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Microstrcutural Stability of Nanostructured Ferritic Alloys (NFA)

Reza Sharghi-Moshtaghin[1], Shenyan Huang[1], Richard DiDomizio[1], Laura Dial[1]

1.GE Global Research Center, 1 Research Circle, Niskayuna, NY 12309

Nanostructured ferritic alloys (NFA), are being developed for various high temperature applications where mechanical strength including creep properties and good resistance to irradiation damage is desired [1,2]. NFAs with a high chromium content (Cr >12%) present a fully ferritic matrix and are envisaged for applications in an extended range of temperature [3]. The high temperature strength is achieved by fine, homogeneously distributed nanoclusters in a ductile matrix that play an important role in enhancing mechanical strength [4]. The balance of chemical composition and most importantly Cr in these alloys is critical in order to maintain a ferritic structure and achieve desired corrosion and oxidation properties. However during thermal exposure at higher temperature and Cr levels due to phase stability or phase separation, high temperature α-BCC may transform into iron rich (BCC) and α'-Cr (BCC) phases. This phase transformation could change corrosion and/or mechanical properties of the alloy and affect performance of the material.

In this study an NFA was prepared via a mechanical alloying process and subsequent hot consolidation, the detail of processing has been discussed elsewhere [5]. The chemical composition of the alloy used in this study is given in table 1. The billet was cut into pieces and aged at 427°C (800°F), 482°C (900°F) and 537°C (1000°F) up to 25,000 hrs. Each aged sample was removed from the furnace at a specific time interval and mechanical properties including Vickers hardness and tensile properties were measured. Microstructural evaluation on each sample was carried out using a 200KV Tecni-Osiris TEM equipped with 4 EDS detectors.

TEM results showed that phase separation leads to the formation of the chromium-rich α' phase (Fig1,2). Also a tungsten rich laves phase was found at the grain boundaries after 2500hrs exposure at 482°C (Fig.2). Experimental results showed that tensile properties of the alloy are not significantly affected by annealing time (Fig. 3). This behavior is attributed to dislocation/NFA interaction and is under investigation.

Reference:

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Table 1. Chemical composition of the ODS alloy used in this study (wt%)

Alloy	Fe	Cr	W	Ti	Y2O3	B
NFA1	Bal.	14	3	1.2	0.75	-
NFA2	Bal.	14	3	0.8	0.5	0.03

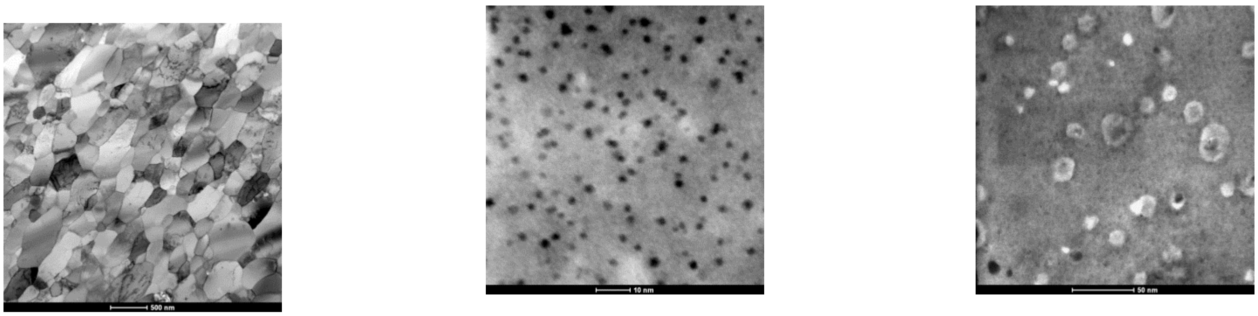

Figure 1. a- general microstructure shows the grain size of the alloy; b-STEM BF image shows 2-5 nm Nanoclusters formed in the microstructure in as-received condition, c- α' Cr particles formed in the microstructure after aging at 482°C (900°F) for 10000hrs.

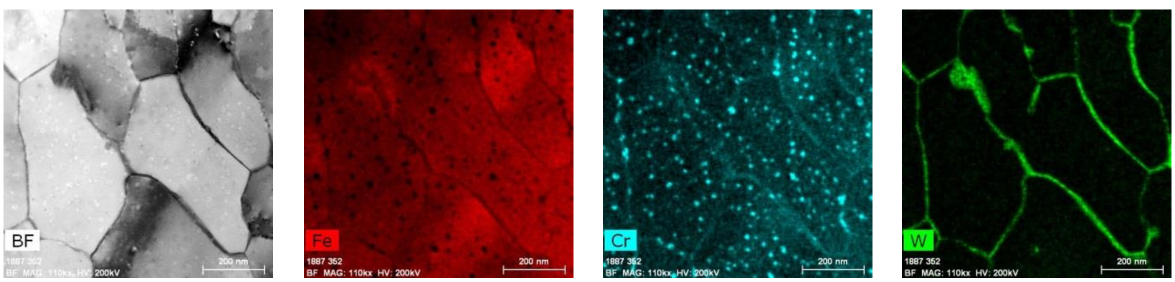

Figure 2. EDS elemental map show formation of α' Cr and Laves phsase in the microstructure after aging the sample at 482°C (900°F) for 10000hrs.

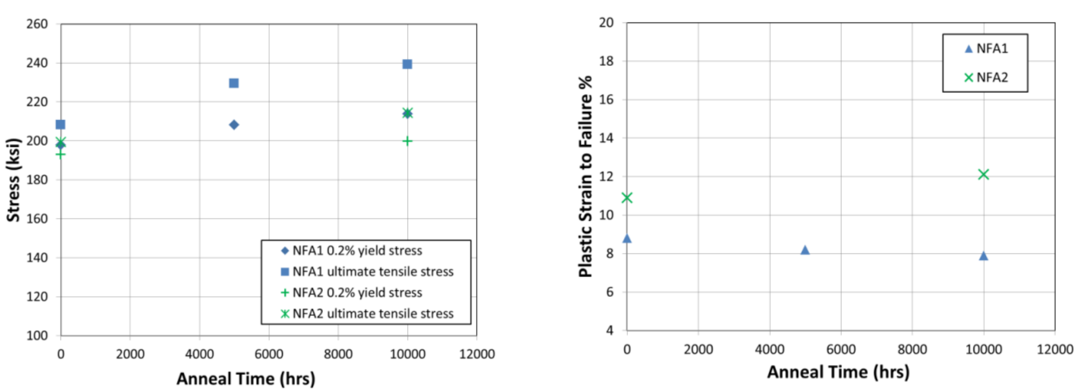

Figure 3. Room temperature 0.2% yield stress and ultimate tensile stress and (b) plastic strain to failure for two NFAs as a function of anneal time at 900F.