Poster

INFLUENCE OF PHASE SEPARATION ON THE ROOM TEMPERATURE MECHANICAL PROPERTIES OF PM 2000 ODS ALLOY

C. Capdevila[1], M. K. Miller[2], J. Aldazabal[3], I. San Sebastián[3], J. Chao[1], J.L. González-Carrasco[1]

[1] Centro Nacional de Investigaciones Metalúrgicas (CENIM-CSIC), Avda. Gregorio del Amo, 8; Madrid, E-28040, Spain
[2] Materials Science and Technology Division, Oak Ridge National Laboratory, PO Box 2008, Oak Ridge, TN 37831-6136, USA
[3] CEIT and Tecnun (University of Navarra), Paseo Manuel de Lardizábal 15, 20018 San Sebastián, Spain

In the last few years, PM 2000(trademark of Plansee GmbH) alloy has been shown to be an advanced material where high temperature applications are paramount. PM 2000is an Fe-based, oxide dispersion strengthened (ODS) alloy, which can be considered as a composite material consisting of a metallic matrix (Fe-20 at.% Cr-11 at% Al) strengthened with a homogeneous dispersion of nanometer-size oxide particles. This oxide dispersion, in combination with a recrystallized coarse grained microstructure, gives PM 2000high hot strength and creep strength up to 1350°C. Due to its high aluminium and chromium content, PM 2000 forms a dense, adherent Al_2O_3 scale when used at high temperatures under oxidizing atmospheres. In addition to the high temperature applications, PM 2000 has been shown to be a biomaterial for its outstanding combination of mechanical properties and corrosion resistance at room temperature.

In this work, the effects of an additional nanometer-scale, phase-separation-producing Fe-rich (α) and Cr-rich (α') phases during low temperature annealing on the room temperature mechanical properties are described. The three-dimensional microstructure, as determined from atom probe tomography, resulting from phase separation during aging for 2040 h at 748 K is shown in Fig. 1. At this aging temperature, and due to the relatively low chromium content of the alloy, the Cr-rich α' phase is in the form of isolated particles rather than the interconnected network structure observed previously in higher chromium (30-45% Cr) alloys [1]. The kinetics of phase separation were quantitatively determined by analyzing the evolution of the geometrical domain size (λ) and the composition amplitude (ΔC). The composition amplitude was determined from the composition frequency distribution with the Langer-Bar-on-Miller (LBM) method [2], and the scale from the 3D autocorrelation function [2]. The evolution of λ and ΔC with aging time, t, at 748 K, shown in Fig. 2, varies as $\sim t^{1/3}$ and is consistent with the Lifshitz-Slyozov-Wagner (LSW) theory [3-4]. It has been shown that annealing at 748 K is responsible for an increase in the yield and ultimate tensile strength with a resulting decrease in ductility. However, despite some loss of ductility, the material exhibited ductile behavior as observed by the necked zone in tensile specimens. This behavior contrasts the so-called "475 ºC embrittlement" observed in other ferritic alloys. Moreover, material aged at 475 ºC exhibits a higher fatigue limit than unaged material (Fig. 3).

Acknowledgements:

The authors acknowledge financial support from the Spanish Ministerio de Educación y Ciencia in the form of a Coordinate Project in the Energy Area of Plan Nacional 2006 (ENE2006-15170-C02). Research at the Oak Ridge National Laboratory SHaRE User Facility was sponsored by the Office of Basic Energy Sciences, Division of Scientific User Facilities, U.S. Department of Energy.

References:

[1] M.K. Miller, et al., *Acta Metall. Mater*. 43 (1995) 3385.

[2] M. K. Miller, *Atom Probe Tomography*, Kluwer Academic / Plenum Press, New York, 2000, pp.177 and 185.

[3] I. M. Lifshitz and V. V. Slyozov, *J. Phys. Chem. Solids* 19 (1961) 35.

[4] C. Wagner, *Z. Elektrochem.* 65 (1961) 581.

Figures

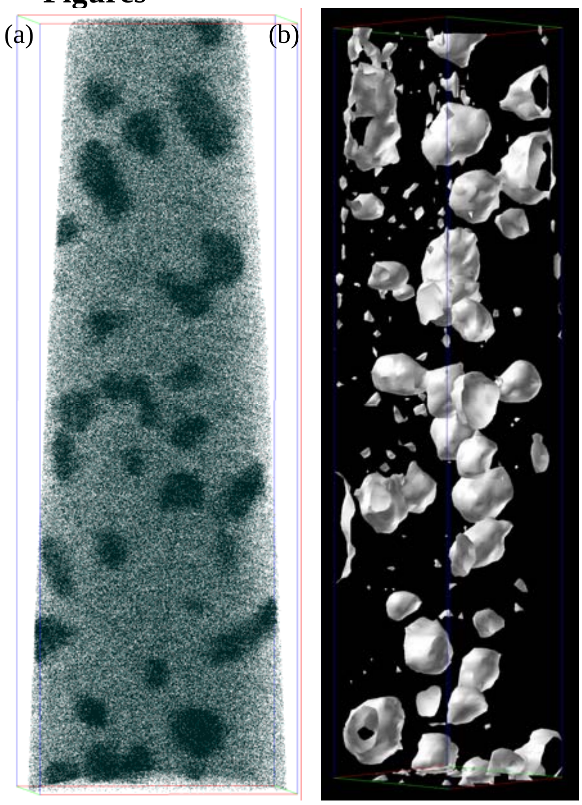

Figure 1: (a) Cr atom map and (b) 20% isoconcentration surface after 2040 h aging at 748 K. At this late stage, the Cr-enriched α′ particles are isolated (volume=30x30x127 nm).

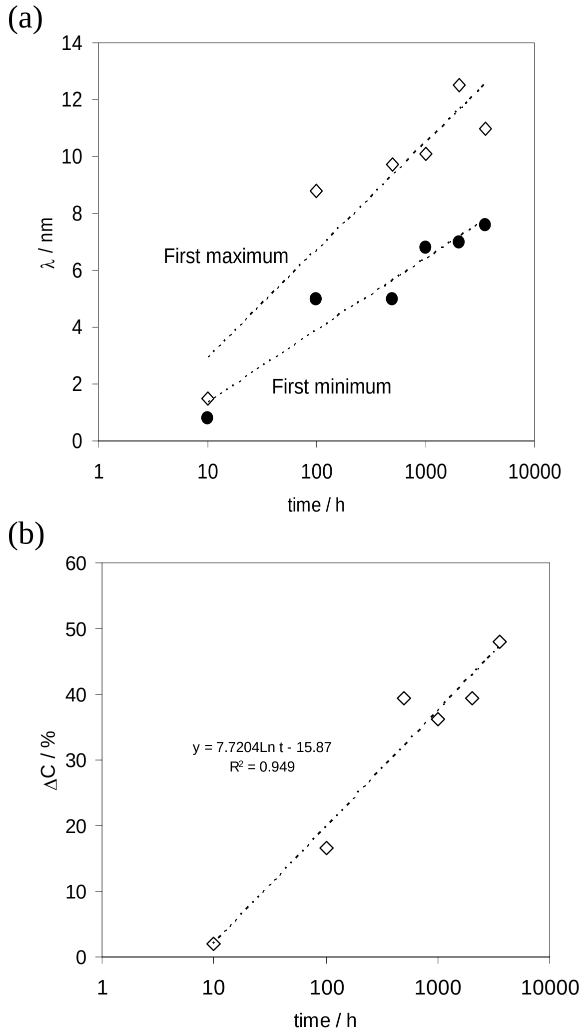

Figure 2: Evolution of (a) ΔC and (b) λ with time

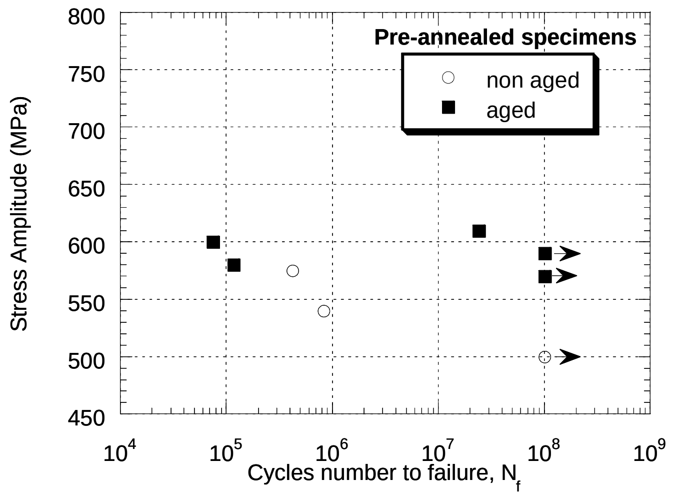

Figure 3: S-N diagram for pre-annealed specimens with and without ageing at 475ºC. The arrows indicate that test was interrupted without failure of the specimen.