CONF-870862-3

APPLICATION OF ANALYTICAL ELECTRON MICROSCOPY TO DESIGN OF CREEP RESISTANT ADVANCED AUSTENITIC STAINLESS STEELS

CONF-870862--3

DE87 003456

P.J. Maziasz

Oak Ridge National Laboratory, P.O. Box X, Oak Ridge, TN 37831-6376

Analytical electron microscopy (AEM) has been used for the last ten years to study precipitation produced in reactor-irradiated austenitic stainless steels, such as AISI type 316.[1] These studies have provided the insight to design irradiation resistant steels based on control of precipitiation. More recently, similar insight into precipitation effects in steels allowed the design of advanced austenitics that also exhibit outstanding thermal creep resistance at 700°C. These steels have direct application for superheater/reheater tubing materials that will withstand higher temperatures and stresses in advanced steam cycle fossil power plants.[2]

In particular, AEM has been used to study fine particles (<10 nm in diam) on extraction replicas using high brightness electron sources like the field emission gun (FEG). These studies allowed alloy compositional modifications to be selected that produced stable, fine precipitates for creep strength. The equiaxed MC and needle phosphide phases were desired for strength because both are very finely dispersed and stable at high temperatures in steels. The Ti, V, and Nb additions were combined to produce a complex MC carbide due to their strong mutual interaction as shown by previous AEM studies on that phase.[1,3] Figure 1 shows the x-ray EDS spectra of small MC particles taken on a Philips EM400T/FEG. Complex (Ti,V,Nb)C carbides form in the advanced-modified 14Cr-16Ni austenitics in contrast to the TiC or (Ti,Nb)C found in more conventional superheater steels (alloy 800H - 20Cr-30Ni,Ti and 17Cr-14Ni,Cu,Mo,Ti,Nb, respectively). The P was added to produce an FeTiP phase which also contains some Nb as well as V (V appears to enhance formation of the phosphides).[1]

Figure 2(a) shows clearly that the creep resistance of the advanced modified 14Cr-16Ni austenitics is greatly improved relative to type 316, alloy 800H or 17-14 CuMo at 700°C and a high stress of 170 MPa. Figure 2(b) shows the strong interaction between dislocations and the combination of MC and phosphide precipitates observed after creep of the advanced-modified alloy, using weak-beam dark field imaging on a Philips EM430T at 300 kV. This observation suggests that these precipitates are primarily responsible for the improved creep strength. This investigation illustrates the power of advanced microanalytical technology that enabled precise and efficient alloy development without empirically testing large matrices of alloy compositions.[4]

References

1. P.J. Maziasz, Conf. Proc. MiCon-86, to be publ. as ASTM-STP in 1987, Am. Soc. for Testing and Matls., Philadelphia PA.
2. M. Gold and R.I. Jaffee, J. Mater. for Energy Syst. (Sept. 1984) 3, 138.
3. P.J. Maziasz, Proc. 42nd Annual EMSA Meeting, San Francisco Press (1984), 496.
4. Research sponsored by the U.S. Department of Energy AR&TD Fossil Energy Materials Program under contract DE-AC05-84OR21400 with Martin Marietta Energy Systems, Inc.

DISCLAIMER

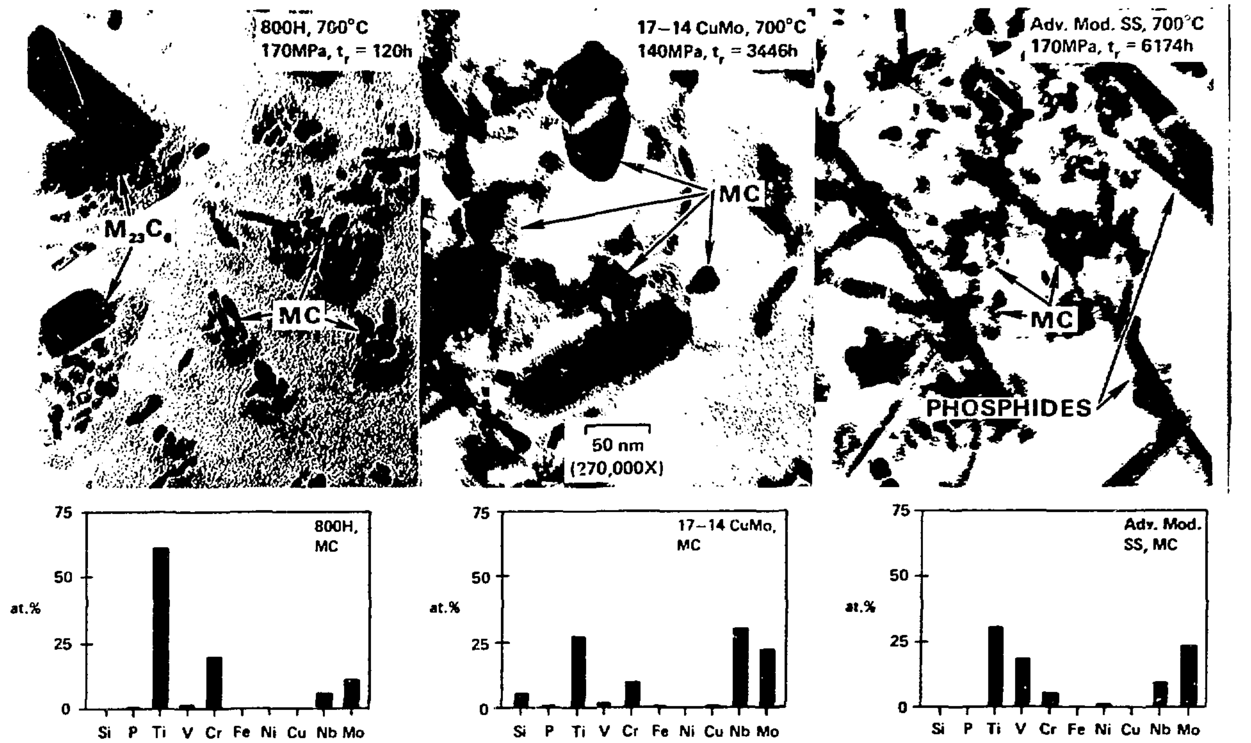
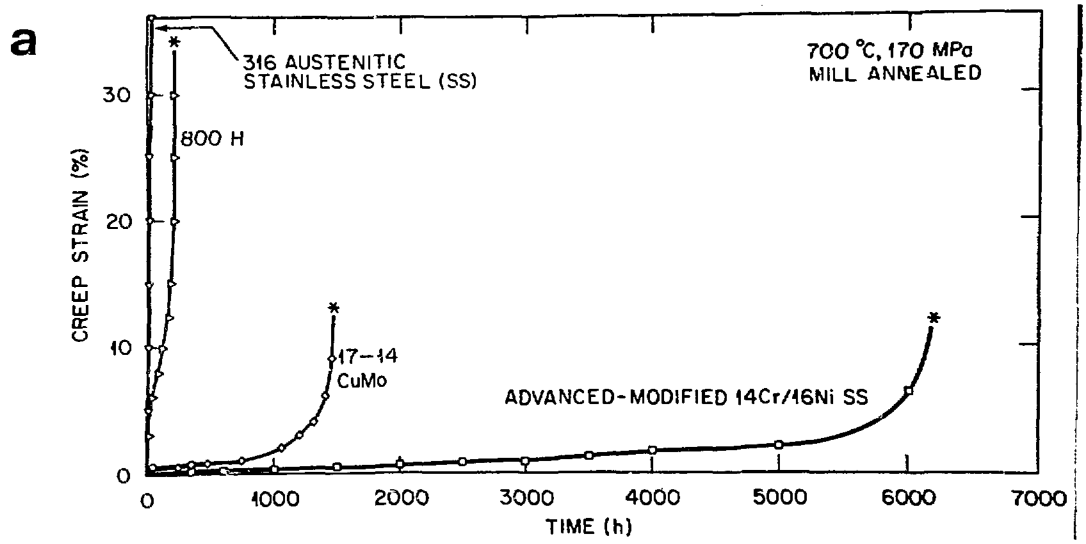


FIG. 1.--X-ray EDS spectra of MC particles on extraction replicas made from the creep tested specimens indicated, using a Philips EM400T/FEG.



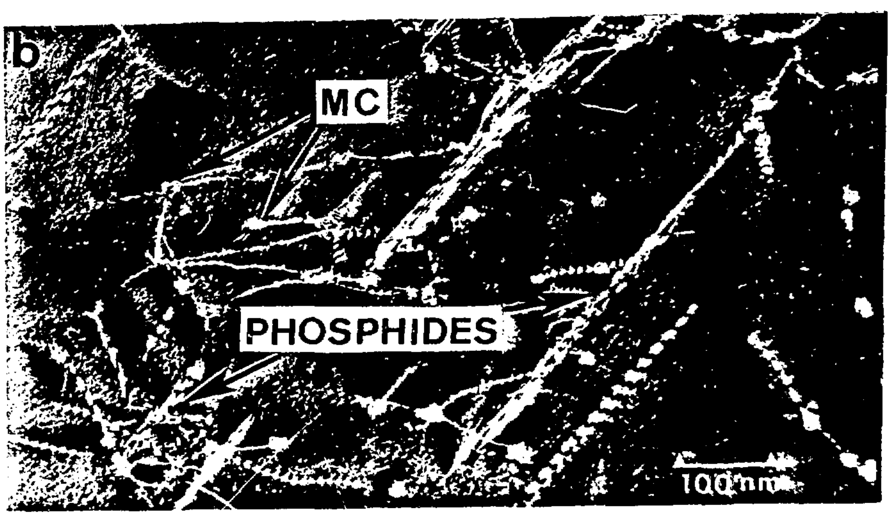


FIG. 2(a)--A plot of creep strain versus time for various alloys tested at 700°C and 170 MPa, and (b) WBDF (g_{200}, g/3g, near [013] of the disloca-tion and fine MC and phosphide structures pro-duced during creep in the advanced-modified 14Cr-16Ni steel.