JPEDAV (2007) 28:559–560
DOI: 10.1007/s11669-007-9177-8
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Al-Mg-Mn-Zn (Aluminum-Magnesium-Manganese-Zinc)

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Recently, [2006Ohn1] presented a thermodynamic assessment of this quaternary system, incorporating new results from a few key experiments. Five vertical sections for Mg-rich alloys were computed and compared with the available experimental data.

Ternary Subsystems

Recently, [2007Rag] reviewed the Al-Mg-Mn and Al-Mg-Zn ternary systems. Thermodynamic assessments have appeared recently of Al-Mg-Mn [2005Ohn], Al-Mg-Zn [1998Lia, 2006Ohn2], and Mg-Mn-Zn [2006Ohn3]. The experimental data on the Al-Mn-Zn system were compiled by [1995Vil].

Quaternary Phase Equilibria

Starting with two commercial alloys AZ91HP and AZ61, [2006Ohn1] prepared two alloys with the following composition in mass %: 6.61Al-1.32Zn-0.24Mn and 8.67Al-0.63Zn-0.21Mn. Differential thermal analysis (DTA) and differential scanning calorimetry techniques were employed to identify the thermal arrests. Heating/cooling rates of 1–5 °C/min were used by [2006Ohn1]. Microstructural and compositional analyses were done with the scanning electron microscope and the energy dispersive x-ray analyzer. [2006Ohn1] emphasized the need for care in interpreting the thermal signals in terms of the phase changes in the alloy.

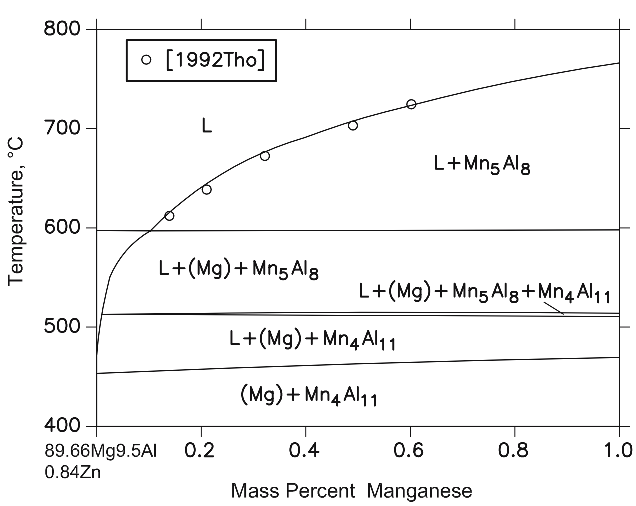

Fig. 1 Al-Mg-Mn-Zn computed vertical section at 9.5Al-0.84Zn (mass%) [2006Ohn1]

The thermodynamic descriptions of Al-Mg-Mn by [2005Ohn], of Al-Mg-Zn by [1998Lia], and of Mg-Mn-Zn by [2006Ohn3] were adopted by [2006Ohn1], with some improvements based on new experimental results. In the absence of a thermodynamic assessment of the Al-Mn-Zn system, it was described as an extrapolation of the binary parameters.

For the quaternary system, [2006Ohn1] computed five vertical sections and compared them with the available thermal data. These sections are shown in Fig. 1 to 5. In Fig. 1 and 2, the computed liquidus agrees well with the liquid-solid equilibrium compositions determined by

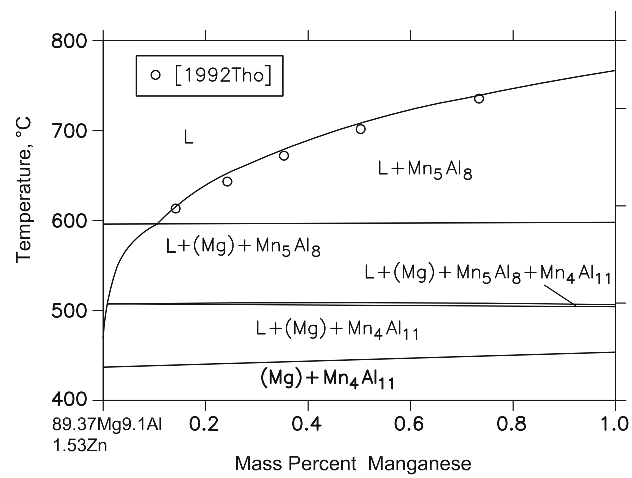

Fig. 2 Al-Mg-Mn-Zn computed vertical section at 9.1Al-1.53Zn (mass%) [2006Ohn1]

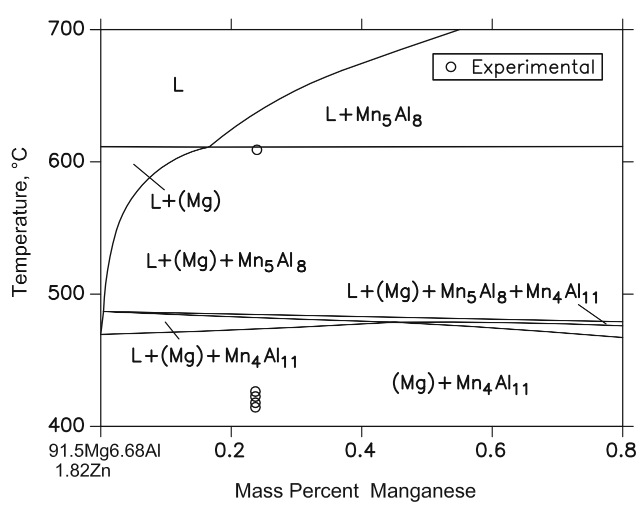

Fig. 3 Al-Mg-Mn-Zn computed vertical section at 6.68Al-1.82Zn (mass%) [2006Ohn1]

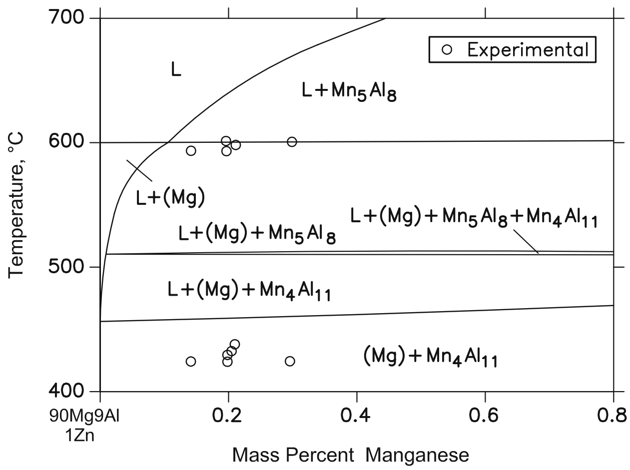

Fig. 4 Al-Mg-Mn-Zn computed vertical section at 9Al-1Zn (mass%) [2006Ohn1]

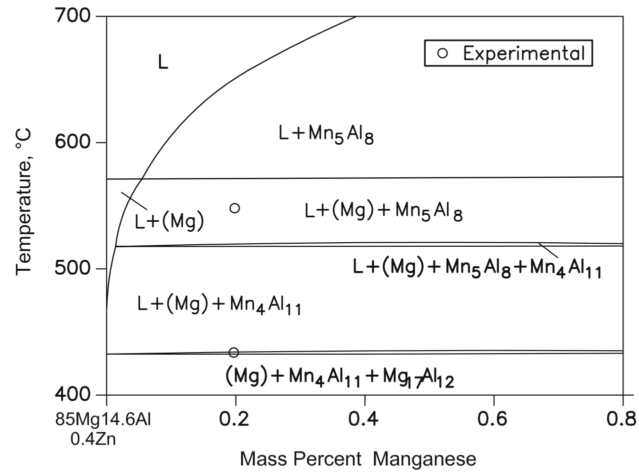

Fig. 5 Al-Mg-Mn-Zn computed vertical section at 14.6Al-0.4Zn (mass%) [2006Ohn1]

[1992Tho]. In Fig. 3 to 5, two thermal signals were observed in all thermal analyses. The signal at the higher temperature does not correspond to the liquidus temperature, but to the phase boundary $(L + Mn_5Al_8)/[L + Mn_5Al_8 + (Mg)]$. Also, the lower signal is below the solidus temperature and corresponds to the precipitation of $Mg_{17}Al_{12}(\gamma)$ under Scheil (nonequilibrium) conditions of cooling. [2006Ohn1] computed constant temperature contours on the solidus surface near the Mg corner. These were found to show fair agreement with the available experimental data.

References

1992Tho: A. Thorvaldsen and C.A. Aliravci, Solubility of Manganese in Liquid Mg-Al Alloys, M.M. Avedesian, L.J. Larouche and J. Masounave, Eds., *Adv. Prod. Fabr. Light Met. Met. Matrix Comp., Int. Symp.*, Can. Inst. Min. Metall. Pet., Montreal, 1992, p 277-288

1995Vil: P. Villars, A. Prince, and H. Okamoto, Al-Mn-Zn, *Handbook of Ternary Alloy Phase Diagrams*, Vol. 4, ASM International, Materials Park, OH, 1995, p 4038-4045

1998Lia: P. Liang, T. Tarfa, J.A. Robinson, S. Wagner, P. Ochin, M.G. Harmelin, H.J. Seifert, H.L. Lukas, and F. Aldinger, Experimental Investigation and Thermodynamic Calculation of the Al-Mg-Zn System, *Thermochim. Acta*, 1998, **314**, p 87-110

2005Ohn: M. Ohno and R. Schmid-Fetzer, Thermodynamic Assessment of Mg-Al-Mn Phase Equilibria, Focusing on Mg-Rich Alloys, *Z. Metallkd.*, 2005, **96**(8), p 857-869

2006Ohn1: M. Ohno, D. Mirkovic, and R. Schmid-Fetzer, Liquidus and Solidus Temperatures of Mg-Rich Mg-Al-Mn-Zn Alloys, *Acta Mater.*, 2006, **54**, p 3883-3891

2006Ohn2: M. Ohno, D. Mirkovic, and R. Schmid-Fetzer, Phase Equilibria and Solidification of Mg-Rich Mg-Al-Zn Alloys, *Mater. Sci. Eng. A*, 2006, **A 421**, p 328-337

2006Ohn3: M. Ohno and R. Schmid-Fetzer, Mg-Rich Phase equilibria of Mg-Mn-Zn Alloys Analyzed by Computational Thermochemistry, *Int. J. Mater. Res.*, 2006, **97**(5), p 526-532

2007Rag: V. Raghavan, Al-Mg-Mn and Al-Mg-Zn, *J. Phase Equilb. Diffus.*, 2007, **28**(2), p 201-202, 203-208