# **In – Zn** (Indium – Zinc)

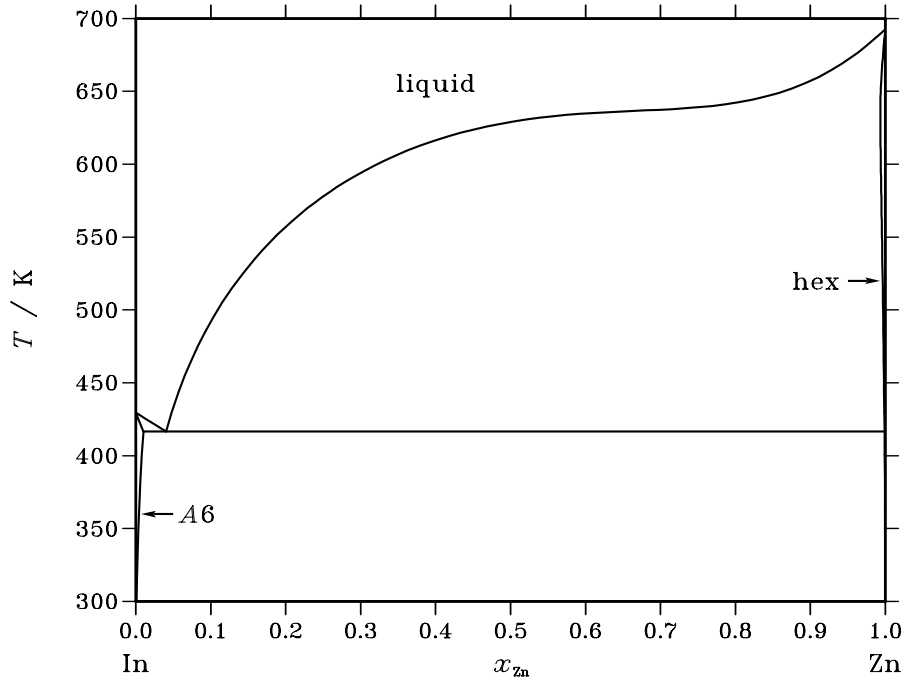


**Fig. 1.** Calculated phase diagram for the system In-Zn.

A good understanding of the thermodynamics and phase equilibria in the In-Zn system is currently very important because of the drive towards the development of Pb-free solder materials for environmental and health reasons. The critically assessed data for this system adopted by SGTE were taken from the assessment of Lee [96Lee]. The experimental information had also been reviewed by Dutkiewicz and Zakulski [84Dut]. The phase diagram for the system is characterised by a simple eutectic close in composition to pure In. The studies of the liquidus surface are in fairly good agreement and shows a tendency towards a metastable miscibility gap in the liquid phase. There seems to be some uncertainty about the exact composition of the eutectic. The value predicted from Lee's assessment is about 4 at.% Zn. There is limited solubility in each of the terminal solid solutions, Zn dissolving in tetragonal In up to about 1.0 at.%. Thermodynamic properties have been determined by calorimetry, EMF studies, vapour pressure measurements and use of an isopiestic technique. The assessed data of Lee provide excellent agreement between calculated and experimental properties.

**Table I.** Phases, structures and models.

| Phase | Struktur-bericht | Prototype | Pearson symbol | Space group | SGTE name | Model |
|---|---|---|---|---|---|---|
| liquid | | | | | LIQUID | $(In,Zn)_1$ |
| $A6$ | $A6$ | In | $tI2$ | $I4/mmm$ | TETRAGONAL_A6 | $(In,Zn)_1$ |
| hex | $A3$ | Mg | $hP2$ | $P6_3/mmc$ | HCP_ZN | $(In,Zn)_1$ |

**Table II.** Invariant reactions.

| Reaction | Type | $T$ / K | Compositions / $x_{Zn}$ | | | $\Delta_r H$ / (J/mol) |
|---|---|---|---|---|---|---|
| liquid $\rightleftharpoons$ $A6$ + hex | eutectic | 416.8 | 0.040 | 0.010 | 0.999 | −3647 |

**Table IIIa.** Integral quantities for the liquid phase at 730 K.

| $x_{\mathrm{Zn}}$ | $\Delta G_{\mathrm{m}}$ [J/mol] | $\Delta H_{\mathrm{m}}$ [J/mol] | $\Delta S_{\mathrm{m}}$ [J/(mol·K)] | $G_{\mathrm{m}}^{\mathrm{E}}$ [J/mol] | $S_{\mathrm{m}}^{\mathrm{E}}$ [J/(mol·K)] | $\Delta C_P$ [J/(mol·K)] |
|---|---|---|---|---|---|---|
| 0.000 | 0 | 0 | 0.000 | 0 | 0.000 | 0.000 |
| 0.100 | −1247 | 926 | 2.977 | 726 | 0.274 | 0.000 |
| 0.200 | −1717 | 1717 | 4.704 | 1321 | 0.543 | 0.000 |
| 0.300 | −1923 | 2359 | 5.866 | 1785 | 0.787 | 0.000 |
| 0.400 | −1973 | 2830 | 6.579 | 2112 | 0.984 | 0.000 |
| 0.500 | −1919 | 3100 | 6.876 | 2288 | 1.112 | 0.000 |
| 0.600 | −1790 | 3136 | 6.748 | 2295 | 1.152 | 0.000 |
| 0.700 | −1603 | 2895 | 6.161 | 2105 | 1.082 | 0.000 |
| 0.800 | −1351 | 2329 | 5.041 | 1686 | 0.881 | 0.000 |
| 0.900 | −973 | 1385 | 3.230 | 1000 | 0.527 | 0.000 |
| 1.000 | 0 | 0 | 0.000 | 0 | 0.000 | 0.000 |

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

**Table IIIb.** Partial quantities for In in the liquid phase at 730 K.

| $x_{\mathrm{In}}$ | $\Delta G_{\mathrm{In}}$ [J/mol] | $\Delta H_{\mathrm{In}}$ [J/mol] | $\Delta S_{\mathrm{In}}$ [J/(mol·K)] | $G_{\mathrm{In}}^{\mathrm{E}}$ [J/mol] | $S_{\mathrm{In}}^{\mathrm{E}}$ [J/(mol·K)] | $a_{\mathrm{In}}$ | $\gamma_{\mathrm{In}}$ |
|---|---|---|---|---|---|---|---|
| 1.000 | 0 | 0 | 0.000 | 0 | 0.000 | 1.000 | 1.000 |
| 0.900 | −574 | 65 | 0.875 | 66 | −0.001 | 0.910 | 1.011 |
| 0.800 | −1094 | 278 | 1.879 | 260 | 0.023 | 0.835 | 1.044 |
| 0.700 | −1571 | 678 | 3.082 | 593 | 0.116 | 0.772 | 1.103 |
| 0.600 | −2006 | 1327 | 4.566 | 1094 | 0.319 | 0.719 | 1.198 |
| 0.500 | −2395 | 2304 | 6.437 | 1812 | 0.673 | 0.674 | 1.348 |
| 0.400 | −2746 | 3708 | 8.841 | 2815 | 1.223 | 0.636 | 1.590 |
| 0.300 | −3116 | 5658 | 12.019 | 4192 | 2.008 | 0.598 | 1.995 |
| 0.200 | −3719 | 8292 | 16.454 | 6049 | 3.073 | 0.542 | 2.709 |
| 0.100 | −5461 | 11769 | 23.603 | 8515 | 4.458 | 0.407 | 4.067 |
| 0.000 | $-\infty$ | 16266 | $\infty$ | 11736 | 6.206 | 0.000 | 6.914 |

Reference state: In(liquid)

**Table IIIc.** Partial quantities for Zn in the liquid phase at 730 K.

| $x_{\mathrm{Zn}}$ | $\Delta G_{\mathrm{Zn}}$ [J/mol] | $\Delta H_{\mathrm{Zn}}$ [J/mol] | $\Delta S_{\mathrm{Zn}}$ [J/(mol·K)] | $G_{\mathrm{Zn}}^{\mathrm{E}}$ [J/mol] | $S_{\mathrm{Zn}}^{\mathrm{E}}$ [J/(mol·K)] | $a_{\mathrm{Zn}}$ | $\gamma_{\mathrm{Zn}}$ |
|---|---|---|---|---|---|---|---|
| 0.000 | $-\infty$ | 9894 | $\infty$ | 7928 | 2.694 | 0.000 | 3.692 |
| 0.100 | −7312 | 8672 | 21.896 | 6664 | 2.751 | 0.300 | 2.998 |
| 0.200 | −4207 | 7477 | 16.005 | 5562 | 2.623 | 0.500 | 2.500 |
| 0.300 | −2743 | 6282 | 12.363 | 4565 | 2.352 | 0.636 | 2.121 |
| 0.400 | −1924 | 5084 | 9.600 | 3638 | 1.981 | 0.728 | 1.821 |
| 0.500 | −1443 | 3897 | 7.315 | 2764 | 1.551 | 0.788 | 1.577 |
| 0.600 | −1153 | 2754 | 5.353 | 1947 | 1.105 | 0.827 | 1.378 |
| 0.700 | −954 | 1710 | 3.651 | 1210 | 0.685 | 0.854 | 1.221 |
| 0.800 | −759 | 838 | 2.188 | 596 | 0.333 | 0.882 | 1.103 |
| 0.900 | −475 | 231 | 0.966 | 165 | 0.090 | 0.925 | 1.028 |
| 1.000 | 0 | 0 | 0.000 | 0 | 0.000 | 1.000 | 1.000 |

Reference state: Zn(liquid)

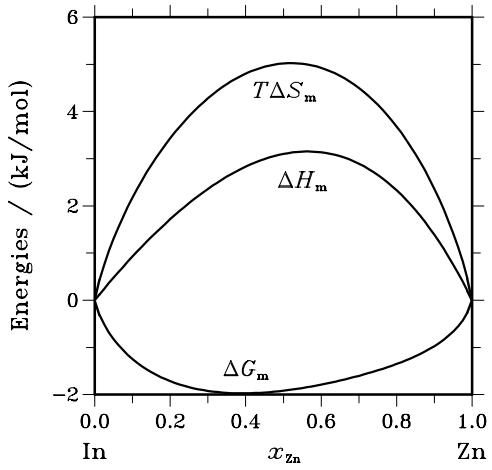


**Fig. 2.** Integral quantities of the liquid phase at $T$=730 K.

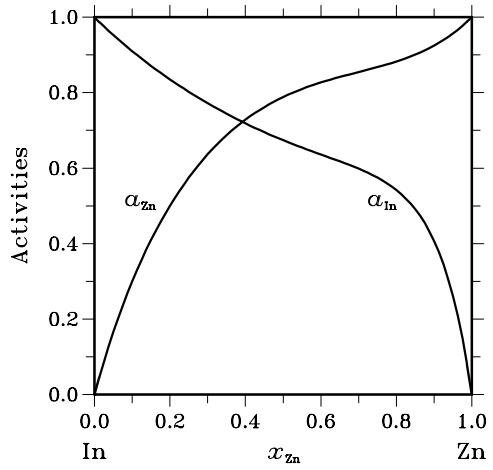


**Fig. 3.** Activities in the liquid phase at $T$=730 K.

## References

[84Dut] J. Dutkiewicz, W. Zakulski: Bull. Alloy Phase Diagrams **5** (1984) 284–289.
[96Lee] B.-J. Lee: Calphad **20** (1996) 471–480.