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

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The detailed review of the early results of the phase equilibria of this system by [1988Ray] presented liquidus and solidus projections, isothermal sections at 1300, 1200, 1100, 1000, 900, 800, 650, and 550 °C, several tables of data on tie-lines between bcc (α) and fcc (γ) and a reaction sequence. The first update by [1994Rag] listed the numerous computed phase equilibria of this system and presented selected data on bcc-fcc-liquid equilibria, isothermal sections at 1400, 650, and 377 °C and a vertical section at 74 wt.% Fe. The second update by [2003Rag] reviewed the new results of [1994Sch] on the liquidus surface in Fe-rich alloys and also the revised calculations by [1999Mie] of the isothermal sections at 1300, 1200, 1100, 1000, 800, and 650 °C. Recently, [2008Yen] reported new experimental results on the isothermal sections at 850 and 750 °C, which are in agreement with the previous data. New thermodynamic descriptions were reported by [2004Chv] and [2004Tom].

Binary Systems

In the Fe-Cr phase diagram reviewed by [1993Itk], a gamma loop restricts the fcc region to about 11 wt.% Cr. The bcc α phase is stable over a large region. The intermediate phase σ ($D8_b$-type tetragonal) forms from α at 820 °C around the mid-composition and decomposes eutectoidally at 545 °C to Fe-rich bcc (α) and Cr-rich bcc (α′) phases. The Cr-Ni phase diagram [Massalski2] has a eutectic reaction at 1345 °C and an ordering reaction at 590 °C around the composition Ni_2Cr. The Fe-Ni phase diagram [1993Swa] is characterized by a very narrow solidification range. A continuous solid solution (γ) between fcc Fe and fcc Ni is stable over a wide range of temperature. An ordered phase $FeNi_3$ ($L1_2$, $AuCu_3$-type cubic, denoted γ′) forms from γ at 517 °C.

Ternary Isothermal Sections

With starting metals of 99.95+% Cr, 99.99+% Fe, and 99.994% Ni, [2008Yen] arc-melted about 40 alloy compositions under Ar atm. The alloys were annealed at 850 or 750 °C for 720 h and quenched in iced water. The phase equilibria were studied with optical and scanning electron microscopy. The local phase compositions were determined with energy dispersive analysis or electron probe microanalysis and listed. The phase structure was identified with x-ray powder diffraction. The isothermal section constructed at 850 °C by [2008Yen] is shown in Fig. 1. The σ phase is present in the ternary region only and its homogeneity range is smaller than at 900 °C given by [1988Ray]. The phase distribution at 850 and 900 °C is similar, except in the bcc-fcc region near the Fe corner. The isothermal section of [2008Yen] at 750 °C is given in Fig. 2. The σ phase is stable along the Fe-Cr side and

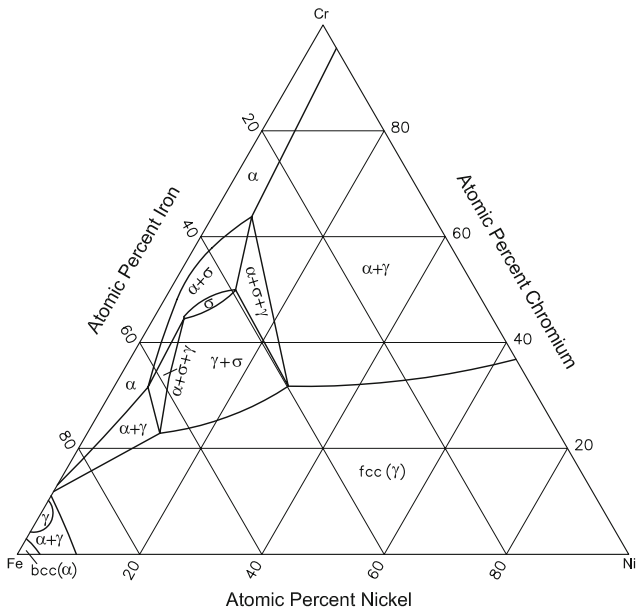

Fig. 1 Cr-Fe-Ni isothermal section at 850 °C [2008Yen]

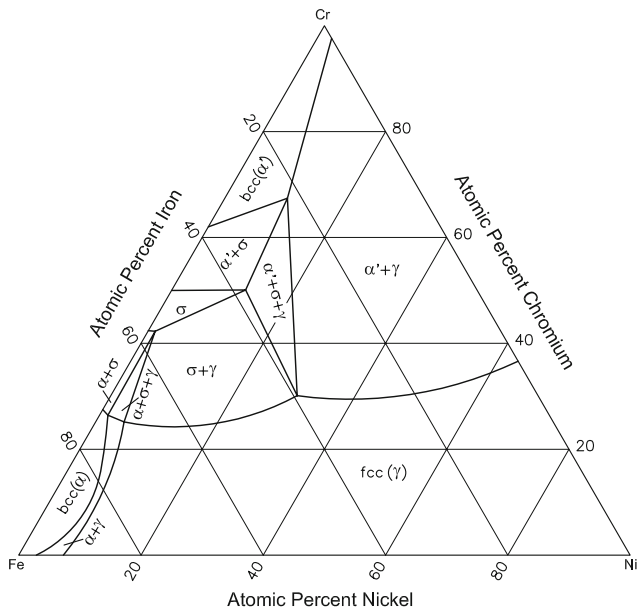

Fig. 2 Cr-Fe-Ni isothermal section at 750 °C [2008Yen]

extends into the ternary region. The triangulations and phase distribution are similar to those at 800 °C shown by [1988Ray].

The energy of formation of the σ phase was estimated by [2004Chv] from first-principles calculations and the isothermal sections at 900 and 800 °C were recomputed and compared with experimental data. Using new data on experimental measurements of the thermodynamic properties and restricting the magnetic contribution to the pure species, [2004Tom] recalculated a number of isothermal sections between 1600 and 800 °C and obtained better agreement with the experimental data than found earlier.

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