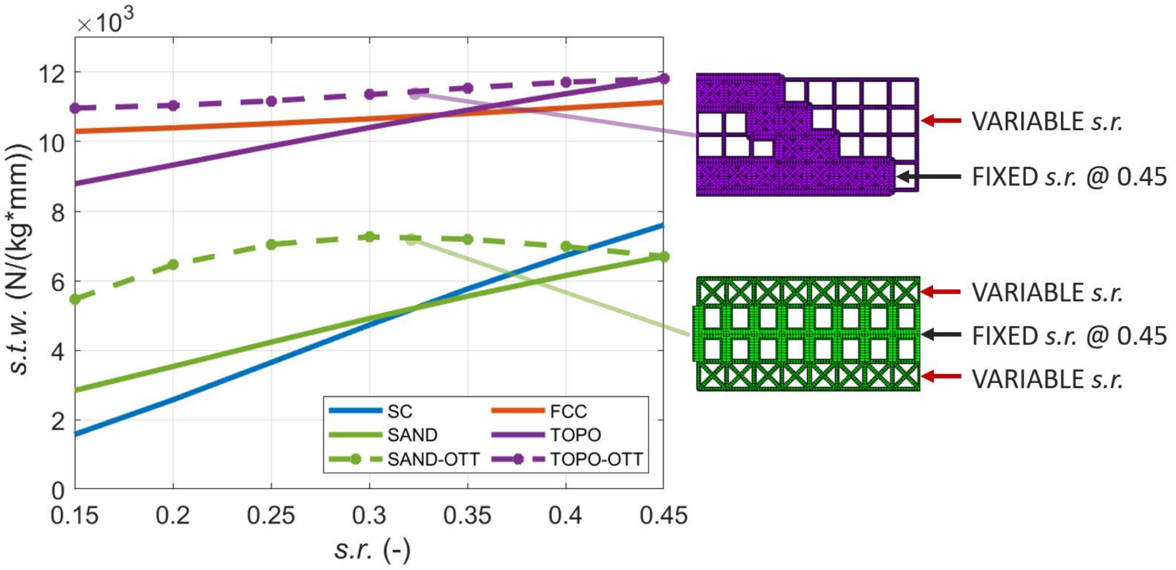

Figure S4 - NHL-structures variable s.r. results. The SC, FCC, SAND, and TOPO curves rae the NHL-structure results, as reported in the paper. In addition, the SAND-OTT-structure and TOPO-OTT structure are reported in this plot. The TOPO-OTT and SAND-OTT curves are obtained by fixing the s.r. of one of the two unit cells and by changing the s.r. value of the other one, as reported in the figure. As we can see the variable s.r. allows one to improve the performances with respect to the reference structure.

Figure S4 shows that having a different *s.r.* characterizing the bending- and the stretching-dominated structures can actually improve the performance. However, the trends are different for the SAND-OTT and the TOPO-OTT. In the former, the optimum is reached by fixing the SC *s.r.* at the maximum value, while the FCC *s.r.* has an intermediate value. For the latter, the better performances are obtained fixing the FCC *s.r.* and varying the SC *s.r.*. Also, for the TOPO-OTT we could improve the performance at low *s.r.* value, and at best matching the performances for *s.r.* =0.45. The different trend might be due to the different failure mode of the structures. In fact, it can be supposed that the SAND-structure should fail due to buckling within the core, thus making the SC struts thicker rise the critical buckling load, improving the overall structure performance. While in the TOPO-structure the load is already distribute through the FCC due to the topological optimization, so lightening the SC does not change the structure stiffness, but reduces its weight improving the *s.t.w.* at low *s.r.*.