Interface damage modeling in a FFT framework

Luv Sharma*[†], Pratheek Shanthraj[‡] , Franz Roters[‡], Ron Peerlings[†] and Marc Geers[†]

[†] Department of Mechanical Engineering
Technische Universiteit Eindhoven
Postbus 513, 5600 MB, Eindhoven
e-mail: l.sharma@tue.nl

[‡]Microstructure Physics and Alloy Design
Max-Planck Institute for Iron Research
Max-Planck Str. 1, 40237 Duesseldorf, Germany

ABSTRACT

In this work, a method to incorporate interface specific mechanics in a FFT based crystal plasticity framework [1] is presented. The method is developed keeping in mind the application to multiphase polycrystalline materials. In order to capture the full three-dimensional state of stress inside the damaging zone, an interphase band is introduced along the sharp interfaces. This band consists of the material points (also called the Fourier sampling points) in the vicinity of the interfaces. Within this band, the plastic constitutive behavior is inherited from the respective adjacent grains. In addition, to model the anisotropic kinematics of the cracking process, a damage eigen strain is introduced [2,3]. The eigen strain is constructed by appropriately mapping the opening strains (in tangential and normal modes) at the interfacial planes. The driving forces for these openings are the resolved tractions which act against a monotonously degraded resisting force (damage yield surface degradation). The degradation (damage) of the yield surface is modeled via a nonlocal damage variable [4] to avoid localisation of the damage within the band. The extent of nonlocality is chosen so that the damage is more or less uniform in the direction perpendicular to the band. We need to ensure that the model predictions are objective with respect to the band thickness. To this end, we demonstrate the scaling relations of the model parameters, first for a uniform opening case and then for a propagating crack. Finally, an application to a cluster of grains is shown.

REFERENCES

[1] F. Roters, P. Eisenlohr, L. Hantcherli, D.D. Tjahjanto, T.R. Bieler, and D. Raabe, 2010. Overview of constitutive laws, kinematics, homogenization and multiscale methods in crystal plasticity finite-element modeling: Theory, experiments, applications. *Acta Materialia*, *58*(4), pp.1152-1211.

[2] O. Aslan, and S. Forest, 2009. Crack growth modelling in single crystals based on higher order continua. *Computational Materials Science*, *45*(3), pp.756-761.

[3] P. Shanthraj, B. Svendsen, L. Sharma, F. Roters and D. Raabe, 2017. Elasto-viscoplastic phase field modelling of anisotropic cleavage fracture. *Journal of the Mechanics and Physics of Solids*, *99*, pp.19-34.

[4] R. Peerlings, R. de Borst, W. Brekelmans, J. de Vree. Gradient enhanced damage for quasi-brittle materials. International Journal for Numerical Methods in Engineering 39, 3391–3403 (1996).