Nb – V (Niobium – Vanadium)

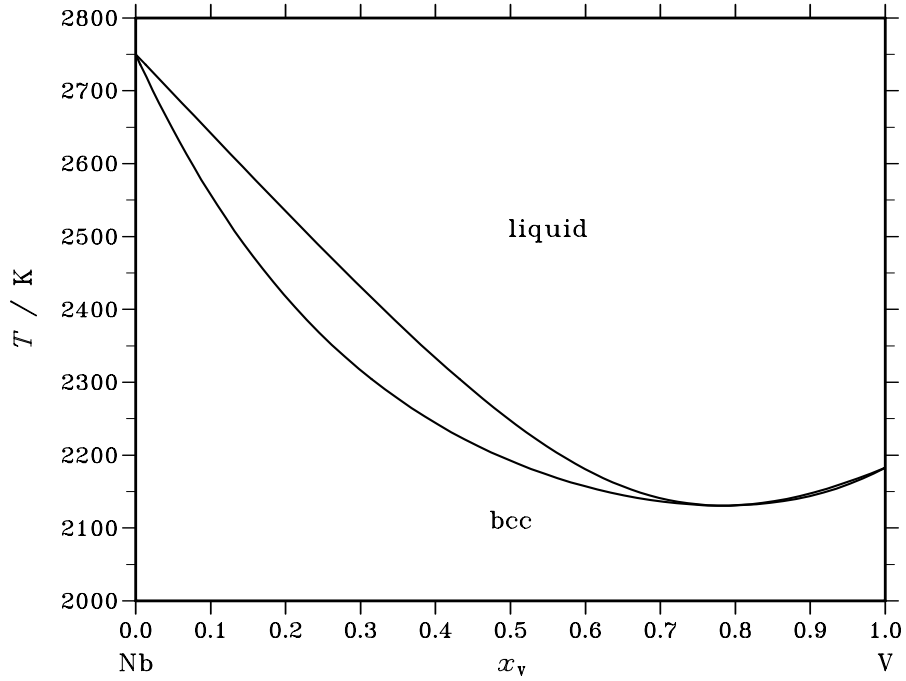

Fig. 1. Calculated phase diagram for the system Nb-V.

Nb and V are added to many alloys in order to increase the strength at high temperatures. Both elements are also strong carbide formers which is useful for hardening and grain fining. The Nb-V system has been reviewed in [83Smi] and a thermodynamic assessment has been reported in [94Har]. There ara only very limited data available and the optimisation has been based on liquidus data only.

Table I. Phases, structures and models.

Phase	Struktur-bericht	Prototype	Pearson symbol	Space group	SGTE name	Model
liquid					LIQUID	$(Nb,V)_1$
bcc	$A2$	W	$cI2$	$Im\overline{3}m$	BCC_A2	$(Nb,V)_1$

Table II. Invariant reactions.

Reaction	Type	T / K	Compositions / x_V		$\Delta_r H$ / (J/mol)
liquid $\rightleftharpoons$ bcc	congruent	2130.8	0.784	0.784	-21352

Table IIIa. Integral quantities for the liquid phase at 2800 K.

x_{V}	ΔG_{m} [J/mol]	ΔH_{m} [J/mol]	ΔS_{m} [J/(mol·K)]	$G_{\mathrm{m}}^{\mathrm{E}}$ [J/mol]	$S_{\mathrm{m}}^{\mathrm{E}}$ [J/(mol·K)]	ΔC_P [J/(mol·K)]
0.000	0	0	0.000	0	0.000	0.000
0.100	−7737	−169	2.703	−169	0.000	0.000
0.200	−11950	−300	4.161	−300	0.000	0.000
0.300	−14615	−394	5.079	−394	0.000	0.000
0.400	−16118	−450	5.596	−450	0.000	0.000
0.500	−16606	−469	5.763	−469	0.000	0.000
0.600	−16118	−450	5.596	−450	0.000	0.000
0.700	−14615	−394	5.079	−394	0.000	0.000
0.800	−11950	−300	4.161	−300	0.000	0.000
0.900	−7737	−169	2.703	−169	0.000	0.000
1.000	0	0	0.000	0	0.000	0.000

Reference states: Nb(liquid), V(liquid)

Table IIIb. Partial quantities for Nb in the liquid phase at 2800 K.

x_{Nb}	ΔG_{Nb} [J/mol]	ΔH_{Nb} [J/mol]	ΔS_{Nb} [J/(mol·K)]	$G_{\mathrm{Nb}}^{\mathrm{E}}$ [J/mol]	$S_{\mathrm{Nb}}^{\mathrm{E}}$ [J/(mol·K)]	a_{Nb}	γ_{Nb}
1.000	0	0	0.000	0	0.000	1.000	1.000
0.900	−2472	−19	0.876	−19	0.000	0.899	0.999
0.800	−5270	−75	1.855	−75	0.000	0.797	0.997
0.700	−8472	−169	2.966	−169	0.000	0.695	0.993
0.600	−12192	−300	4.247	−300	0.000	0.592	0.987
0.500	−16606	−469	5.763	−469	0.000	0.490	0.980
0.400	−22007	−675	7.619	−675	0.000	0.389	0.971
0.300	−28948	−919	10.010	−919	0.000	0.288	0.961
0.200	−38669	−1200	13.382	−1200	0.000	0.190	0.950
0.100	−55124	−1519	19.145	−1519	0.000	0.094	0.937
0.000	$-\infty$	−1875	∞	−1875	0.000	0.000	0.923

Reference state: Nb(liquid)

Table IIIc. Partial quantities for V in the liquid phase at 2800 K.

x_{V}	ΔG_{V} [J/mol]	ΔH_{V} [J/mol]	ΔS_{V} [J/(mol·K)]	$G_{\mathrm{V}}^{\mathrm{E}}$ [J/mol]	$S_{\mathrm{V}}^{\mathrm{E}}$ [J/(mol·K)]	a_{V}	γ_{V}
0.000	$-\infty$	−1875	∞	−1875	0.000	0.000	0.923
0.100	−55124	−1519	19.145	−1519	0.000	0.094	0.937
0.200	−38669	−1200	13.382	−1200	0.000	0.190	0.950
0.300	−28948	−919	10.010	−919	0.000	0.288	0.961
0.400	−22007	−675	7.619	−675	0.000	0.389	0.971
0.500	−16606	−469	5.763	−469	0.000	0.490	0.980
0.600	−12192	−300	4.247	−300	0.000	0.592	0.987
0.700	−8472	−169	2.966	−169	0.000	0.695	0.993
0.800	−5270	−75	1.855	−75	0.000	0.797	0.997
0.900	−2472	−19	0.876	−19	0.000	0.899	0.999
1.000	0	0	0.000	0	0.000	1.000	1.000

Reference state: V(liquid)

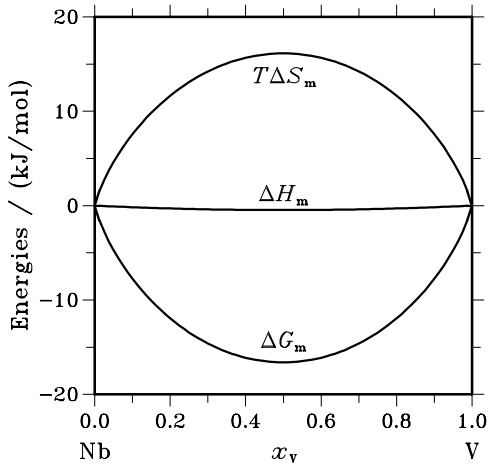

Fig. 2. Integral quantities of the liquid phase at T=2800 K.

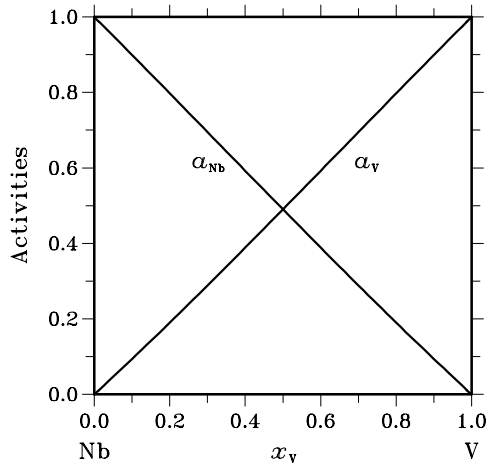

Fig. 3. Activities in the liquid phase at T=2800 K.

Table IVa. Integral quantities for the stable phases at 1600 K.

Phase	x_{V}	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)]
bcc	0.000	0	0	0.000	0	0.000	0.000
	0.100	−3507	817	2.703	817	0.000	0.000
	0.200	−5204	1453	4.161	1453	0.000	0.000
	0.300	−6220	1907	5.079	1907	0.000	0.000
	0.400	−6774	2179	5.596	2179	0.000	0.000
	0.500	−6951	2270	5.763	2270	0.000	0.000
	0.600	−6774	2179	5.596	2179	0.000	0.000
	0.700	−6220	1907	5.079	1907	0.000	0.000
	0.800	−5204	1453	4.161	1453	0.000	0.000
	0.900	−3507	817	2.703	817	0.000	0.000
	1.000	0	0	0.000	0	0.000	0.000

Reference states: Nb(bcc), V(bcc)

Table IVb. Partial quantities for Nb in the stable phases at 1600 K.

Phase	x_{Nb}	ΔG_{Nb} [J/mol]	ΔH_{Nb} [J/mol]	ΔS_{Nb} [J/(mol·K)]	$G^{\mathrm{E}}_{\mathrm{Nb}}$ [J/mol]	$S^{\mathrm{E}}_{\mathrm{Nb}}$ [J/(mol·K)]	a_{Nb}	γ_{Nb}
bcc	1.000	0	0	0.000	0	0.000	1.000	1.000
	0.900	−1311	91	0.876	91	0.000	0.906	1.007
	0.800	−2605	363	1.855	363	0.000	0.822	1.028
	0.700	−3928	817	2.966	817	0.000	0.744	1.063
	0.600	−5343	1453	4.247	1453	0.000	0.669	1.115
	0.500	−6951	2270	5.763	2270	0.000	0.593	1.186
	0.400	−8921	3269	7.619	3269	0.000	0.511	1.279
	0.300	−11568	4449	10.010	4449	0.000	0.419	1.397
	0.200	−15600	5811	13.382	5811	0.000	0.310	1.548
	0.100	−23277	7355	19.145	7355	0.000	0.174	1.738
	0.000	$-\infty$	9080	∞	9080	0.000	0.000	1.979

Reference state: Nb(bcc)

Table IVc. Partial quantities for V in the stable phases at 1600 K.

Phase	x_V	ΔG_V [J/mol]	ΔH_V [J/mol]	ΔS_V [J/(mol·K)]	G_V^E [J/mol]	S_V^E [J/(mol·K)]	a_V	γ_V
bcc	0.000	$-\infty$	9080	∞	9080	0.000	0.000	1.979
	0.100	−23277	7355	19.145	7355	0.000	0.174	1.738
	0.200	−15600	5811	13.382	5811	0.000	0.310	1.548
	0.300	−11568	4449	10.010	4449	0.000	0.419	1.397
	0.400	−8921	3269	7.619	3269	0.000	0.511	1.279
	0.500	−6951	2270	5.763	2270	0.000	0.593	1.186
	0.600	−5343	1453	4.247	1453	0.000	0.669	1.115
	0.700	−3928	817	2.966	817	0.000	0.744	1.063
	0.800	−2605	363	1.855	363	0.000	0.822	1.028
	0.900	−1311	91	0.876	91	0.000	0.906	1.007
	1.000	0	0	0.000	0	0.000	1.000	1.000

Reference state: V(bcc)

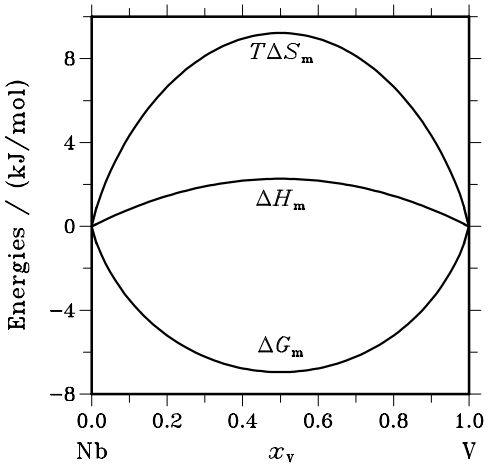

Fig. 4. Integral quantities of the stable phases at T=1600 K.

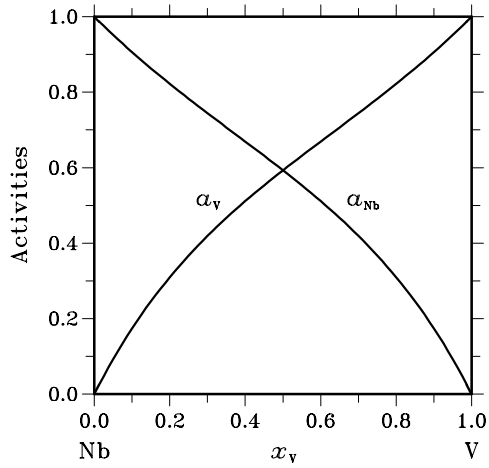

Fig. 5. Activities in the stable phases at T=1600 K.

References

[83Smi] J.F. Smith, O.N. Carlson: Bull. Alloy Phase Diagrams **4** (1983) 46–49.
[94Har] K.C. Hari Kumar, P. Wollants, L. Delaey: Calphad **18** (1994) 71–79.