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Effect of Interfacial Dislocation Networks on the Evolution of Matrix Dislocations in Nickel-Based Superalloy

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Abstract: The discrete-continue model (DCM) combining the three dimensional discrete dislocation dynamics (DDD) and finite element method (FEM) is employed to investigate the influence of interfacial dislocation networks (IDNs) and lattice mismatch on the dynamics evolution of dislocations in the matrix channel of the single crystalline Nickel-bases superalloys (SCNBSs). For a given slip plane, the matrix dislocations with all three possible Burgers vectors are considered. For comparison, the critical resolved shear stresses (CRSSs) for matrix dislocation entering and freely gliding in the channel are calculated for both cases with and without IDNs considered. It is found that the CRSS for free gliding is evidently larger than that for entering the matrix channel, although the latter only considering the Orowan mechanism is generally used to describe the hardening of SCNBSs in the literatures. More importantly, the IDNs not only increase the CRSS for free gliding evidently but also change the matrix dislocations dissociation to a certain extent. The IDNs and lattice mismatch can either promote the dislocation dissociation or has no evident influence on it. Which effect the IDNs take depends on the character of the matrix dislocation. By means of DDD simulations, new CRSS models considering the effects of IDNs, lattice mismatch, matrix dislocation character and dislocation dissociation are suggested. Further, a criterion is also developed to estimate whether the dislocation dissociation can happen or not in the matrix channel with or without IDNs.

Keywords: Nickel-based superalloy; Discrete dislocation dynamics; Discrete-continue method; Interfacial dislocation networks; Critical bowing-out stress

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