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A simplified 2.5D discrete dislocation dynamics framework for simulating the deformation of single crystal nickel base superalloys

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The use of Ni-base superalloys for high temperature applications such as gas turbine engine blades has become widely accepted due to their high strength and creep resistance. In particular, the elimination of grain boundaries in single crystal components confers additional improvement in creep performance in most demanding applications. A “2.5D”discrete dislocation dynamics (DDD) modelling setup (that can be thought of as an extension of the Van der Giessen and Needleman framework [1]) has been used in the present study. Four slip planes characteristic of the FCC crystal structure were considered, and both glide and climb dislocation motion were taken into account in describing the interaction between edge dislocations and γ' cuboidal inclusions. Initial work on the 2.5D dislocation dynamics model has been presented by Gaucherin et al [2], reflecting the lattice orientation effect and succeeding in capturing kinematic and isotropic hardening under cyclic loading. In the present study, this setup has been modified to better fit the problem with single crystal superalloys, where dislocations are squeezed in γ channels. Fig. 1 shows a snapshot of the discrete dislocation arrangement under a remotely applied tensile stress of 300MPa in a unit cell Representative Volume Element (RVE).

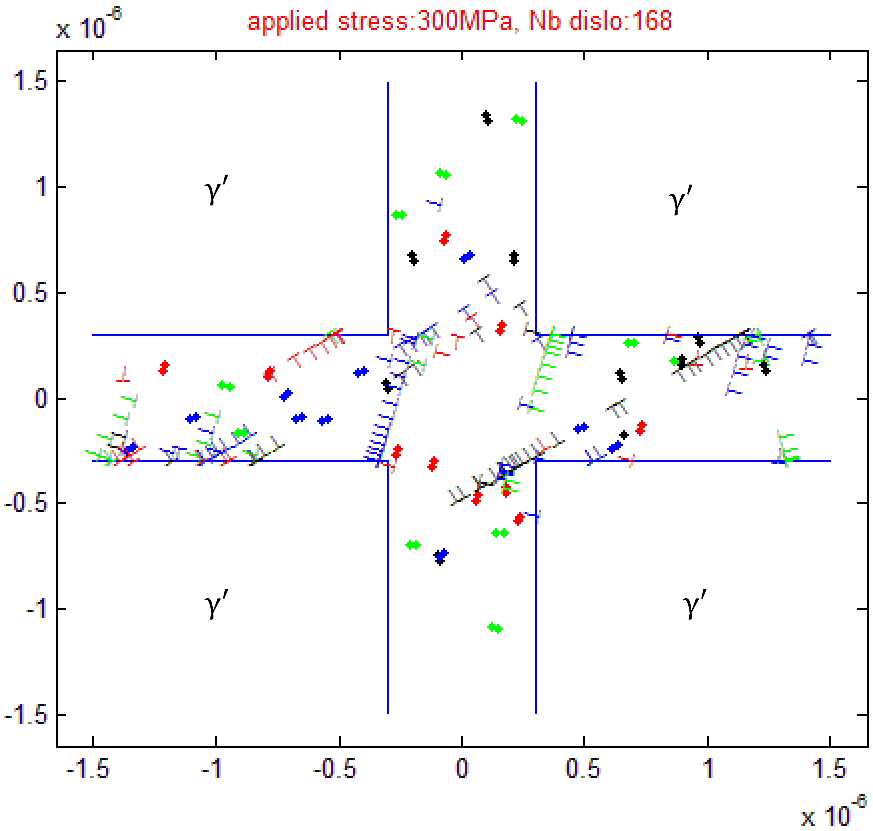

Figure 1: Simulation plane view of the discrete dislocation distribution within the ductile γ-phase under a tensile remote stress of 300Mpa within a unit cell of the single crystal nickel base superalloy. The Frank-Read sources are represented by pairs of dots.

The results of the simulation provide a simplified description of the interaction between glide and climb during the high temperature motion of dislocations within Ni-base superalloys, including dislocation pile-ups in the vicinity of γ/γ′ interface and cyclic strain hardening effects.

REFERENCES

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