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Atom probe tomography study of Fe-Ni-Al-Cr-Ti ferritic steels with hierarchically-structured precipitates

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Abstract

The ferritic Fe-Ni-Al-Cr-Mo steel (FBB8) has good creep properties up to 700 °C due to B2-NiAl nanoscale precipitates and its creep resistance can be further improved by additions of 2 or 4% Ti, as a result of sub-precipitates within the main precipitates. Here, the hierarchical structure of the precipitates is studied in the light of phase separation via transmission electron microscopy (TEM) and atom probe tomography (APT). For FBB8-2Ti (with 2% Ti added) exhibiting B2-NiAl precipitates with L2₁-Ni₂AlTi sub-precipitates, APT analysis shows strong partitioning of Ni, Al and Ti from the ferritic matrix into the B2/L2₁ precipitates and, within the precipitates, partitioning of Ti and Fe within the L2₁ sub-precipitates. Based on the published pseudo-binary phase-diagram between (Ni,Fe)Al and (Ni,Fe)Ti, this hierarchical precipitate microstructure is discussed based on the known miscibility gap between the B2 and L2₁ phases, due to partitioning of Ti into the L2₁ phase and ordering of Al and Ti on the Al sub-lattice of the B2 structure. For FBB8-4Ti (with 4% Ti added), by contrast, the L2₁ precipitates exhibit bcc sub-precipitates rich in Fe and Cr, with a composition close to that of the matrix; the absence of the B2 structure is consistent with an increase of Fe concentration, to 19.3 at.%, as measured via APT, in the L2₁ precipitates.

Keywords: ferritic steel; precipitate strengthening; hierarchical precipitate structure; B2-L2₁ phase separation; transmission electron microscopy (TEM); atom-probe tomography (APT)

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