Mo – W (Molybdenum – Tungsten)

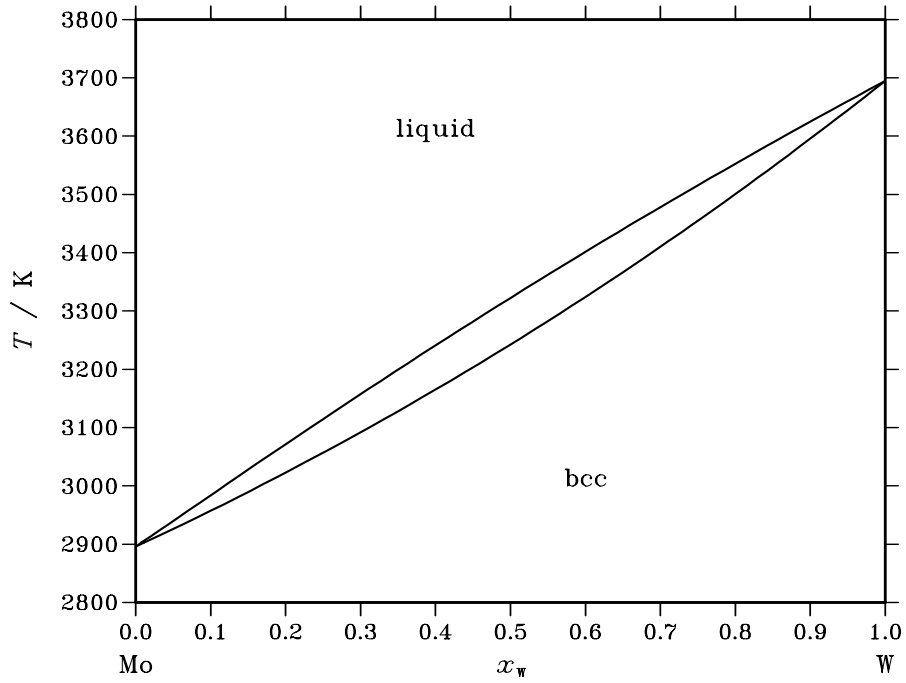

Fig. 1. Calculated phase diagram for the system Mo-W.

Molybdenum-tungsten alloys are used for high temperature electric elements. Both are also important additions to many alloys, such as superalloys and refractory alloys. The Mo-W system is fairly simple with only two condensed stable phases, liquid and bcc. In spite of the high temperatures of the solidus and liquidus, the experimental data are in fairly good agreement. In the most recent assessment by [88Gus] it was assumed that the liquid phase forms an ideal solution. The interaction parameter for the regular solution model of the bcc phase was adjusted to reproduce the experimental phase diagram.

Table I. Phases, structures and models.

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

Table IIa. Integral quantities for the liquid phase at 3700 K.

x_{W}	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	−10001	0	2.703	0	0.000	0.000
0.200	−15394	0	4.161	0	0.000	0.000
0.300	−18792	0	5.079	0	0.000	0.000
0.400	−20704	0	5.596	0	0.000	0.000
0.500	−21324	0	5.763	0	0.000	0.000
0.600	−20704	0	5.596	0	0.000	0.000
0.700	−18792	0	5.079	0	0.000	0.000
0.800	−15394	0	4.161	0	0.000	0.000
0.900	−10001	0	2.703	0	0.000	0.000
1.000	0	0	0.000	0	0.000	0.000

Reference states: Mo(liquid), W(liquid)

Table IIb. Partial quantities for Mo in the liquid phase at 3700 K.

x_{Mo}	ΔG_{Mo} [J/mol]	ΔH_{Mo} [J/mol]	ΔS_{Mo} [J/(mol·K)]	$G_{\mathrm{Mo}}^{\mathrm{E}}$ [J/mol]	$S_{\mathrm{Mo}}^{\mathrm{E}}$ [J/(mol·K)]	a_{Mo}	γ_{Mo}
1.000	0	0	0.000	0	0.000	1.000	1.000
0.900	−3241	0	0.876	0	0.000	0.900	1.000
0.800	−6865	0	1.855	0	0.000	0.800	1.000
0.700	−10973	0	2.966	0	0.000	0.700	1.000
0.600	−15715	0	4.247	0	0.000	0.600	1.000
0.500	−21324	0	5.763	0	0.000	0.500	1.000
0.400	−28189	0	7.619	0	0.000	0.400	1.000
0.300	−37039	0	10.010	0	0.000	0.300	1.000
0.200	−49512	0	13.382	0	0.000	0.200	1.000
0.100	−70836	0	19.145	0	0.000	0.100	1.000
0.000	$-\infty$	0	∞	0	0.000	0.000	1.000

Reference state: Mo(liquid)

Table IIc. Partial quantities for W in the liquid phase at 3700 K.

x_{W}	ΔG_{W} [J/mol]	ΔH_{W} [J/mol]	ΔS_{W} [J/(mol·K)]	$G_{\mathrm{W}}^{\mathrm{E}}$ [J/mol]	$S_{\mathrm{W}}^{\mathrm{E}}$ [J/(mol·K)]	a_{W}	γ_{W}
0.000	$-\infty$	0	∞	0	0.000	0.000	1.000
0.100	−70836	0	19.145	0	0.000	0.100	1.000
0.200	−49512	0	13.382	0	0.000	0.200	1.000
0.300	−37039	0	10.010	0	0.000	0.300	1.000
0.400	−28189	0	7.619	0	0.000	0.400	1.000
0.500	−21324	0	5.763	0	0.000	0.500	1.000
0.600	−15715	0	4.247	0	0.000	0.600	1.000
0.700	−10973	0	2.966	0	0.000	0.700	1.000
0.800	−6865	0	1.855	0	0.000	0.800	1.000
0.900	−3241	0	0.876	0	0.000	0.900	1.000
1.000	0	0	0.000	0	0.000	1.000	1.000

Reference state: W(liquid)

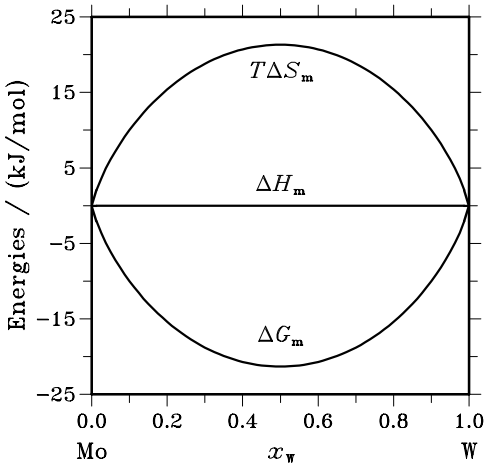

Fig. 2. Integral quantities of the liquid phase at T=3700 K.

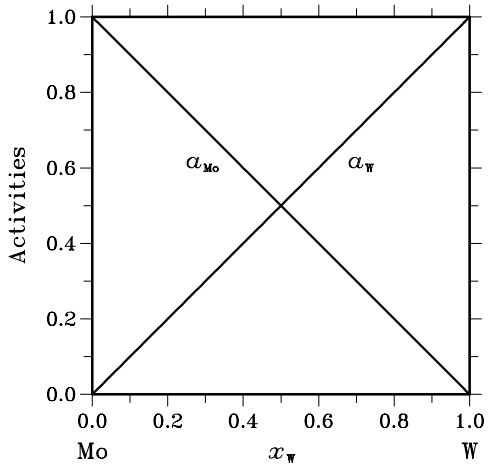

Fig. 3. Activities in the liquid phase at T=3700 K.

Table IIIa. Integral quantities for the stable phases at 2000 K.

Phase	x_{W}	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)]
bcc	0.000	0	0	0.000	0	0.000	0.000
	0.100	−5226	180	2.703	180	0.000	0.000
	0.200	−8001	320	4.161	320	0.000	0.000
	0.300	−9738	420	5.079	420	0.000	0.000
	0.400	−10712	480	5.596	480	0.000	0.000
	0.500	−11026	500	5.763	500	0.000	0.000
	0.600	−10712	480	5.596	480	0.000	0.000
	0.700	−9738	420	5.079	420	0.000	0.000
	0.800	−8001	320	4.161	320	0.000	0.000
	0.900	−5226	180	2.703	180	0.000	0.000
	1.000	0	0	0.000	0	0.000	0.000

Reference states: Mo(bcc), W(bcc)

Table IIIb. Partial quantities for Mo in the stable phases at 2000 K.

Phase	x_{Mo}	ΔG_{Mo} [J/mol]	ΔH_{Mo} [J/mol]	ΔS_{Mo} [J/(mol·K)]	$G_{\mathrm{Mo}}^{\mathrm{E}}$ [J/mol]	$S_{\mathrm{Mo}}^{\mathrm{E}}$ [J/(mol·K)]	a_{Mo}	γ_{Mo}
bcc	1.000	0	0	0.000	0	0.000	1.000	1.000
	0.900	−1732	20	0.876	20	0.000	0.901	1.001
	0.800	−3631	80	1.855	80	0.000	0.804	1.005
	0.700	−5751	180	2.966	180	0.000	0.708	1.011
	0.600	−8175	320	4.247	320	0.000	0.612	1.019
	0.500	−11026	500	5.763	500	0.000	0.515	1.031
	0.400	−14517	720	7.619	720	0.000	0.418	1.044
	0.300	−19041	980	10.010	980	0.000	0.318	1.061
	0.200	−25483	1280	13.382	1280	0.000	0.216	1.080
	0.100	−36670	1620	19.145	1620	0.000	0.110	1.102
	0.000	$-\infty$	2000	∞	2000	0.000	0.000	1.128

Reference state: Mo(bcc)

Table IIIc. Partial quantities for W in the stable phases at 2000 K.

Phase	x_W	ΔG_W [J/mol]	ΔH_W [J/mol]	ΔS_W [J/(mol·K)]	G_W^E [J/mol]	S_W^E [J/(mol·K)]	a_W	γ_W
bcc	0.000	$-\infty$	2000	∞	2000	0.000	0.000	1.128
	0.100	−36670	1620	19.145	1620	0.000	0.110	1.102
	0.200	−25483	1280	13.382	1280	0.000	0.216	1.080
	0.300	−19041	980	10.010	980	0.000	0.318	1.061
	0.400	−14517	720	7.619	720	0.000	0.418	1.044
	0.500	−11026	500	5.763	500	0.000	0.515	1.031
	0.600	−8175	320	4.247	320	0.000	0.612	1.019
	0.700	−5751	180	2.966	180	0.000	0.708	1.011
	0.800	−3631	80	1.855	80	0.000	0.804	1.005
	0.900	−1732	20	0.876	20	0.000	0.901	1.001
	1.000	0	0	0.000	0	0.000	1.000	1.000

Reference state: W(bcc)

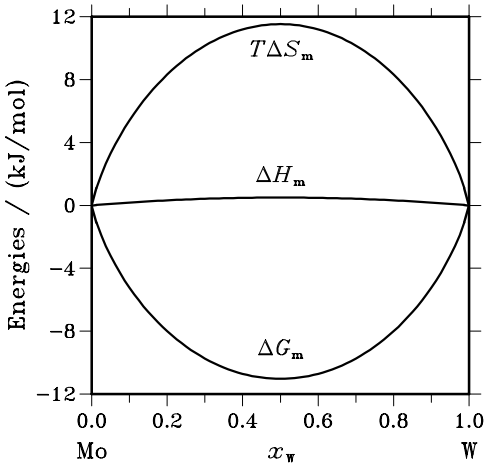

Fig. 4. Integral quantities of the stable phases at T=2000 K.

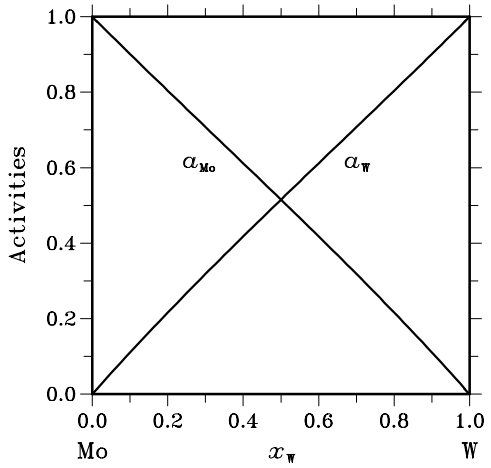

Fig. 5. Activities in the stable phases at T=2000 K.

References

[88Gus] P. Gustafson: Z. Metallkd. **79** (1988) 388–396.