Fe – W (Iron – Tungsten)

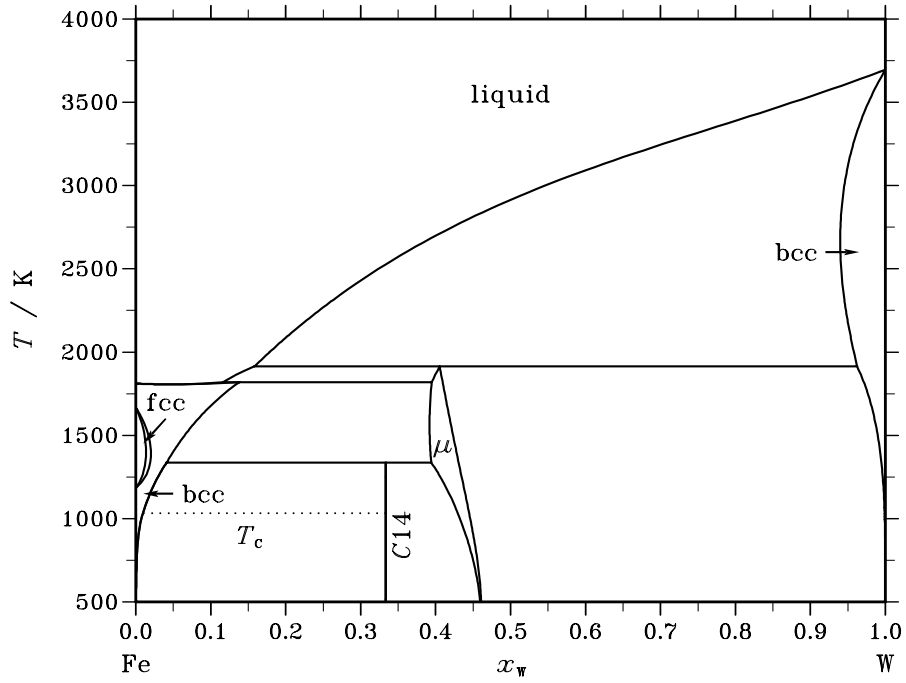

Fig. 1. Calculated phase diagram for the system Fe-W.

The high melting temperature of W dominates the phase diagram. There is an intermetallic μ-phase with $D8_5$ structure and a $C14$ Laves phase. The fcc phase is stable in a narrow "gamma-loop" close to the Fe side and the mutual solubilities in the bcc phase is quite small. The assessment [87Gus] is quite old but still the most used. W is a strong carbide former and in combination with Fe they appear in tool steels and other hard materials. W and Mo are quite similar and can partially replace each other.

Table I. Phases, structures and models.

Phase	Struktur-bericht	Prototype	Pearson symbol	Space group	SGTE name	Model
liquid					LIQUID	$(Fe,W)_1$
fcc	$A1$	Cu	$cF4$	$Fm\overline{3}m$	FCC_A1	$(Fe,W)_1$
bcc	$A2$	W	$cI2$	$Im\overline{3}m$	BCC_A2	$(Fe,W)_1$
$C14$	$C14$	$MgZn_2$	$hP12$	$P6_3/mmc$	LAVES_C14	Fe_2W_1
μ	$D8_5$	Fe_7W_6	$hR13$	$R\overline{3}m$	D85_MUPHASE	$Fe_7W_2(Fe,W)_4$

Table II. Invariant reactions.

Reaction	Type	T / K	Compositions / x_W			$\Delta_r H$ / (J/mol)
liquid + bcc $\rightleftharpoons \mu$	peritectic	1914.3	0.158	0.962	0.405	−17734
liquid + $\mu \rightleftharpoons$ bcc	peritectic	1819.8	0.116	0.395	0.138	−11827
liquid $\rightleftharpoons$ bcc	congruent	1806.2	0.048	0.048		−13790
bcc + $\mu \rightleftharpoons C14$	peritectoid	1335.4	0.041	0.394	0.333	−2314
$C14 \rightleftharpoons$ bcc + μ	eutectoid	383.8	0.333	0.000	0.461	−678

Table IIIa. Integral quantities for the stable phases at 1873 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)]
liquid	0.000	0	0	0.000	0	0.000	0.000
	0.100	−2254	4499	3.605	2809	0.903	0.000
	0.138	−2338	6310	4.617	3917	1.277	0.001
μ	0.401	−2149	−12142	−5.335	8336	−10.934	−2.780
	0.407	−2137	−12163	−5.352	8387	−10.971	−2.755
bcc	0.966	−541	1270	0.967	1750	−0.256	−0.131
	1.000	0	0	0.000	0	0.000	0.000

Reference states: Fe(liquid), W(bcc)

Table IIIb. Partial quantities for Fe in the stable phases at 1873 K.

Phase	x_{Fe}	ΔG_{Fe} [J/mol]	ΔH_{Fe} [J/mol]	ΔS_{Fe} [J/(mol·K)]	$G_{\mathrm{Fe}}^{\mathrm{E}}$ [J/mol]	$S_{\mathrm{Fe}}^{\mathrm{E}}$ [J/(mol·K)]	a_{Fe}	γ_{Fe}
liquid	1.000	0	0	0.000	0	0.000	1.000	1.000
	0.900	−1713	−178	0.820	−72	−0.057	0.896	0.995
	0.862	−2438	−324	1.129	−122	−0.108	0.855	0.992
μ	0.599	−2438	−10859	−4.496	5535	−8.753	0.855	1.427
	0.593	−3300	−10859	−4.036	4841	−8.382	0.809	1.365
bcc	0.034	−3300	35266	20.590	49541	−7.622	0.809	24.076
	0.000	$-\infty$	40430	∞	54705	−7.622	0.000	33.542

Reference state: Fe(liquid)

Table IIIc. Partial quantities for W in the stable phases at 1873 K.

Phase	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}
liquid	0.000	$-\infty$	43105	∞	27258	8.461	0.000	5.756
	0.100	−7125	46592	28.679	28734	9.534	0.633	6.329
	0.138	−1716	47673	26.369	29103	9.915	0.896	6.481
μ	0.401	−1716	−14061	−6.591	12527	−14.195	0.896	2.235
	0.407	−445	−14061	−7.270	13551	−14.742	0.972	2.387
bcc	0.966	−445	88	0.284	88	0.000	0.972	1.006
	1.000	0	0	0.000	0	0.000	1.000	1.000

Reference state: W(bcc)

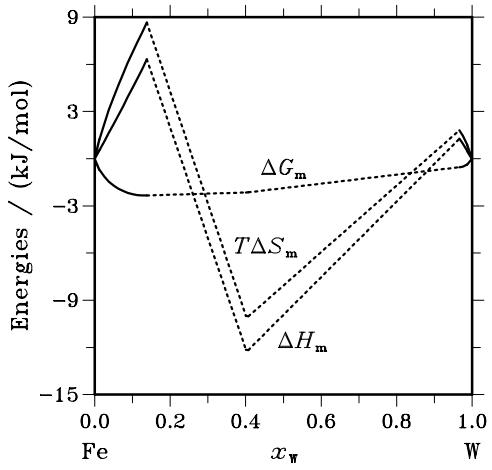

Fig. 2. Integral quantities of the stable phases at T=1873 K.

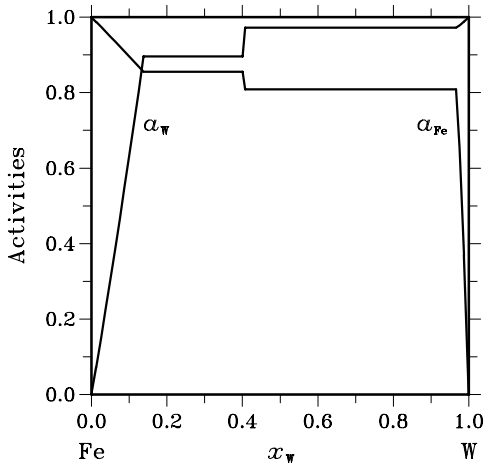

Fig. 3. Activities in the stable phases at T=1873 K.

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

Compound	x_W	$\Delta_f G^\circ$ / (J/mol)	$\Delta_f H^\circ$ / (J/mol)	$\Delta_f S^\circ$ / (J/(mol·K))	$\Delta_f C_P^\circ$ / (J/(mol·K))
$C14$	0.333	−402	815	4.082	0.234
μ	0.462	−767	183	3.185	0.189

References

[87Gus] P. Gustafson: Metall. Trans. A **18A** (1987) 175–188.