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ABSTRACT

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Crystal Plasticity Based Modelling of Viscoplasticity in Nanocrystalline FCC Thin Films

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ABSTRACT

Thin films ("thin" meaning thinner than 1μm) are nowadays present everywhere such as in MEMS. The mechanical integrity of the films is the key for the reliability of the devices under interest. Compared to their bulk counterparts, thin films involve, owing to the very fine microstructure, high strength, long elasto-plastic transition and moderate to high strain rate sensitivity, which can lead to detrimental creep.

Crystal plasticity based finite element modelling (CPFEM) is used to analyse the strain hardening and creep response of freestanding nanocrystalline (nc) Pd thin films. The model accounts for the confinement of plasticity due to grain boundaries as well as for the significant viscoplastic effects associated to dislocation dominated thermally activated mechanisms. Numerical predictions are assessed based on experimental tensile test data on freestanding films, gathered using lab-on-chip technique [1]. The model is based on $\{111\}\ \langle 100\rangle$ dislocation slip with grain size dependant CRSS. Isotropic hardening of the slip systems is assumed to be dependant of a single parameter: the total dislocation density, ρ. The Kocks-Mecking-Estrin approach is used to describe the evolution of ρ. Rate dependent plasticity mechanisms are magnified in nc metals. Slip rate are then based on the thermally activated generalized rate equation.

The simulations demonstrate that stress heterogeneity significantly contributes to strain hardening. The largest grains yield much earlier than the hardest ones, inducing a significant kinematic hardening contribution. When thermal activation and grain size distribution are taken into account, the model properly reproduces experimental relaxation and backward creep observed by *Van Petegem et al.* [2].

References

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