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Applying ultra-high shear strains to aluminium-graphene composites to achieve an exceptional strength-ductility combination

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High-pressure torsion (HPT) can introduce large shear strains to refine the grain structure in metallic materials and make the reinforcements redistribute within the metal matrix through the flow of turbulent eddy currents. Aluminium-graphene composites with 5% graphene nanoplates (GNPs) as reinforcement were successfully processed at room temperature to 20 turns with significant microstructure refinement and hardness improvement. Agglomerated GNPs were fragmented during HPT processing and tended to become more dispersed in the aluminium matrix. The composites display excellent tensile strength (345 MPa) and very limited ductility (1.6%).

Further HPT processing to 100 turns on the aluminium-graphene composites showed that the materials achieve not only higher strength (more than 405 MPa) but also excellent elongation (15.5%). There was no post-HPT heat treatment applied to the tensile specimens of 100 turns aluminium-graphene composites. The extra-large shear strains applied on aluminium-graphene composites through HPT processing produced an exceptional strength-ductility combination.

Keywords: graphene-aluminium composites, high-pressure torsion, strength-ductility relationship