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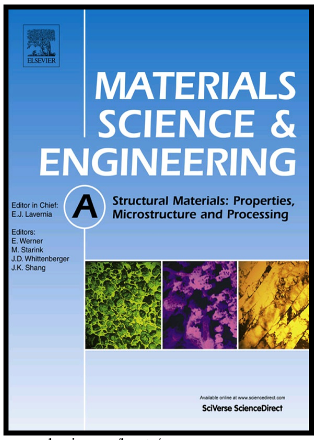

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Discrete dislocation plasticity analysis of the high-temperature cyclic response of composites

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Abstract

Discrete dislocation plasticity (DDP) analysis of the high-temperature cyclic deformation of two-phase composites comprising a plastic matrix and elastic precipitates is presented. Deformation of the matrix is by climb-assisted glide of dislocations while the precipitates deform by a combination of bulk elasticity and stress-driven interfacial diffusion. The DDP calculations predict a cyclically softening response due to the formation of dislocation cell structures within the matrix. The dislocation cell sizes decrease with decreasing size of the unit cell (or equivalently matrix channels) and this results in an increased cyclic softening rate in composites with smaller unit cells. Interfacial diffusion also enhances the formation of dislocation cell structures and thereby promotes cyclic softening. These results are consistent with predictions of the creep behaviour that indicate that the increase in the creep rate (i.e. tertiary creep) is also associated with the formation of dislocation cell structures within the matrix.

Keywords: High-temperature composite, cyclic loading, interfacial diffusion, discrete dislocation plasticity, size effects

1. Introduction

Nickel-based superalloys typically consist of a γ plastic matrix strengthened by over 50 vol.% of γ' elastic precipitates. These composites often exhibit stress softening during low cycle fatigue (LCF) at temperatures above ~ 700°C [1, 2, 3]. This softening has been qualitatively associated with two critical micro-structural changes [4, 5]: (i) formation of

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