The present work has investigated the evolution of strain-induced NbC precipitates in a model austenitic Fe-30Ni-Nb steel deformed at 925 °C to a strain of 0.2 during post-deformation holding between 3 and 1000 s and their effect on the reloading flow stress. The microstructural examination was performed using a JEM 2100F transmission electron microscope operated at 200 kV. A range of imaging and diffraction techniques was used to determine the crystal structure, coherency state, size, shape, number density and volume fraction of the precipitates in conjunction with the dislocation substructure. Extensive use of moiré-fringe technique allowed to distinguish down to 3 nm scale precipitates clearly from the dislocation contrast background. Foil thickness measurements, required for the precipitate volume fraction estimation, were performed using the convergent beam electron diffraction. The precipitate particles preferentially nucleated on the nodes of the periodic dislocation networks constituting microband walls (Fig. 1a). Holding for 10 s resulted in the formation of fine, coherent NbC particles with a mean diameter of about 5 nm (Figs. 1b and 1e) that displayed the cube-on-cube orientation relationship with austenite (Figs. 1c and 1d) and caused the maximum increase in the reloading steady-state flow stress. A further increase in the holding time from 30 to 1000 s led to the formation of semi-coherent (Fig. 1f), gradually coarser and more widely spaced particles with a mean diameter of 8 nm and above, which led to a gradual decrease in the reloading steady-state flow stress. The holding time increase resulted in progressive disintegration of the dislocation substructure and dislocation annihilation through static recovery processes, which was also reflected by the measured softening fractions. The precipitate particle shape changed during post-deformation annealing from elliptical to faceted octahedral and subsequently to tetra-kai-decahedral.

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Fig. 1: TEM observations of the NbC particles at a strain of 0.2 and holding for 10 s (a-e) and 1000 s (f). (a) Bright-field micrograph of the particles (circled) on the dislocations network constituting a microband wall; (b) Enlarged particle; (c) Nanobeam diffraction pattern for (b); (d) Pattern indexing; (e,f) NbC/austenite interphase lattice images.