



This is a repository copy of *Damage-tolerant architected materials inspired by crystal microstructure*.

White Rose Research Online URL for this paper:
<http://eprints.whiterose.ac.uk/141436/>

Version: Supplemental Material

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>

© 2019 Springer Nature Limited. This is an author produced version of a paper subsequently published in *Nature*. Uploaded in accordance with the publisher's self-archiving policy.

Reuse

Items deposited in White Rose Research Online are protected by copyright, with all rights reserved unless indicated otherwise. They may be downloaded and/or printed for private study, or other acts as permitted by national copyright laws. The publisher or other rights holders may allow further reproduction and re-use of the full text version. This is indicated by the licence information on the White Rose Research Online record for the item.

Takedown

If you consider content in White Rose Research Online to be in breach of UK law, please notify us by emailing eprints@whiterose.ac.uk including the URL of the record and the reason for the withdrawal request.



eprints@whiterose.ac.uk
<https://eprints.whiterose.ac.uk/>

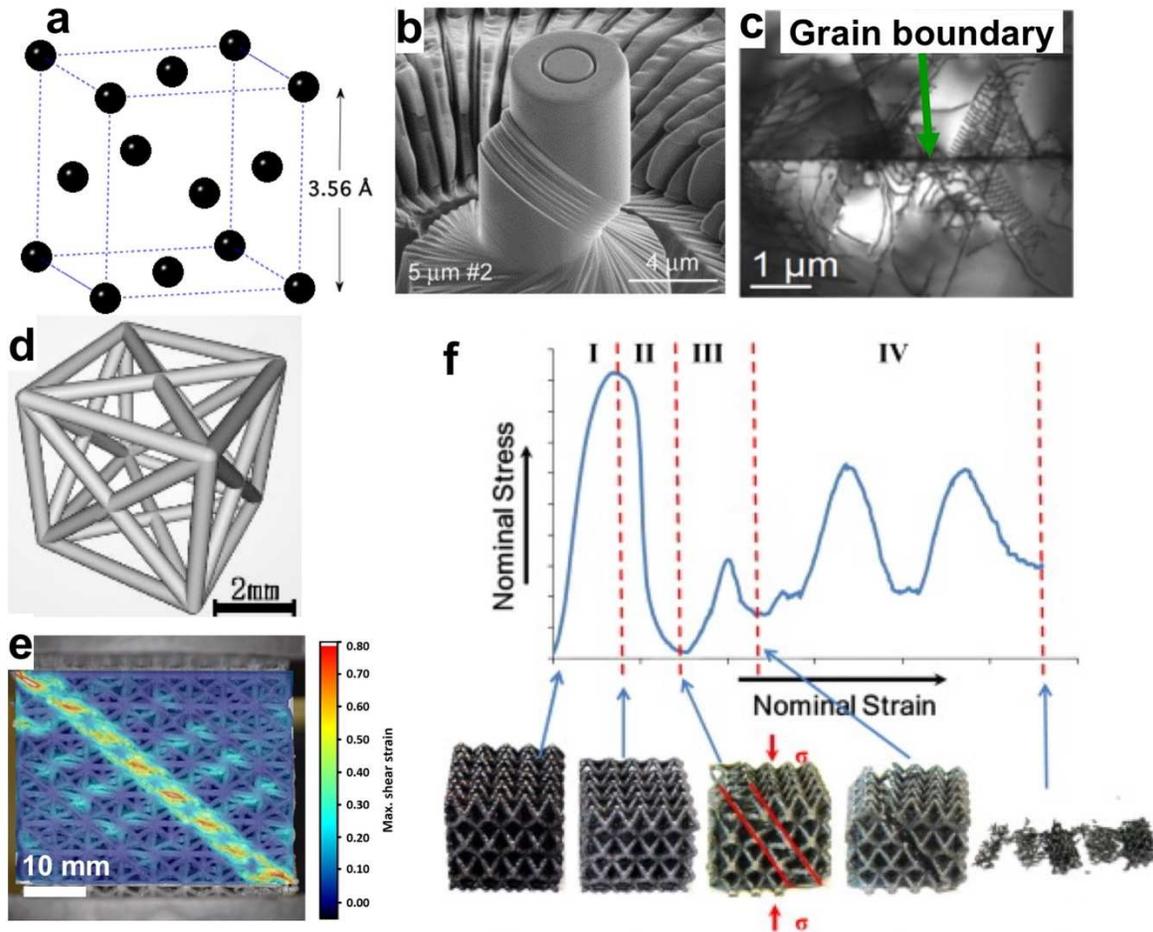


Figure 1: Lattice structures and deformation behaviour. (a) Face-centred-cubic (FCC) crystal lattice, (b) Single slips in a single crystal (re-used from ⁸ with permission from Elsevier), (c) Slips at grain boundary in a polycrystalline steel (re-used from ⁹ with permission from Elsevier), (d) Architected FCC lattice, (e) Single slip in a single oriented lattice, (f) Unstable behaviour of architected metallic lattices (reused from ¹⁰ under the Creative Commons Attribution 4.0 International License).

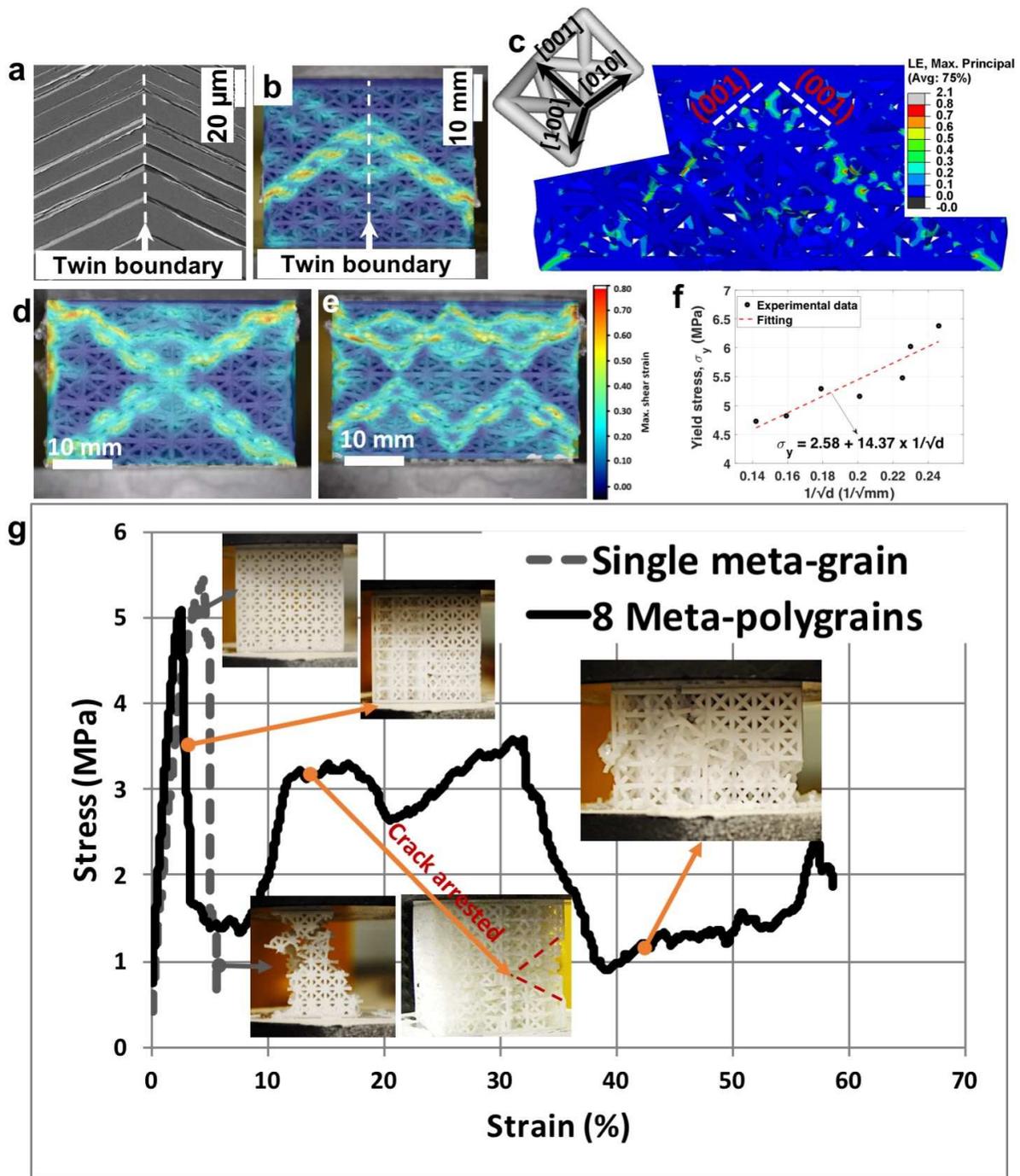


Figure 2: Roles of lattice orientation in the deformation behaviour of crystals and architected lattices. (a) Twin bi-crystal (re-used from²⁷ with permission from Elsevier), Shear bands in meta-grain twins observed in experiment (b) and predicted by FEM (c) (Note: Cut sections shows the deformation of internal struts. The sections were formed thanks to two cutting planes that were parallel to {001} planes of FCC lattice), (d) – (e): Shear bands were controlled by orientation of meta-grains: (d) 8 meta-grains and (e) 16 meta-grains (note the nominal strain was of 30%). (f) Yield strength versus the size of meta-grains, (g) Boundaries between meta-grains effectively stops cracks in brittle lattices, leading to a drastic increase in toughness of architected materials.

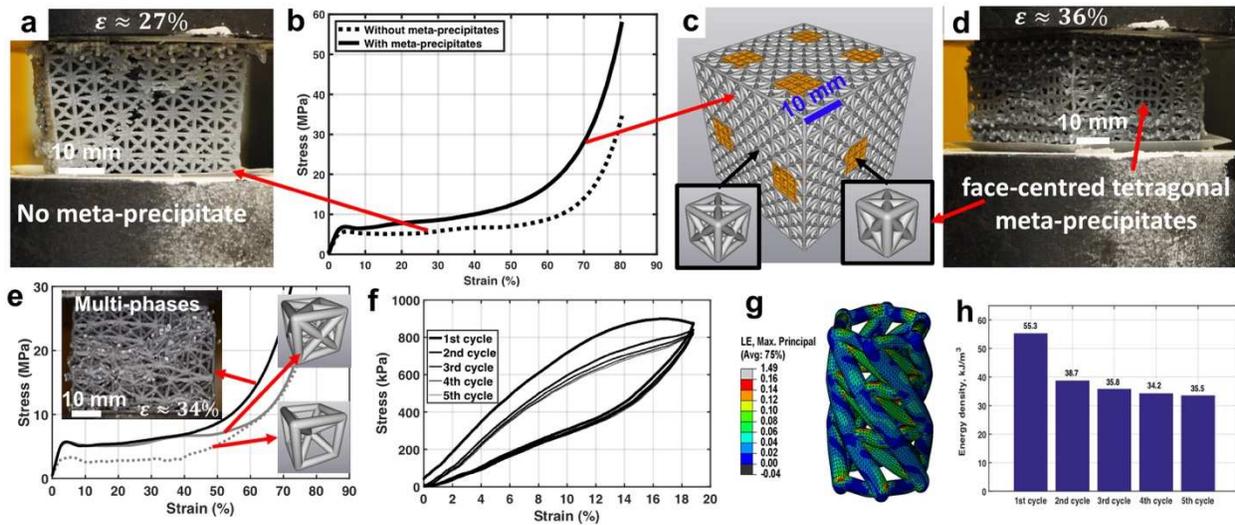


Figure 3: Precipitation and multiphase hardening in architected materials. (a) A single oriented without meta-precipitates. (b) Constitutive stress-strain responses of architected materials without meta-precipitates (a) and with meta-precipitates (c, d). (e) Mechanical behaviour of single phase versus multiphase architected materials. (f) Pseudo-superelasticity of Kresling lattice, (g) FEM simulation shows the strain localisation and local buckling of struts, and (h) Energy per unit volume of the first five cycles.

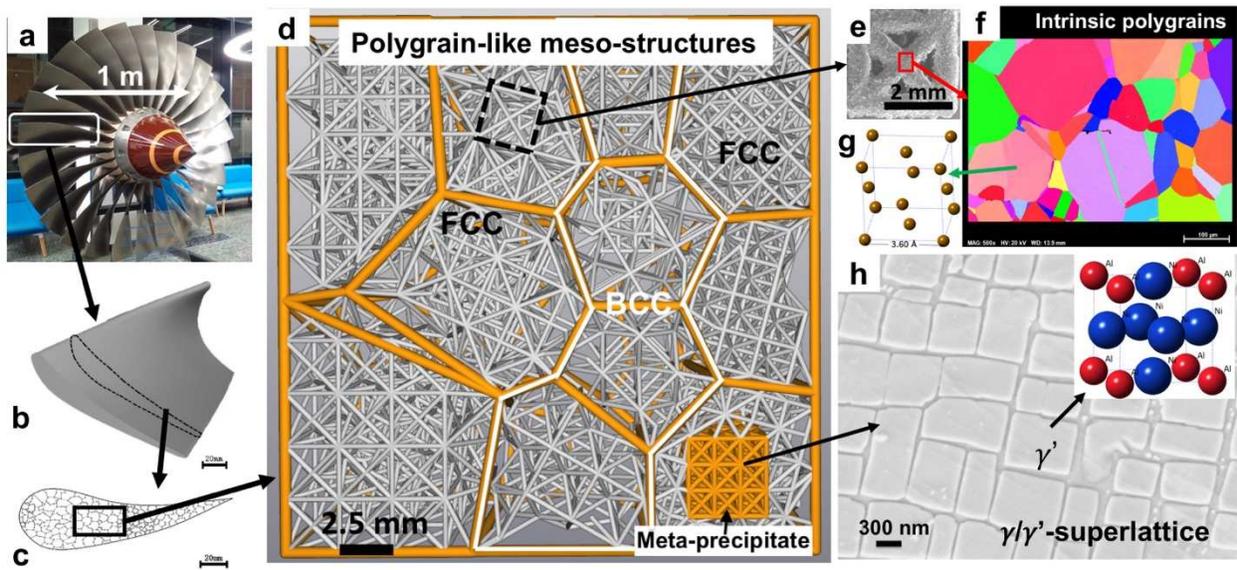


Figure 4: Lightweight and damage-tolerant architected materials inspired by crystal microstructure. (a)-(d) Lightweight lattice component. (e)-(g) FCC fractal lattices from atomic up to cm scales, (h) γ/γ' scalable fractal super-lattices.