Article:

Pham, M.-S., Liu, C., Todd, I. orcid.org/0000-0003-0217-1658 et al. (1 more author) (2019) Damage-tolerant architected materials inspired by crystal microstructure. Nature, 565 (7739). pp. 305-311. ISSN 0028-0836

https://doi.org/10.1038/s41586-018-0850-3

	Tensile modulus (MPa)	Tensile strength (MPa)	Elongation (%)
Ductile PLA *	3,310	110	160
Resin *	1,000 - 1,600	37 - 47	7 - 16
Natural FLEX 45 *	95	24	530
316L **	185,000 – 200,000	585	40 - 50

Table E1: Mechanical properties of printed polymers. * data provided by RS Limited and 3D Systems Limited. ** data obtained from 3 tensile tests of solid cylindrical samples (fabricated by powder-bed selective laser fusion) at room temperature and a strain rate of 10^{-3} 1/s).

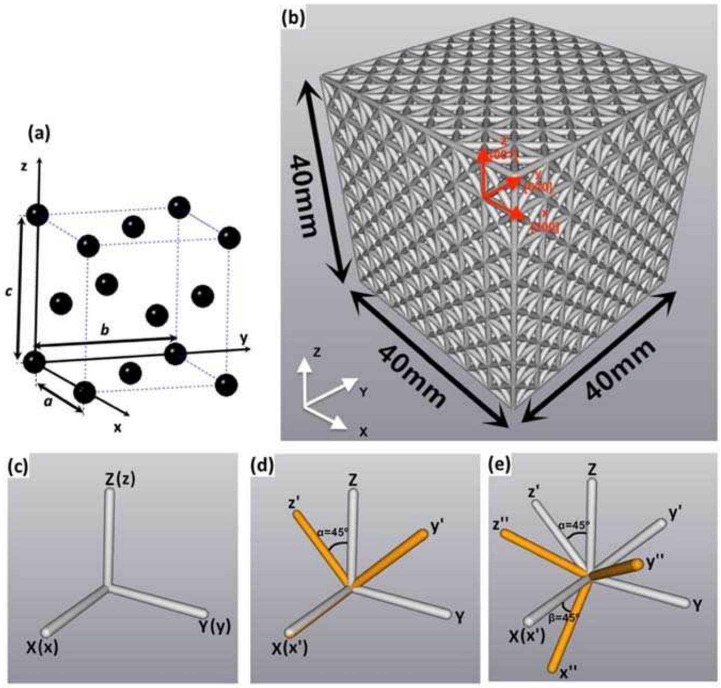

Figure E1: Mimicry of crystal lattice. (a) Unit cell of lattice, (b) A macro-lattice cube consisting of 8 x 8 x 8 macro-unit cells. (c) – (e) The rotation sequence to form a twin meta-grain of lattice.

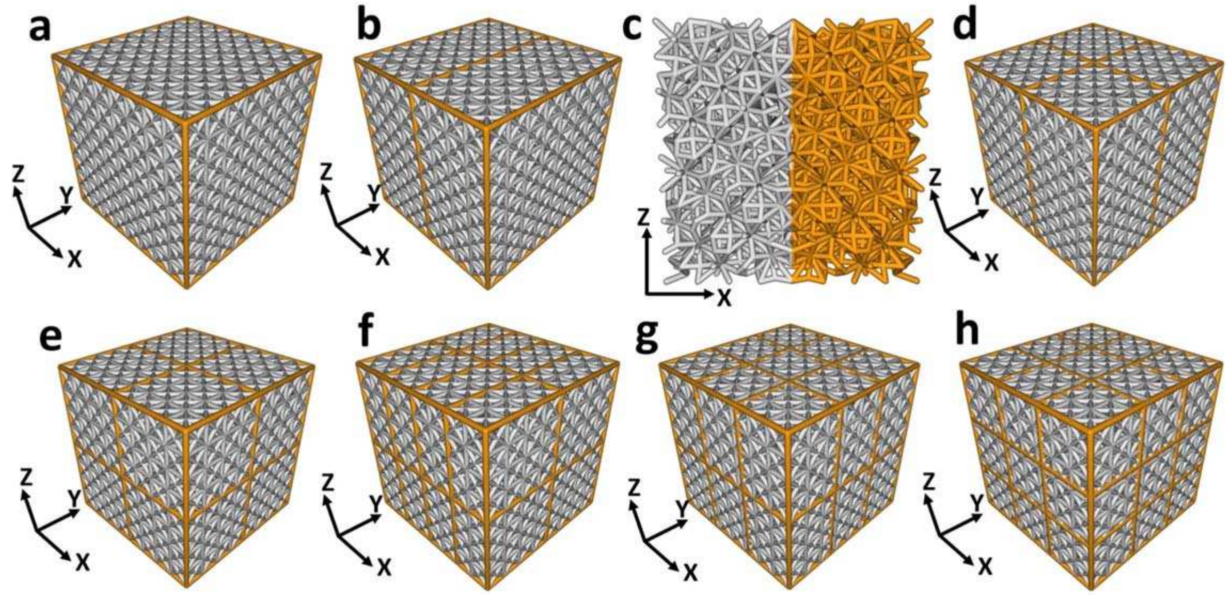

Figure E2: A different number of meta-grains within the same global volume (40mm x 40mm x 40mm). (a) 1 meta-grain, (b)-(c) 2 twinned meta-grains: (b) with outer frame and (c) without the outer frame, (d) 4 meta-grains, (e) 8 meta-grains, (f) 16 meta-grains, (g) 18 meta-grains and (e) 27 meta-grains. The locations of boundaries were highlighted.

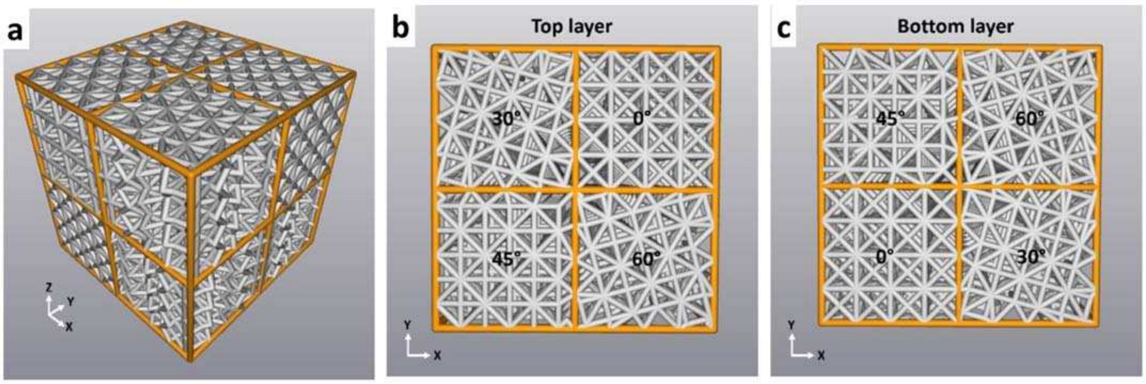

Figure E3: Mimicry of crystallie grains seperated by incoherent high angle boundaries. (a) Model of 8 meta-grains. The orientations of lattices in the four meta-grains in (b) the top layer and (c) the bottom layer

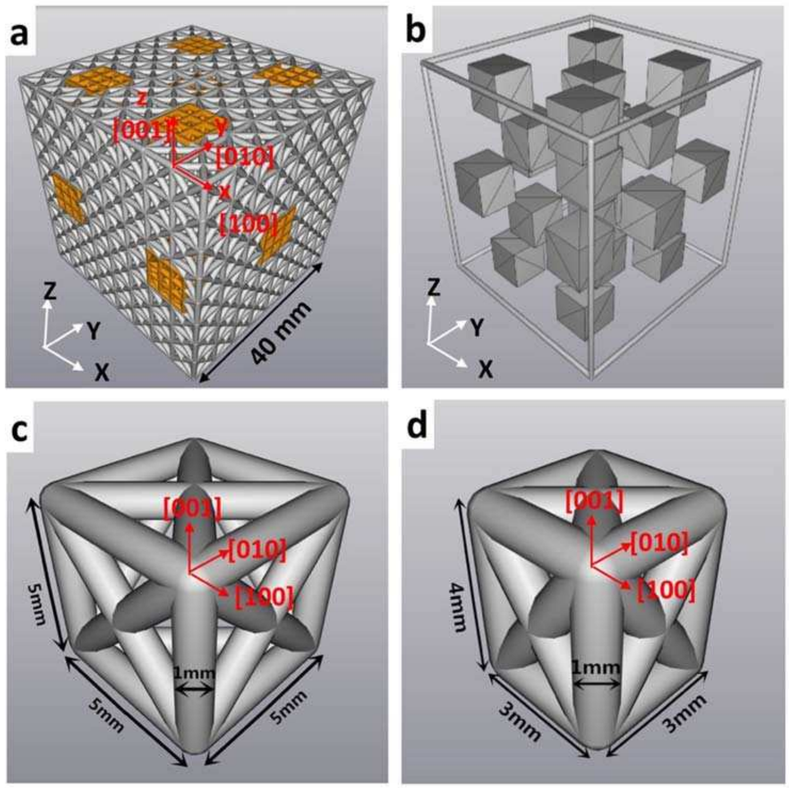

Figure E4: Mimicry of precipitates. (a) Meta-precipitate lattice. (b) Cubic morphology and locations of meta-precipitates inside the FCC meta-phase. (c) FCC unit cell of the matrix and (d) FCT unit cell of meta-precipitate.

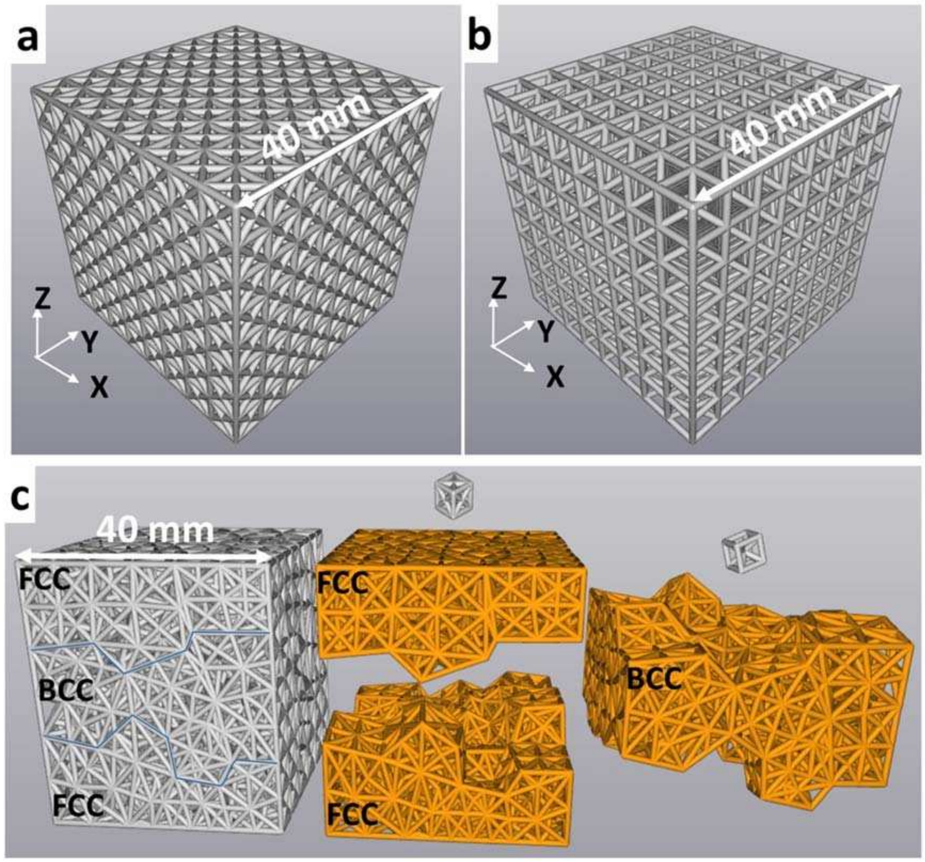

Figure E5: Mimicry of multi-phases. (a) Single meta-grain of FCC meta-phase, (b) Single meta-grain of BCC meta-phase, (c) A cube of meta-polygrains consisting of two meta-phases: FCC (top and bottom layers) and BCC (middle layer).

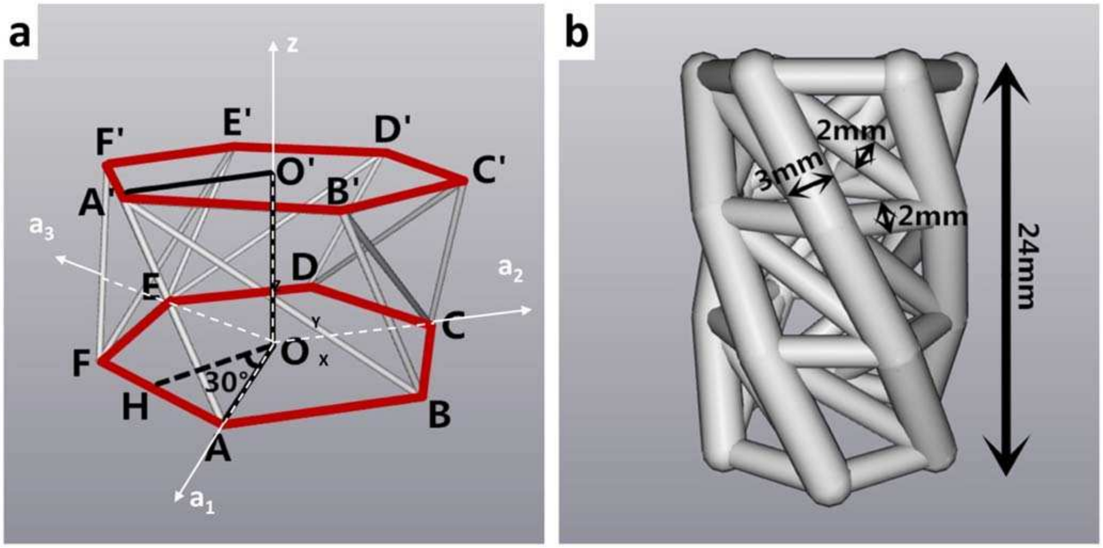

Figure E6: Kresling lattice. (a) unit cell, (b) HCP meta-phase

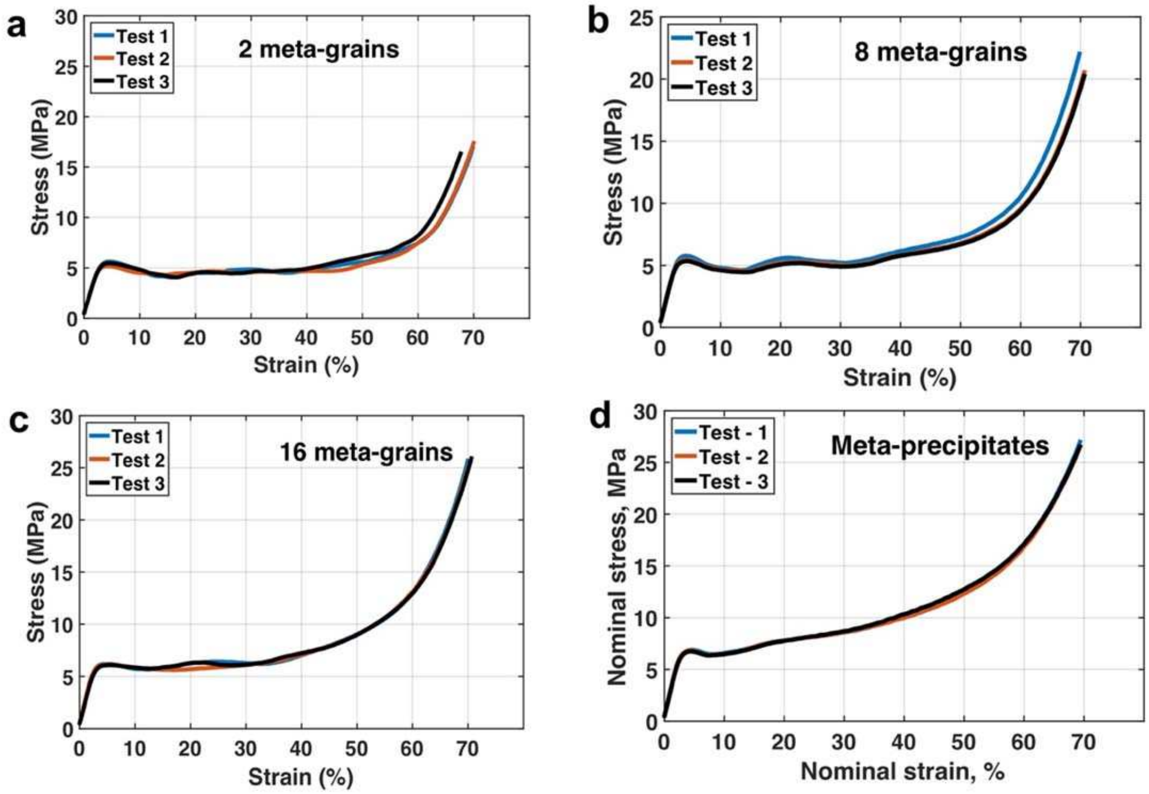

Figure E7: The repeatibility of mechanical behaviour of architectured materials. (a), (b) and (c) materials consist of 2, 8 and 16 meta-grains, respectively; and (d) materials contain 25 meta-precipitates.

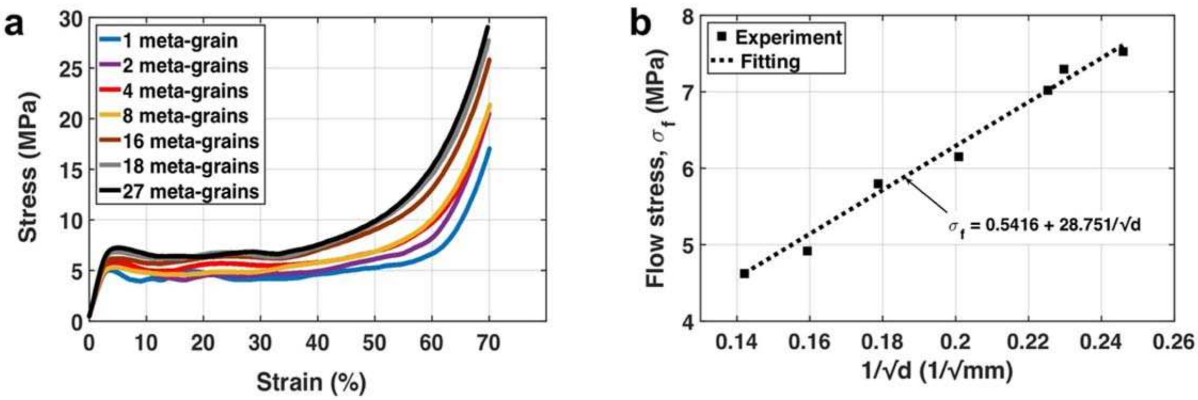

Figure E8: Effect of the size of meta-grains. (a) Stress-strain curves of architectured materials consisting a different number of Voronoi domains of lattices. (b) Flow stress of architectured materials containing meta-grains at a given nominal strain of 40% increases with reducing the size of meta-grains.

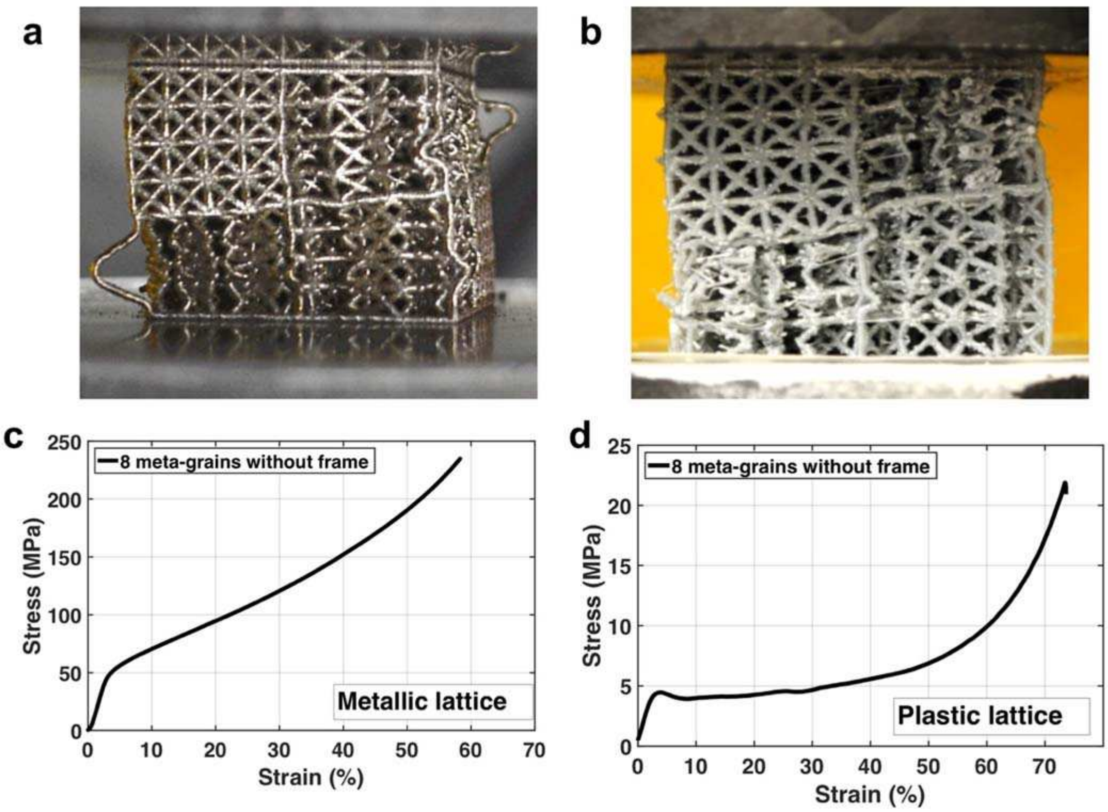

Figure E9: Deformation behaviours of an architectured material containing 8 meta-grains separated by incoherent high angle boundaries. (a) and (b) the macro-lattice was fabricated by 316L stainless steel and elasto-plastic polymer, respectively. (c) and (d) stress-strain constitutive behaviour of the macro-lattices fabricated by the steel and polymer.

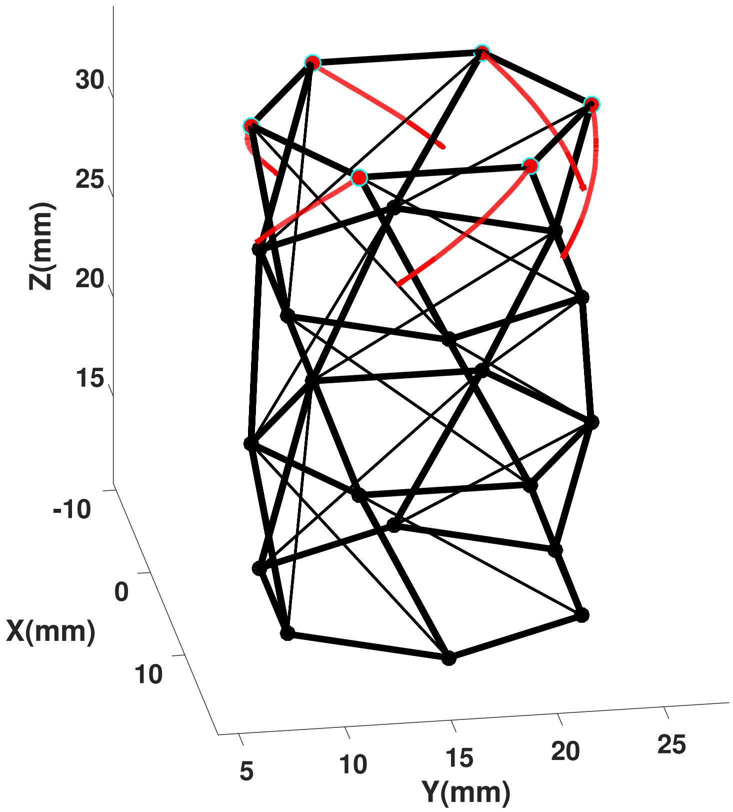

Figure E10: Helical movement enables the change in the stack sequence of nodes. Red lines represent helical movements of basal nodes. Note: only the movement trajectory of basal nodes on the top plane were shown by the red curves.