"Mechanisms of plastic deformation of magnesium matrix nanocomposites developed by friction stir processing"

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Abstract

Magnesium based composites have attracted much attention over the past few years as a promising solution to lightweighting, energy saving and emission reduction, especially for automotive and aerospace applications. With a specific weight as low as 1.74 g.cm-3, magnesium is the lightest of all structural metals. However, the strength of Mg needs to be improved in order to compete with other light metals such as Al or Ti alloys. The study focuses on Mg reinforced by Y2O3 nanoparticles. The aim of the work is to investigate the typical plastic behavior of Mg single crystal strengthened by oxide dispersed particles. One challenge is to elaborate samples with a homogeneous distribution of particles. First, yttrium oxide reinforced magnesium matrix nanocomposites were prepared by Friction Stir Processing (FSP). This technique shows to be an efficient method to elaborate metal-based composites. As shown in Fig.1(a), the initial 3 µm particles were milled during the process and their size ...

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Mechanisms of plastic deformation of magnesium matrix nanocomposites developed by friction stir processing

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Magnesium based composites have attracted much attention over the past few years as a promising solution to lightweighting, energy saving and emission reduction, especially for automotive and aerospace applications. With a specific weight as low as 1.74 g.cm^{-3}, magnesium is the lightest of all structural metals. However, the strength of Mg needs to be improved in order to compete with other light metals such as Al or Ti alloys. The study focuses on Mg reinforced by Y_2O_3 nanoparticles. The aim of the work is to investigate the typical plastic behavior of Mg single crystal strengthened by oxide dispersed particles. One challenge is to elaborate samples with a homogeneous distribution of particles.

First, yttrium oxide reinforced magnesium matrix nanocomposites were prepared by Friction Stir Processing (FSP). This technique shows to be an efficient method to elaborate metal-based composites. As shown in Fig.1(a), the initial 3 µm particles were milled during the process and their size was reduced to few hundreds of nanometers. The three-dimensional dispersion was confirmed by nano-holotomography.

A subsequent heat treatment was performed to enable abnormal grain growth. Microcolumns were machined inside a single grain using Focus Ion Beam (Fig.1(b)). Microcompression experiments were then conducted (Fig. 1(c-d)) to obtain the stress-strain response for different single crystal orientations.

Three-dimensional discrete dislocation dynamics (3D DDD) simulations were compared with the experimental results. The simulations provide relevant insights on the role of nanoparticles on the onset of plastic deformation as well as twinning nucleation in Mg nanocomposites.

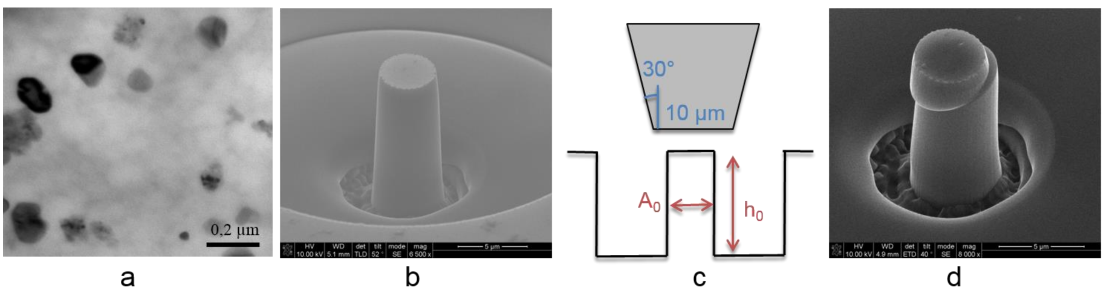

Figure 1 - TEM micrograph showing the size of the Y2O3 particles in the FSPed sample (b). SEM micrographs of the columns prior to (b) and after microcompression (d). Shcematic drawsing of the microcompression test (c).