In-reactor tensile tests (IRTs) on pure Cu and CuCrZr alloy have revealed a deformation behaviour which differs significantly from that observed in conventional post-irradiation tensile tests (PITs). In contrast to PITs where the deformation behaviour is commonly characterised by yield drop and by pronounced localisation of deformation in cleared channels, in IRTs, the materials deform uniformly and homogeneously. A prominent feature observed in IRTs is that an increase in the pre-yield dose causes an increase in the yield stress and changes the evolution of the flow stress with strain (dose). These features are modelled analytically in terms of the interaction of dislocations with clouds of small dislocation loops decorating them. During irradiation without deformation (in PITs and in IRTs during pre-yield irradiation), decoration of dislocations at rest is due to the trapping of one-dimensionally diffusing clusters of self-interstitial atoms (SIAs) whereas dislocations moving during deformation are primarily supplied with loops by sweeping. Loops gliding parallel to the glide plane ("aligned" loops) join the loop cloud accompanying the dislocation; loops gliding transversely to the glide plane ("non-aligned" loops) approach the dislocation where they are annihilated.

We have formulated rate equations for the evolution of dislocation decoration under pre-yield and post-yield irradiation. In the first case, the production terms are defined by the diffusion fluxes of cascade induced glissile loops, in the second by the swept apparent matrix loop fluxes to the evolving dislocations. For aligned loops accompanying moving dislocations, we have included terms describing the following reactions with matrix clusters: alignment of non-aligned matrix loops, annihilation of SIAs in aligned loops with vacancies in stacking fault tetrahedra and blocking of aligned loops by immobile or non-aligned matrix clusters.

During yielding and post-yield deformation, temporary or definitive blocking of members of the loop cloud by their mutual interaction and their interaction with matrix clusters is associated with forces on the dislocations which contribute to yield and flow stresses, respectively. Estimates of these contributions reproduce qualitatively the main trends in the evolution of yield and flow stresses observed in IRTs.

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