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Cr-Fe-Si (Chromium-Iron-Silicon)

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The previous review of this system by [1987Rag] presented a tentative liquidus projection, a reaction scheme, and two isothermal sections at 900 and 427 °C. Two updates added isothermal sections at 1127 and 1027 °C [1993Rag] and at 1047 and 947 °C [2003Rag]. Very recently, [2004Yam] investigated Fe-rich alloys in the order-disorder region of the body-centered-cubic (bcc) phase α and determined an isothermal section at 600 °C and a vertical section at 10 at.% Cr.

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 12 at.% Cr. The bcc phase α is stable over a large region. The intermediate phase σ forms from α at 820 °C around the midcomposition and decomposes eutectoidally at 545 °C to Fe-rich and Cr-rich bcc phases. In the Cr-Si system [2000Du], there are four intermediate phases: Cr_3Si, Cr_5Si_3, CrSi, and $CrSi_2$. Among these, Cr_3Si has a significant homogeneity range. In the Fe-Si system [1982Kub], the Fe-based fcc phase is restricted by a γ loop. The bcc phase exists in the disordered form (α) and the ordered *B*2 and $D0_3$ forms. The intermediate phases in this system are Fe_2Si, Fe_5Si_3, FeSi, and $FeSi_2$. There are two polymorphs of $FeSi_2$. The low-temperature form $\alpha FeSi_2$ occurs at the stoichiometric composition. The high-temperature form $\beta FeSi_2$ is Fe-deficient. For crystal structure data of the above intermediate phases, see [Pearson3].

Ternary Phase Equilibria

Using starting metals of 99.9% Fe, 99.99% Cr, and 99.999% Si, [2004Yam] melted 16 Fe-rich alloys in an arc furnace under Ar atm. After annealing at temperatures in the range of 1100-600 °C, the alloys were quenched in water. The phase equilibria were studied by scanning and transmission electron microscopy. The compositions of the coexisting phases were determined by the electron probe microanalyzer. The critical temperatures in the order-disorder transitions were determined by differential scanning calorimetry and thermogravimetry. The disordered state at high temperatures, which could not be preserved by quenching, was identified by the small size of the antiphase domains in quenched samples.

The vertical section for Fe-rich alloys with a constant Cr content of 10 at.% is redrawn in Fig. 1 [2004Yam]. Two-phase fields of ($A2 + D0_3$) and ($B2 + D0_3$) are present. The transition from $A2 \rightarrow B2$ is second-order. So is the $B2 \rightarrow D0_3$ transition at higher temperatures. The partial isothermal section at 600 °C, depicting the order-disorder transition as a function of composition in Fe-rich alloys [2004Yam], is redrawn in Fig. 2 to agree with the accepted binary data.

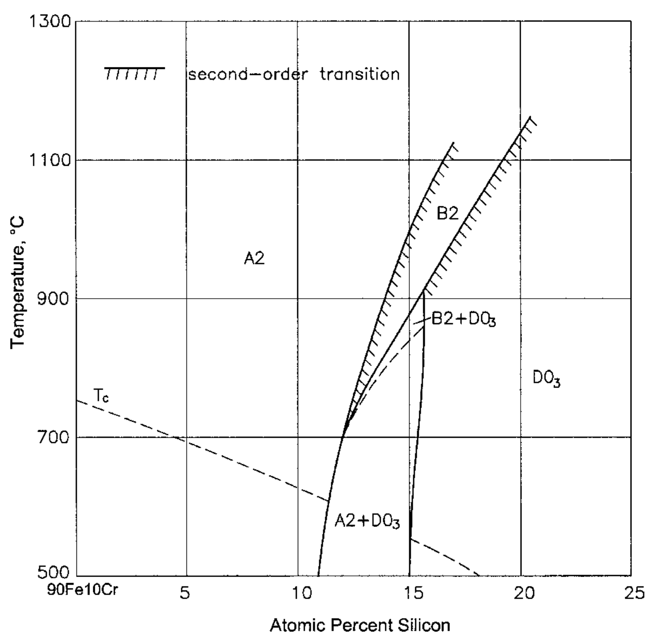

Fig. 1 Cr-Fe-Si vertical section at 10 at.% Cr [2004Yam]

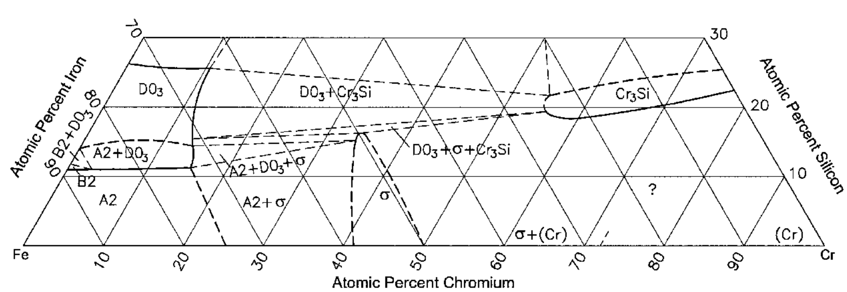

Fig. 2 Cr-Fe-Si isothermal section at 600 °C [2004Yam]

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