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Al-B-Si (Aluminum-Boron-Silicon)

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This ternary system was assessed thermodynamically by [1990Luk], who computed a liquidus projection and two isothermal sections at 1300 and 500 °C. Recently, [2005Yos] investigated the L/(L + AlB_{12}) equilibrium and reconstructed the isothermal section at 1300 °C.

Binary Systems

There are two intermediate phases in the Al-B system: AlB_2 ($C32$, AlB_2-type hexagonal) and AlB_{12} (AlB_{12}-type tetragonal). The Al-Si phase diagram is a simple eutectic system with the eutectic reaction at 577 °C and 12.2 at.% Si. The B-Si phase diagram [Massalski2] depicts the following phases: SiB_6 (SiB_6-type orthorhombic), SiB_n ($n \sim 23$, rhombohedral) and a low temperature phase SiB_3 ($D1_g$, B_4C-type rhombohedral, stable below 1270 °C).

Ternary Phase Equilibria

[2005Yos] employed the electron microprobe analysis and x-ray diffraction to study the boride in equilibrium with Al-Si melts at 1300, 1200, and 1100 °C. They concluded that the boride in equilibrium with the melt is AlB_{12} with some dissolved Si, which substitutes for Al. The maximum fraction of Al substituted by Si in AlB_{12} is 0.23. This value was found at 1300 °C in Si-saturated Al-Si melt with about 80 at.% Si. Figure 1 shows the L/(L + AlB_{12}) equilibrium at 1300, 1200 and 1100 °C [2005Yos]. An isothermal section at 1300 °C constructed by [2005Yos] is shown Fig. 2. The boride in equilibrium with the Al-Si melt is AlB_{12} with dissolved Si, as discussed above and not SiB_6 as concluded by [1990Luk]. The findings of [2005Yos] are consistent with the recent calculations of [2005Gro] of a tie-line between AlB_{12} and (Si) and not between (Al) and silicon boride.

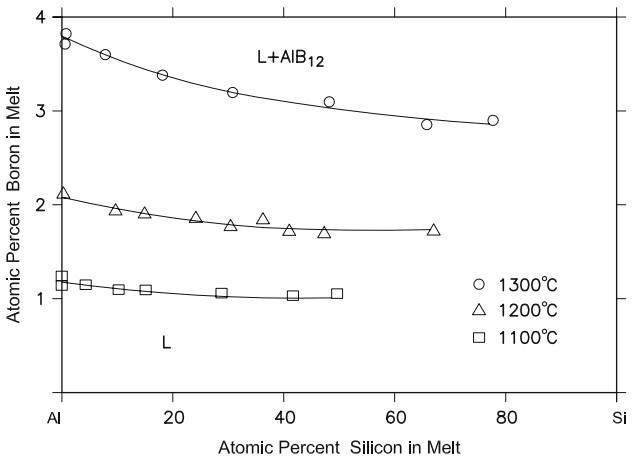

Fig. 1 Al-B-Si the L/(L + AlB_{12}) phase boundary at 1300, 1200, and 1100 °C [2005Yos]

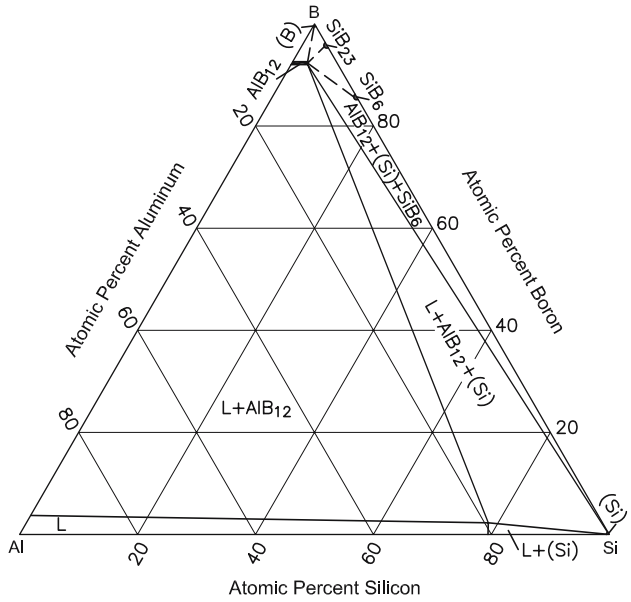

Fig. 2 Al-B-Si isothermal section at 1300 °C [2005Yos]. Narrow two-phase regions are omitted

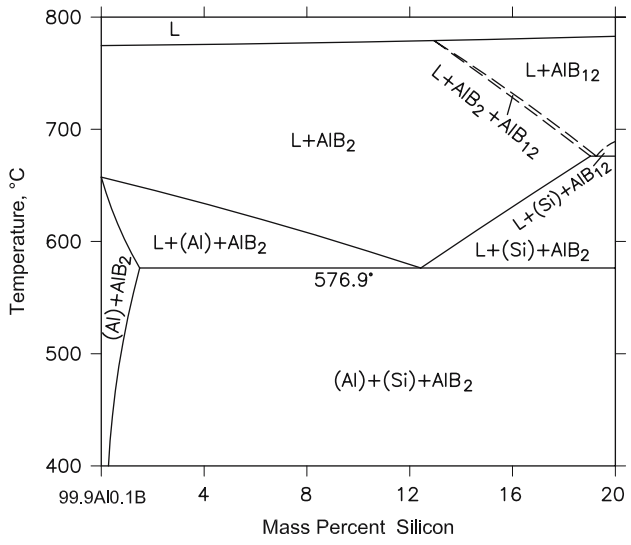

Fig. 3 Al-B-Si computed vertical section at 0.1 mass% B [2005Gro]

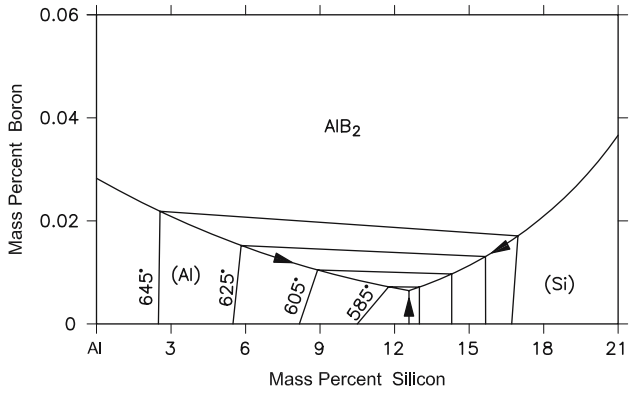

Fig. 4 Al-B-Si computed liquidus projection for Al-rich alloys [1993Ton]

In the course of their work to establish a thermodynamic data base for the Al-B-Si-Ti quaternary system, [2005Gro] presented a computed vertical section for the Al-B-Si system at a constant B content of 0.1 mass %. This is shown in Fig. 3. The ternary eutectic reaction L ↔ (Al) + (Si) + AlB_2 occurs at 576.9 °C, only 0.1 °C below the binary eutectic of the Al-Si system. The ternary eutectic liquid contains 0.01 mass% B. During their study of the grain refinement by B of Al-Si hypoeutectic alloys, [1993Ton] presented a computed liquidus projection for Al-rich alloys as shown in Fig. 4.

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