2076
doi:10.1017/S1431927620020358
Microsc. Microanal. 26 (Suppl 2), 2020

An Atom-probe Tomographic Study of Kinetic Pathways of Retention Excesses and Depletions at Gamma(F.C.C.)/gamma-prime ($L1_2$) Interfaces in a Ni-Al-Cr-Re Superalloy

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The nucleation, growth and coarsening kinetics of coherent gamma-prime-($L1_2$)-precipitates in a quaternary Ni–10Al-8.5Cr-2Re (at.%) alloy, (1), aged at 700 ^{o}C from 0 to 1024 h, are studied utilizing atom-probe tomography (APT) and transmission electron microscopy (TEM). The temporal evolutions of the concentration profiles yield retention excesses and depletions at gamma(FCC)/gamma-prime-interfaces, which are discussed in detail. The compositional trajectories are plotted in a quaternary phase diagram, which is displayed in a tetrahedron whose apexes are equal to 100 at.% Ni, Al, Cr and Re, thereby yielding a three-dimensional picture of the compositional evolutions of the gamma-prime(L12)-precipitates and gamma(FCC)-matrix phase. The gamma-prime(L12)-phase is nucleated in the gamma-prime (L12) phase-field and it commences evolving with a curvilinear composition trajectory, which corresponds to the nucleation and growth regimes of the gamma-prime(L12)-precipitates. This curvilinear composition trajectory becomes linear when stationary-coarsening commences and it continues as a vector until it reaches the solvus-surface between the gamma-prime(L12)-phase-field and the [gamma-prime(L12) plus gamma(FCC)]-phase-field. Alternatively, the gamma(FCC)phase commences with a mean composition of Ni–10Al-8.5Cr-2Re (at.%) in the [gamma-prime(L12) plus gamma(FCC)]-phase-field it begins with a curvilinear composition trajectory, corresponding to the nucleation and growth of the gamma(FCC)-phase. This trajectory becomes linear when stationary coarsening occurs and it stops on a conjugate solvus-surface, which is between the [gamma-prime(L12) plus gamma(FCC)]-phase-field and the gamma(FCC)-phase field. A straight-line (a vector) can then be drawn between these two endpoints, which is a tie line for this mean composition. The stationary coarsening regime is analyzed in terms of the Philippe-Voorhees (P-V) coarsening model, which includes the thermodynamics of the gamma(FCC)-matrix phase and a diffusion tensor that includes off-diagonal terms, implying that solvent-solute terms are contributing to the fluxes that exist in this quaternary alloy. When the off-diagonal terms are neglected then solvent-solute terms are absent, which can yield a misleading picture of the temporal evolution of the gamma-prime(L12)-precipitate phase.

References

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