

## Al – C (Aluminum – Carbon)

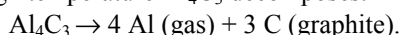
### Phase diagram

Using thermodynamic models Qiu et al. [94 Qiu] have calculated phase equilibria (see Fig. 1).

A somewhat differing partial phase diagram has been calculated by Schuster [91 Sch] (see Fig. 2).

The calculated solubility of  $\text{Al}_4\text{C}_3$  as a function of temperature agrees within the experimental scatter with those measured by Simensen [89 Sim] (Fig. 3).

At high temperature  $\text{Al}_4\text{C}_3$  decomposes:



The decomposition pressures calculated by [94 Qiu] are given in Fig. 4. The results are in agreement with experimental data reported by Rinhart et al. [80 Rin] at lower temperatures. At higher temperatures the calculated decomposition vapor pressure is in agreement with experimental values published by Plante et al. [66 Pla].

By mechanical alloying (ball milling) of elemental Al and C Wu et al. [97 Wu] found the carbide  $\text{Al}_4\text{C}_3$ . Further milling causes a destabilization of this intermediate compound. As a final product there results a face centered solid solution with up to 23 at% C. In the range between 28 and 50 at% C an amorphous phase has been found.

A more comprehensive phase diagram, especially phase equilibria at higher temperatures at a pressure of  $10^5$  Pa (1 bar) has been calculated from thermodynamic data by Gokcen et al. [98 Gok]. The resulting phase diagram is shown in Fig. 5.

### Crystal structure

The intermediate phases of this system are listed in Table 1.

It should be mentioned that in addition to phases compiled in Table 1 there is known a lot of other intermediate compounds, which are impurity-stabilized. For these phases the reader is referred to the publication performed by Duschanek et al. [94 Dus].

**Table 1.** Al–C. Crystallographic data of intermediate phases in the Al-C-system.

Phase	Composition [at% C]	Structure	Type	Lattice parameters [nm]			Reference
				<i>a</i>	<i>b</i>	<i>c</i>	
$\text{Al}_2\text{C}_3$	60	hex	$\text{Al}_2\text{B}_3$	1.840		0.896	[92 Var]
$\text{AlC}_2$	66.7	hex	$\text{AlB}_2$	0.3006		0.3252	[56 Fel]
$\alpha\text{-AlC}_{12}$	92.3	tet	$\alpha\text{-AlB}_{12}$	1.0158		1.4270	[77 Hig]
$\gamma\text{-AlC}_{12}$	92.3	ort	$\gamma\text{-AlB}_{12}$	1.6573	1.7510	1.0144	[83 Hig]

### Thermodynamics

From temperature dependence of decomposition pressures there results the enthalpy of formation of  $\text{Al}_4\text{C}_3$  at 298.15 K [94 Qiu]. The value amounts to:

$$\Delta H^S = -206.9 \text{ kJ mol}^{-1}.$$

This value is in good agreement with the enthalpy of formation found calorimetrically by King et al. [64 Kin] but not with the value found by Meschel et al. [95 Mes]:

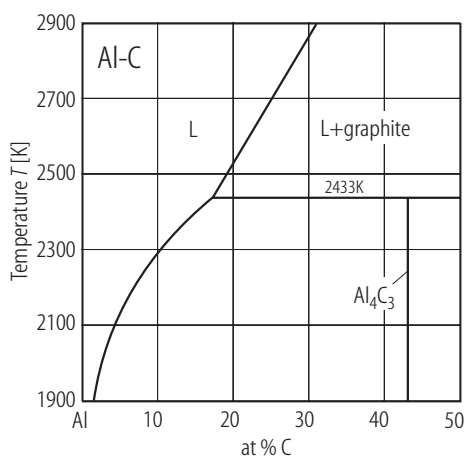
$$\Delta H^S = -128.1 \text{ kJ mol}^{-1}.$$

A summary of the standard enthalpy of formation found in the literature and presented by Rinehart et al. [80 Rin] is given in Table 2.

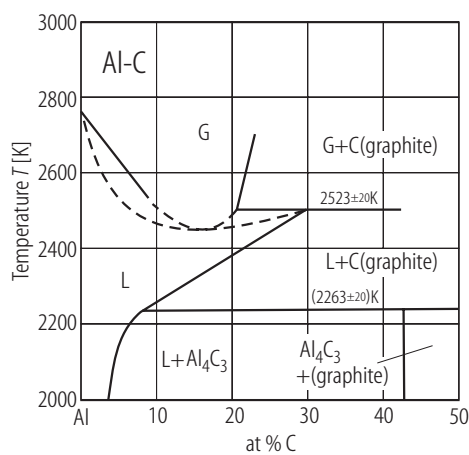
**Table 2.** Al–C. Standard enthalpy of formation of  $\text{Al}_4\text{C}_3$ .

Author	Technique	$\Delta H$ [kJ mol <sup>-1</sup> ] at 298 K
[64 Kin]	combustion calorimetry	- 207.9 ± 5.0
[70 Bla]	solution calorimetry	- 207.3 ± 2.4
[64 Mah]	combustion calorimetry	- 223.4 ± 8.4
[77 Cho]	activity of Al in C-saturated Fe-Al alloys	- 221.8 ± 11.2
[34 Mei]	combustion calorimetry	- 203.3 ± 12.6
[62 Cam]	activity of Al in $\text{Al}_4\text{C}_3$	
[28 Pre]	( $\text{Al}_4\text{C}_3 + \text{N}_2$ ) equilibrium	- 170.7
[64 Grj]	( $\text{MgO} + \text{Al}_4\text{C}_3$ ) equilibrium	- 244.8
[66 Pla]	mass-loss effusion (third law)	- 228.4 ± 35.1
[59 Mes]	mass-loss effusion and torsion effusion (third law)	- 260.4 ± 60.2
[66 Pot]	torsion effusion (third law)	- 259.4 ± 34.0
[64 Tho]	DTA (third law)	- 138.4 ± 33.7
[80 Rin]	mass-spectrometer Knudsen effusion (third law)	- 187.4 ± 33.6

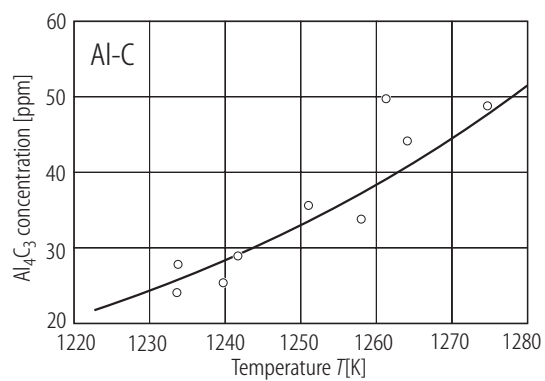
## Figures



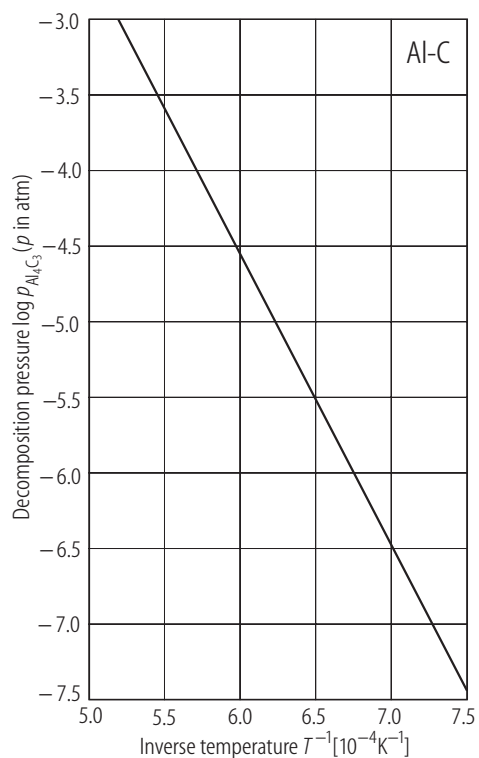
**Fig. 1.** Al–C. Phase equilibria calculated using thermodynamic models [94 Qiu].



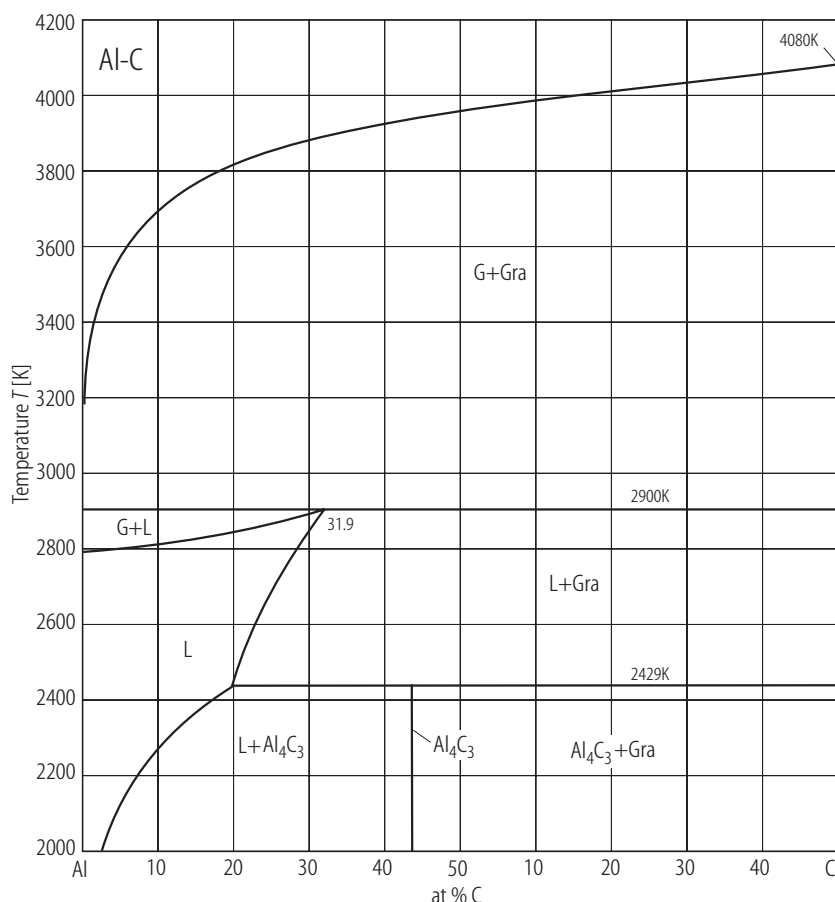
**Fig. 2.** Al–C. Phase equilibria calculated by [91 Sch].



**Fig. 3. Al-C.** Calculated solubility of  $\text{Al}_4\text{C}_3$  in comparison with experimental results [89 Sim].



**Fig. 4. Al-C.** Decomposition of  $\text{Al}_4\text{C}_3$  calculated by [94 Qiu].



**Fig. 5.** Al-C. Phase equilibria especially at high temperatures calculated by [98 Gok].

## References

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