Pb – Zn (Lead – Zinc)

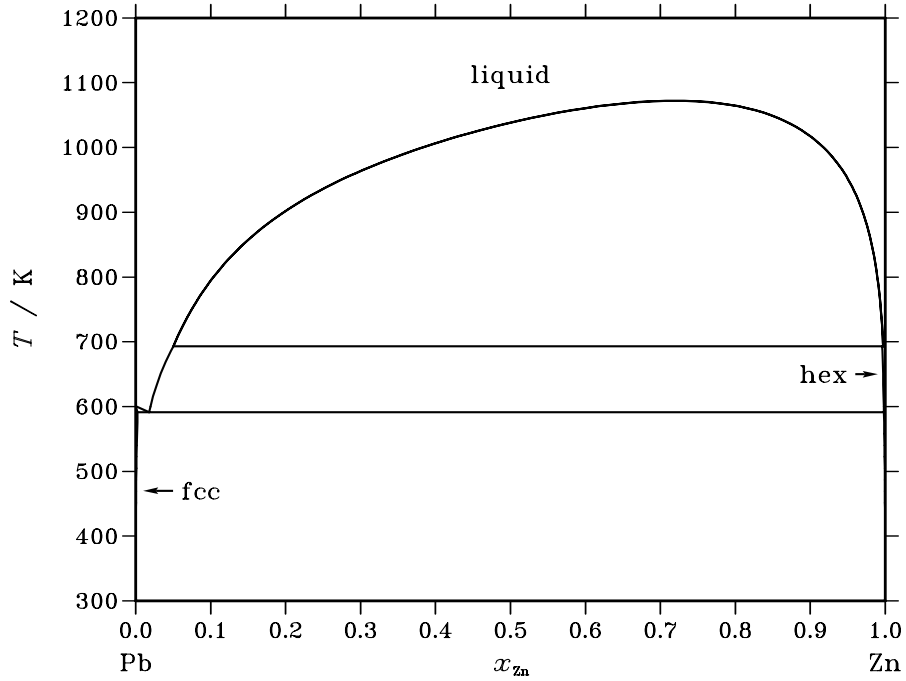

Fig. 1. Calculated phase diagram for the system Pb-Zn.

While the lead-tin system is a basic building block for a range of commonly used solders there has been a growing requirement for the development of alternative materials which are more environmentally sound and provide fewer potential health problems. The more favoured tin based solders containing elements such as Ag, Bi, In, Sb and Zn, may nevertheless come into contact with conventional lead-tin solders. Therefore a detailed understanding of the thermodynamics and phase equilibria in the Pb-Zn system is required in order to provide background data in order to model possible consequences.
The phase diagram for the Pb-Zn system is dominated by a miscibility gap in the liquid phase closing at 1070 K and a value of x_{Zn} of approximately 0.72. There is negligible solubility in the terminal solid phases, fcc-Pb and hcp-Zn. Studies of the miscibility gap have been reported in a number of papers and there is a fair degree of agreement between the different sets of results. There have also been a number of measurements of the enthalpies of mixing in the liquid phase by calorimetry and activities of Zn by EMF and vapour pressure studies.
The critically assessed data adopted by SGTE are from the work of Srivastava and Sharma [93Sri] and is in good agreement with the experimental phase diagram information. The data for this system have also been critically assessed by Moser *et al.* [94Mos].

Table I. Phases, structures and models.

Phase	Struktur-bericht	Prototype	Pearson symbol	Space group	SGTE name	Model
liquid					LIQUID	$(Pb,Zn)_1$
fcc	$A1$	Cu	$cF4$	$Fm\overline{3}m$	FCC_A1	$(Pb,Zn)_1$
hex	$A3$	Mg	$hP2$	$P6_3/mmc$	HCP_ZN	$(Pb,Zn)_1$

Table II. Invariant reactions.

Reaction	Type	T / K	Compositions / x_{Zn}			$\Delta_{\mathrm{r}}H$ / (J/mol)
liquid $\rightleftharpoons$ liquid′ + liquid″	critical	1071.9	0.719	0.719	0.719	0
liquid″ $\rightleftharpoons$ liquid′ + $A4$	monotectic	693.3	0.996	0.050	0.997	−7345
liquid′ $\rightleftharpoons$ fcc + $A4$	eutectic	591.5	0.018	0.003	0.998	−5131

Table IIIa. Integral quantities for the liquid phase at 923 K.

x_{Zn}	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	−961	2277	3.508	1534	0.805	0.000
0.200	−1061	4418	5.936	2780	1.776	0.000
0.229	−1038	5010	6.552	3095	2.074	0.000
0.962	−270	1881	2.330	962	0.996	0.000
1.000	0	0	0.000	0	0.000	0.000

Reference states: Pb(liquid), Zn(liquid)

Table IIIb. Partial quantities for Pb in the liquid phase at 923 K.

x_{Pb}	ΔG_{Pb} [J/mol]	ΔH_{Pb} [J/mol]	ΔS_{Pb} [J/(mol·K)]	$G^{\mathrm{E}}_{\mathrm{Pb}}$ [J/mol]	$S^{\mathrm{E}}_{\mathrm{Pb}}$ [J/(mol·K)]	a_{Pb}	γ_{Pb}
1.000	0	0	0.000	0	0.000	1.000	1.000
0.900	−659	54	0.772	150	−0.104	0.918	1.020
0.800	−1156	331	1.612	556	−0.244	0.860	1.075
0.771	−1278	487	1.913	722	−0.254	0.847	1.099
0.038	−1278	46679	51.959	23885	24.696	0.847	22.473
0.000	−∞	53398	∞	27290	28.286	0.000	35.022

Reference state: Pb(liquid)

Table IIIc. Partial quantities for Zn in the liquid phase at 923 K.

x_{Zn}	ΔG_{Zn} [J/mol]	ΔH_{Zn} [J/mol]	ΔS_{Zn} [J/(mol·K)]	$G^{\mathrm{E}}_{\mathrm{Zn}}$ [J/mol]	$S^{\mathrm{E}}_{\mathrm{Zn}}$ [J/(mol·K)]	a_{Zn}	γ_{Zn}
0.000	−∞	23185	∞	16908	6.801	0.000	9.054
0.100	−3681	22287	28.134	13990	8.989	0.619	6.190
0.200	−678	20767	23.235	11673	9.853	0.915	4.577
0.229	−230	20198	22.132	11068	9.892	0.970	4.230
0.962	−230	128	0.388	65	0.068	0.970	1.008
1.000	0	0	0.000	0	0.000	1.000	1.000

Reference state: Zn(liquid)

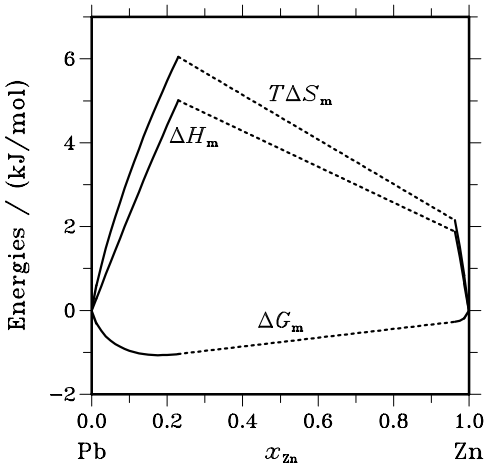

Fig. 2. Integral quantities of the liquid phase at T=923 K.

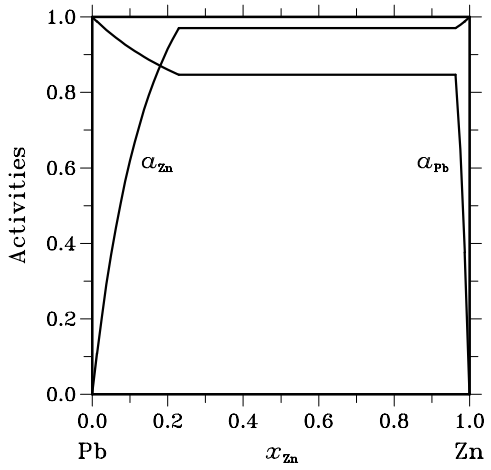

Fig. 3. Activities in the liquid phase at T=923 K.

References

[93Sri] M. Srivastava, R.C. Sharma: J. Phase Equilibria **14** (1993) 700–709.

[94Mos] Z. Moser, L. Zabdyr, W. Gąsior, J. Salawa, W. Zakulski: J. Phase Equilibria **15** (1994) 643–649.