University of Bristol — Bristol Composites Institute (ACCIS)

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HiPerDuCT Programme Grant

Final report: Ductile Superlattice Nanoparticle Matrices

Ductility via Dislocation-based Deformation in an Ordered Supercrystal Matrix

In a metal, dislocations allow high levels of deformation and require significant atomic ordering but suffer from high densities. A similar but lightweight approach is the use of metal oxide nanoparticles coated with ligands. These structures are expected to yield under high shear forces whilst exhibiting high strength. To further improve the ductility (as well as allowing self-healing) of these materials, cross-linking is performed with a unit containing a central disulphide bond, which easily opens and closes.

Metal-oxide nanoparticles were synthesised and cross-linked to produce a composite then tested using a nanoindentator, and the indentation properties compared to a standard epoxy resin. The metal-oxide superlattice showed a similar mechanical response in terms of stiffness and strength compared to epoxy, however it is capable of significantly more plastic deformation, with plasticities of >0.80 and 0.41 respectively. Metal-oxide composites which fail with a truly plastic deformation similar to metals is a new class of materials that can potentially compete with commercially available materials that exhibit high strength and stiffness.

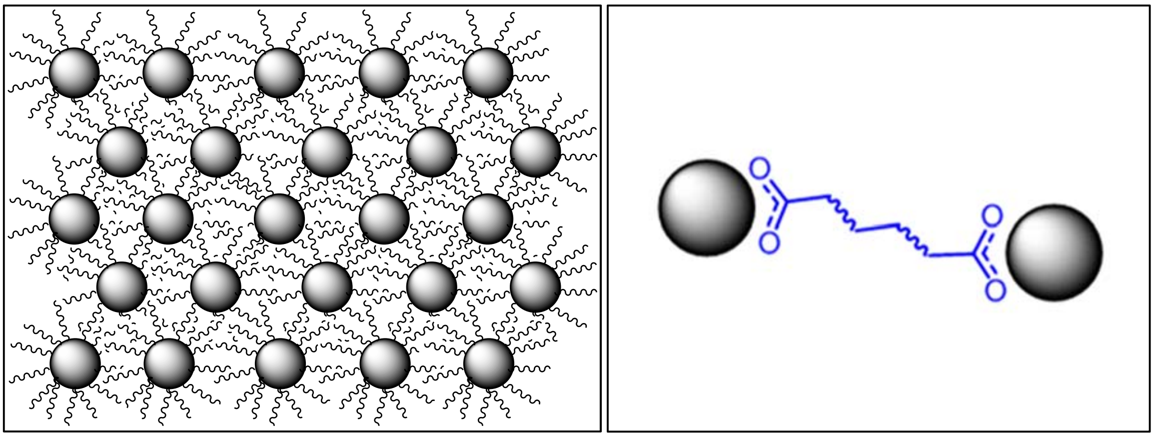
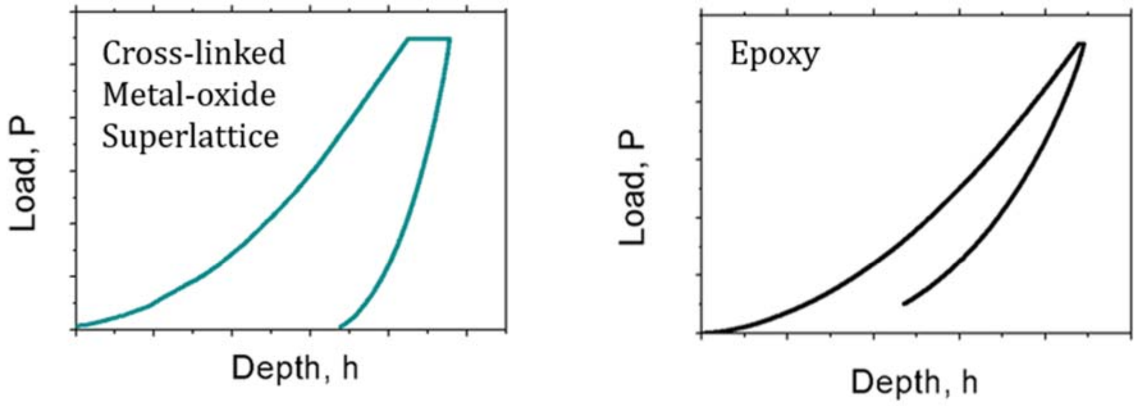


Figure 1. (a)**:** Schematic of ligand-coated nanoparticle superlattice. (b): Schematic of cross-linked metal-oxide nanoparticles with central disulphide bond.



Sample	Elastic modulus	Hardness	Plasticity
Epoxy	3.66 GPa	0.36 GPa	0.41
Superlattice	4.18 GPa	0.16 GPa	> 0.80

Figure 2. Comparison of an epoxy with the cross-linked metal-oxide superlattices.