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Coupled glide-climb diffusion-enhanced crystal plasticity

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Abstract

This paper presents a fully coupled glide-climb crystal plasticity model, whereby climb is controlled by the diffusion of vacancies. An extended strain gradient crystal plasticity model is therefore proposed, which incorporates the climbing of dislocations in the governing transport equations. A global-local approach is adopted to separate the scales and assess the influence of local diffusion on the global plasticity problem. The kinematics of the crystal plasticity model is enriched by incorporating the climb kinematics in the crystallographic split of the plastic strain rate tensor. The potential of the fully coupled theory is illustrated by means of two single slip examples that illustrate the interaction between glide and climb in either bypassing a precipitate or destroying a dislocation pile-up.

Keywords: crystal plasticity, dislocation climb, vacancy diffusion, dislocation pile-ups, strain gradient

1. Introduction

Many metallic systems are nowadays operated in a regime where the evolving mechanical properties do not just depend on dislocation glide mechanisms within the underlying crystals. This is typically the case for climb-

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