Zhang, F., Huang, Y., Hwang, K., Qu, S., and Liu, C., Three-Dimensional Strain Gradient Plasticity Analysis of Particle Size Effect in Composite Materials, Materials and Manufacturing Processes, 22, no. 2, 2007, pp. 140-148

Abstract

Recent experiments on particle-reinforced metal-matrix composite materials have shown particle size effects. Small particles tend to give larger plastic work hardening than large particles at the same particle volume fraction. Prior models used to study the particle size effect are based on the strain gradient plasticity theories, and these models are mainly axisymmetric models with vanishing lateral stress tractions in order to represent the uniaxial tension condition. However, the prior results fall short to agree with the experimental data. A three-dimensional (3D) unit-cell model is adopted in the present study. The periodic boundary conditions are imposed for the 3D unit cell to ensure the compatibility of the unit cell before and after the deformation. The particles are elastic, while the metal matrix is elastic-plastic and is characterized by the conventional theory of mechanism-based strain gradient plasticity, which is established from the Taylor dislocation model but does not involve the higher-order stress. It is shown that the 3D unit-cell model with the periodic boundary conditions gives better agreements with the experimental data than the unit-cell model with the traction-free boundary conditions on the lateral surfaces.

Keywords

Composite material, FEM, Strain gradient, Three-dimension