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Titel: **A fast Fourier Transform based method for mesoscale field dislocation mechanics (MFDM-EVPFFT) - Applications to micro-structural length scale effects in composites and polycrystals**

Abstract

An enhanced crystal plasticity elasto-viscoplastic FFT (Fast Fourier Transform) formulation coupled with a mesoscale continuum dislocation mechanics theory (MFDM) is presented [1,2]. The present numerical approach, named "MFDM-EVPFFT", accounts for plastic flow and hardening from densities of geometrically necessary dislocations (GNDs) in addition to statistically stored dislocations (SSDs). The model also captures GND density evolution through a filtered numerical spectral approach [3], which is here coupled with stress equilibrium through the elasto-viscoplastic FFT method (EVPFFT) [4]. The discrete Fourier transform method together with finite difference schemes is applied to solve both lattice incompatibility problem and Lippmann-Schwinger equation (see [5] and [6] for numerical details). Numerical results are first shown for two-phase laminate composites with plastic single crystal channels and elastic precipitates for both monotonous and reversible shear loadings. A grain size effect is obtained due to the influence of GND densities on the overall and local hardening behaviors [7]. In addition, the role of GND densities on the Bauschinger effect is reported during reversible loadings, where the hardening mechanisms due to piling-up/unpiling-up of GNDs is examined [8]. 3D face-centered cubic (FCC) polycrystals using periodic Voronoï tessellations are considered using different RVEs with various average grain sizes. In comparison with conventional crystal plasticity models, it is shown that GND density accumulations at grain boundaries modify both intra-granular plastic fields and stress profiles, which is at the origin of the grain size effect on the flow stress of polycrystals [9]. Lastly, the MFDM-EVPFFT model is also applied to particle interspacing effects on the mechanical behavior of a Fe-TiB2 metal matrix composite [10].

References

[1] A. Acharya, A. Roy. J. Mech. Phys. Solids 54 (2006) 1687-1710
[2] A. Acharya. J. Elasticity 104 (2011) 23-44
[3] K. S. Djaka, V. Taupin, S. Berbenni, C. Fressengeas, Modell. Simul. Materi. Sci. and Eng. 23 (2015) 065008
[4] R. A. Lebensohn, A. K. Kanjarla, P. Eisenlohr, Int. J. Plast. 32-33 (2012) 59-69.
[5] F. Willot, C. Rendus Mecanique 343 (2015) 232-245
[6] K. S. Djaka, A. Villani, V. Taupin, L. Capolungo, S. Berbenni, Comp. Appl. Mech. Eng. 315 (2017) 921-942
[7] K. S. Djaka, S. Berbenni, V. Taupin, R. A. Lebensohn, Int. J. Solids Struct. 184 (2020),136-152
[8] S. Berbenni, R. A. Lebensohn. C. Rendus Physique (2021) submitted.
[9] S. Berbenni, V. Taupin, R. A. Lebensohn, J. Mech. Phys. Solids 135 (2020) 103808
[10] J. Genée, S. Berbenni, N. Gey, R. A. Lebensohn, F. Bonnet, Adv. Modell. Simul. Eng. Sci. 7 (2020) 1-23

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