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Al-Mg-Si (Aluminum-Magnesium-Silicon)

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The compilation of the experimental data on this ternary system by [1995Vil] includes a liquidus projection and 15 vertical sections from [1977Sch] and partial isothermal sections at 1050, 800, 460, 430, 427, 400, and 300 °C from several sources. Subsequent to the thermodynamic assessment of this system by [1992Cha], new assessments were reported by [1997Feu, 2005Lac].

Binary Systems

The Al-Mg phase diagram [2003Cze] has the following intermediate phases: Mg_2Al_3 (cubic, denoted β), R or ε (rhombohedral) and $Mg_{17}Al_{12}$ (*A*12-type cubic, denoted γ). The Al-Si phase diagram is a simple eutectic system with the eutectic at 577 °C and 12.2 at.% Si.

In the Mg-Si system, [1997Feu] performed calorimetric studies to determine the enthalpies of formation and fusion, and the heat capacity of Mg_2Si and the enthalpy of mixing of liquid Mg-Si alloys. The new experimental results were used in the optimization of the Mg-Si phase diagram by computation. The diagram depicts a stoichiometric compound Mg_2Si (*C*1, CaF_2-type cubic), with negligible terminal solid solubility. [2000Yan] developed a new thermodynamic description of the Mg-Si system that uses fewer model parameters than [1997Feu]. More recently, [2004Kev] remodeled the Mg-Si description to obtain a phase diagram without an artificial miscibility gap in the liquid phase at high temperatures, as found in the descriptions of [1997Feu, 2000Yan].

Ternary Phase Equilibria

With starting metals of 99.999% Al, 99.98% Mg and 99.999% Si, [1997Feu] induction-melted alloy samples under Ar atm. Differential thermal analysis (DTA) was done at heating/cooling rates between 2 and 5 °C per min. Using the new data with those in the literature (as selected by [1992Cha]), [1997Feu] reoptimized the thermodynamic parameters. The liquid, the face-centered cubic (fcc) and the close-packed hexagonal (cph) phases were modeled as single-lattice substitutional solutions. The Al-Mg compounds, Mg_2Si and Si were treated as stoichiometric phases. Ternary interaction parameters were determined for the liquid phase. The earlier description of the Al-Mg phase diagram [1990Sau], which includes an unconfirmed compound ζ, was used. This, however, did not change the computed results in the Al-rich region. In Fig. 1-4, the four vertical sections at 95, 90, 85 and 80 mass% Al respectively

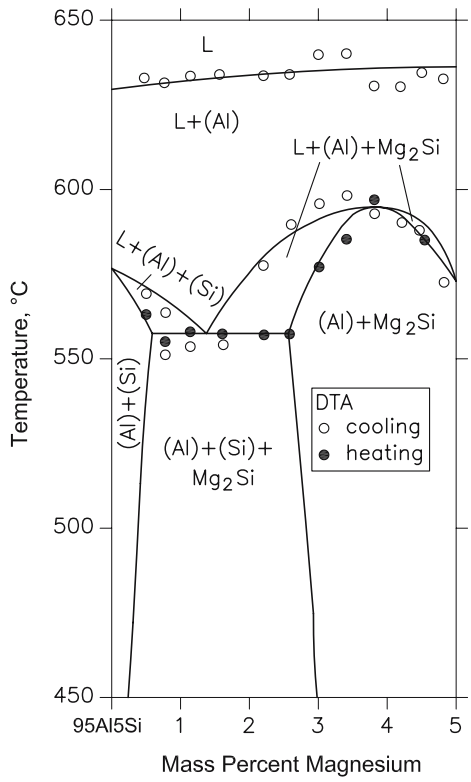

Fig. 1 Al-Mg-Si computed vertical section at 95 mass% Al [1997Feu]

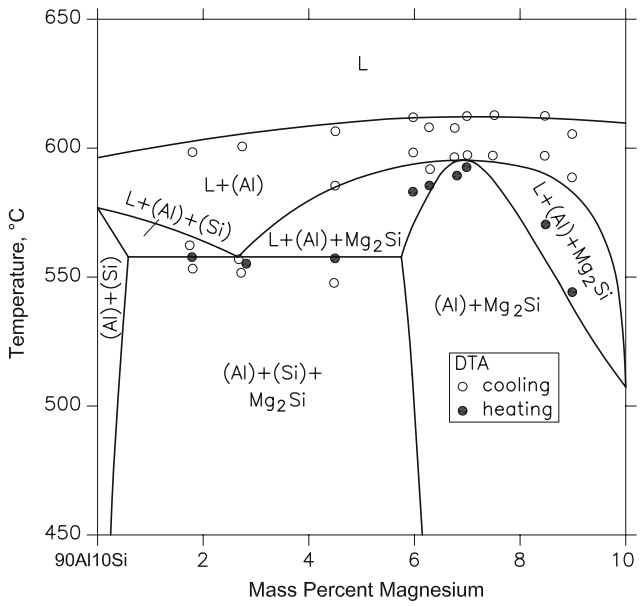

Fig. 2 Al-Mg-Si computed vertical section at 90 mass% Al [1997Feu]

computed by [1997Feu] are compared with their own DTA data on solidification temperatures. The agreement with the experimental data is good.

[2005Lac] carried out a new thermodynamic assessment of this system, which uses the revised Al-Mg description with only the three intermediate phases, Mg_2Al_3 (β), ε and γ. They used a larger set of data for the liquid-solid equilibria from the experimental results of [1977Sch, 1997Feu]. Temperature-independent ternary interaction parameters were obtained for the liquid phase. A partial liquidus projection and three vertical sections at 5 and 85 mass% Al and 2 mass% Si respectively were computed by [2005Lac]. The vertical section at 2 mass% Si is redrawn in Fig. 5. The agreement with the experimental results of [1977Sch, 1931Los] is satisfactory.

The eutectic maximum (e_3) of the reaction L ↔ (Al)+ Mg_2Si does not lie on the Al-Mg_2Si join but on the Mg-rich side of this line [1992Cha, 1997Feu, 2001Bar, 2005Lac]. The partial liquidus projection in Fig. 6 depicts the above univariant line determined by [2001Bar]. Other recent references on the phase equilibria of this system include [1999Esk, 2002Fro, 2003Erm, 2003Roo, 2004Liu, 2005Don].

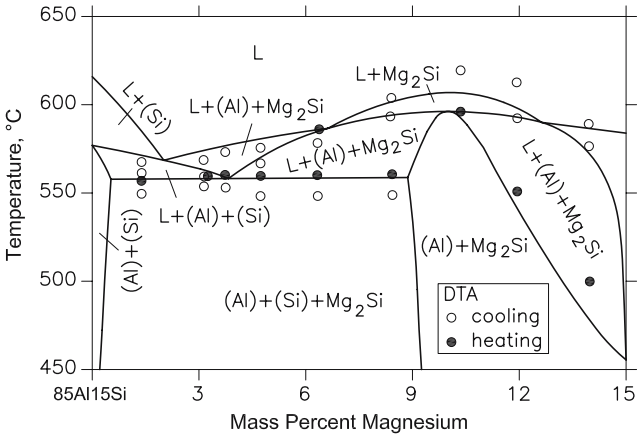

Fig. 3 Al-Mg-Si computed vertical section at 85 mass% Al [1997Feu]

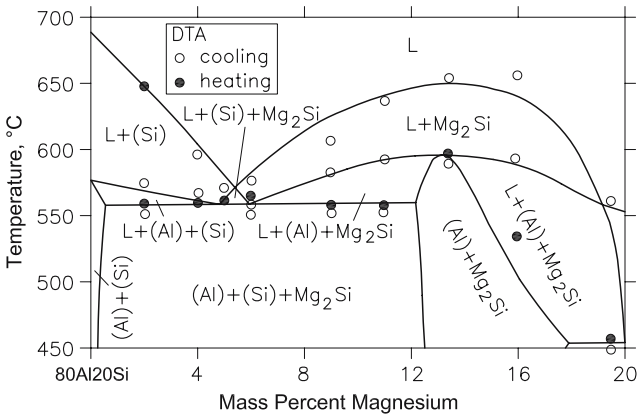

Fig. 4 Al-Mg-Si computed vertical section at 80 mass% Al [1997Feu]

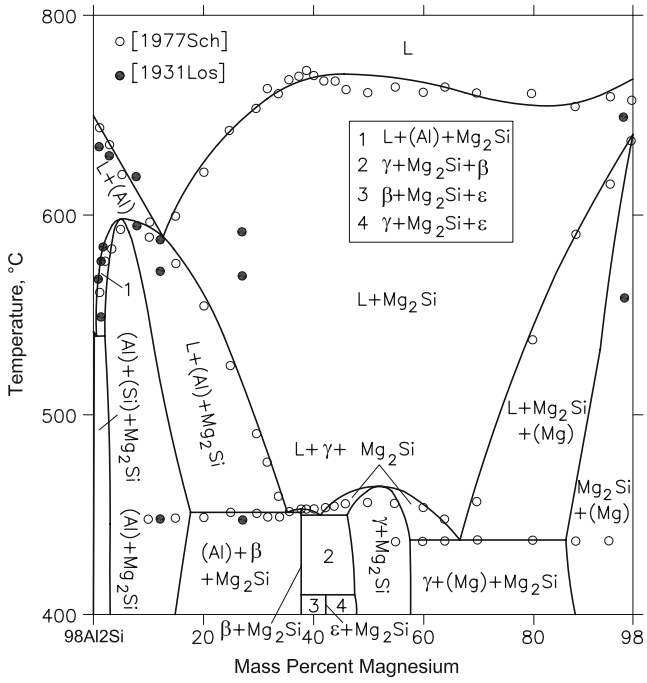

Fig. 5 Al-Mg-Si computed vertical section at 2 mass% Si [2005Lac]

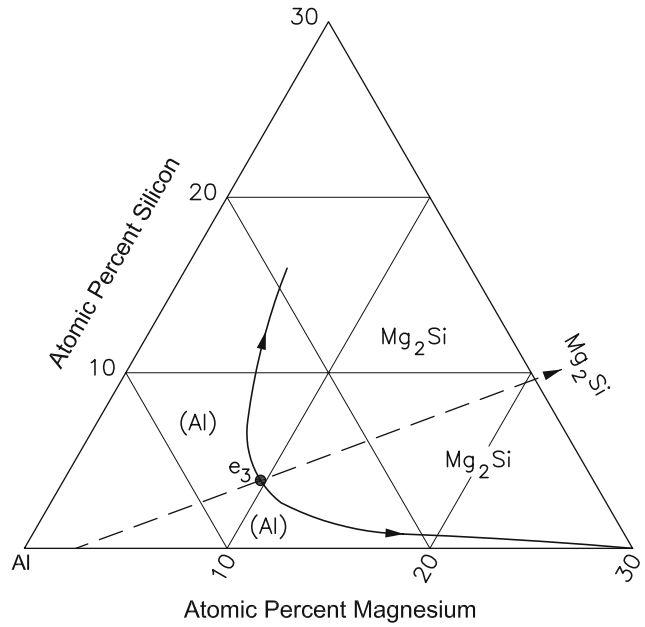

Fig. 6 Al-Mg-Si partial liquidus projection depicting the univariant line of $L \leftrightarrow (Al) + Mg_2Si$ [2001Bar]

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