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Cr-Fe-Nb-Ni (Chromium-Iron-Niobium-Nickel)

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The previous review of this quaternary system by [1996Rag] presented a computed isothermal section at 700 °C and 1 at.% Nb and a polythermal section at 20Fe-1Nb (wt.%). The reviewed results included the computed Cr equivalent of Nb as a function of Ni in stainless steels. Recently, [2001Tak] studied the phase equilibria at 1200 °C and estimated the extension of the binary compounds into the composition tetrahedron.

Binary Systems

The Fe-Cr phase diagram was reviewed by [1993Itk]. Here, a gamma loop restricts the face-centered-cubic (fcc) phase γ to about 11 wt.% Cr. The body-centered cubic (bcc) phase α is stable over a large region. The intermediate phase σ ($D8_b$, tetragonal) forms from α at 820 °C around the midcomposition and decomposes eutectoidally at 545 °C to Fe-rich and Cr-rich bcc phases. The Cr-Nb phase diagram [1993Oka] depicts one intermediate phase Cr_2Nb with two modifications. The high-temperature form is of the *C*14-type Laves phase, and the low-temperature form is of the *C*15-type Laves phase. The transition temperature lies above 1550 °C. The Cr-Ni phase diagram [Massalski2] is a simple eutectic system with large terminal solid solubilities. For brief descriptions of the Fe-Nb, Fe-Ni, and Ni-Nb phase diagrams, see the Fe-Nb-Ni update in this issue.

Ternary Systems

For the Cr-Fe-Nb system, the compilation of [1995Vil] gives two isothermal sections at 1000 and 700 °C and several partial isothermal sections between 1250 and 900 °C depicting the fcc-bcc equilibrium in Fe-rich alloys. A comprehensive review of the Cr-Fe-Ni system was done by [1988Ray] with updates by [1994Rag] and [2003Rag]. The Cr-Nb-Ni system reviewed by [1990Gup] presented a liquidus projection; five isothermal sections at 1200, 1175, 1173, 1160, and 1100 °C; a pseudobinary section along the Cr_2Nb-Ni_3Nb join; a vertical section along the Cr-Ni_3Nb join; and a reaction scheme. An update of the Fe-Nb-Ni system appears in this issue.

Quaternary Phase Equilibria

Using high-purity metals, [2001Tak] arc melted six quaternary compositions with 2-6Nb, 25-40Ni, and 20Cr

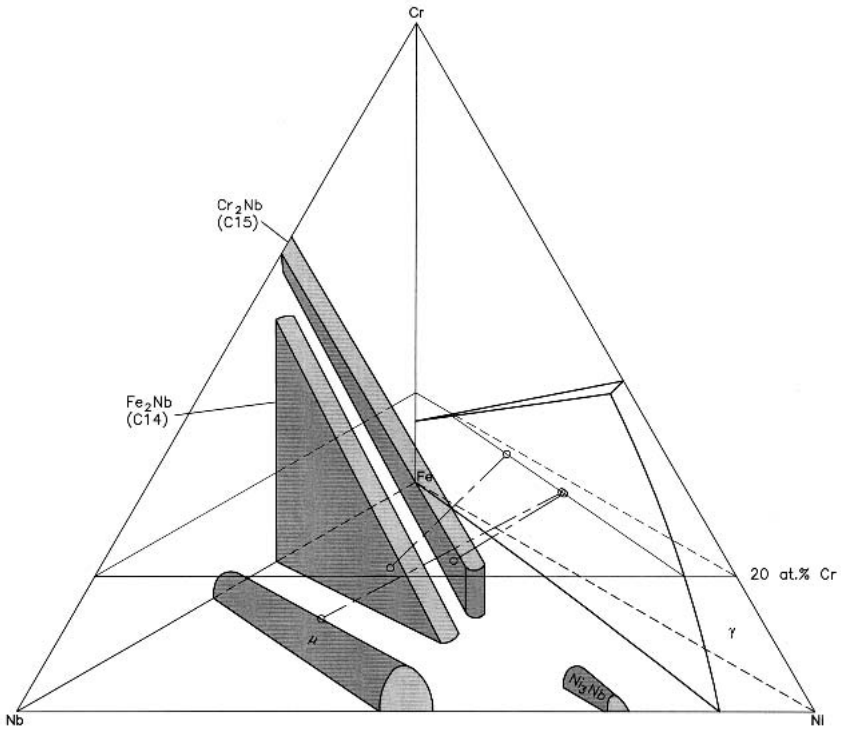

Fig. 1 Cr-Fe-Nb-Ni perspective view of the intermetallic phases in equilibrium with γ at 1200 °C [2001Tak]

(at.%). They were given a final anneal at 1200 °C for 240 h. The phase equilibria were studied by scanning and transmission electron microscopy, electron probe microanalysis, and x-ray powder diffraction. The extension of the binary phases into the composition tetrahedron is shown in a perspective view in Fig. 1. Typically, the *C*14 Laves phase Fe_2Nb dissolves 18Ni and 14Cr. The μ phases of the Fe-Nb and Nb-Ni sides form a continuous solid solution, which typically dissolves up to 13Cr. The *C*15 phase Cr_2Nb dissolves 29Fe and 32Ni. The compositions given previously are in atomic percent. The tie-lines between these three phases and γ are indicated in Fig. 1. The tie-line between the μ and γ phases is through a narrow slit-like gap between the *C*14 and *C*15 extensions.

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