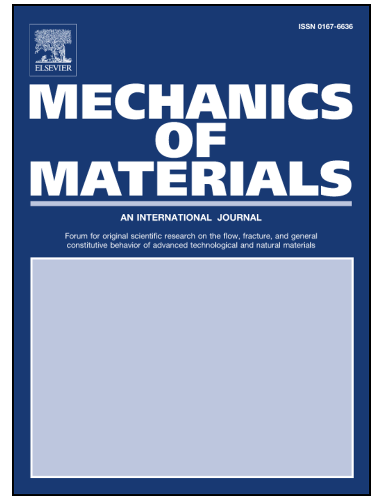

Representation of a Microstructure with Bimodal Grain Size Distribution through Crystal Plasticity and Cohesive Interface Modeling

Andrew C. Magee, Leila Ladani

PII: S0167-6636(14)00215-4
DOI: http://dx.doi.org/10.1016/j.mechmat.2014.12.002
Reference: MECMAT 2343

To appear in: *Mechanics of Materials*

Received Date: 22 July 2014
Revised Date: 2 December 2014

Representation of a Microstructure with Bimodal Grain Size Distribution through Crystal Plasticity and Cohesive Interface Modeling

Andrew C. Magee and Leila Ladani

University of Connecticut

Abstract

The microscale loading effects in a bimodal Al 5083 microstructure are examined through finite element modeling. A crystal plasticity model is adapted to this problem and its parameters are derived from the material properties of pure Al through representation as the additive combination of effects attributable to grain size and solute strengthening. This model is used in conjunction with a cohesive interface grain boundary description. Large scale and microscale finite element models are procedurally generated and used in a multiscale model fitting process to extract the necessary properties of conventional (coarse grained) and ultrafine grained Al 5083. The results of these simulations show large strain concentrations between closely spaced coarse grains, highlighting the activity of these areas in the final failure behavior of the material. At the microstructural level, individual grains oriented in more compliant configurations are observed to experience high strains, which place stresses on adjacent grains. These results suggest a competition between inter- and intragranular fracture mechanisms.

1. Introduction

There has been recent interest in metals with bimodal grain size distributions owing to their improved strength resulting from grain size refinement. The microstructures of these materials consist of two phases, differentiated by grain size. The ultrafine grains (UFGs) provide strength through Hall-Petch mechanisms; coarse grains (CGs) improve the overall ductility of the composite, which is otherwise quite limited [1–3]. At the grain level, the properties of the two phases are dramatically different. The UFGs are much stronger and harder than the CGs. This leads to complex stress and strain contours in the microstructure, complicating the deformation and failure behavior of the material. Bimodal microstructures have been utilized for many material systems, but Al-Mg is a commonly studied one. This work is based on experimental data collected in uniaxial tensile tests of 10% CG (by volume) Al 5083. These specimens were