

Friction stir processing - an effective tool for fabricating high-property nano-carbon reinforced aluminum alloy composites

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Abstract

Nano-carbon reinforcements (including two-dimensional graphene and one-dimensional carbon nanotube (CNT)) with extremely high strength and modulus have been considered as ideal reinforcements for high-performance composites. However, it is extremely difficult to uniformly disperse nano-carbon reinforcements into metal matrices because of large specific surface area. In this study, a new dispersion method – friction stir processing (FSP) was developed to fabricate graphene nanoplatelets reinforced 2009Al (GNP/2009Al) composites and CNT/2009Al composites. As FSP pass increased, the dimension of the nano-carbon reinforcements decreased and meanwhile, the clustering of nano-carbon reinforcement reduced significantly. It is found that the reciprocal of the nano-carbon reinforcement dimension had an approximately linear relationship with the FSP passes, and a model was proposed to describe the reinforcement dimension evolution during mechanical effect.

Uniformly dispersed GNPs and CNTs for GNP/2009Al and CNT/2009Al composites were respectively achieved after 2 and 3 FSP passes. Microstructure observing indicates that, for either the 2-pass FSP GNP/2009Al or the 3-pass FSP CNT/2009Al, the layered structure of GNPs and the tube structure of CNTs were well retained. Also, most of the carbon-Al interfaces were clean and well bonded. Tensile tests demonstrate that nano-carbon reinforcement addition led to significantly increased strength. GNP/2009Al showed a higher strengthening efficiency (~25) compared with that of the CNT/2009Al (~16). A strength calculation based on load transfer indicates that the high efficiency strengthening of the GNP/2009Al composite is attributed to much high effective interfacial area of GNPs.