Temperature dependence of mechanical properties and deformation mechanisms in an equiatomic CrFeNi medium-entropy alloy

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Abstract

An equiatomic CrFeNi medium-entropy alloy (MEA) that constitutes a cornerstone of austenitic stain- less steels and Fe-based superalloys is investigated. Anneals at various temperatures revealed that CrFeNi forms a stable face-centered cubic (FCC) solid solution above ~1223 K. Based on this result, this alloy was cold-worked and recrystallized between 1273 K and 1473 K to produce different grain sizes. Compression tests were carried out at 293 K to investigate grain boundary strengthening (Hall-Petch slope: 966 MPa $\mu m^{1/2}$) and this contribution was then subtracted from the overall strength to reveal the intrinsic uniaxial lattice strength (80 MPa). Additional compression and tensile tests were performed between 77 K and 873 K to study the effect of temperature on mechanical properties and deformation mechanisms. Ductility, yield and ultimate tensile strengths increased with decreasing temperature. To reveal the active deformation mechanisms in CrFeNi with the coarsest grain size (160 μm), tensile tests at 77 K and 293 K were interrupted at different strains followed by transmission electron microscopy analyses. In all cases, the deformation was accommodated by dislocation glide at low strains, while twinning additionally occurred above a critical resolved shear stress of 165 MPa, which was roughly temperature independent. This value compares well with predictions (180 MPa) based on the Kibey's model for twin nucleation. Moreover, the fact that this value is roughly temperature-independent is also consistent with the Kibey's model since the twin nucleation barrier (unstable twin stacking fault energy) of FCC metals and alloys does not vary significantly with temperature.