Mg – Yb (Magnesium – Ytterbium)

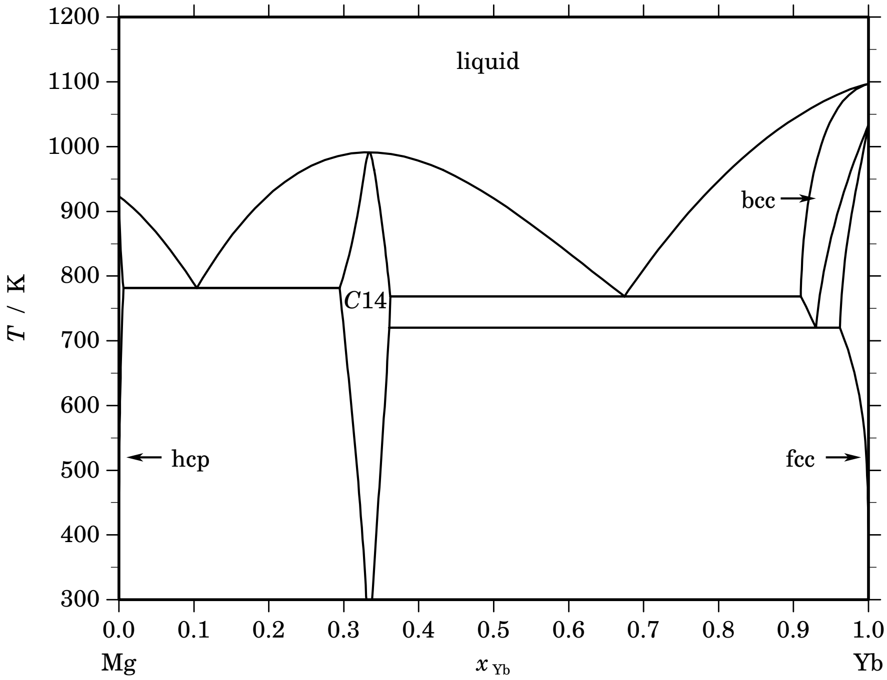

Fig. 1. Calculated phase diagram for the system Mg-Yb.

This system was assessed by Guo and Du [2006Guo], from the available experimental information on the phase diagram and thermodynamics. The interest of magnesium alloys is the potential weight saving in comparison with aluminium, and rare earth elements improve casting characteristics and enhance high temperature properties in these alloys. The phase diagram has been established by McMasters and Gschneidner [1965McM] using differential thermal analysis, metallographic methods and X-ray diffractography. It presents four solution phases, the liquid with a complete miscibility range, the magnesium rich hexagonal (hcp), and ytterbium rich bcc and fcc terminal solid solutions. There is only one non-stoichiometric intermetallic compound, Mg_2Yb, with a $C14$ structure, isotypic with $MgZn_2$, having a homogeneity range of 63.8-70.7 at.% Mg. The enthalpy of mixing of liquid alloys has been determined by Agarwal *et al.* [1995Aga] at 1013 K, 1016 K and 1018 K.

Table I. Phases, structures and models.

Phase	Struktur-bericht	Prototype	Pearson symbol	Space group	SGTE name	Model
liquid					LIQUID	$(Mg,Yb)_1$
hcp	$A3$	Mg	$hP2$	$P6_3/mmc$	HCP_A3	$(Mg,Yb)_1$
$C14$	$C14$	$MgZn_2$	$hP12$	$P6_3/mmc$	C14_LAVES	$(Mg,Yb)_2(Mg,Yb)_1$
bcc	$A2$	W	$cI2$	$Im\overline{3}m$	BCC_A2	$(Mg,Yb)_1$
fcc	$A1$	Cu	$cF4$	$Fm\overline{3}m$	FCC_A1	$(Mg,Yb)_1$

Table II. Invariant reactions.

Reaction	Type	T / K	Compositions / x_{Yb}			$\Delta_{\mathrm{r}}H$ / (J/mol)
liquid $\rightleftharpoons C14$	congruent	991.3	0.334	0.334		−16954
liquid $\rightleftharpoons$ hcp + $C14$	eutectic	781.6	0.104	0.006	0.294	−9642
liquid $\rightleftharpoons C14$ + bcc	eutectic	768.7	0.674	0.362	0.910	−9677
bcc $\rightleftharpoons C14$ + fcc	eutectoid	720.0	0.930	0.361	0.962	−1402

Table IIIa. Integral quantities for the liquid phase at 1100 K.

x_{Yb}	ΔG_{m} [J/mol]	ΔH_{m} [J/mol]	ΔS_{m} [J/(mol·K)]	$G^{\mathrm{E}}_{\mathrm{m}}$ [J/mol]	$S^{\mathrm{E}}_{\mathrm{m}}$ [J/(mol·K)]	ΔC_P [J/(mol·K)]
0.000	0	0	0.000	0	0.000	0.000
0.100	−6510	−2203	3.916	−3537	1.213	0.000
0.200	−10482	−3534	6.316	−5905	2.156	0.000
0.300	−12836	−4137	7.909	−7249	2.829	0.000
0.400	−13866	−4154	8.829	−7711	3.234	0.000
0.500	−13774	−3729	9.132	−7435	3.368	0.000
0.600	−12719	−3007	8.829	−6564	3.234	0.000
0.700	−10828	−2129	7.909	−5241	2.829	0.000
0.800	−8188	−1240	6.316	−3611	2.156	0.000
0.900	−4789	−482	3.916	−1816	1.213	0.000
1.000	0	0	0.000	0	0.000	0.000

Reference states: Mg(liquid), Yb(liquid)

Table IIIb. Partial quantities for Mg in the liquid phase at 1100 K.

x_{Mg}	ΔG_{Mg} [J/mol]	ΔH_{Mg} [J/mol]	ΔS_{Mg} [J/(mol·K)]	$G^{\mathrm{E}}_{\mathrm{Mg}}$ [J/mol]	$S^{\mathrm{E}}_{\mathrm{Mg}}$ [J/(mol·K)]	a_{Mg}	γ_{Mg}
1.000	0	0	0.000	0	0.000	1.000	1.000
0.900	−1572	−460	1.011	−608	0.135	0.842	0.936
0.800	−4282	−1648	2.394	−2241	0.539	0.626	0.783
0.700	−7875	−3279	4.178	−4613	1.213	0.423	0.604
0.600	−12107	−5064	6.403	−7435	2.156	0.266	0.444
0.500	−16762	−6717	9.132	−10422	3.368	0.160	0.320
0.400	−21668	−7952	12.469	−13287	4.851	0.094	0.234
0.300	−26755	−8481	16.613	−15743	6.602	0.054	0.179
0.200	−32223	−8017	22.005	−17503	8.623	0.030	0.148
0.100	−39340	−6275	30.059	−18280	10.914	0.014	0.136
0.000	$-\infty$	−2967	∞	−17788	13.474	0.000	0.143

Reference state: Mg(liquid)

Table IIIc. Partial quantities for Yb in the liquid phase at 1100 K.

x_{Yb}	ΔG_{Yb} [J/mol]	ΔH_{Yb} [J/mol]	ΔS_{Yb} [J/(mol·K)]	$G^{\mathrm{E}}_{\mathrm{Yb}}$ [J/mol]	$S^{\mathrm{E}}_{\mathrm{Yb}}$ [J/(mol·K)]	a_{Yb}	γ_{Yb}
0.000	$-\infty$	−26868	∞	−41690	13.474	0.000	0.010
0.100	−50956	−17891	30.059	−29896	10.914	0.004	0.038
0.200	−35282	−11077	22.005	−20562	8.623	0.021	0.106
0.300	−24412	−6138	16.613	−13401	6.602	0.069	0.231
0.400	−16505	−2789	12.469	−8124	4.851	0.165	0.411
0.500	−10786	−742	9.132	−4447	3.368	0.307	0.615
0.600	−6753	290	6.403	−2081	2.156	0.478	0.796
0.700	−4003	593	4.178	−740	1.213	0.646	0.922
0.800	−2179	455	2.394	−138	0.539	0.788	0.985
0.900	−950	162	1.011	13	0.135	0.901	1.001
1.000	0	0	0.000	0	0.000	1.000	1.000

Reference state: Yb(liquid)

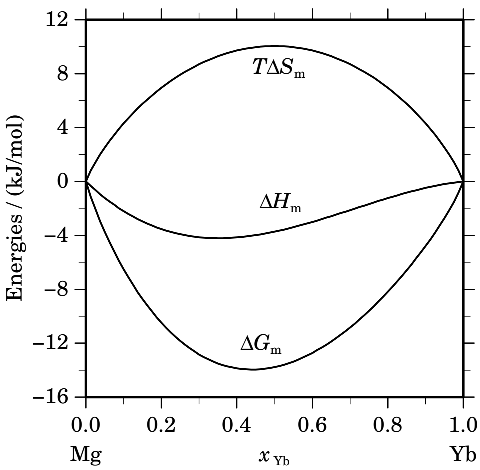

Fig. 2. Integral quantities of the liquid phase at T=1100 K.

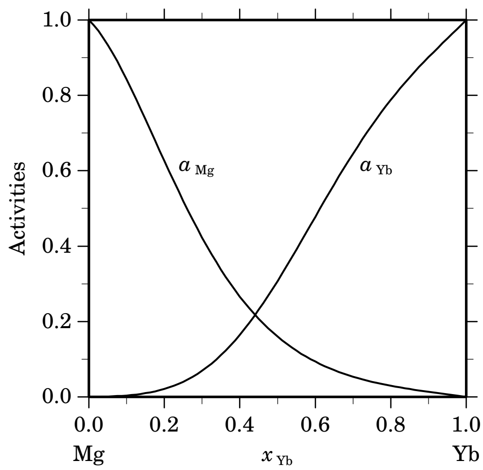

Fig. 3. Activities in the liquid phase at T=1100 K.

Table IV. Standard reaction quantities at 298.15 K for the compounds per mole of atoms.

Compound	x_{Yb}	$\Delta_{\mathrm{f}}G^{\circ}$ / (J/mol)	$\Delta_{\mathrm{f}}H^{\circ}$ / (J/mol)	$\Delta_{\mathrm{f}}S^{\circ}$ / (J/(mol·K))	$\Delta_{\mathrm{f}}C^{\circ}_{P}$ / (J/(mol·K))
$C14$	0.333	−12533	−12533	0.000	0.000

References

[1965McM] O.D. McMasters, K.A. Gschneidner Jr.: J. Less-Common Met. **8** (1965) 289–298.
[1995Aga] R. Agarwal, H. Feufel, F. Sommer: J. Alloys Comp. **217** (1995) 59–64.
[2006Guo] C. Guo, Z. Du: J. Alloys Comp. **422** (2006) 102–108.