Al – Mg (Aluminum – Magnesium)

Phase diagram

For a short discussion of phase equilibria and crystal structure of intermediate phases see [98 Oka]. Su et al. [97 Su] have reinvestigated the phase equilibria in the concentration range between 37 and 53 at% Mg. The resulting partial phase diagram is shown in Fig. 1.

Chartrand et al. [94 Cha] have critically evaluated all thermodynamic data and phase equilibria in the Al-Mg system. Of special interest is the middle of the concentration range. The results obtained in this area are shown in Fig. 2.

The whole phase diagram, as recommended by Okamoto [98 Oka], is given in Fig. 3.

By rapid solidification of liquid alloys Hehmann [90 Heh] has prepared metastable solid alloys (partially amorphous). Transformation of these metastable phases have been investigated thoroughly.

By ball-milling of mixtures of elemental Al and Mg powder alloys with extended solid solubility of Mg in Al could be observed [93 Cal]. Starting with a mixture of $Al_{70}Mg_{30}$ solid solution with 18 at% Mg and starting with the composition of $Al_{50}Mg_{50}$ metastable solid solution with 45 at% Mg could be obtained.

Zhang et al. [94 Zha] have prepared by mechanical alloying stable as well as metastable phases.

By twin roll technique [99 Cho] produced such flakes, in which the solubility of Al in Mg-solid solution increased from < 1 at-% Al (equilibration condition) to 10.6 at-% Al (metastable, remaining at RT).

Thermodynamics

Soares et al. [95 Soa], using an isopiestic method, have determined thermodynamic activities of Mg in liquid alloys at concentrations < 50 at% Mg and at temperatures 900 > T > 1150 K. The results obtained are not realistic. The activity coefficient γ_{Mg} should be due to the overall tendency for compound formation $\gamma_{Mg} < 1$. But within the experimental scatter the authors found $\gamma_{Mg} > 1$.

Critical evaluation by [94 Cha] yields some reliable thermodynamic data. They are given in the next figures.

The thermodynamic activities of Mg in liquid Al-Mg alloys are shown in Fig. 4. Thermodynamic activities of Mg in solid Mg alloys are plotted in Fig. 5 (710 K).

By high-temperature calorimetry Agarwal et al. [91 Aga] have determined enthalpies of mixing of liquid alloys. The results are plotted in Fig. 6.

Belton et al. [69 Bel] have determined partial Gibbs free enthalpies of liquid alloys (Fig. 7). The results obtained are in good agreement with partial Gibbs free enthalpies obtained by evaluation of ΔH^L data given in Fig. 6 [91 Aga].

Figures

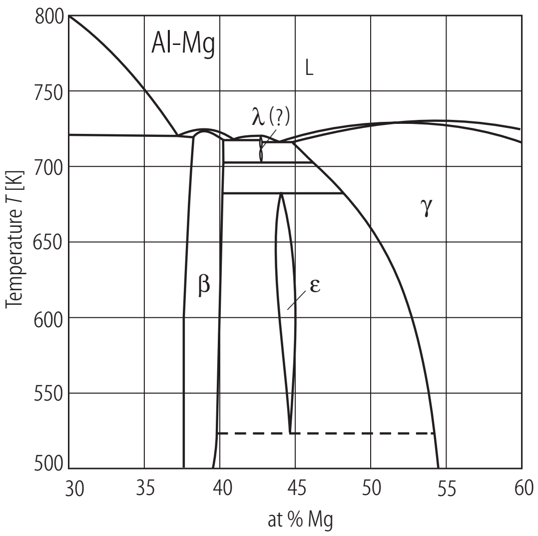

Fig. 1. Al–Mg. Partial phase diagram for 37 to 53 at% Mg [97 Su].

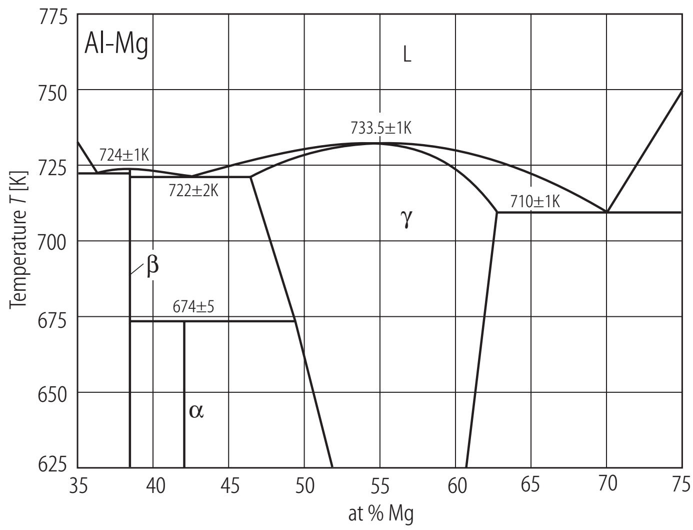

Fig. 2. Al–Mg. Partial phase diagram calculated by [94 Cha].

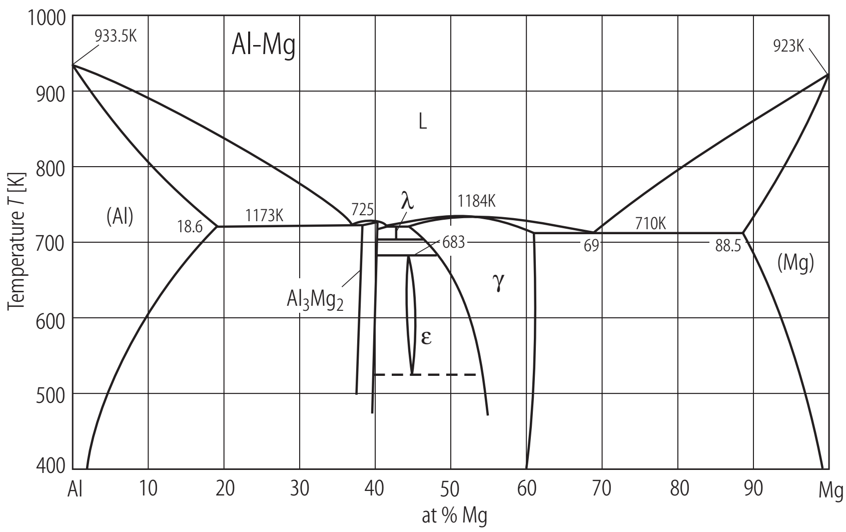

Fig. 3. Al–Mg. Phase diagram recommended by [98 Oka].

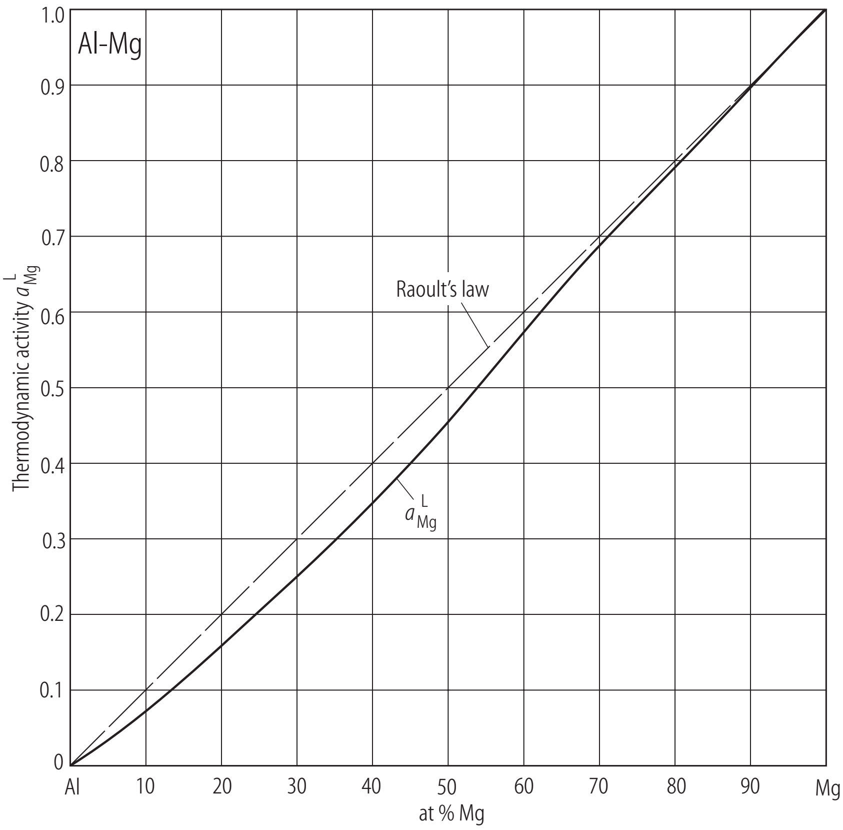

Fig. 4. Al–Mg. Thermodynamic activities of Mg in liquid Al-Mg alloys [94 Cha], [93 Zuo].

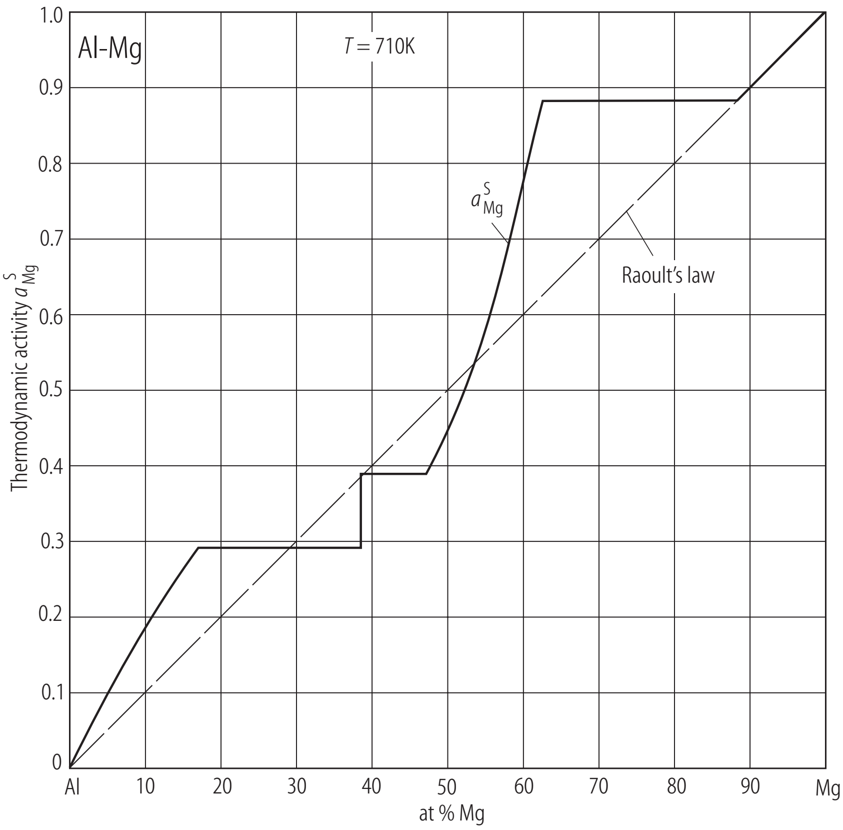

Fig. 5. Al–Mg. Thermodynamic activities of Mg in solid alloys at 710 K [94 Cha].

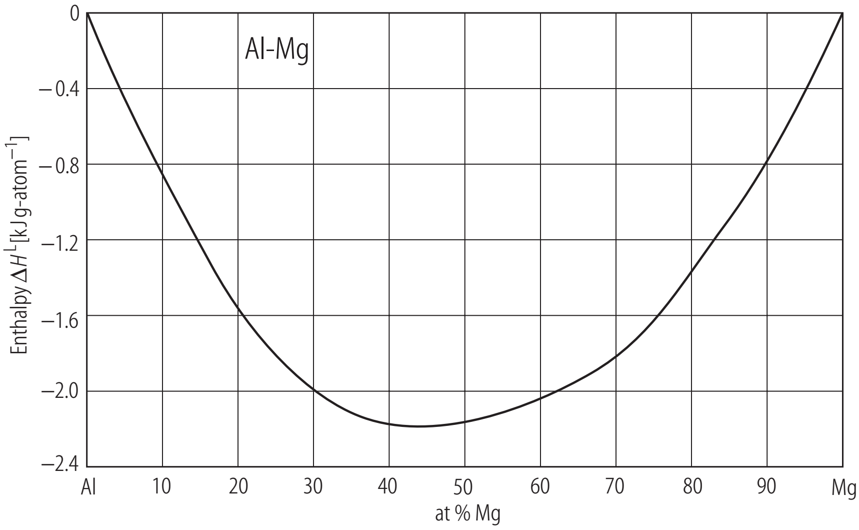

Fig. 6. Al–Mg. Calorimetrically determined enthalpies of mixing of liquid alloys [91 Aga].

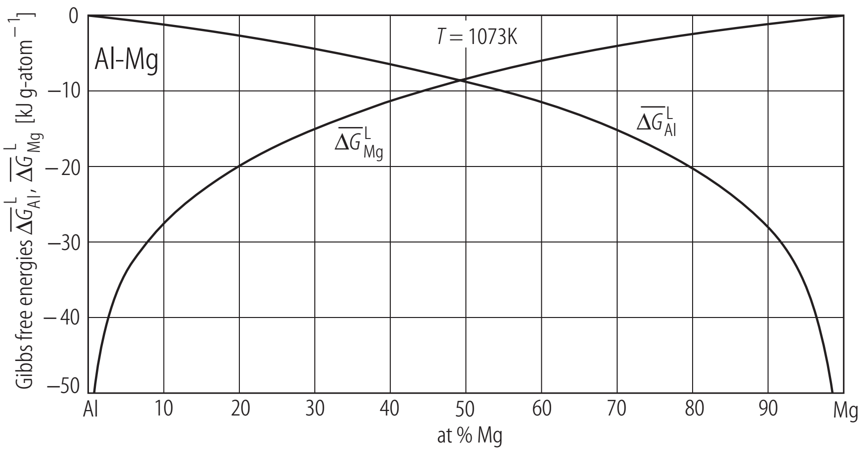

Fig. 7. Al–Mg. Partial Gibbs free enthalpies of mixing of liquid alloys [91 Aga].

References

[69 Bel] Belton, G.R., Rao, Y.K.: Trans. Met. Soc. **245** (1969) 2189
[90 Heh] Hehmann, F.: Acta Metall. Mater. **38** (1990) 979
[91 Aga] Agarwal, R., Sommer, F.: Z. Metallkde. **82** (1991) 118
[93 Cal] Calka, A., Kaczmarek, W., Williams, J.S.: J. Mater. Sci. **28** (1993) 15
[93 Zuo] Zuo, Y., Chang, Y.A.: Calphad **17** (1993) 161
[94 Cha] Chartrand, P., Pelton, A.D.: J. Phase Equilibria **15** (1994) 591

[94 Zha] Zhang, D.L., Massalski, T.B., Paruchuri, M.R.: Metall. Mater. Trans. A **25A** (1994) 73
[95 Soa] Soares, D., Malheiros, L.F., Hämäläinen, M., Castro, F.: J. Alloys and Comp. **220** (1995) 179
[97 Su] Su, H.L., Harmelin, M., Donnadieu, P., Baetzner, C., Seifert, H.J., Lukas, H.L., Effenberg, G., Aldinger, F.: J. Alloys and Comp. **247** (1997) 57
[98 Lia] Liang, P., Su, H.-L., Donnadieu, P., Harmelin, M.G., Quivy, A., Ochin, P., Effenberg, G., Siefert, H.-J., Lukas, H.-L., Aldinger, F.: Z. Metallkde. **89** (1998) 536
[98 Oka] Okamoto, H.: J. Phase Equilibria **19** (1998) 598
[99 Cho] Cho, S.S., Chun, B.S., Won, C.W., Kim, S.D., Lee, B.S., Baek, H., Suryanarayana, C.: J. Mater. Science **34** (1999) 4311