A TEM, STEM and backscattered electron channeling imaging study of martensite formation in Co-19.6Fe

Conference or Workshop Item

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Co-20Fe has been used as a model alloy for studying the proeutectoid fcc (γ) → bcc (α) transformation in steels because the γ phase was retained on quenching without the interference of martensitic or bainitic transformations. However, a high purity, C-free Co-19.6Fe alloy has been shown to undergo a variety of such transformations. TEM, STEM and back-scattered electron channelling patterns and images have been used to study the effects of ageing at temperatures below the α solvus and of grain boundary misorientation on the occurrence of martensitic transformations in the adjacent grains, and the nature of their products.

Water quenching from 1200°C produced grain boundary Widmannstatten α with laths of bcc martensite within the grains, most of which were heavily dislocated, frequently associated with retained γ films to which it was approximately Kurjumov-Sachs related. Some of the laths however showed extensive faulting and no retained γ was detected in these regions.

Quenching after 24 hrs at 810°C produced more fingerlike well define laths of dislocated martensite with retained austenite films and broader diffuse sub-cells with no retained γ. At grain boundaries the positions of lath edges on each side of the boundary frequently corresponded. STEM microanalysis showed no partition of Fe or Co to lath boundaries, whether there was retained γ or not. Furnace cooling from 730°C also produced plate martensite in which the rectangular dislocation array was concentrated around a central midrib, with a jagged edge which was surrounded by an array of faults or microtwins. Furnace cooling after short ageing times promoted sympathetic nucleation adjacent to intergranular precipitates but in longer aged specimens there was a marked tendency for less transformation when there were well developed grain boundary precipitates.

Both SEM and TEM showed retention of γ in regions ahead of the advancing tips of growing precipitates. These regions were shown by STEM to be depleted in Fe. There was full transformation of regions adjacent to flat, immobile precipitate faces which did not deplete their surroundings of Fe. Thermodynamic calculations indicate that at room temperature the martensitic transformation would be energetically favourable for compositions > 16%Fe. $\Sigma 3$ twin boundaries which were all free of α precipitates and shown to be of low diffusivity showed an increased incidence of adjacent intragranular transformation, their Fe content remains constant during ageing allowing martensite nucleation on cooling and giving a reversal of the usual pattern of reduced transformation at twin boundaries.

This study shows that on cooling Co-19.6Fe, martensitic transformations to a bcc product with a variety of morphologies occur. Grain boundaries are the major nucleation sites for the transformations and where a local redistribution of iron has occurred due to the prior growth of iron rich bcc precipitates at grain boundaries, martensitic transformation of the adjacent grains is suppressed.