SEMINAIRE ROBERVAL

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CRACK INITIATION AND PROPAGATION IN FATIGUED 316L STAINLESS STEELS: A 3D DISCRETE DISLOCATION DYNAMICS INVESTIGATION

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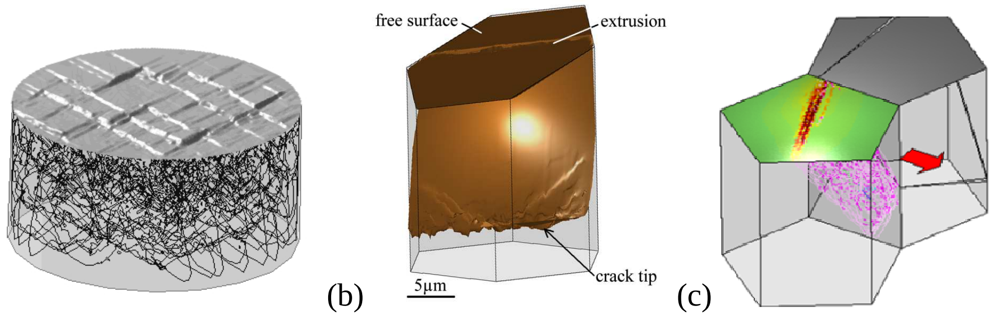

(a) (b) (c)

Figure: 3 types of DD simulations are considered. (a) Crack initiation. (b) Crack propagation in first grain. (c) Crack transmission to the second grain

ABSTRACT

Since in most of metals, crack nucleation and crack growth are intimately related to dislocation plasticity, discrete dislocation dynamics simulation is a very promising numerical tool to address damage mechanics. The recent improvement of 3D discrete dislocation dynamics codes makes it now possible to perform realistic simulations of the intragranular crack propagations.

In this presentation, three types of 3D discrete dislocation dynamics investigations are presented with the goal to better understand fatigue damage in 316L stainless steels.

First, crack initiation mechanisms are investigated in a surface grain cyclically loaded under symmetric plastic strain amplitude. After few cycles, the dislocations organize into a complex 3D microstructure made of persistent slip bands. Extrusions are evidenced at the surface, precisely where the bands are located. Calculations of the elastic energy stored within the simulated grain and the stress tensor inside the simulation box show that the first crack will initiate at the surface, at the bottom of the extrusion.

Secondly, the propagation of a fatigue crack is investigated using the same modeling technics in which a crack is now introduced. The role of the pre-existing slip band on the crack path is analyzed. The magnitude of the crack tip slip displacement is evaluated quantitatively for various distances between the tip and the grain boundary. This shows that grain boundaries systematically amplify the slip dispersion ahead of the crack tip and consequently, slow down the crack growth rate.

Finally, the model is used to study crack transmission from one grain to the next one. Indirect transmission is observed: the second crack initiate from the surface relief developed in the secondary grain. Crack transmission strongly depends on grain disorientation. For instance, a small grain disorientation induces plastic strain localisation ahead of the crack and hence, faster transmission. Conversely, large grain disorientation induces plastic strain spreading (similar to crack tip blunting) and hence, slower indirect transmission.