Ga – Te (Gallium – Tellurium)

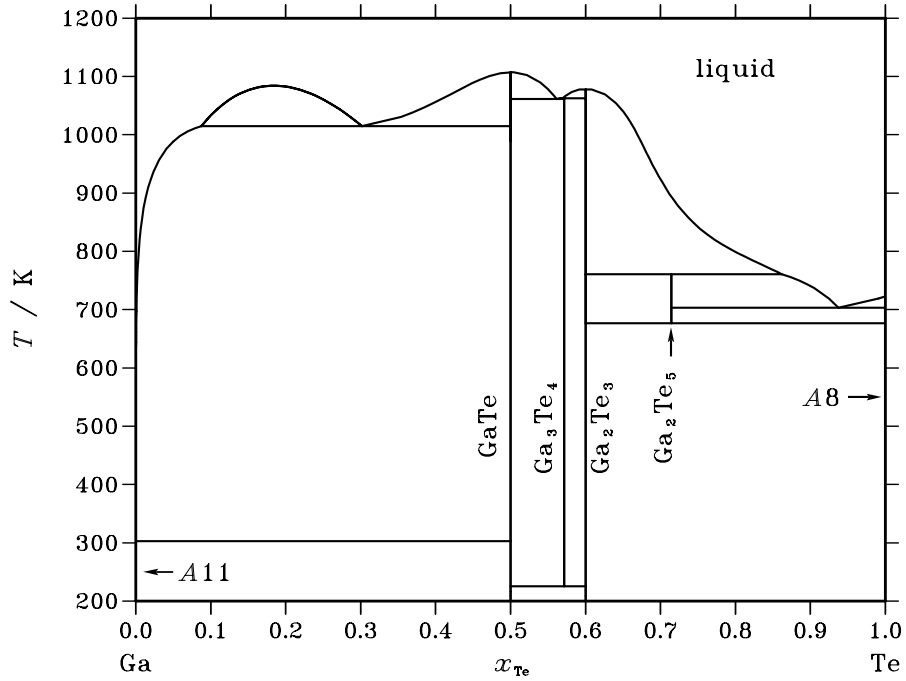

Fig. 1. Calculated phase diagram for the system Ga-Te.

The interest of this system is due to the semiconducting properties in the liquid state. For this reason, much work is devoted to the physical properties in this state. The liquid is characterised by a strong tendency for local ordering, as it is observed for many binary systems containing Te and post-transition elements. The phase diagram is not easily investigated because equilibria in the solid state are difficult to establish. The Ga-rich side is characterised by liquid-liquid de-mixing. On the Te-rich side different compounds are described by Oh and Lee [92Oh]: GaTe, Ga_3Te_4, Ga_2Te_3 and Ga_2Te_5, the last one being stable only between 677 and 761 K. A different version is proposed by [95Mou] based on new experimental results. In this version only three compounds are considered as stable: GaTe, Ga_2Te_3 and Ga_2Te_5. This last version is supported by the study of the ternary system with Au.

Table I. Phases, structures and models.

Phase	Struktur-bericht	Prototype	Pearson symbol	Space group	SGTE name	Model
liquid					LIQUID	$Ga_p^{3+}(Te^{2-},Te,\square)_q$
$A11$	$A11$	αGa	$oC8$	$Cmca$	ORTHORHOMBIC_C	Ga_1
GaTe	$\cdots$	GaTe	$mC24$	$C2/m$	GA1TE1	Ga_1Te_1
Ga_3Te_4	$\cdots$	$\cdots$	$\cdots$	$\cdots$	GA3TE4	Ga_3Te_4
Ga_2Te_3	$B3$	ZnS	$cF8$	$F\overline{4}3m$	GA2TE3	Ga_2Te_3
Ga_2Te_5	$\cdots$	Ga_2Te_5	$tI14$	$I4/m$	GA2TE5	Ga_2Te_5
$A8$	$A8$	γSe	$hP3$	$P3_121$	TRIGONAL_A8	Te_1

Table II. Invariant reactions.

Reaction	Type	T / K	Compositions / x_{Te}			$\Delta_{\mathrm{r}}H$ / (J/mol)
liquid $\rightleftharpoons$ GaTe	congruent	1107.2	0.500	0.500		−18532
liquid $\rightleftharpoons$ liquid′ + liquid″	critical	1083.1	0.183	0.183	0.183	0
liquid $\rightleftharpoons$ Ga_2Te_3	congruent	1078.5	0.600	0.600		−18789
liquid + Ga_2Te_3 $\rightleftharpoons$ Ga_3Te_4	peritectic	1062.7	0.570	0.600	0.571	−16067
liquid $\rightleftharpoons$ GaTe + Ga_3Te_4	eutectic	1061.4	0.561	0.500	0.571	−16587
liquid″ $\rightleftharpoons$ liquid′ + GaTe	monotectic	1014.6	0.302	0.088	0.500	−12969
Ga_2Te_3 + liquid $\rightleftharpoons$ Ga_2Te_5	peritectic	760.8	0.600	0.862	0.714	−4130
liquid $\rightleftharpoons$ Ga_2Te_5 + $A8$	eutectic	703.2	0.937	0.714	1.000	−16238
Ga_2Te_5 $\rightleftharpoons$ Ga_2Te_3 + $A8$	eutectoid	676.9	0.714	0.600	1.000	−5680
liquid $\rightleftharpoons$ $A11$ + GaTe	degenerate	302.9	0.000	0.000	0.500	−5590

Table IIIa. Integral quantities for the liquid phase at 1130 K.

x_{Te}	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	−5729	−3260	2.185	−2674	−0.518	0.597
0.200	−10745	−7954	2.470	−6044	−1.691	1.112
0.300	−15643	−14256	1.228	−9904	−3.851	1.683
0.400	−20081	−22341	−2.000	−13758	−7.596	3.184
0.500	−23104	−31869	−7.757	−16592	−13.520	11.553
0.600	−23189	−36862	−12.100	−16866	−17.696	35.265
0.700	−20218	−29959	−8.620	−14479	−13.699	14.698
0.800	−15180	−18804	−3.207	−10479	−7.367	2.394
0.900	−8699	−8710	−0.010	−5645	−2.712	0.391
1.000	0	0	0.000	0	0.000	0.000

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

Table IIIb. Partial quantities for Ga in the liquid phase at 1130 K.

x_{Ga}	ΔG_{Ga} [J/mol]	ΔH_{Ga} [J/mol]	ΔS_{Ga} [J/(mol·K)]	$G^{\mathrm{E}}_{\mathrm{Ga}}$ [J/mol]	$S^{\mathrm{E}}_{\mathrm{Ga}}$ [J/(mol·K)]	a_{Ga}	γ_{Ga}
1.000	0	0	0.000	0	0.000	1.000	1.000
0.900	−625	691	1.164	365	0.288	0.936	1.040
0.800	−805	2980	3.349	1292	1.494	0.918	1.147
0.700	−1337	7252	7.600	2014	4.635	0.867	1.239
0.600	−4266	13640	15.845	534	11.598	0.635	1.058
0.500	−14120	14837	25.624	−7608	19.861	0.222	0.445
0.400	−32906	−45314	−10.980	−24297	−18.598	0.030	0.075
0.300	−49304	−104844	−49.146	−37992	−59.157	0.005	0.018
0.200	−61611	−105479	−38.818	−46490	−52.200	0.001	0.007
0.100	−73520	−92944	−17.188	−51887	−36.333	0.000	0.004
0.000	$-\infty$	−81230	∞	−115696	31.414	0.000	0.000

Reference state: Ga(liquid)

Table IIIc. Partial quantities for Te in the liquid phase at 1130 K.

x_{Te}	ΔG_{Te} [J/mol]	ΔH_{Te} [J/mol]	ΔS_{Te} [J/(mol·K)]	$G^{\mathrm{E}}_{\mathrm{Te}}$ [J/mol]	$S^{\mathrm{E}}_{\mathrm{Te}}$ [J/(mol·K)]	a_{Te}	γ_{Te}
0.000	$-\infty$	−25960	∞	−23053	−2.585	0.000	0.086
0.100	−51659	−38810	11.369	−30025	−7.776	0.004	0.041
0.200	−50507	−51689	−1.046	−35386	−14.428	0.005	0.023
0.300	−49024	−64440	−13.641	−37712	−23.652	0.005	0.018
0.400	−43804	−76313	−28.767	−35195	−36.386	0.009	0.024
0.500	−32088	−78577	−41.137	−25575	−46.900	0.033	0.066
0.600	−16711	−31226	−12.844	−11911	−17.091	0.169	0.281
0.700	−7753	2134	8.749	−4402	5.783	0.438	0.626
0.800	−3573	2865	5.696	−1476	3.841	0.684	0.855
0.900	−1497	649	1.899	−507	1.023	0.853	0.947
1.000	0	0	0.000	0	0.000	1.000	1.000

Reference state: Te(liquid)

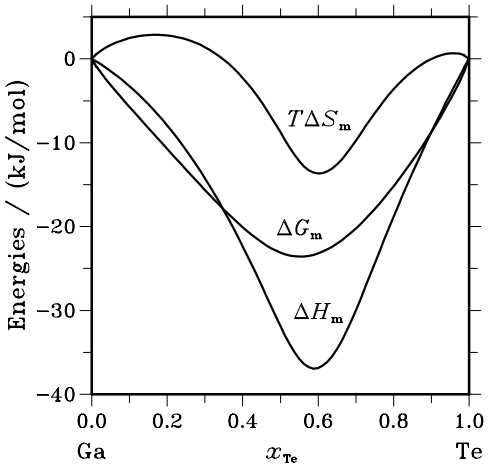

Fig. 2. Integral quantities of the liquid phase at T=1130 K.

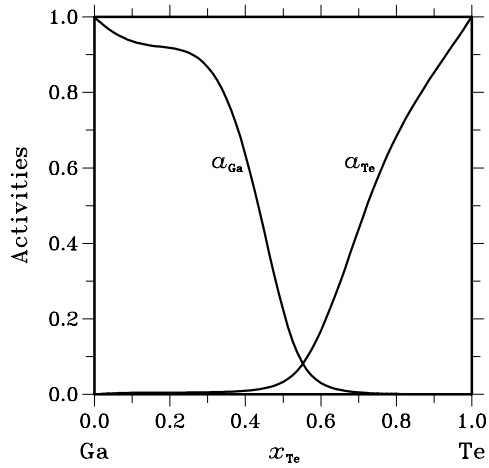

Fig. 3. Activities in the liquid phase at T=1130 K.

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

Compound	x_{Te}	$\Delta_{\mathrm{f}}G^{\circ}$ / (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))
Ga_1Te_1	0.500	−38106	−39197	−3.659	1.678
Ga_3Te_4	0.571	−37714	−37370	1.155	−2.625
Ga_2Te_3	0.600	−37066	−37863	−2.672	3.138
Ga_2Te_5	0.714	−19364	−10313	30.356	−25.702

References

[92Oh] C.-S. Oh, D.N. Lee: Calphad **16** (1992) 317–330.
[95Mou] D. Mouani, G. Morgant, B. Legendre: J. Alloys Comp. **226** (1995) 222–231.