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B-Fe-Si (Boron-Iron-Silicon)

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The previous review of this system by [1992Rag] presented a liquidus projection for B-lean alloys, a reaction sequence for liquid-solid reactions, an isothermal section for B-lean alloys at 1050 °C from [1989Des], and a full isothermal section at 900 °C from [1970Cha]. Recently, [2004Tok] obtained new experimental results, optimized the thermodynamic parameters, and computed isothermal sections at 1000 and 900 °C. Three vertical sections were also computed at 65 at.% Fe, 10 at.% B, and 10 at.% Si, respectively.

Binary Systems

The Fe-B phase diagram [1993Lia] depicts two intermediate phases: Fe_2B (*C*16, $CuAl_2$-type tetragonal) and FeB (*B*27-type orthorhombic). Fe_3B is a metastable phase with several crystal modifications. The B-Si phase diagram [1992Rag] depict three intermediate phases. SiB_3 ($D1_g$, B_4C-type rhombohedral) is stable below ~1270 °C. SiB_6 is orthorhombic and SiB_n (93.8-98 at.% B) is β B-type rhombohedral. The Fe-Si phase diagram [Massalski2] depicts a γ loop, restricting the Fe-based face-centered cubic (fcc) solid solution to 3.2 at.% Si. The body-centered cubic (bcc) solid solution α exists in the disordered *A*2 form, as well as in the ordered forms of *B*2 and $D0_3$. The intermediate phases are: Fe_2Si (hexagonal), Fe_5Si_3 ($D8_8$, Mn_5Si_3-type hexagonal), FeSi (*B*20-type cubic), $\alpha FeSi_2$ (orthorhombic), and $\beta FeSi_2$ (tetragonal).

Ternary Phase Equilibria

The structural details of the three confirmed ternary compounds in this system, Fe_5SiB_2 (τ_1), $Fe_{4.7}Si_2B$ (τ_2), and $Fe_3(Si,B)$ (τ_3) were listed by [1992Rag]. It is possible that $Fe_3(Si,B)$ is a Si-stabilized phase originating from one of the metastable forms of Fe_3B. A fourth compound $Fe_2Si_{0.4}B_{0.6}$ (τ_4) reported by [1960Aro] was not confirmed by [1970Cha].

With starting metals of 99% B, 99.998% Fe, and 99.9% Si [2004Tok] arc-melted 13 Fe-rich ternary alloys. Differ-

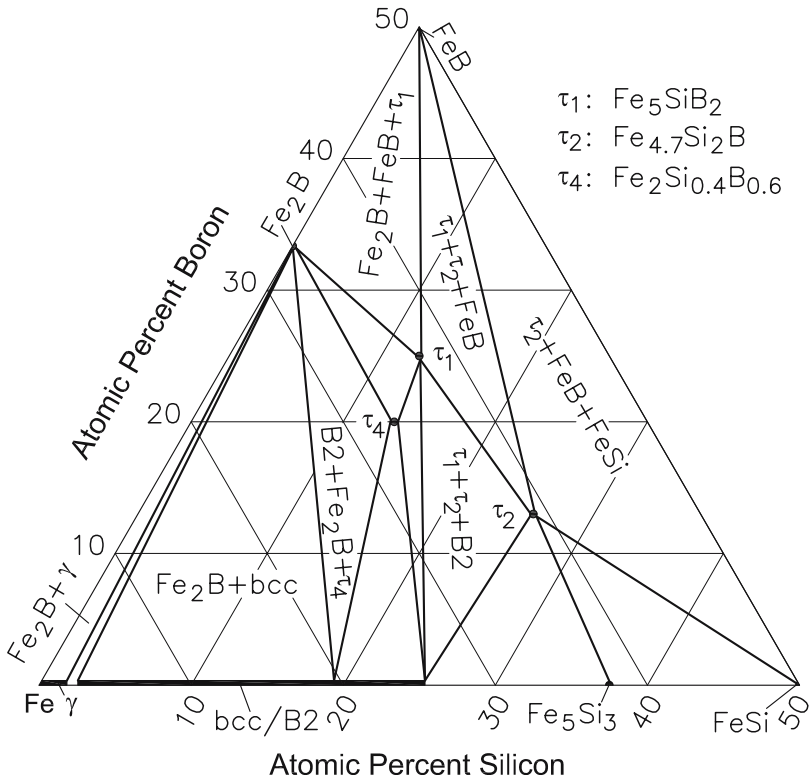

Fig. 1 B-Fe-Si computed isothermal section at 1000 °C [2004Tok]. Narrow two-phase regions are omitted

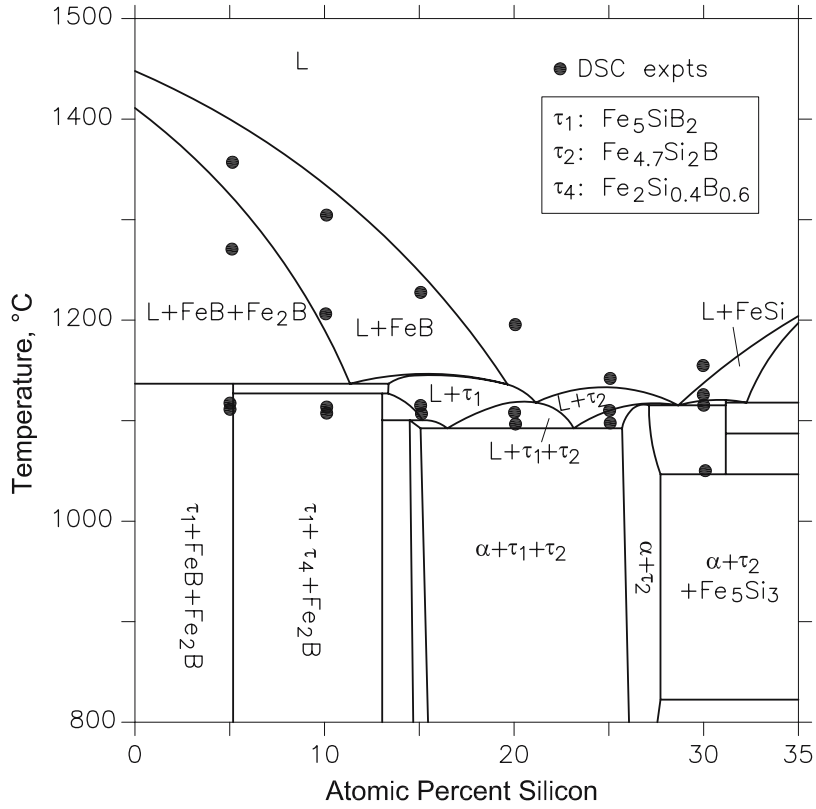

Fig. 2 B-Fe-Si computed vertical section at 65 at.% Fe [2004Tok]

ential scanning calorimetry (DSC) was performed at a cooling/heating rate of 5 °C per min. Peak DSC temperatures during heating were used to identify the phase changes. In the thermodynamic modeling by [2004Tok], the Gibbs energies of the liquid and fcc phases were described by the regular solution model. The third component solubility in all the binary phases was neglected. The three ternary compounds Fe_5SiB_2 (τ_1), $Fe_{4.7}Si_2B$ (τ_2), and $Fe_2Si_{0.4}B_{0.6}$(τ_4) were treated as stoichiometric, neglecting the small homogeneity ranges. The ternary compound $Fe_3(Si,B)$ (τ_3) was not considered by [2004Tok]. The bcc phase was described by a two-sublattice model, so that the B2 ordering is accounted for. Two isothermal sections at 1000 and 900 °C were computed. The computed section at 1000 °C is shown in Fig. 1. In place of the three-phase equilibria of $(\tau_1 + \text{FeB} + \text{FeSi})$ and $(\tau_1 + \tau_2 + \text{FeSi})$ found by [1960Aro], the computed section shows $(\tau_2 + \text{FeB} + \text{FeSi})$ and $(\tau_1 + \tau_2 + \text{FeB})$. A U-type transition reaction $\tau_1 + \text{FeSi} \leftrightarrow \tau_2 + \text{FeB}$ connects the above pairs of three-phase equilibria. [2004Tok] also computed three vertical sections at 65 at.% Fe, 10 at.% B, and 10 at.% Si, respectively. The vertical section at 65 at.% Fe is redrawn in Fig. 2 and compared with the DSC measurements. [2004Tok] made no reference to the liquid-solid experimental results of [1989Des] nor to the review of [1992Rag], which included the work of [1989Des].

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