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C-Fe-Nb (Carbon-Iron-Niobium)

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The update of this ternary system by [2003Rag] included a review of the data on the solubility of NbC in austenite, two computed isothermal sections at 1200 and 1000 °C from [1990Hua] and a computed liquidus projection for Fe-rich alloys also from [1990Hua]. Recently, [2008Had] reported an experimental determination of the liquidus projection for Fe-rich alloys.

Binary Systems

The C-Fe phase diagram [1992Oka] is in the form of a double diagram, corresponding to the metastable equilibrium with Fe_3C (cementite) or the stable equilibrium with graphite. The face-centered cubic (fcc) solid solution γ (austenite) forms peritectically from body-centered cubic (bcc) δ and liquid. The eutectic reaction around 1150 °C yields austenite and cementite (or graphite). The eutectoid decomposition around 730 °C yields ferrite (α) and cementite (or graphite). The C-Nb phase diagram [Massaslki2] has

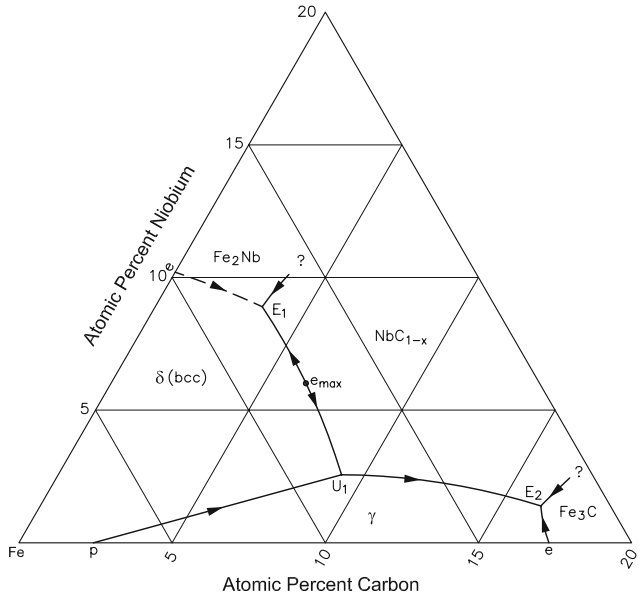

Fig. 1 C-Fe-Nb liquidus projection for Fe-rich alloys [2008Had]

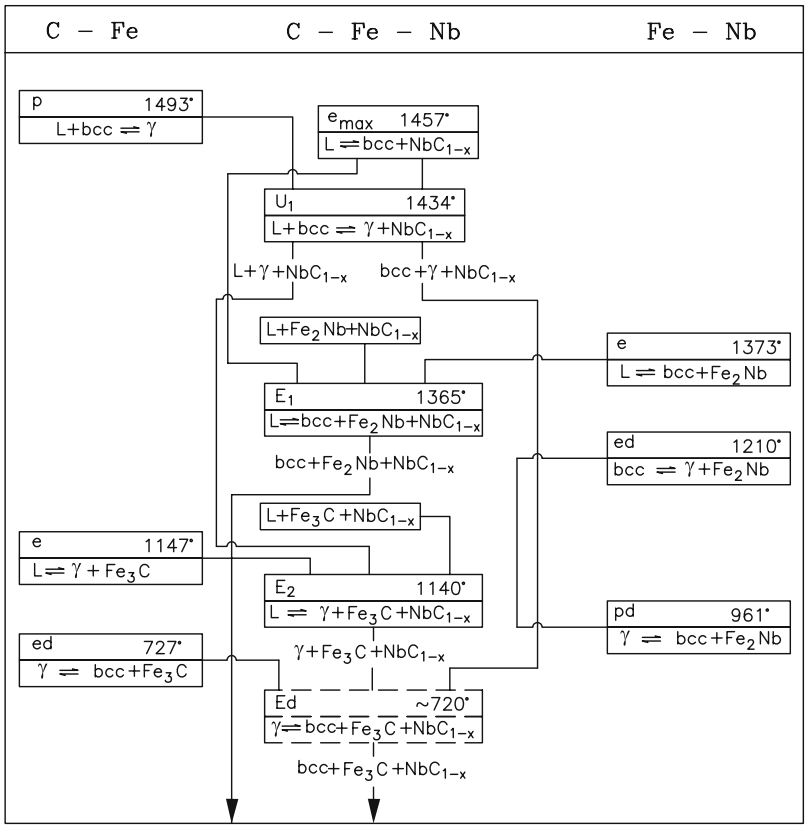

Fig. 2 C-Fe-Nb reaction sequence for Fe-rich alloys

two established intermediate phases: Nb_2C (hexagonal) and NbC ($B1$, NaCl-type cubic). NbC has a homogeneity range on the C-deficient side and is denoted also as NbC_{1-x} or $NbC_{0.87}$. The Fe-Nb phase diagram [1993Bej] shows two intermediate phases: Fe_2Nb ($C14$, $MgZn_2$-type hexagonal) and Fe_7Nb_6 ($D8_5$, Fe_7W_6-type rhombohedral).

Ternary Phase Equilibria

With starting metals of 99.98% Fe, 99.8% Ni and graphite, [2008Had] arc-melted under Ar atm about fifteen Fe-rich alloys, with Nb contents up to 16.2 at.% and C contents up to 16.1 at.%. The phase equilibria were studied with optical microscopy, a scanning electron microscope equipped with an energy dispersive x-ray analyzer, and differential thermal analysis at a cooling rate of 10 °C/min. The liquidus projection for cementite equilibrium in Fe-rich alloys constructed by [2008Had] is redrawn in Fig. 1. The primary phases of crystallization are: δ, γ, Fe_2Nb, NbC_{1-x}, and Fe_3C. On the univariant line $L + \delta + NbC_{1-x}$, a eutectic maximum e_{max} occurs at ~1457 °C. Near the Fe-Nb side, the solidification is complete through the ternary eutectic reaction E_1 at 1365 °C. Near the Fe-C side, solidification is complete through the reaction E_2 at 1140 °C. A reaction sequence for Fe-rich alloys is shown in Fig. 2. The solid-state invariant reaction, Ed is placed in a broken box in Fig. 2 to indicate that it has no experimental confirmation.

References

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