Sn – Zn (Tin – Zinc)

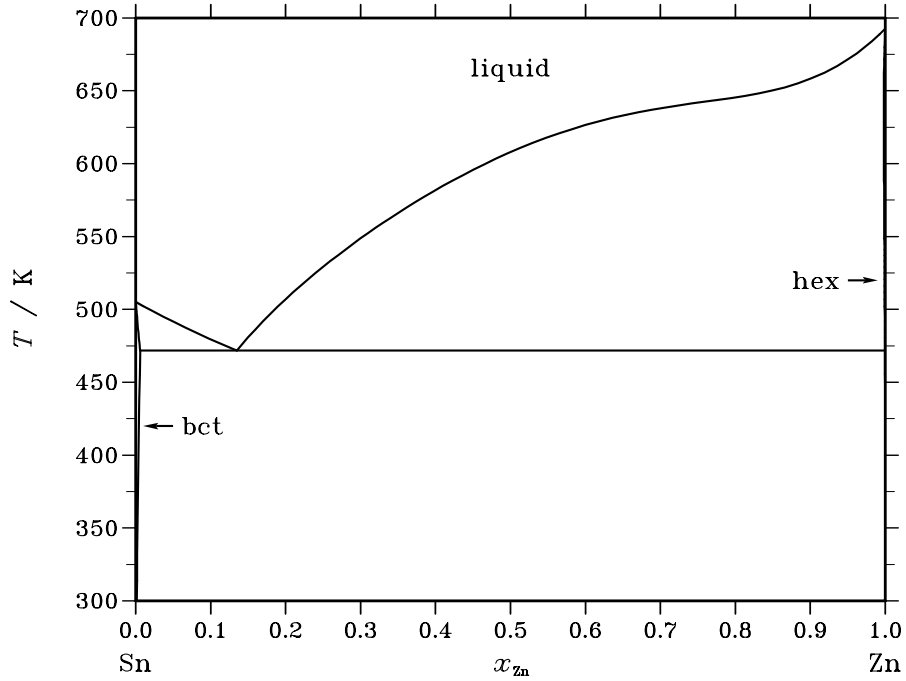

Fig. 1. Calculated phase diagram for the system Sn-Zn.

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. Tin based solders containing elements such as Ag, Bi, In, Sb and Zn are candidate replacements and therefore a detailed understanding of the thermodynamics and phase equilibria in the Sn-Zn system is required.
The data for the Sn-Zn system adopted by SGTE are taken from the assessment of Fries and Lukas [98Fri], recently updated to improve the solubility of Sn in hcp Zn. The phase diagram for the system is characterised by a simple eutectic with a slight indication towards a metastable miscibility gap in the liquid phase. Solubility in the terminal crystalline phases is low. The Sn-Zn system has also been critically assessed by Lee [96Lee] and by Srivastava and Sharma [93Sri]. All the experimental data prior to 1985 have been reviewed by Moser *et al.* [85Mos]. There have been numerous studies of the liquidus surface and these are in general in very good agreement. There have also been measurements of the enthalpies of mixing by calorimetry and by thermal analysis. The activity of Zn in the liquid phase has also been studied by an emf technique and by vapour pressure measurements. The critically assessed data are in excellent agreement with the experimental properties.

Table I. Phases, structures and models.

Phase	Struktur-bericht	Prototype	Pearson symbol	Space group	SGTE name	Model
liquid					LIQUID	$(Sn,Zn)_1$
bct	$A5$	βSn	$tI4$	$I4_1/amd$	BCT_A5	$(Sn,Zn)_1$
hex	$A3$	Mg	$hP2$	$P6_3/mmc$	HCP_ZN	$(Sn,Zn)_1$

Table II. Invariant reactions.

Reaction	Type	T / K	Compositions / x_{Zn}			$\Delta_{\mathrm{r}}H$ / (J/mol)
liquid $\rightleftharpoons$ bct + hex	eutectic	471.7	0.135	0.006	1.000	−8372

Table IIIa. Integral quantities for the liquid phase at 750 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	−1582	797	3.173	445	0.470	−0.788
0.200	−2328	1553	5.175	793	1.014	−1.400
0.300	−2737	2234	6.628	1073	1.549	−1.838
0.400	−2900	2797	7.596	1297	2.000	−2.100
0.500	−2862	3188	8.066	1460	2.303	−2.188
0.600	−2656	3344	7.999	1541	2.403	−2.100
0.700	−2309	3191	7.334	1500	2.255	−1.838
0.800	−1839	2647	5.981	1281	1.821	−1.400
0.900	−1216	1617	3.778	811	1.075	−0.788
1.000	0	0	0.000	0	0.000	0.000

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

Table IIIb. Partial quantities for Sn in the liquid phase at 750 K.

x_{Sn}	ΔG_{Sn} [J/mol]	ΔH_{Sn} [J/mol]	ΔS_{Sn} [J/(mol·K)]	$G^{\mathrm{E}}_{\mathrm{Sn}}$ [J/mol]	$S^{\mathrm{E}}_{\mathrm{Sn}}$ [J/(mol·K)]	a_{Sn}	γ_{Sn}
1.000	0	0	0.000	0	0.000	1.000	1.000
0.900	−602	16	0.824	55	−0.052	0.908	1.009
0.800	−1220	103	1.764	172	−0.091	0.822	1.028
0.700	−1906	344	3.001	318	0.035	0.737	1.052
0.600	−2673	851	4.698	512	0.451	0.651	1.086
0.500	−3498	1764	7.016	824	1.253	0.571	1.141
0.400	−4340	3255	10.127	1374	2.508	0.499	1.247
0.300	−5173	5527	14.267	2335	4.257	0.436	1.454
0.200	−6108	8810	19.892	3928	6.510	0.375	1.877
0.100	−7930	13366	28.395	6428	9.250	0.280	2.803
0.000	$-\infty$	19485	∞	10161	12.432	0.000	5.101

Reference state: Sn(liquid)

Table IIIc. Partial quantities for Zn in the liquid phase at 750 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	$-\infty$	8092	∞	5071	4.028	0.000	2.255
0.100	−10404	7829	24.310	3955	5.166	0.189	1.885
0.200	−6760	7352	18.816	3276	5.434	0.338	1.691
0.300	−4675	6644	15.091	2833	5.080	0.473	1.575
0.400	−3240	5716	11.942	2474	4.324	0.595	1.487
0.500	−2226	4612	9.117	2097	3.354	0.700	1.400
0.600	−1533	3402	6.581	1652	2.333	0.782	1.303
0.700	−1082	2190	4.362	1142	1.397	0.841	1.201
0.800	−772	1106	2.504	619	0.649	0.884	1.104
0.900	−470	312	1.043	187	0.167	0.927	1.030
1.000	0	0	0.000	0	0.000	1.000	1.000

Reference state: Zn(liquid)

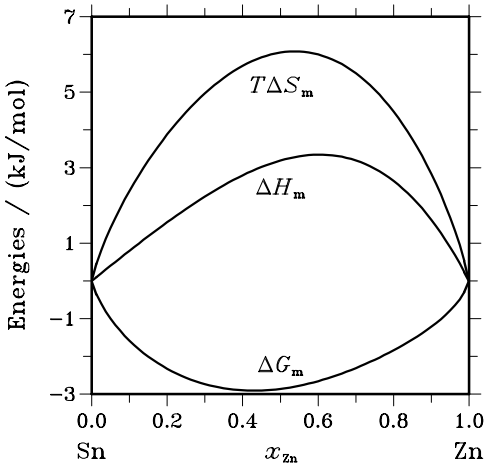

Fig. 2. Integral quantities of the liquid phase at T=750 K.

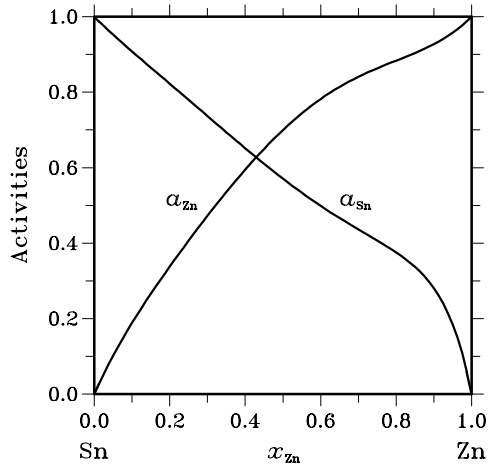

Fig. 3. Activities in the liquid phase at T=750 K.

References

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