Evolution of tempered martensite ferritic steel microstructures during long term creep

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Tempered martensite ferritic steels are important high temperature materials which are used for critical components in fossil fired power plants which operate in the creep range [1]. Their creep strength is governed by a complex microstructure which forms during heat treatment (austenitizing and tempering) and evolves during creep [2]. Prominent microstructural features of tempered martensite ferritic steel microstructures after a typical thermo mechanical treatments include prior austenite grains (≈ 50 µm), oriented blocks of elongated micrograins (≈ 5 µm), small ferritic micro grains (≈ 0.5 µm), carbides which decorate internal interfaces and a high density of dislocations [3]. In the present study we use scanning and transmission electron microscopy (SEM and TEM) to show how the microstructure of a 12%- Cr tempered martensite ferritic steel (German grade: X20) evolves under conditions of long term creep (550°C; 120 MPa; 12456, 51072, 81984 and 139971 h).

SEM was performed using a Leo 1530 VP. The SEM features of the microstructure of a tempered martensite ferritic steel are shown in Figure 1. SEM reveals the formation of creep cavities on prior austenite grain boundaries during long term creep. Orientation imaging scanning electron microscopy (OIM-SEM) was used to study the distribution of misorientation angles between micrograins.

TEM was performed using a Tecnai F20 supertwin. Montages of TEM micrographs were taken using bright field diffraction contrast and Z-contrast in the high angle annular dark field (HAADF) STEM-mode. Figure 2 shows a HAADF micrograph with particles and dislocations. The parameters characterizing populations of $M_{23}C_6$, VX and Laves phase particles were measured (size distributions, volume fractions, crystallography and chemical composition). Our results show that even under long term creep conditions the microstructure of the tempered martensite ferritic steel does not reach thermal equilibrium. The results are discussed in the light of previous work and in view of new material developments.

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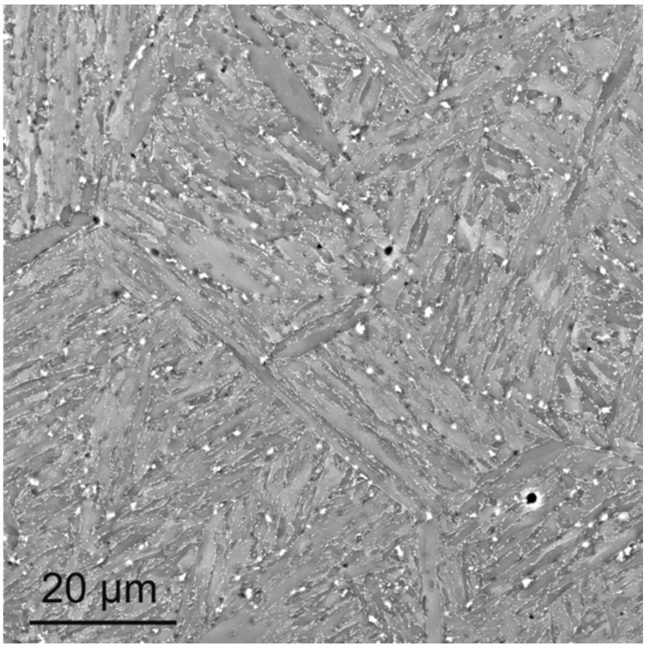

Figure 1. SEM back scatter micrograph showing the microstructure of a 12 % Chromium tempered martensite ferritic steel prior to creep.

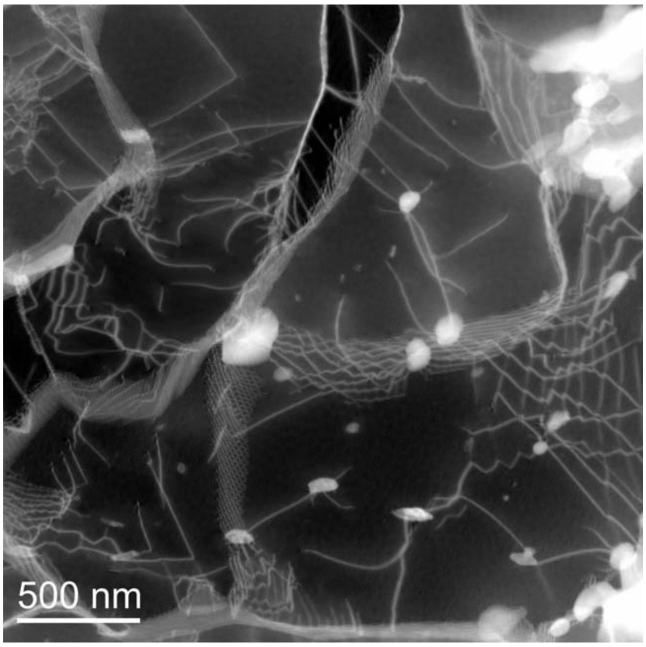

Figure 2. STEM micrograph of dislocations and carbides in a 12 % chromium tempered martensite ferritic steel (HAADF contrast) after long term creep.

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