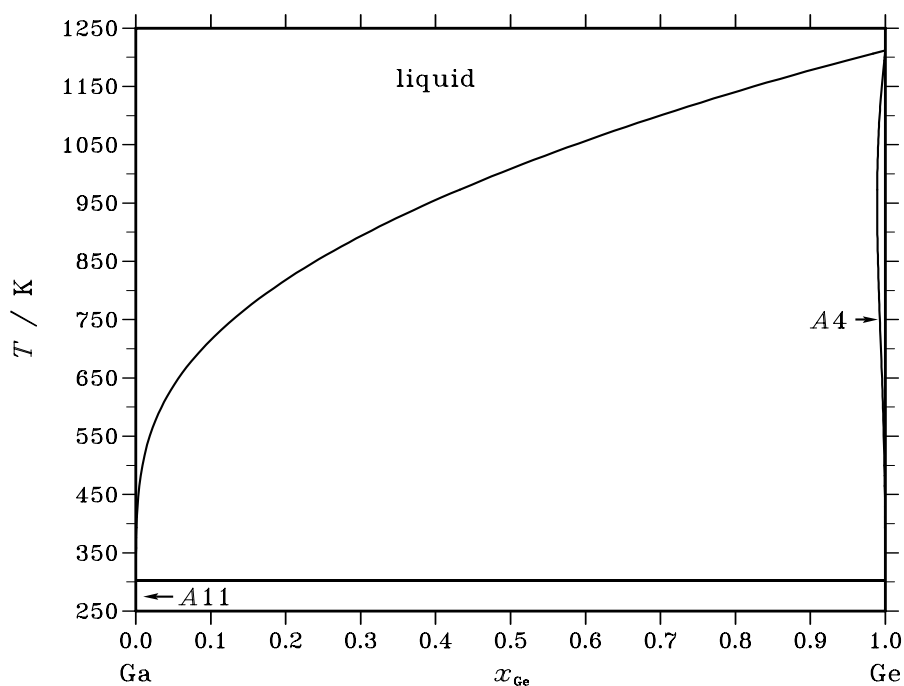


Ga – Ge (Gallium – Germanium)**Fig. 1.** Calculated phase diagram for the system Ga-Ge.

The gallium-germanium system is important for the growth of III-V semiconductor compounds by liquid phase epitaxy from a Al-Ga-As-Ge melt. This binary system is of the eutectic type and has been assessed by Ansara *et al.* [79Ans]. The solubility of Ga in solid Ge is small and has been determined by Trumbore [59Tru]. The liquidus line has been measured by Keck *et al.* [53Kec], Greiner *et al.* [55Gre], de Roche *et al.* [57deR] and Thurmond *et al.* [60Thu]. This experimental phase diagram information as well as the measured heats of formation [71Pre, 79Esl] are well reproduced by the selected thermodynamic assessment.

Table I. Phases, structures and models.

Phase	Strukturbericht	Prototype	Pearson symbol	Space group	SGTE name	Model
liquid					LIQUID	(Ga,Ge) ₁
A11	A11	α Ga	<i>oC</i> 8	<i>Cmca</i>	ORTHORHOMBIC_CMCA	Ga ₁
A4	A4	C(diamond)	<i>cF</i> 8	<i>Fd$\bar{3}$m</i>	DIAMOND_A4	(Ga,Ge) ₁

Table II. Invariant reactions.

Reaction	Type	T / K	Compositions / x_{Ge}			$\Delta_{\text{r}}H / (\text{J/mol})$
liquid \rightleftharpoons A11 + A4	eutectic	302.9	0.000	0.000	1.000	–5591

Table IIIa. Integral quantities for the liquid phase at 1240 K.

x_{Ge}	ΔG_{m} [J/mol]	ΔH_{m} [J/mol]	ΔS_{m} [J/(mol·K)]	G_{m}^{E} [J/mol]	S_{m}^{E} [J/(mol·K)]	ΔC_P [J/(mol·K)]
0.000	0	0	0.000	0	0.000	0.000
0.100	−3480	−234	2.617	−128	−0.086	0.000
0.200	−5386	−413	4.011	−227	−0.150	0.000
0.300	−6598	−540	4.886	−300	−0.193	0.000
0.400	−7288	−618	5.379	−349	−0.217	0.000
0.500	−7519	−648	5.541	−373	−0.222	0.000
0.600	−7309	−630	5.387	−371	−0.209	0.000
0.700	−6636	−561	4.900	−338	−0.179	0.000
0.800	−5430	−437	4.027	−271	−0.134	0.000
0.900	−3512	−252	2.629	−161	−0.074	0.000
1.000	0	0	0.000	0	0.000	0.000

Reference states: Ga(liquid), Ge(liquid)

Table IIIb. Partial quantities for Ga in the liquid phase at 1240 K.

x_{Ga}	ΔG_{Ga} [J/mol]	ΔH_{Ga} [J/mol]	ΔS_{Ga} [J/(mol·K)]	G_{Ga}^{E} [J/mol]	S_{Ga}^{E} [J/(mol·K)]	a_{Ga}	γ_{Ga}
1.000	0	0	0.000	0	0.000	1.000	1.000
0.900	−1101	−29	0.865	−15	−0.011	0.899	0.999
0.800	−2356	−109	1.813	−56	−0.043	0.796	0.995
0.700	−3795	−233	2.872	−118	−0.093	0.692	0.989
0.600	−5469	−401	4.087	−202	−0.161	0.588	0.981
0.500	−7462	−617	5.521	−316	−0.243	0.485	0.970
0.400	−9917	−889	7.281	−470	−0.337	0.382	0.955
0.300	−13094	−1231	9.567	−681	−0.443	0.281	0.936
0.200	−17564	−1662	12.824	−971	−0.558	0.182	0.910
0.100	−25105	−2207	18.466	−1365	−0.679	0.088	0.876
0.000	−∞	−2894	∞	−1895	−0.805	0.000	0.832

Reference state: Ga(liquid)

Table IIIc. Partial quantities for Ge in the liquid phase at 1240 K.

x_{Ge}	ΔG_{Ge} [J/mol]	ΔH_{Ge} [J/mol]	ΔS_{Ge} [J/(mol·K)]	G_{Ge}^{E} [J/mol]	S_{Ge}^{E} [J/(mol·K)]	a_{Ge}	γ_{Ge}
0.000	−∞	−2643	∞	−1439	−0.971	0.000	0.870
0.100	−24883	−2085	18.385	−1143	−0.759	0.090	0.895
0.200	−17506	−1630	12.803	−912	−0.579	0.183	0.915
0.300	−13139	−1255	9.584	−726	−0.427	0.280	0.932
0.400	−10016	−943	7.317	−569	−0.302	0.379	0.946
0.500	−7576	−680	5.562	−430	−0.201	0.480	0.959
0.600	−5571	−458	4.124	−304	−0.124	0.583	0.971
0.700	−3869	−274	2.899	−191	−0.066	0.687	0.982
0.800	−2396	−131	1.827	−96	−0.028	0.793	0.991
0.900	−1113	−35	0.869	−27	−0.007	0.898	0.997
1.000	0	0	0.000	0	0.000	1.000	1.000

Reference state: Ge(liquid)

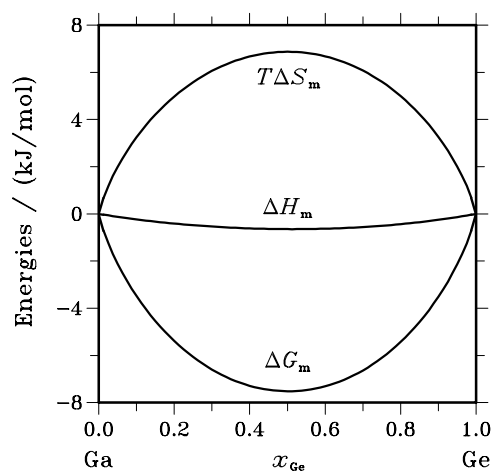


Fig. 2. Integral quantities of the liquid phase at $T=1240$ K.

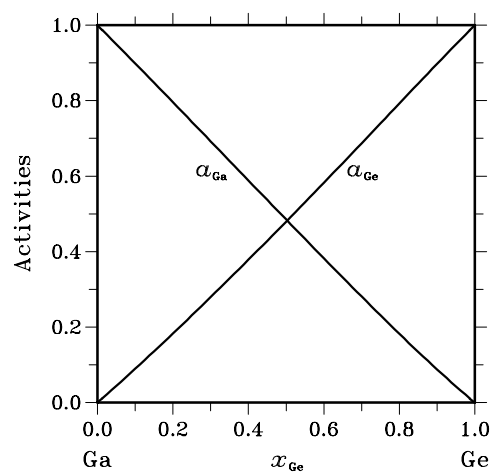


Fig. 3. Activities in the liquid phase at $T=1240$ K.

References

- [53Kec] P.H. Keck, J. Broder: Phys. Rev. Lett. **90** (1953) 521–522.
- [55Gre] E.S. Greiner, P. Breidt: Trans. Met. Soc. AIME **203** (1955) 187–188.
- [57deR] N. de Roche: Z. Metallkd. **48** (1957) 58–60.
- [60Thu] C.D. Thurmond, M. Kowalchik: Bell Sys. Tech. J. **39** (1960) 169–204.
- [71Pre] B. Predel, D.W. Stein: Z. Metallkd. **62** (1971) 499–504.
- [79Esl] H. Eslami, Y.M. Muggianu, M. Gambino, J.P. Bros, P. Leydet: J. Less-Common Met. **64** (1979) 31–44.
- [79Ans] I. Ansara, J.P. Bros, M. Gambino: Calphad **3** (1979) 225–233.