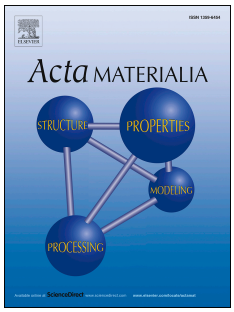
Accepted Manuscript



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Sung-Il Baik, Michael J.S. Rawlings, David C. Dunand

PII: S1359-6454(17)30956-4

DOI: 10.1016/j.actamat.2017.11.013

Reference: AM 14184

To appear in: *Acta Materialia*

Received Date: 19 July 2017

Revised Date: 13 October 2017

Accepted Date: 5 November 2017

Please cite this article as: S.-I. Baik, M.J.S. Rawlings, D.C. Dunand, Atom probe tomography study of Fe-Ni-Al-Cr-Ti ferritic steels with hierarchically-structured precipitates, *Acta Materialia* (2017), doi: 10.1016/j.actamat.2017.11.013.

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

Sung-Il Baik [a,b,*], Michael J. S. Rawlings [a], David C. Dunand [a]

[a.] *Department of Materials Science & Engineering, Northwestern University, Evanston, IL 60208, USA*
[b.] *Northwestern University Center for Atom-Probe Tomography, Evanston, IL 60028, USA*

** Corresponding author: si-baik@northwestern.edu*

Abstract

The ferritic Fe-Ni-Al-Cr-Mo steel (FBB8) has good creep properties up to 700 ºC 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 $L2_1$-Ni_2AlTi sub-precipitates, APT analysis shows strong partitioning of Ni, Al and Ti from the ferritic matrix into the B2/$L2_1$ precipitates and, within the precipitates, partitioning of Ti and Fe within the $L2_1$ 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 $L2_1$ phases, due to partitioning of Ti into the $L2_1$ 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 $L2_1$ 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 $L2_1$ precipitates.

Keywords: ferritic steel; precipitate strengthening; hierarchical precipitate structure; B2-$L2_1$ phase separation; transmission electron microscopy (TEM); atom-probe tomography (APT)