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Simulation of intragranular plastic strain localisation within irradiated polycrystals

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Dislocation channeling induced by irradiation is very often observed among metallic crystals. It results in severe intragranular strain localization within narrow channels. Predictive models for the macroscopic mechanical behaviour of irradiated polycrystals based on crystal plasticity already exist, but they fail to capture the microscopic localization behavior. Such knowledge of local strain fields is essential to understand irradiation effect at the grain scale on phenomenon such as grain boudary cracking or back-stresses.

In this work we investigate the capacity of local strain-softening crystal plasticity to produce such strain localization bands. An FFT based solver is used to perform high resolution polycristalline simulations. Results exhibit strain localization within crystallographic bands but highlight the limitations of local crystal plasticity : strong mesh dependency and overestimated kink banding. In particular, the formation of slip and kink bands within small deformation and finite strain framework will be discussed.

In order to influence the localization bands pattern, a simple hardening model based on a realistic random irradiation defects distribution is used to perform simulations with an heterogeneous critical resolved shear stress field. Simulations evidence very little influence of this model on mechanical fields, and should not be further investigated to simulate irradiation induced strain localization within the crystal plasticity framework.

Finally a new strategy based on strain gradient crystal plasticity and geometrically prescribed localization to overcome the limitations observed with classical crystal plasticity will be presented.

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