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In-Situ TEM Studies of Deformation Mechanisms in Nanograined Al Strengthened with Al_2O_3 Nanoparticles

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Nanograined metals have emerged in the last decade as an exceptional class of materials with a significant increase in strength over their bulk counterparts, but with an unfavorable loss of ductility. Recently several studies have identified nanoparticle addition as a potential route for optimizing mechanical properties [1, 2]. However, while nanoparticle-strengthened nanograined metals are of interest for a wide range of systems and applications [3, 4-7], and while efforts have been made to understand the origin of their properties [8], a direct correlation of their deformation mechanisms with measured material properties has not been established.

In order to probe the deformation mechanisms responsible for improved ductility in nanoparticle-strengthened nanograined metals, in-situ TEM straining experiments have been performed on nanograined Al thin films strengthened with Al_2O_3 nanoparticles. Using pulsed-laser deposition and subsequent annealing, an array of films with variation in grain size, particle size, and particle volume fraction were produced. Through observation of deformation mechanisms in-situ in the TEM, direct correlations between the starting microstructures and the resulting qualitative behavior have been established. In addition, mechanical testing on Al_2O_3 films provides complimentary quantitative information concerning the ductility and toughness [9].

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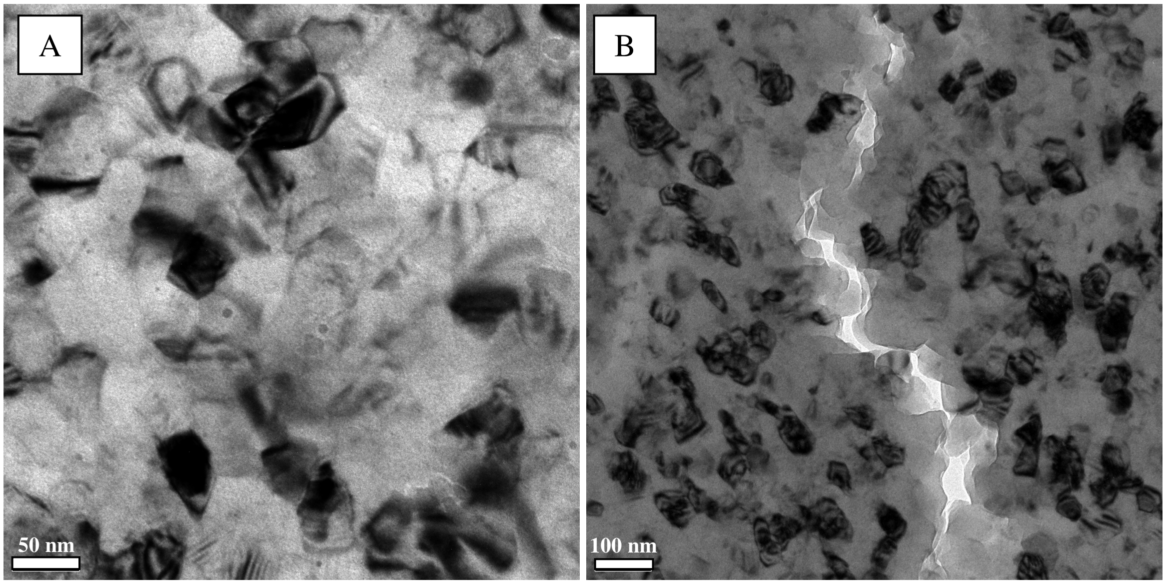

FIG. 1. Results from a nanograined, pulsed-laser deposited Al film with 1 vol% Al_2O_3 nanoparticles. (a) Initial microstructure, and (b) crack path during in-situ TEM tensile deformation.

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