JPEDAV (2007) 28:549–551
DOI: 10.1007/s11669-007-9168-9
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Al-Li-Si (Aluminum-Lithium-Silicon)

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The previous review of this system by [1991Goe] presented a liquidus projection and an isothermal section at 550 °C for Al-rich alloys, a pseudobinary section along the Al-AlLiSi join and four vertical sections at 2Si, 5Si, 5Li, and 92Al (mass%) respectively. Recent work of [2001Kev] and [2001Gro] clarified the stable ternary compounds of this system and computed the phase equilibria, using the new experimental results in the optimization.

Binary Systems

The Al-Li phase diagram [1989Sau, 1991Goe] has the following intermediate phases: LiAl (45-55 at.% Li; NaTl-type cubic), Li_3Al_2 (Bi_2Te_3-type rhombohedral), and Li_9Al_4 (two modifications stable below 330 °C). The Li-Si phase diagram [Massalski2] has the following intermediate compounds: $Li_{22}Si_5$ ($Li_{22}Pb_5$-type cubic), $Li_{13}Si_4$ (*Pbam*, orthorhombic), Li_7Si_3 (rhombohedral), and $Li_{12}Si_7$ (*Pnma*, orthorhombic). The Al-Si phase diagram is a simple eutectic system with the eutectic reaction at 577 °C and 12.2 at.% Si.

Ternary Compounds

There are three ternary compounds of nearly-fixed stoichiometry in this system [2001Kev]. The phase LiAlSi (denoted τ_1) is cubic, 12 atoms/cell, space group $F\bar{4}3m$, a = 0.59282 nm. $Li_{5.3}Al_{0.7}Si_2$ (τ_2) is hexagonal, 8 atoms/cell, $P6_3/mmc$, a = 0.43410 nm and c = 0.81052 nm. $Li_8Al_3Si_5$ (τ_3) is cubic, 16 atoms/cell, $P\bar{4}3m$, and a = 0.61146 nm [2001Kev]. All three compounds melt congruently, at 811 °C (τ_1), 793 °C (τ_2) and 833 °C (τ_3) [2001Gro].

Ternary Phase Equilibria

With starting metals of 99.8 mass% Al, 99.9 mass% Li, and 99.9998 mass% Si, [2001Kev] levitation melted about 15 ternary alloys under Ar atm. The alloys were annealed at 250 °C for 13-30 days. The phase equilibria were studied with x-ray diffraction and the scanning electron microscope fitted with the energy dispersive x-ray analyzer. The isothermal section constructed by [2001Gro] at 250 °C is

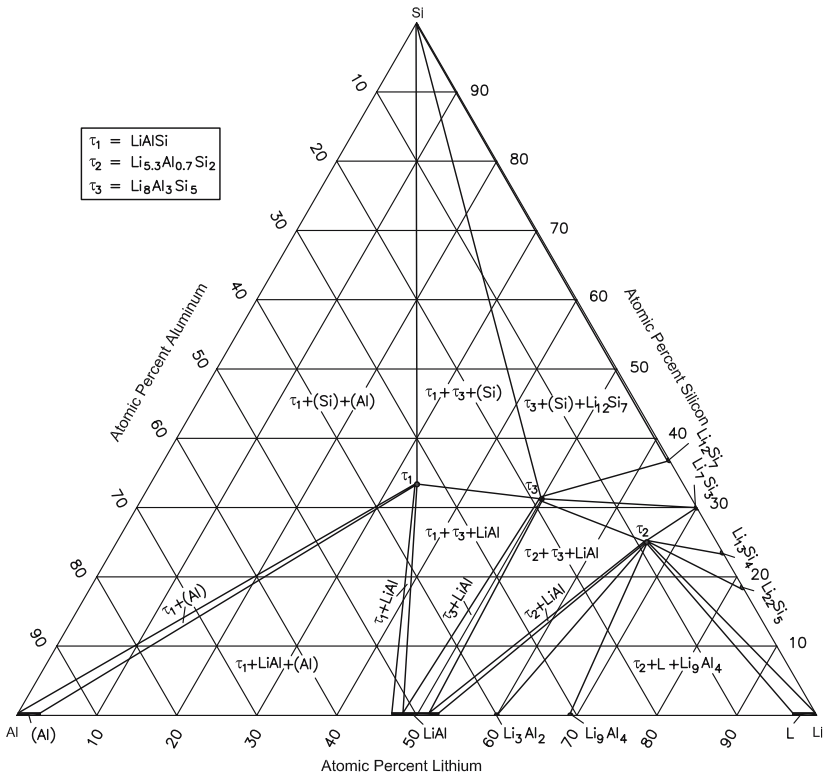

Fig. 1 Al-Li-Si isothermal section at 250 °C [2001Kev]

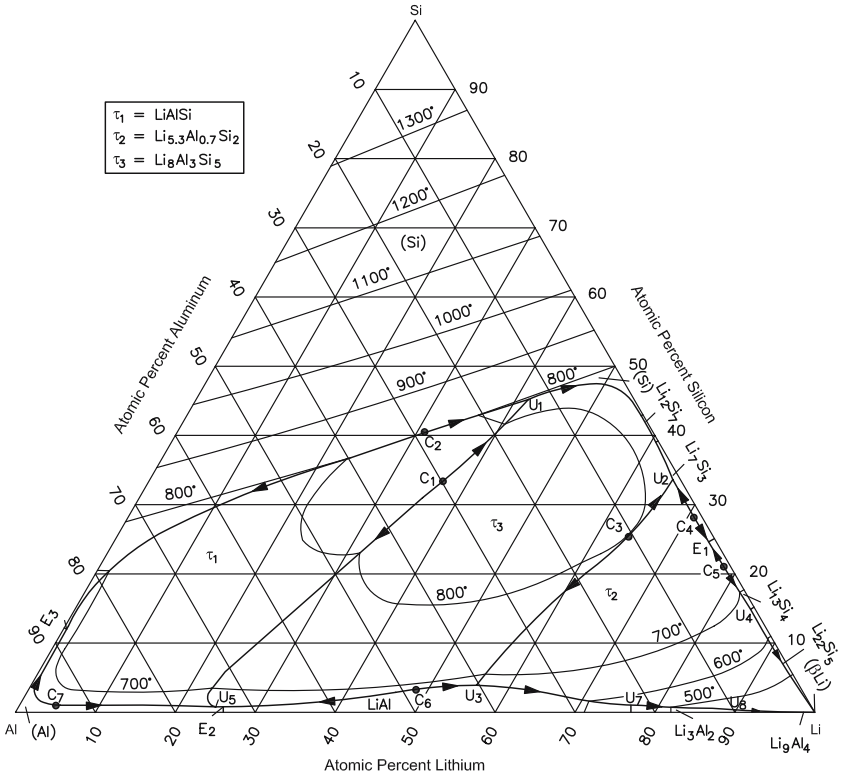

Fig. 2 Al-Li-Si computed liquidus projection [2001Gro]

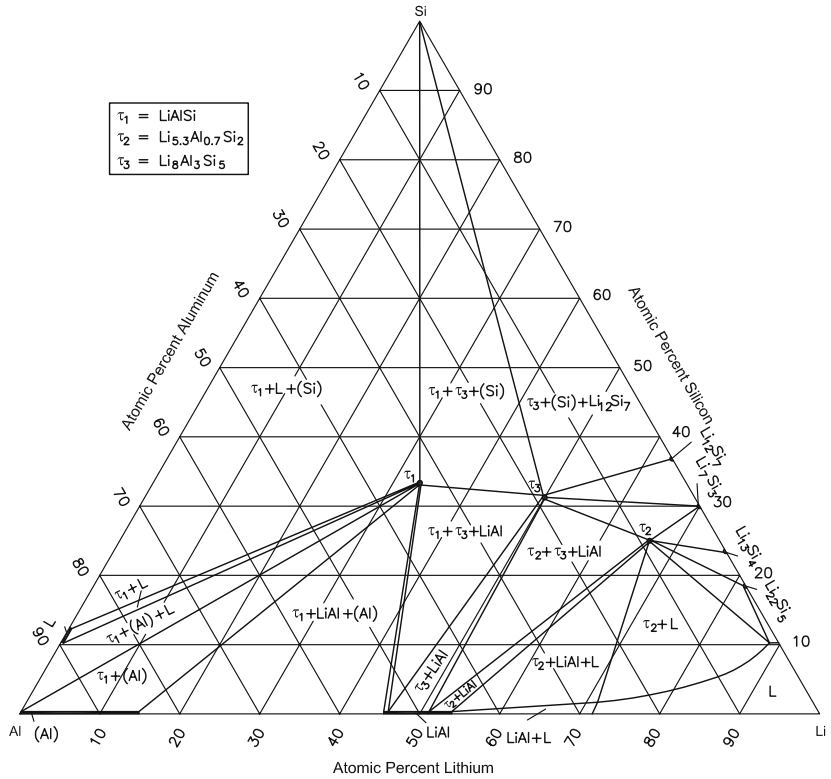

Fig. 3 Al-Li-Si computed isothermal section at 590 °C [2001Gro]

shown in Fig. 1. All three ternary phases are present. No solubility of the third component in the binary compounds was found.

Using the same starting metals as above, [2001Gro] prepared seven ternary alloys and performed differential thermal analysis (DTA) at a heating/cooling rate of 1 °C per min. The post-DTA samples were examined by x-ray diffraction. Results of the thermal arrests were used in the thermodynamic optimization. The binary descriptions of [1989Sau] (Al-Li), [1996Gro] (Al-Si), and [1995Bra] (Li-Si) were accepted by [2001Gro]. The liquid phase and (Al) were modeled as a regular solution without any ternary interaction parameter. The ternary phases were modeled as stoichiometric compounds. The binary phases were taken to have no ternary solubility. A liquidus projection and five isothermal sections at 800, 700, 605, 597, and 590 °C were computed. These five sections demonstrate the changes in tie-lines and phase distribution with decreasing temperature. Comparison of the invariant reactions and temperatures with the available experimental data shows generally good agreement, except for a discrepancy. In the ternary eutectic reaction at 596 °C, the participating ternary phase as computed by [2001Gro] is τ_3, as against τ_1 in the experimental results. The computed liquidus projection and the isothermal section at 590 °C are shown in Fig. 2 and 3. In Fig. 2, (Si), τ_1, τ_2, and τ_3 have large areas of primary crystallization.

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