FE modeling of the microscopic strain heterogeneity along grain boundaries inside metallic polycrystalline aggregates

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Abstract

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This work investigates the influence of the anisotropy of dislocation glide on the highly heterogeneous strain field across polycrystalline aggregates. The vicinity of grain boundaries and triple junctions is known to host high stresses due to the constrained plasticity (1). It is however debated whether this raises, or rather lowers, the local heterogeneity relative to the macroscopic strain (2). We first address this issue using CPFEM on meshes that conform to the grain boundary geometry. A careful statistical analysis reveals that the amplitude of strain heterogeneity varies depending on the distance to GB and TJ. Based on these results, an alternative approach is then suggested using a simpler voxelized representation, which does not perfectly align with the grain boundaries (3). Every finite element that is intersected by grain boundaries is assigned a bicrystal behavior, by adopting the main hypotheses of the ALAMEL model (4). This original strategy is shown to capture the interactions between neighboring grains along the grain boundaries, resulting in predictions of the macroscopic strain field that closely match those obtained with a conforming FE mesh, while maintaining a low computational cost.

References.

(1) Yin, C., Terentyev, D., Pardoen, T., Bakaeva, A., Petrov, R., Antusch, S., ... & Zhang, T. (2018). Tensile properties of baseline and advanced tungsten grades for fusion applications. International Journal of Refractory Metals and Hard Materials, 75, 153-162.

(2) Martin, G., Sinclair, C. W., & Lebensohn, R. A. (2014). Microscale plastic strain heterogeneity in slip dominated deformation of magnesium alloy containing rare earth. Materials Science and Engineering: A, 603, 37-51.

(3) Hanon, G., & Delannay, L. (2023, June). Refined modeling of the interaction of adjacent grains inside a Tungsten polycrystal . In Proceedings of the 7th ECCOMAS Young Investigators Conference, YIC 2023 (pp. 220-221). Eccomas.

(4) Van Houtte, P., Delannay, L., & Kalidindi, S. R. (2002). Comparison of two grain interaction models for polycrystal plasticity and deformation texture prediction. International Journal of Plasticity, 18(3), 359-377.

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