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Segregation to creep-induced planar faults in Ni-base SX superalloys

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Ni-base single-crystal (SX) superalloys find application in turbine blades for gas engines due to the high-temperature and high-stress strength originating from the coherent γ/γ'microstructure. It is well-known at sufficiently high stresses, two 1/2<101> dislocation families with different Burgers vector can react and dissociate into two partial dislocations in γ channels. This allows the leading 1/3[-1-12] Shockley partial dislocation continuously gliding on {111} planes to cut into γ'precipitates where they create planar faults [1]. We study the segregation behaviours of alloying elements across the planar faults by performing the [11-2] (111) creep shear experiments, to intentionally activate the slip system [11-2] (111) with the highest Schmid factor of 1 where the resolved shear stress is exactly equal to loading stress. The creep-deformed specimens are interrupted after 1% and 2% shear strain under 250 MPa at 750 °C. The resulting microstructure is investigated using conventional transmission electron microscopy (TEM), analytical scanning TEM (STEM) with energy-dispersive X-ray spectroscopy (EDXS) focussing on structural, physical, and chemical details of the local deformation.
We investigated the specimen perpendicular to the (111) plane with the [1-10] direction parallel to the electron beam. Numerous stacking faults (SF) are observed after 1% and 2% creep strains. Fringe contrasts under two-beam conditions indicate inclined stacking faults, where the 2% strain sample has more planar faults within one γ'precipitate indicating a higher density of planar faults in the 2% sample. High-resolution STEM micrographs illustrate the superlattice extrinsic nature of stacking faults (SESF) in the 1% and 2% strained samples. The chemical distributions across SESF are measured by EDXS and the corresponding concentration profile of 1% and 2% samples. Both samples show almost similar segregation tendency, which is that γ forming elements Cr, Co and Re are enriched across the SESF while γ'alloying elements Ni and Al are depleted, which is partly in agreement with theoretical predictions [2]. For these measurements all microscope parameters and sample thickness for EDXS analysis are kept the same to quantitatively find out how creep strain and time affect the evolution of segregation.

Category

Solid State (Experiment)

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