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Al-Cu-Fe-Si (Aluminum-Copper-Iron-Silicon)

V. Raghavan

Since the early investigation of [1950Phr], Zakharov et al. [1989Zak, 1990Zak] have reported several polythermal and isothermal sections for this quaternary system.

Ternary Systems

For recent updates on ternary systems, see [2005Rag] (Al-Cu-Fe), [2002Rag1] (Al-Fe-Si), [2002Rag2] (Cu-Fe-Si), and this issue (Al-Cu-Si).

Quaternary Phase Equilibria

With starting metals of 99.995% Al, 99.99% Cu, 99.98% Si, and Al-Fe master alloys, [1989Zak] melted samples under a protective layer of a flux. The phase equilibria were studied by differential thermal analysis, metallography, X-ray powder diffraction, and micro X-ray spectral analysis. The isothermal sections at 25 mass% Cu constructed by [1989Zak] at 850, 750, and 625 °C are shown in Fig. 1. At 850 °C (Fig. 1a), only one phase precipitates from the liquid: $FeAl_3$, which dissolves up to 27 mass% Cu. The solubility of Si in $FeAl_3$ was found not to exceed 0.9 mass%. At 750 °C (Fig. 1b), the second precipitate to form is αAlFeSi ($Al_{7.4}Fe_2Si$, denoted τ_5 by [2002Rag1]), which dissolves up to 22 mass% Cu. At 700 °C (Fig. 1c), Al_7Cu_2Fe is present as an additional phase in the section. Al_7Cu_2Fe dissolves less than 0.9 mass% Si.

With starting metals of high purity, [1990Zak] melted alloys in a resistance furnace under a protective layer of a flux. The phase equilibria were studied by differential

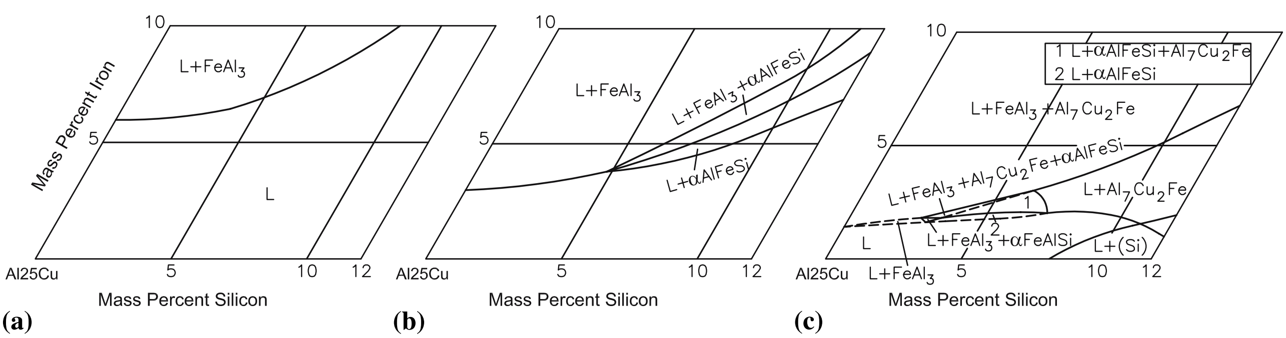

Fig. 1 Al-Cu-Fe-Si isothermal sections at 25 mass% Cu and at (a) 850, (b) 750, and (c) 625 °C [1989Zak]

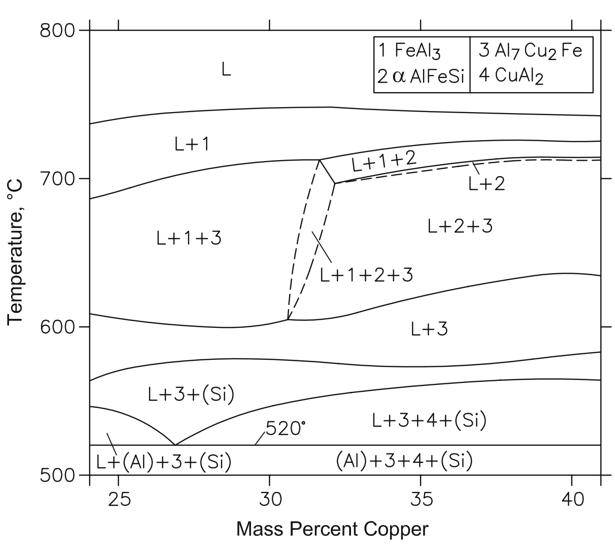

Fig. 2 Al-Cu-Fe-Si polythermal section at 5Fe-5Si (in mass%) [1990Zak]

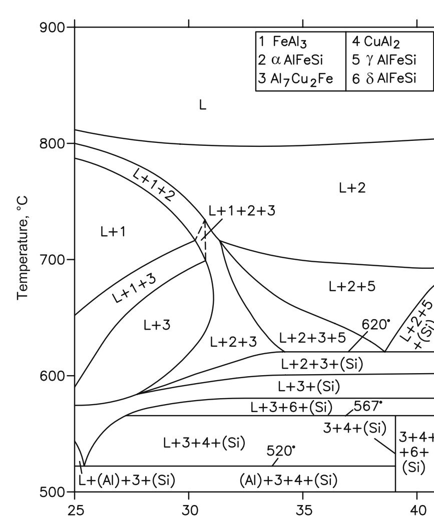

Fig. 3 Al-Cu-Fe-Si polythermal section at 10Fe-11Si (in mass%) [1990Zak]

thermal analysis (at a heating or cooling rate of 3-4 °C/min), metallography, and X-ray powder diffraction. The polythermal sections constructed by [1990Zak] at 5Fe-5Si and 10Fe-11Si (in mass%) are shown in Fig. 2 and 3 respectively. The compound phases present are $FeAl_3$ (with dissolved Cu), $CuAl_2$, αAlFeSi, γAlFeSi ($Al_5Fe_2Si_2$, denoted τ_4 by [2002Rag1]), δAlFeSi ($Al_{2.7}FeSi_{2.3}$ denoted τ_7 by [2002Rag1]) and Al_7Cu_2Fe. The following five-phase invariant reactions are seen in Fig. 3: at 620 °C, L + γAlFeSi $\leftrightarrow$ Al_7Cu_2Fe + αAlFeSi + (Si); at 567 °C, L + δAlFeSi $\leftrightarrow$ Al_7Cu_2Fe + $CuAl_2$ + (Si); and at 520 °C, L $\leftrightarrow$ (Al) + Al_7Cu_2Fe + $CuAl_2$ + (Si). [1990Zak] found that the liquidus temperature is increased by Fe, decreased by Si, with Cu having little effect.

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