Re – W (Rhenium – Tungsten)

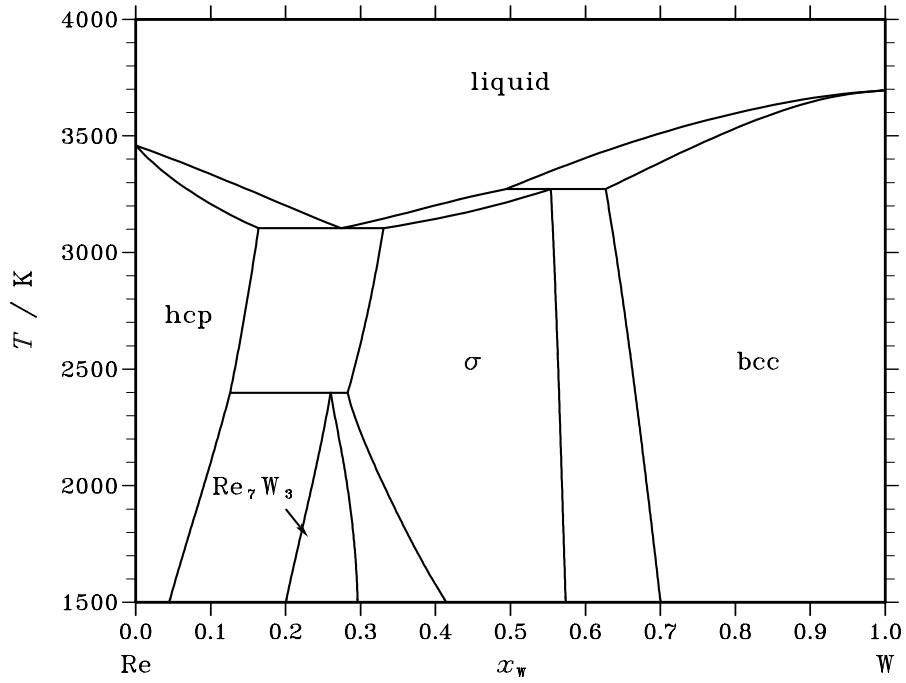

Fig. 1. Calculated phase diagram for the system Re-W.

Rhenium-tungsten alloys are used for high melting wires and rods. Both are also important additions to many alloys, such as superalloys and refractory alloys. The Re-W system consists of five condensed stable phases, liquid, bcc (W-rich terminal solid solution), hcp (Re-rich terminal solid solution) and two ordered intermediate phases, Re_7W_3 and σ. [00Liu] used three-sublattice models for the description of the two ordered phases. Substitution is considered to occur on two sublattices of the Re_7W_3 phase model description and on one sublattice of the σ phase description. The two models are in accord with the recommendations of [97Ans]. The assessment reproduces the experimental phase diagram and theoretical enthalpy of formation data reasonably well.

Table I. Phases, structures and models.

Phase	Struktur-bericht	Prototype	Pearson symbol	Space group	SGTE name	Model
liquid					LIQUID	$(Re,W)_1$
hcp	$A3$	Mg	$hP2$	$P6_3/mmc$	HCP_A3	$(Re,W)_1$
Re_7W_3	$A12$	αMn	$cI58$	$I\bar{4}3m$	A12_CHI	$Re_{12}(Re,W)_5(Re,W)_{12}$
σ	$D8_b$	σCrFe	$tP30$	$P4_2/mnm$	DB8_SIGMA	$Re_{10}W_4(Re,W)_{16}$
bcc	$A2$	W	$cI2$	$Im\bar{3}m$	BCC_A2	$(Re,W)_1$

Table II. Invariant reactions.

Reaction	Type	T / K	Compositions / x_W			$\Delta_r H$ / (J/mol)
liquid + bcc $\rightleftharpoons \sigma$	peritectic	3271.8	0.494	0.627	0.554	−28693
liquid $\rightleftharpoons$ hcp + σ	eutectic	3103.9	0.274	0.164	0.331	−51593
hcp + $\sigma \rightleftharpoons Re_7W_3$	peritectoid	2398.6	0.126	0.283	0.260	−1217

Table IIIa. 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	−12585	−2585	2.703	−2585	0.000	0.000
0.200	−19806	−4412	4.161	−4412	0.000	0.000
0.300	−24343	−5550	5.079	−5550	0.000	0.000
0.400	−26773	−6068	5.596	−6068	0.000	0.000
0.500	−27359	−6035	5.763	−6035	0.000	0.000
0.600	−26223	−5519	5.596	−5519	0.000	0.000
0.700	−23381	−4589	5.079	−4589	0.000	0.000
0.800	−18707	−3313	4.161	−3313	0.000	0.000
0.900	−11761	−1761	2.703	−1761	0.000	0.000
1.000	0	0	0.000	0	0.000	0.000

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

Table IIIb. Partial quantities for Re in the liquid phase at 3700 K.

x_{Re}	ΔG_{Re} [J/mol]	ΔH_{Re} [J/mol]	ΔS_{Re} [J/(mol·K)]	$G_{\mathrm{Re}}^{\mathrm{E}}$ [J/mol]	$S_{\mathrm{Re}}^{\mathrm{E}}$ [J/(mol·K)]	a_{Re}	γ_{Re}
1.000	0	0	0.000	0	0.000	1.000	1.000
0.900	−3631	−390	0.876	−390	0.000	0.889	0.987
0.800	−8334	−1469	1.855	−1469	0.000	0.763	0.953
0.700	−14072	−3100	2.966	−3100	0.000	0.633	0.904
0.600	−20859	−5144	4.247	−5144	0.000	0.508	0.846
0.500	−28790	−7466	5.763	−7466	0.000	0.392	0.785
0.400	−38115	−9927	7.619	−9927	0.000	0.290	0.724
0.300	−49428	−12390	10.010	−12390	0.000	0.201	0.668
0.200	−64229	−14717	13.382	−14717	0.000	0.124	0.620
0.100	−87608	−16772	19.145	−16772	0.000	0.058	0.580
0.000	$-\infty$	−18417	∞	−18417	0.000	0.000	0.550

Reference state: Re(liquid)

Table IIIc. 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	$-\infty$	−29863	∞	−29863	0.000	0.000	0.379
0.100	−93171	−22335	19.145	−22335	0.000	0.048	0.484
0.200	−65694	−16182	13.382	−16182	0.000	0.118	0.591
0.300	−48306	−11268	10.010	−11268	0.000	0.208	0.693
0.400	−35643	−7454	7.619	−7454	0.000	0.314	0.785
0.500	−25928	−4604	5.763	−4604	0.000	0.430	0.861
0.600	−18295	−2580	4.247	−2580	0.000	0.552	0.920
0.700	−12218	−1245	2.966	−1245	0.000	0.672	0.960
0.800	−7327	−462	1.855	−462	0.000	0.788	0.985
0.900	−3334	−93	0.876	−93	0.000	0.897	0.997
1.000	0	0	0.000	0	0.000	1.000	1.000

Reference state: W(liquid)

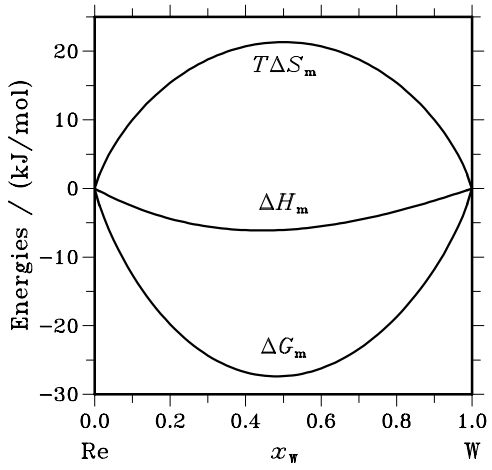

Fig. 2. Integral quantities of the liquid phase at T=3700 K.

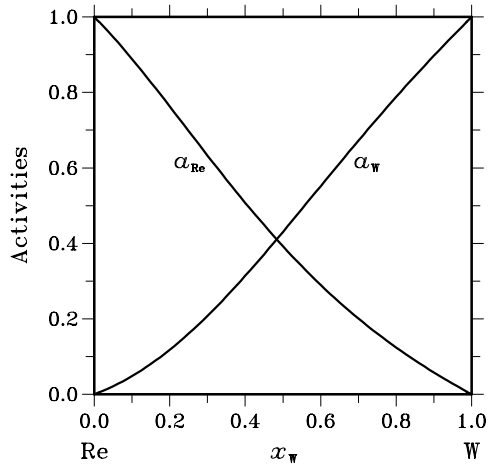

Fig. 3. Activities in the liquid phase at T=3700 K.

Table IVa. Integral quantities for the stable phases at 2500 K.

Phase	x_W	ΔG_m [J/mol]	ΔH_m [J/mol]	ΔS_m [J/(mol·K)]	G_m^E [J/mol]	S_m^E [J/(mol·K)]	ΔC_P [J/(mol·K)]
hcp	0.000	0	0	0.000	0	0.000	0.000
	0.100	−6001	756	2.703	756	0.000	0.000
	0.132	−7085	1034	3.248	1034	0.000	0.000
σ	0.291	−11897	−2253	3.858	645	−1.159	0.000
	0.300	−12152	−2188	3.986	545	−1.093	0.000
	0.400	−14459	−1704	5.102	−469	−0.494	0.000
	0.500	−15649	−1701	5.579	−1241	−0.184	0.000
	0.564	−15720	−1949	5.508	−1482	−0.187	0.000
bcc	0.662	−15289	−1955	5.334	−1998	0.017	0.000
	0.700	−15003	−2521	4.993	−2305	−0.086	0.000
	0.800	−12943	−3134	3.923	−2541	−0.237	0.000
	0.900	−8578	−2341	2.495	−1820	−0.208	0.000
	1.000	0	0	0.000	0	0.000	0.000

Reference states: Re(hcp), W(bcc)

Table IVb. Partial quantities for Re in the stable phases at 2500 K.

Phase	x_{Re}	ΔG_{Re} [J/mol]	ΔH_{Re} [J/mol]	ΔS_{Re} [J/(mol·K)]	$G^{\mathrm{E}}_{\mathrm{Re}}$ [J/mol]	$S^{\mathrm{E}}_{\mathrm{Re}}$ [J/(mol·K)]	a_{Re}	γ_{Re}
hcp	1.000	0	0	0.000	0	0.000	1.000	1.000
	0.900	−2270	−80	0.876	−80	0.000	0.897	0.996
	0.868	−3088	−140	1.179	−140	0.000	0.862	0.993
σ	0.709	−3088	−4486	−0.559	4072	−3.423	0.862	1.216
	0.700	−3434	−4363	−0.372	3980	−3.337	0.848	1.211
	0.600	−7465	−2679	1.915	3153	−2.333	0.698	1.164
	0.500	−12696	−514	4.873	1712	−0.890	0.543	1.086
	0.436	−18183	1116	7.720	−943	0.824	0.417	0.956
bcc	0.338	−18183	9535	11.087	4387	2.059	0.417	1.235
	0.300	−22659	6364	11.609	2367	1.599	0.336	1.121
	0.200	−37745	−3661	13.633	−4290	0.252	0.163	0.814
	0.100	−60905	−16231	17.869	−13043	−1.275	0.053	0.534
	0.000	$-\infty$	−31630	∞	−24175	−2.982	0.000	0.313

Reference state: Re(hcp)

Table IVc. Partial quantities for W in the stable phases at 2500 K.

Phase	x_{W}	ΔG_{W} [J/mol]	ΔH_{W} [J/mol]	ΔS_{W} [J/(mol·K)]	$G^{\mathrm{E}}_{\mathrm{W}}$ [J/mol]	$S^{\mathrm{E}}_{\mathrm{W}}$ [J/(mol·K)]	a_{W}	γ_{W}
hcp	0.000	$-\infty$	6764	∞	6764	0.000	0.000	1.385
	0.100	−39581	8281	19.145	8281	0.000	0.149	1.489
	0.132	−33320	8736	16.822	8736	0.000	0.201	1.522
σ	0.291	−33320	3179	14.599	−7688	4.347	0.201	0.691
	0.300	−32494	2887	14.152	−7468	4.142	0.209	0.698
	0.400	−24949	−241	9.883	−5902	2.265	0.301	0.753
	0.500	−18602	−2887	6.286	−4194	0.523	0.409	0.817
	0.564	−13814	−4322	3.797	−1899	−0.969	0.514	0.913
bcc	0.662	−13814	−7812	2.401	−5252	−1.024	0.514	0.777
	0.700	−11721	−6328	2.157	−4307	−0.808	0.569	0.813
	0.800	−6742	−3002	1.496	−2104	−0.359	0.723	0.904
	0.900	−2763	−798	0.786	−573	−0.090	0.876	0.973
	1.000	0	0	0.000	0	0.000	1.000	1.000

Reference state: W(bcc)

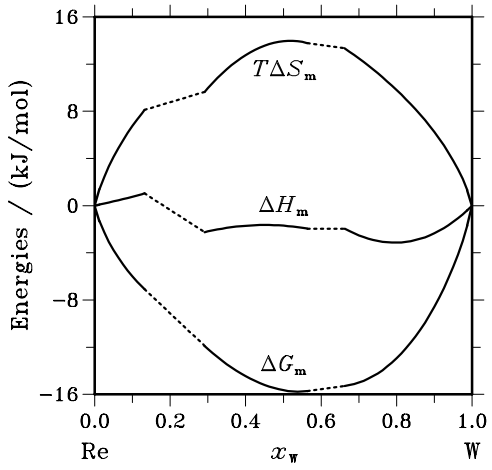

Fig. 4. Integral quantities of the stable phases at T=2500 K.

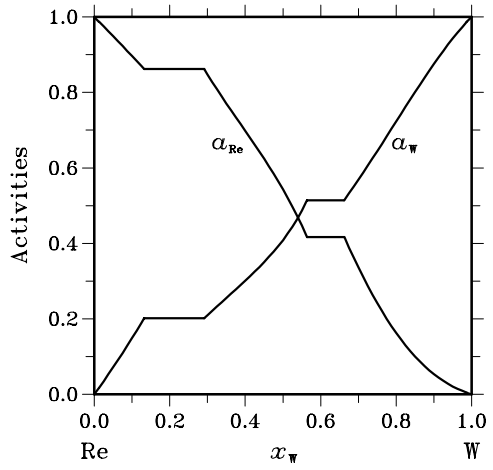

Fig. 5. Activities in the stable phases at T=2500 K.

References

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