

Microstructure and Microanalysis of Crept Alloy 740

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Alloy 740 is a new Ni-Cr-Co superalloy developed by Special Metals Corp. for ultra-supercritical steam boiler tubing applications [1]. To evaluate the potential for using alloy 740 above 700°C, this work examines the stability or aging effects on the initial precipitation-hardened microstructure after creep-rupture testing at 816°C. Here, material was solution annealed 0.5h at 1200°C, followed by 16h at 800°C, then crept 2500h at 816°C/20ksi. Both uncrept and crept samples were examined by scanning electron microscopy (SEM) and transmission electron microscopy (TEM).

The uncrept alloy consists of a matrix of disordered fcc γ with typically 50-nm-diam. ordered fcc γ' precipitates. Grain boundaries appear free of precipitates (Fig. 1a). In contrast, the backscattered electron (BSE) image acquired from the crept specimen reveals that grain boundaries are heavily decorated with at least two phases, and a phase having a lath morphology extends from grain boundaries and twin boundaries into the matrix (Fig. 1b).

Phase identification via TEM was accomplished by combined EDS and selected area diffraction (SAD) analysis [2]. Measured compositions of identified phases (for elements with atomic number $Z > 12$) are listed in Table 1. Figure 2, from the crept specimen, shows the expected γ phase and a γ' precipitate ([001] diffraction pattern in Fig. 3a), and the lath phase. Diffraction patterns from the lath can be indexed as hcp η (eta) phase (Fig. 3b). Grain boundary phases (Fig. 4a, and 4b with an inset BSE image to verify phase is within a boundary) were identified as fcc chromium carbide, $M_{23}C_6$ (Fig. 3c) and fcc G phase (Fig. 3d), which is a complex silicide, respectively.

TABLE 1. Measured Composition (at.%) of phases observed in crept Alloy 740 by EDS

Phase	Al	Si	Ti	Cr	Fe	Co	Ni	Nb	Mo
γ	0.1	0.3	0.3	32.7	0.5	21.2	44.6	0.2	0.1
γ'	6.1	-	10.0	1.6	0.3	6.2	73.3	2.4	-
η	2.3	-	10.4	1.3	0.1	8.9	71.0	6.0	-
$M_{23}C_6$	-	-	0.1	93.4	-	1.6	3.4	-	1.2
G	0.1	21.9	2.8	2.1	0.1	10.1	47.3	15.3	0.2

Preliminary analysis shows that creep at 816°C for 2500h produces significant changes in the initial as-heat-treated microstructure of alloy 740. Within grains, initially coherent γ' loses coherency and coarsens during creep. Significant precipitation occurs along grain boundaries, including coarse laths of eta phase, and smaller particles of $M_{23}C_6$ and G-phase silicide.

[1] G.D. Smith and H.W. Sizek, paper number 256 presented at NACE 2000, NACE-International, Houston.

[2] M.J. Donachie and S.J. Donachie, *Superalloys: a Technical Guide*, 2nd Ed., ASM International, Metals Park, OH 2002.

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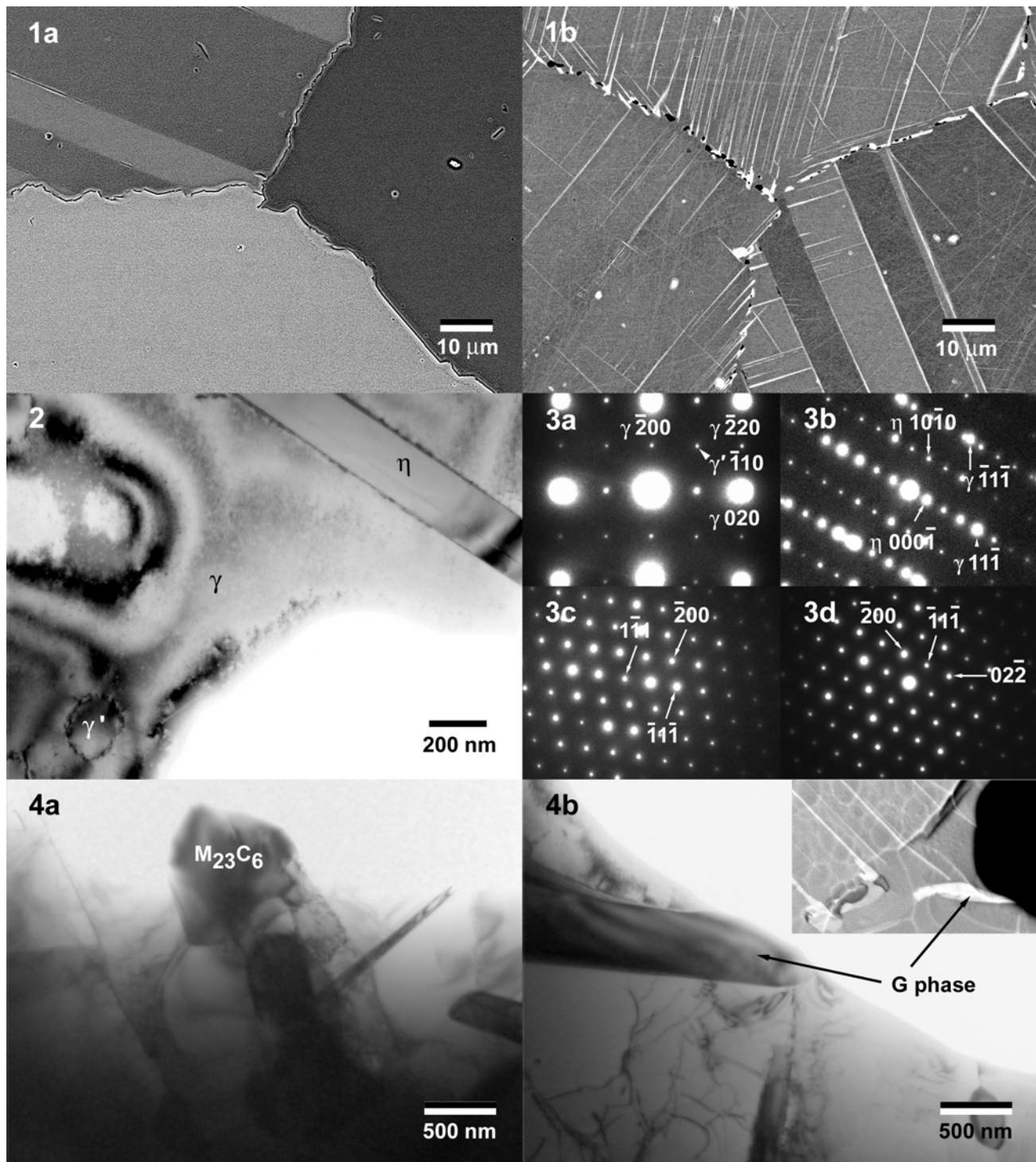


Fig. 1 SEM BSE images of a) uncrept Alloy 740; b) crept Alloy 740
 Fig. 2 TEM image of crept Alloy 740 shows continuous γ , γ' precipitate, and η lath
 Fig. 3 SAD patterns from a) $[001]$ γ with γ' ; b) $[1\bar{2}10]$ η ; c) $[011]$ $M_{23}C_6$; d) $[011]$ G phase
 Fig. 4 Grain boundary phases in crept Alloy 740 a) $M_{23}C_6$; b) G phase