Cu – Mg (Copper – Magnesium)

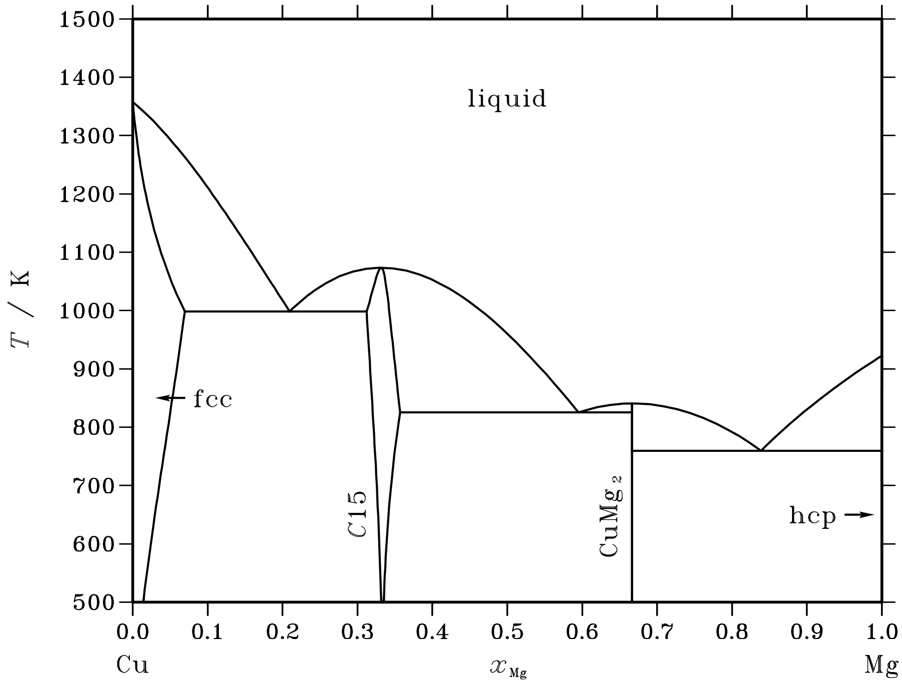

Fig. 1. Calculated phase diagram for the system Cu-Mg.

The copper-magnesium system is part of Al-Cu-Mg-Zn which has been investigated in the framework of the COST 507 program on light metal alloys. The selected assessment has been performed by Coughanowr *et al.* [91Cou]. The experimental data has been critically reviewed by Nayeb-Hashemi and Clark [84Nay]. Two congruent melting intermetallic compounds are known in the system: stoichiometric $CuMg_2$ and the cubic Laves phase Cu_2Mg ($C15$) which has a homogeneity range of a few at.%. The solubility of Cu in solid Mg is negligible and an experimental value of 0.013 at.% Cu is given at the eutectic liquid$\rightleftharpoons$$CuMg_2$+hcp. The maximum solubility of Mg in solid Cu is 6.9 at.% Mg at the eutectic liquid$\rightleftharpoons$fcc+$C15$. The assessment is in good agreement with the experimental liquidus and the invariant points as determined by Jones [31Jon] and Bagnoud *et al.* [78Bag] and all the thermodynamic data cited in [84Nay].

Table I. Phases, structures and models.

Phase	Struktur-bericht	Prototype	Pearson symbol	Space group	SGTE name	Model
liquid					LIQUID	$(Cu,Mg)_1$
fcc	$A1$	Cu	$cF4$	$Fm\overline{3}m$	FCC_A1	$(Cu,Mg)_1$
$C15$	$C15$	Cu_2Mg	$cF24$	$Fd\overline{3}m$	LAVES_C15	$(Cu,Mg)_2(Cu,Mg)_1$
$CuMg_2$	C_b	$CuMg_2$	$oF48$	$Fddd$	CUMG2	Cu_1Mg_2
hcp	$A3$	Mg	$hP2$	$P6_3/mmc$	HCP_A3	$(Cu,Mg)_1$

Table II. Invariant reactions.

Reaction	Type	T / K	Compositions / x_{Mg}			$\Delta_{\mathrm{r}}H$ / (J/mol)
liquid ⇌ $C15$	congruent	1073.5	0.331	0.331		−12520
liquid ⇌ fcc + $C15$	eutectic	998.6	0.209	0.070	0.312	−11056
liquid ⇌ $CuMg_2$	congruent	840.8	0.667	0.667		−11821
liquid ⇌ $C15$ + $CuMg_2$	eutectic	825.5	0.595	0.357	0.667	−11386
liquid ⇌ $CuMg_2$ + hcp	eutectic	759.7	0.839	0.667	1.000	−9385

Table IIIa. Integral quantities for the liquid phase at 1400 K.

x_{Mg}	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	−7102	−3916	2.276	−3318	−0.427	0.000
0.200	−11462	−6700	3.402	−5637	−0.759	0.000
0.300	−14165	−8449	4.083	−7055	−0.996	0.000
0.400	−15504	−9264	4.457	−7670	−1.139	0.000
0.500	−15649	−9241	4.577	−7580	−1.186	0.000
0.600	−14718	−8478	4.457	−6884	−1.139	0.000
0.700	−12791	−7075	4.083	−5680	−0.996	0.000
0.800	−9891	−5129	3.402	−4066	−0.759	0.000
0.900	−5924	−2738	2.276	−2140	−0.427	0.000
1.000	0	0	0.000	0	0.000	0.000

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

Table IIIb. Partial quantities for Cu in the liquid phase at 1400 K.

x_{Cu}	ΔG_{Cu} [J/mol]	ΔH_{Cu} [J/mol]	ΔS_{Cu} [J/(mol·K)]	$G^{\mathrm{E}}_{\mathrm{Cu}}$ [J/mol]	$S^{\mathrm{E}}_{\mathrm{Cu}}$ [J/(mol·K)]	a_{Cu}	γ_{Cu}
1.000	0	0	0.000	0	0.000	1.000	1.000
0.900	−1742	−582	0.829	−516	−0.047	0.861	0.957
0.800	−4530	−2199	1.666	−1933	−0.190	0.678	0.847
0.700	−8206	−4652	2.539	−4054	−0.427	0.494	0.706
0.600	−12630	−7747	3.488	−6684	−0.759	0.338	0.563
0.500	−17694	−11286	4.577	−9626	−1.186	0.219	0.437
0.400	−23349	−15074	5.911	−12683	−1.708	0.135	0.336
0.300	−29674	−18914	7.686	−15659	−2.325	0.078	0.260
0.200	−37093	−22609	10.346	−18358	−3.036	0.041	0.207
0.100	−47386	−25963	15.302	−20584	−3.843	0.017	0.171
0.000	$-\infty$	−28781	∞	−22139	−4.744	0.000	0.149

Reference state: Cu(liquid)

Table IIIc. Partial quantities for Mg in the liquid phase at 1400 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}
0.000	$-\infty$	−45145	∞	−38503	−4.744	0.000	0.037
0.100	−55340	−33916	15.302	−28537	−3.843	0.009	0.086
0.200	−39187	−24704	10.346	−20453	−3.036	0.035	0.173
0.300	−28070	−17310	7.686	−14056	−2.325	0.090	0.299
0.400	−19814	−11539	5.911	−9148	−1.708	0.182	0.456
0.500	−13603	−7195	4.577	−5535	−1.186	0.311	0.622
0.600	−8965	−4081	3.488	−3019	−0.759	0.463	0.772
0.700	−5555	−2001	2.539	−1403	−0.427	0.620	0.886
0.800	−3090	−758	1.666	−493	−0.190	0.767	0.959
0.900	−1317	−157	0.829	−90	−0.047	0.893	0.992
1.000	0	0	0.000	0	0.000	1.000	1.000

Reference state: Mg(liquid)

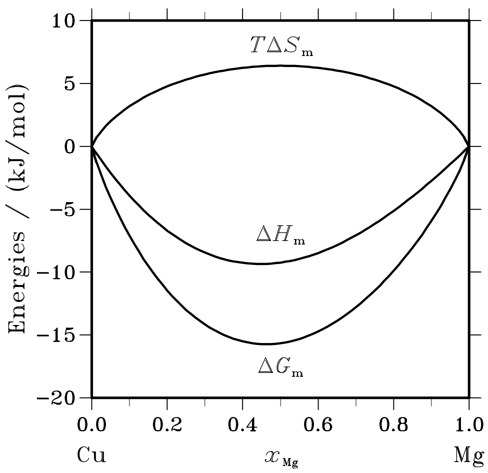

Fig. 2. Integral quantities of the liquid phase at T=1400 K.

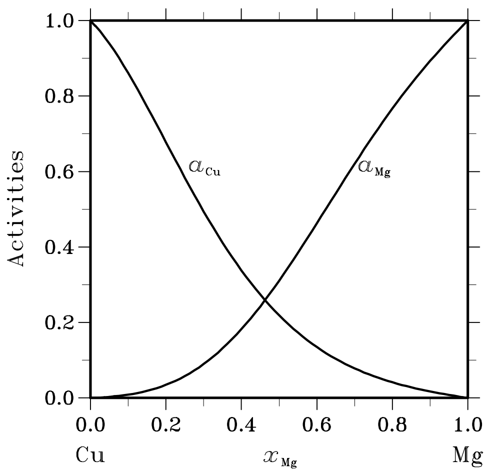

Fig. 3. Activities in the liquid phase at T=1400 K.

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

Compound	x_{Mg}	$\Delta_{\mathrm{f}}G^{\circ}$ / (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))
$C15$	0.333	−11278	−10908	1.241	−1.432
$\mathrm{Cu_1Mg_2}$	0.667	−9355	−9540	−0.622	0.000

References

[31Jon] W.R.D. Jones: J. Inst. Met. **46** (1931) 395–419.
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[84Nay] A.A. Nayeb-Hashemi, J.B. Clark: Bull. Alloy Phase Diagrams **5** (1984) 36–48.
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