The manufacturing of graphene-reinforced nanocomposites using severe plastic deformation technique

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ABSTRACT

The conventional metal matrix composites are either manufactured by liquid method (e.g. casting) or powder metallurgy method (e.g. sintering). The liquid processing methods usually produces agglomerated particles in the ductile metal matrix due to the large density difference between graphene and the metal matrix which leads to an unwanted brittle nature. The powder metallurgy method would cause oxidation of the metal matrix and produce unclean interfaces between the particulates and the matrix leading to a weak bonding and consequent low mechanical strength. In addition, both liquid and powder methods will not generate a matrix with ultrafine-grained structure due to casting structure from liquid method and unexpected grain growth in the matrix during high temperature sintering.

High-pressure torsion (HPT), as a new severe plastic deformation technique, can introduce severe shear strain to refine the grain structure in metallic materials and make the reinforcements redistribute within the metal matrix through the flow of turbulent eddy currents. The most important thing is HPT can easily process materials at room temperature without introducing cracks, and can avoid all disadvantages from high temperature processing. Through HPT processing we can attain the real meaning of graphene-reinforced nanocomposites with graphene acting as nano-additives and the metal matrix having nanocrystalline grain structure.

We have successfully developed a room temperature route combined with HPT to manufacture graphene-reinforced aluminium-based nanocomposites with improved dispersion of graphene in aluminium matrix and ultrafine-grained structure in aluminium matrix. The synthesized graphene-Al nanocomposites have improved mechanical strength compared to commercial purity Al.