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

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One of the early reports on this quinary system is by [1950Phr]. [2002Bel1, 2002Bel2] studied the phase equilibria in Al-rich alloys with a constant Cu content of 10 mass% and up to a few percent each of Fe, Mg and Si. They constructed plots to show the solidification reactions, the phase distribution in the solid state and the polythermal section at 10Cu-1.5Mg-0.5Si (in mass%). Earlier, [1998Bel] reported similar results in Al-rich alloys with a constant Si content of 10 mass%.

Quaternary Systems

Updates on the Al-Cu-Fe-Si, Al-Cu-Mg-Si and Al-Fe-Mg-Si systems appear in this issue. In the Al-Cu-Fe-Mg system, [2002Bel1] found no quaternary phases in Al-rich alloys. [1950Phr] investigated all the above four quaternary systems, as a first step to the study of this quinary system.

The ternary and quaternary phases found in the alloy compositions investigated by [2002Bel1] and [1998Bel] are denoted as follows: Al_2CuMg (denoted S), Al_7CuFe (denoted N by [2002Bel1]), $FeSiAl_5$ (β), $Cu_2Mg_8Si_6Al_5$ (Q) and $Fe_2Mg_7Si_{10}Al_{18}$ (π).

Quinary Phase Equilibria

With starting metals of 99.99% Al, 99.9% Cu, 99.95% Mg, 99.99% Si and an Al-Fe master alloy, [1998Bel] melted and cast in air Al-rich alloys containing a constant Si content of 10 mass%, and smaller quantities of Cu, Fe and Mg. The phase equilibria were studied with scanning electron microscope and electron probe microanalysis. The temperatures of the phase changes were determined by thermal analysis.

Assuming that (Al) solidified first and then (Si), followed by other ternary and quaternary solidification reactions, [1998Bel] projected the liquidus on a triangle as shown in Fig. 1. All regions contain additionally (Al) and (Si). The liquidus lines correspond to five-phase equilibrium. For example, p_2-U_2 and e_1-E lines refer to the equilibrium $L + FeSiAl_5 \leftrightarrow (Al) + (Si) + \pi$ and $L \leftrightarrow (Al) + (Si) + Q + \theta$, respectively. The final solidification is through the six-phase eutectic reaction (point E): $L \leftrightarrow (Al) + (Si) + Q + \theta + \pi$. Using the observation that all their alloys necessarily contain (Al) and (Si), [1998Bel] plotted the phase distribution in the solid state on a triangle, Fig. 2. All phase regions contain additionally (Al) and (Si). A polythermal section at constant 5Cu-0.4Mg-10Si (in mass%) is shown in Fig. 3. [1998Bel] also derived isothermal sections

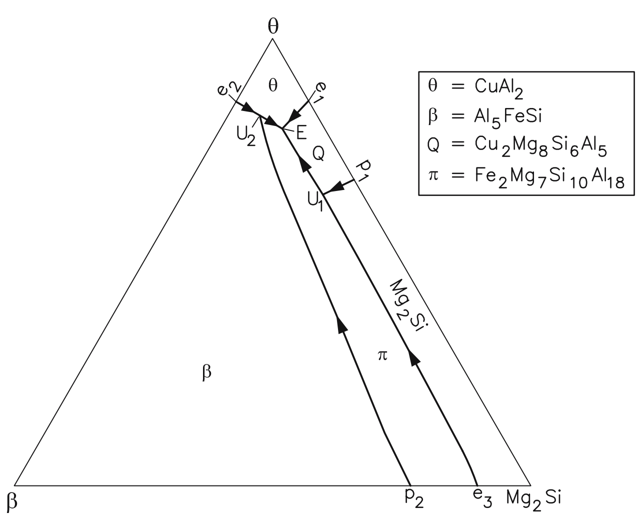

Fig. 1 Al-Cu-Fe-Mg-Si liquidus in Al-rich alloys with 10 mass% Si, projected from Al apex. All regions have additionally (Al) and (Si) [1998Bel]

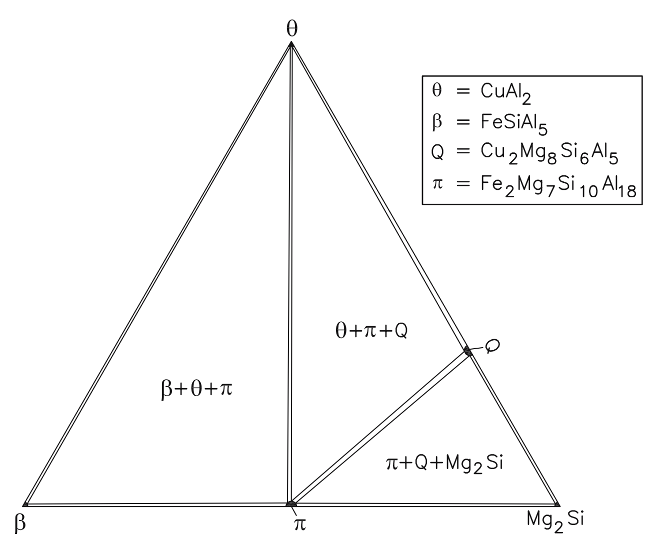

Fig. 2 Al-Cu-Fe-Mg-Si phase distribution in the solid state in Al-rich alloys with 10 mass% Si. All regions have additionally (Al) and (Si) [1998Bel]

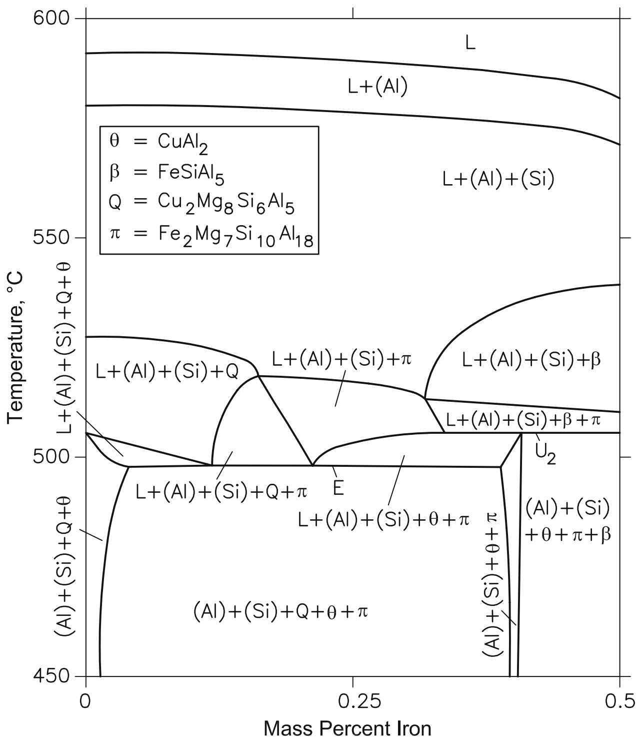

Fig. 3 Al-Cu-Fe-Mg-Si polythermal section at 5Cu-0.4Mg-10Si (in mass%) [1998Bel]

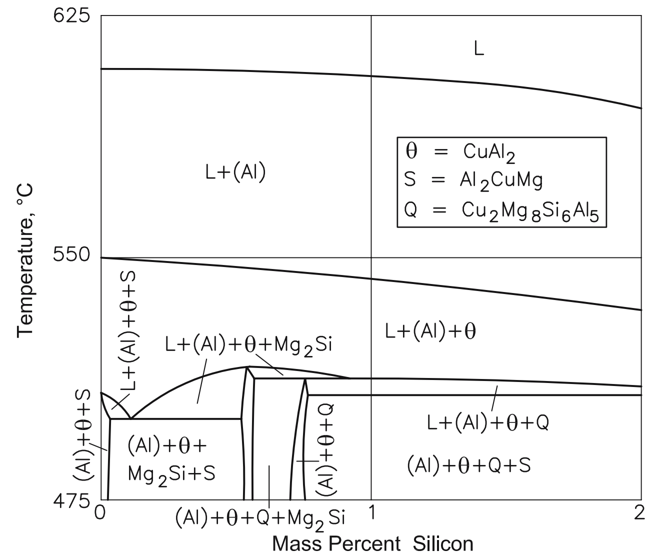

Fig. 5 Al-Cu-Fe-Mg-Si polythermal section at 10Cu-0Fe-2Mg (in mass%) [2002Bel1]

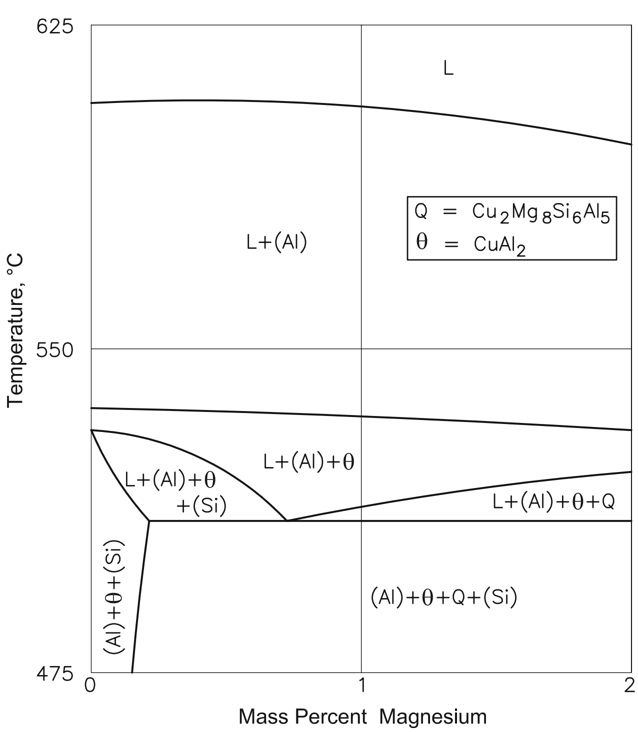

Fig. 4 Al-Cu-Fe-Mg-Si polythermal section at 10Cu-0Fe-2Si (in mass%) [2002Bel1]

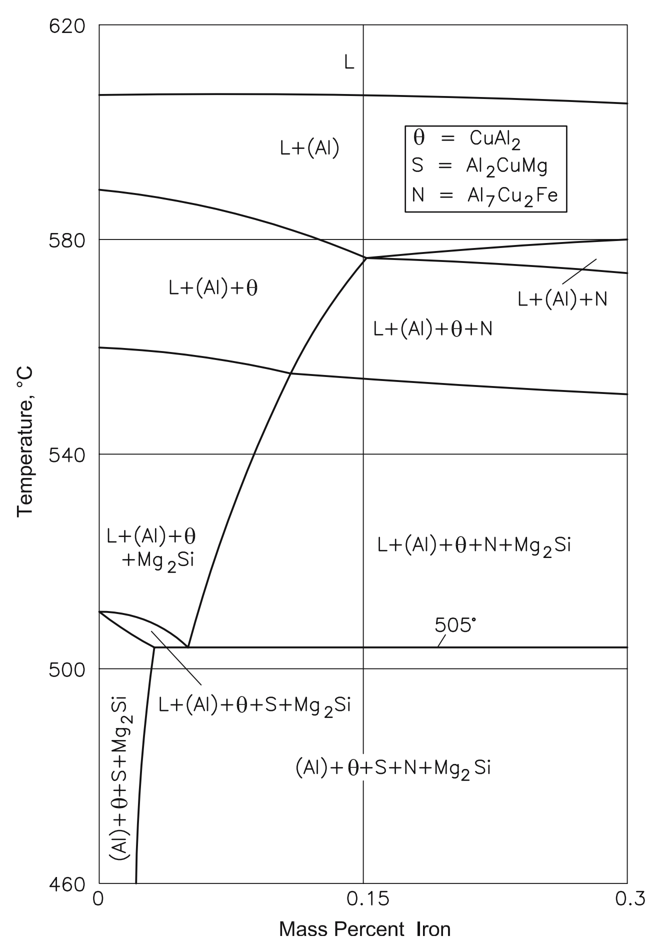

Fig. 6 Al-Cu-Fe-Mg-Si polythermal section at 10Cu-1.5Mg-0.5Si (in mass%) [2002Bel1]

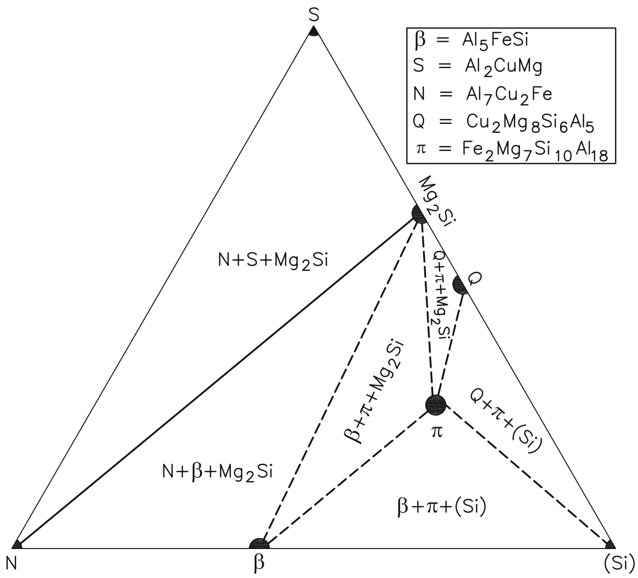

Fig. 7 Al-Cu-Fe-Mg-Si phase distribution in the solid state in Al-rich alloys with 10 mass% Cu. All phase fields contain additionally (Al) and $CuAl_2$(θ) [2002Bel1]

at room temperature and phase fractions as a function of Fe content.

Using the same starting metals as [1998Bel], [2002Bel1] melted 11 Al-rich quinary alloys in air. The alloys had a constant Cu content of 10 wt.%, Fe (0.1-0.5 wt.%), Mg (0.4-3 wt.%) and Si (0.4-1.75 wt.%). The samples were remelted and cooled in a furnace to obtain coarse crystals for easy metallographic identification. Quantitative analysis was performed in a scanning electron microscope. The composition of the alloys was such that (Al) solidifies first, then $CuAl_2$ (θ) crystallizes, followed by ternary and quaternary reactions.

The polythermal sections at Al-10Cu-0Fe-2Si and Al-10Cu-0Fe-2Mg (in mass%) are shown in Fig. 4 and 5 as a function of Mg and Si, respectively. In Fig. 1, the Mg-rich compound Mg_2Si is not present, whereas in Fig. 2, (Si) is not present. Figure 6 shows a polythermal section at Al-10Cu-1.5Mg-0.5Si as a function of Fe content. A six-phase invariant reaction (quinary eutectic) occurs at about 505 °C. In Fig. 7, the phase distribution in the solid state is shown on a triangle for Al-rich alloys containing a constant 10 mass% Cu [2002Bel1]. All phase fields contain additionally (Al) and $CuAl_2$ (θ). Thus the triangular regions are five-phase fields.

References

1950Phr: G. Phragmen, On the Phases Occurring in Alloys of Aluminum with Copper, Magnesium, Manganese, Iron and Silicon, *J. Inst. Metals (London)*, 1950, **77**, p 489-552

1998Bel: N.A. Belov, Yu.A. Gusev, and D.G. Eskin, Evaluation of Five-component Phase Diagrams for the Analysis of Phase Composition in Al-Si based Alloys, *Z. Metallkd.*, 1998, **89**(9), p 618-622

2002Bel1: N.A. Belov, A.V. Koltsov, and D.G. Eskin, The Al-Cu-Fe-Mg-Si Phase Diagram in the Range of Al-Cu Alloys, *Mater. Sci. Forum*, 2002, **396-402**, p 929-934

2002Bel2: N.A. Belov and A.V. Koltsov, Phase Diagram of the Al-Cu-Fe-Mg-Si System in the Region of Al-Cu Alloys, *Tsvetn. Metall.* (2), p 37-48, in Russian