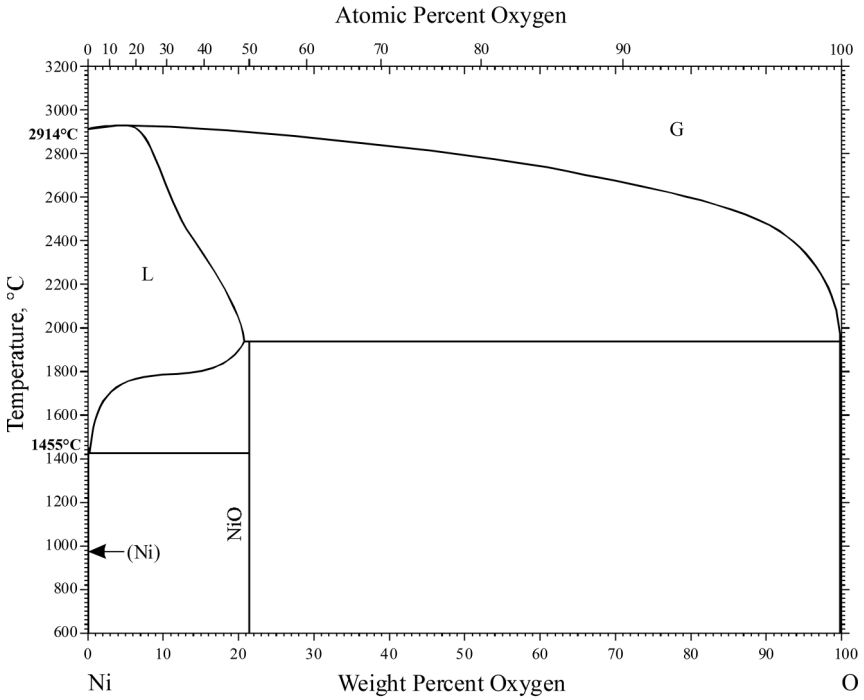
ASM Handbook, Volume 3: *Alloy Phase Diagrams*
H. Okamoto, M.E. Schlesinger, and E.M. Mueller, editors, p 520–533
DOI: 10.31399/asm.hb.v03.a0006189

Ni (Nickel) Binary Alloy Phase Diagrams

Ni-O (Nickel-Oxygen)

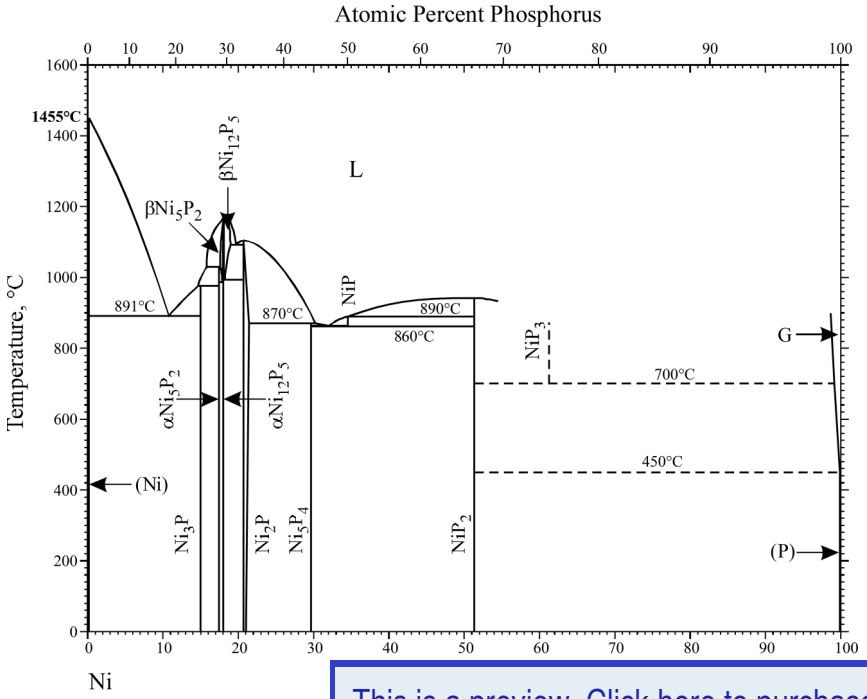


Ni-O crystallographic data

Phase	Composition, wt% O	Pearson symbol	Space group	Prototype
(Ni)	0	*cF*4	$Fm\bar{3}m$	Cu
NiO	21.4	*cF*8	$Fm\bar{3}m$	NaCl

M. Kowalski and P.J. Spencer, *Calphad*, tVol 19, 1995, p 229–239

Ni-P (Nickel-Phosphorus)

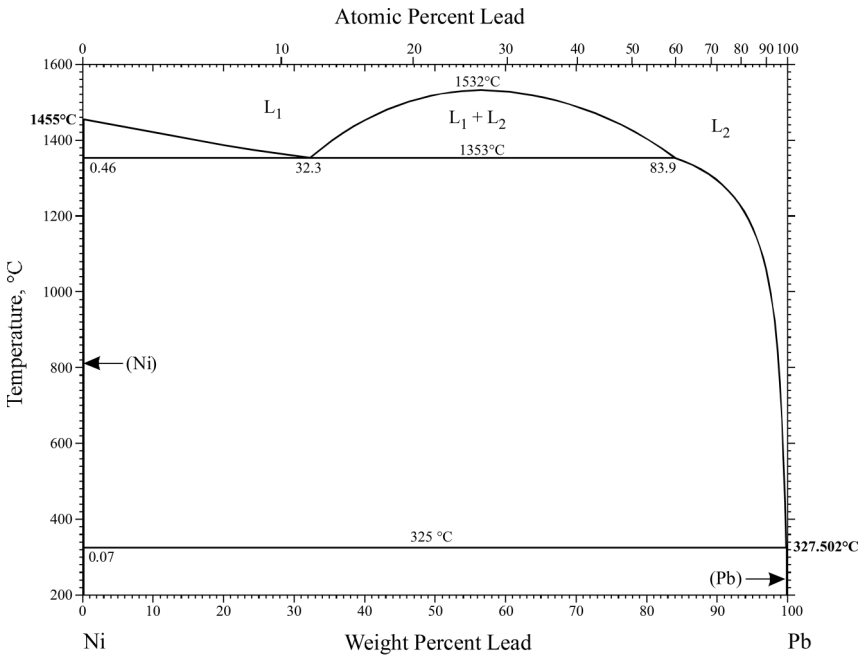


Ni-P crystallographic data

Phase	Composition, wt% P	Pearson symbol	Space group	Prototype
(Ni)	0	*cF*4	$Fm\bar{3}m$	Cu
Ni_3P	15.0	*tI*32	$I\bar{4}$	Ni_3P
βNi_5P_2	17.5 to 17.9	...	...	...
αNi_5P_2	17.4	*hP*168	$P\bar{3}$	...
$\beta Ni_{12}P_5$	18 to 19	...	...	...
$\alpha Ni_{12}P_5$	18.0	*tI*34	*I*4/*m*	...
Ni_2P	20.9. to 21.4	*hP*9	$P\bar{6}2m$	Fe_2P
Ni_5P_4	29.7	*hP*36	$P6_3mc$	...
NiP	34.5	*aP*16	*Pcba*	...
NiP_2	51.4	*mC*12	*C*2/*c*	...
NiP_3	61.3	*cI*32	$Im\bar{3}$	$CoAs_3$
(P)	100	...	...	...

H. Okamoto, *J. Phase Equilib. Diff.*, Vol 31 (No. 2), 2010, p 200–201

Ni-Pb (Nickel-Lead)

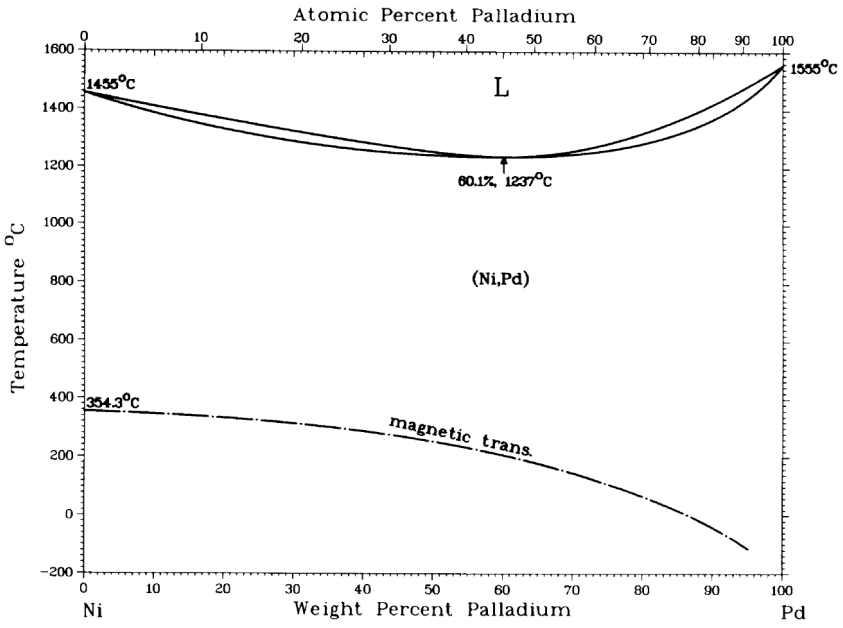


Ni-Pb crystallographic data

Phase	Composition, wt% Pb	Pearson symbol	Space group	Prototype
(Ni)	0 to 0.46	*cF*4	$Fm\bar{3}m$	Cu
(Pb)	100	*cF*4	$Fm\bar{3}m$	Cu

I. Kainulainen, P. Taskinen, and J. Gisby, *Calphad*, Vol 34, 2010, p 441–445

Ni-Pd (Nickel-Palladium)

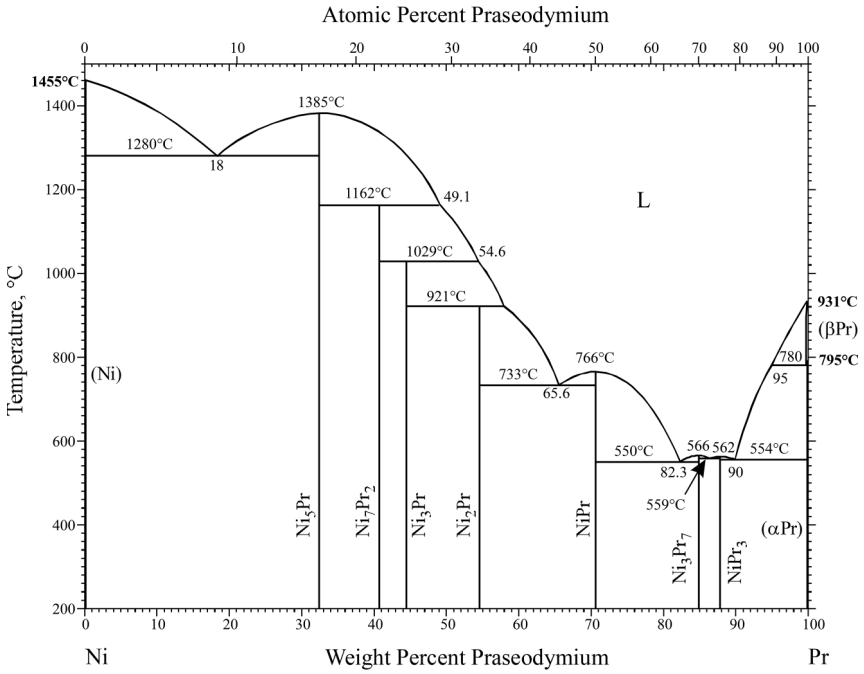


Ni-Pd crystallographic data

Phase	Composition, wt% Pd	Pearson symbol	Space group	Prototype
(Ni,Pd)	0 to 100	*cF*4	$Fm\bar{3}m$	Cu

A. Nash and P. Nash, *Phase Diagrams of Binary Nickel Alloys*, P. Nash, Ed., ASM International, 1991, p 251–256

Ni-Pr (Nickel-Praseodymium)

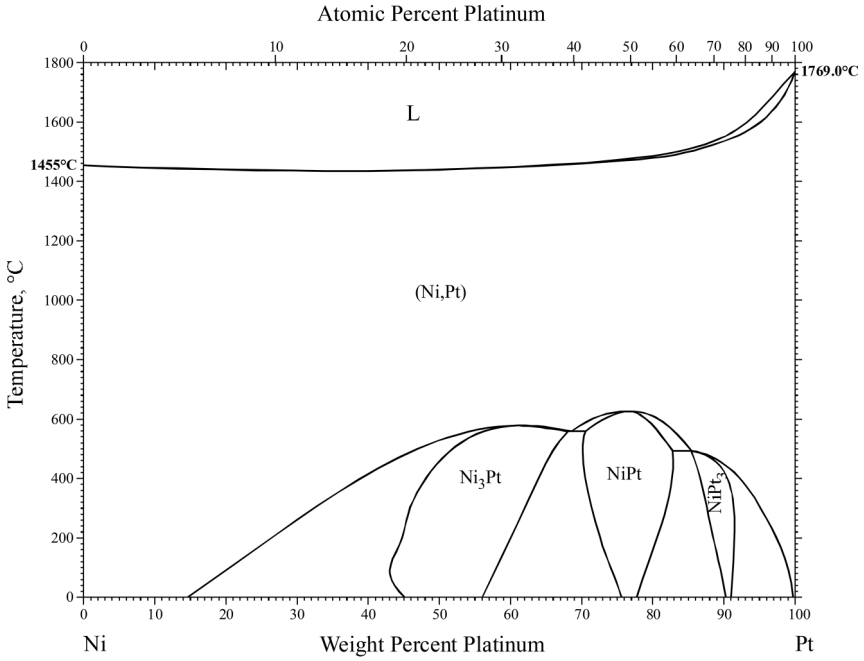


Ni-Pr crystallographic data

Phase	Composition, wt% Pr	Pearson symbol	Space group	Prototype
(Ni)	0	*cF*4	$Fm\bar{3}m$	Cu
Ni_5Pr	32.4	*hP*6	*P*6/*mmm*	$CaCu_5$
Ni_7Pr_2	40.7	*hP*36	$P6_3/mmc$	Ce_2Ni_7
		*hR*54	$R\bar{3}m$	Co_7Gd_2
Ni_3Pr	44.5	*hR*24	$R\bar{3}m$	$PuNi_3$
Ni_2Pr	54.6	*cF*24	$Fd\bar{3}m$	Cu_2Mg
NiPr	70.6	*oC*8	*Cmcm*	CrB
Ni_3Pr_7	84.9	*hP*20	$P6_3/mc$	Fe_3Th_7
$NiPr_3$	87.8	*oP*16	*Pnma*	Fe_3C
(βPr)	99.7 to 100	*cI*2	$Im\bar{3}m$	W
(αPr)	100	*hP*4	$P6_3/mmc$	αLa

M. Huang and T.A. Lograsso, *J. Alloy. Compd.*, Vol 395, 2005, p 75–79

Ni-Pt (Nickel-Platinum)

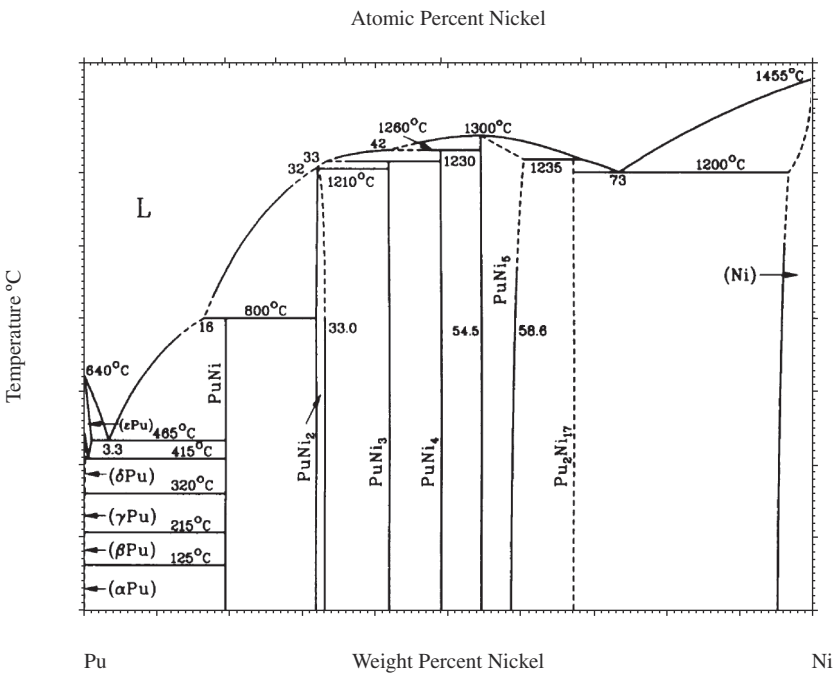


Ni-Pt crystallographic data

Phase	Composition, wt% Pt	Pearson symbol	Space group	Prototype
(Ni,Pt)	0 to 100	*cF*4	$Fm\bar{3}m$	Cu
Ni_3Pt	43 to 68	*cP*4	$Pm\bar{3}m$	$AuCu_3$
NiPt	70 to 83	*tP*4	*P*4/*mmm*	AuCu
$NiPt_3$	85 to 92	*cP*4	$Pm\bar{3}m$	$AuCu_3$

X.G. Lu, B. Sundman, and J. Ågren, *Calphad*, Vol 33, 2009, p 450–456

Ni-Pu (Nickel-Plutonium)

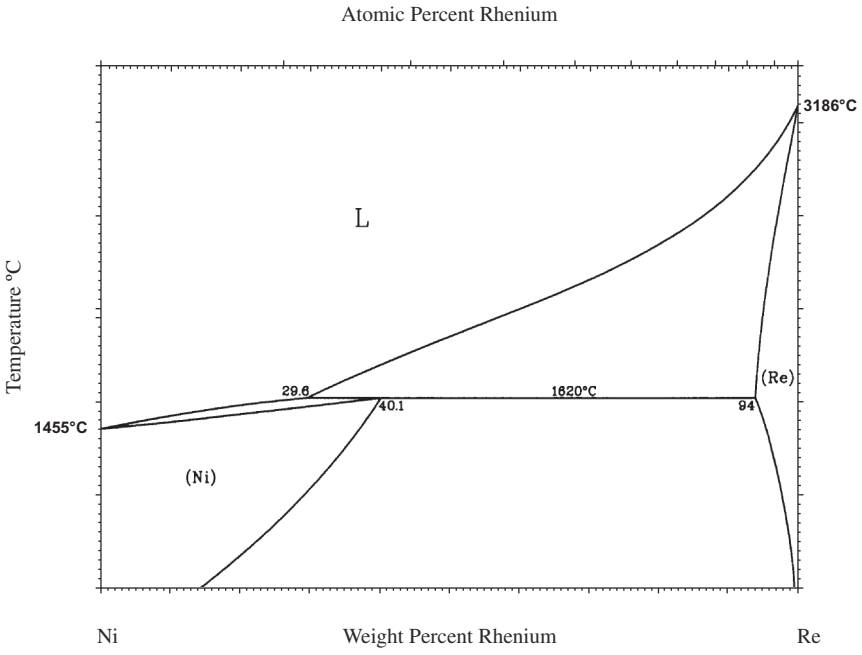


Ni-Pu crystallographic data

Phase	Composition, wt% Ni	Pearson symbol	Space group	Prototype
(εPu)	0 to 1.1	*cI*2	$Im\bar{3}m$	W
(δ′Pu)	0 to 0.04	*tI*2	*I*4/*mmm*	In
(δPu)	0 to 0.1	*cF*4	$Fm\bar{3}m$	Cu
(γPu)	0	*oF*8	*Fddd*	γPu
(βPu)	0	*mC*34	*C*2/*m*	βPu
(αPu)	0	*mP*16	$P2_1/m$	αPu
PuNi	19.4	*oC*8	*Cmcm*	CrB
$PuNi_2$	32.5 to 34	*cF*24	$Fd\bar{3}m$	Cu_2Mg
$PuNi_3$	42	*hR*12	$R\bar{3}m$	···
$PuNi_4$	49	*mC*30	*C*2/*m*	···
$PuNi_5$	54.5 to 60	*hP*6	*P*6/*mmm*	$CaCu_5$
Pu_2Ni_{17}	67.2	*hP*38	$P6_3/mmc$	···
(Ni)	92.9 to 100	*cF*4	$Fm\bar{3}m$	Cu

D.E. Peterson, *Phase Diagrams of Binary Nickel Alloys*, P. Nash, Ed., ASM International, 1991, p 265–268

Ni-Re (Nickel-Rhenium)

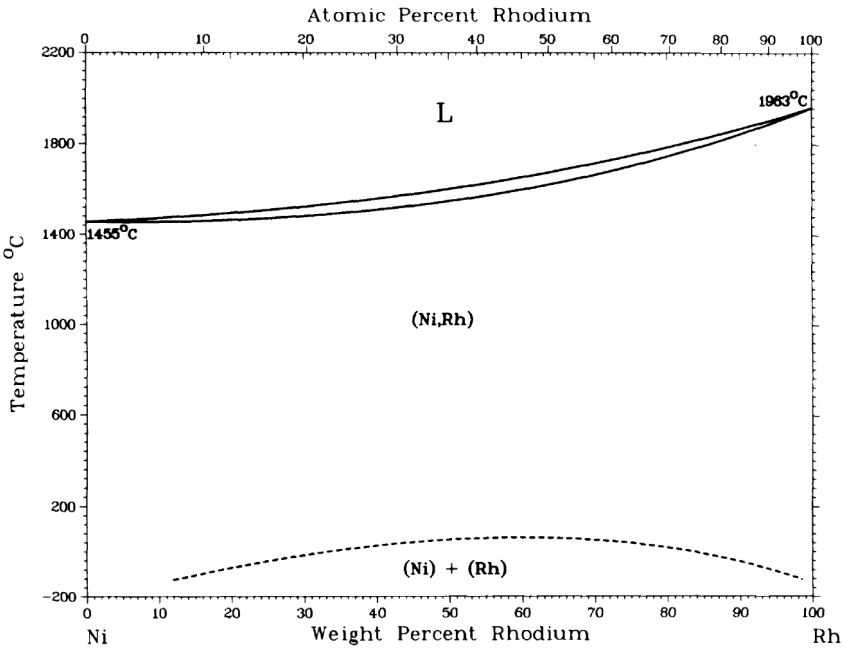


Ni-Re crystallographic data

Phase	Composition, wt% Re	Pearson symbol	Space group	Prototype
(Ni)	0 to 40.1	*cF*4	$Fm\bar{3}m$	Cu
(Re)	94 to 100	*hP*2	$P6_3/mmc$	Mg

H. Okamoto, *J. Phase Equilib.*, Vol 13 (No. 3), 1992, p 335

Ni-Rh (Nickel-Rhodium)

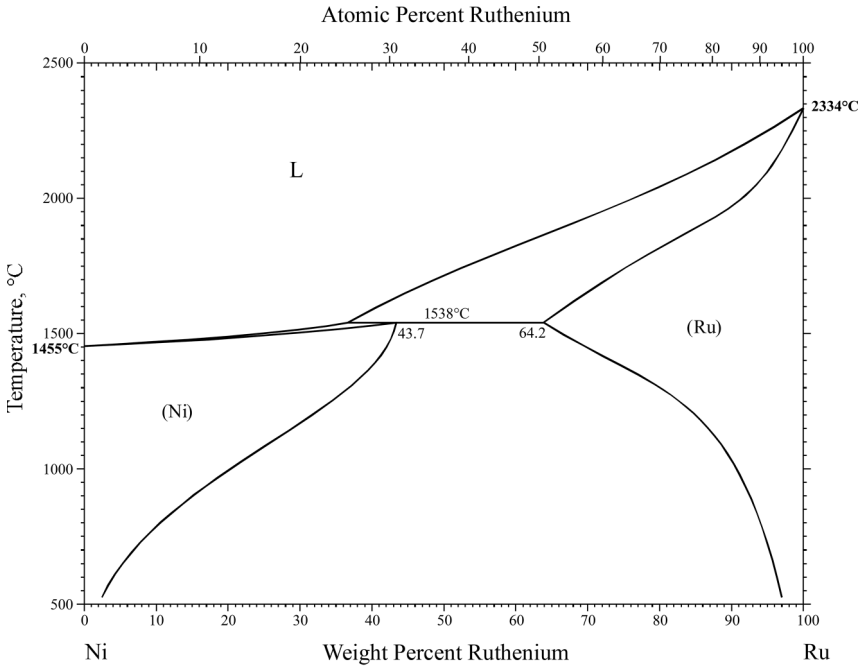


Ni-Rh crystallographic data

Phase	Composition, wt% Rh	Pearson symbol	Space group	Prototype
(Ni,Rh)	0 to 100	*cF*4	$Fm\bar{3}m$	Cu

A. Nash and P. Nash, *Phase Diagrams of Binary Nickel Alloys*, P. Nash, Ed., ASM International, 1991, p 271–273

Ni-Ru (Nickel-Ruthenium)

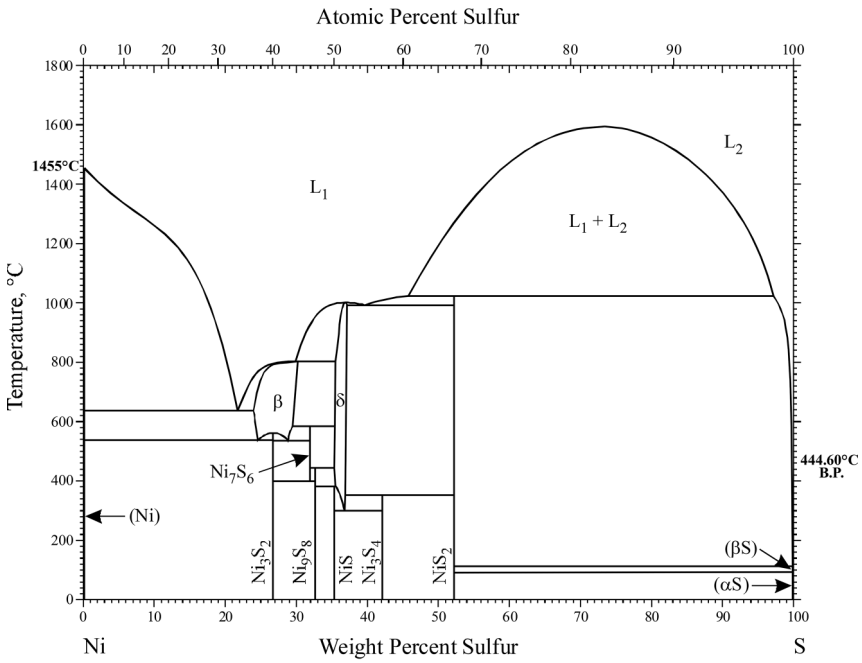


Ni-Ru crystallographic data

Phase	Composition, wt% Ru	Pearson symbol	Space group	Prototype
(Ni)	0 to 43.7	*cF*4	$Fm\bar{3}m$	Cu
(Ru)	64.2 to 100	*hP*2	$P6_3/mmc$	Mg

S. Hallström, D. Andersson, A. Ruban, and J. Ågren, *Acta Mater.*, Vol 56 (No. 15), 2008, p 4062–4069

Ni-S (Nickel-Sulfur)

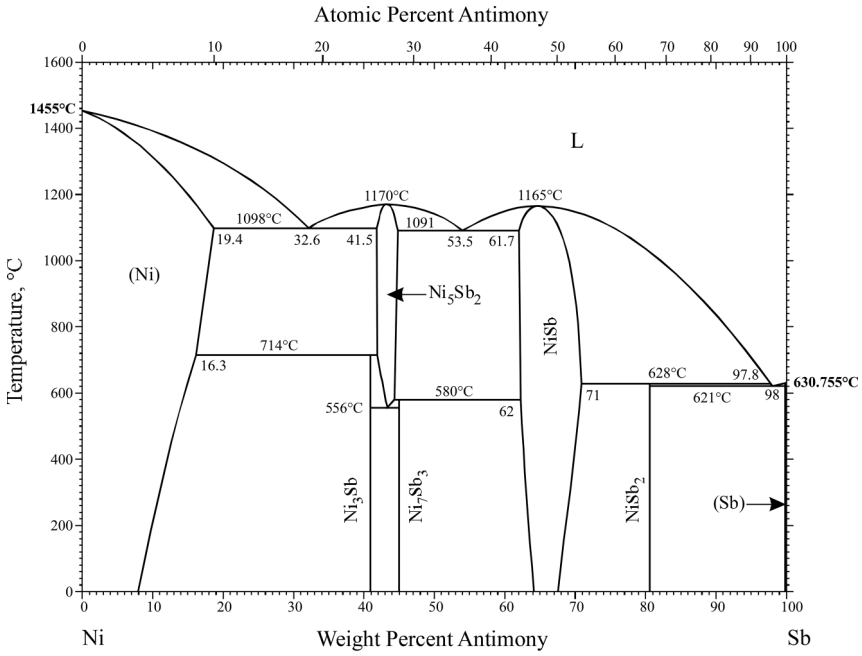


Ni-S crystallographic data

Phase	Composition, wt% S	Pearson symbol	Space group	Prototype
(Ni)	0	*cF*4	$Fm\bar{3}m$	Cu
β	24 to 30	*hP**	···	···
Ni_3S_2	26.7	*hR*5	*R*32	···
Ni_7S_6	31.9	*oC*56	*Cmcm*	···
Ni_9S_8	32.7	···	···	···
NiS	35.3	*hR*6	$R\bar{3}m$	NiS
δ	35.3 to 37.2	*hP*4	$P6_3/mmc$	NiAs
Ni_3S_4	42.1	*cF*56	$Fd\bar{3}m$	Co_3S_4
NiS_2	52.2	*cP*12	$Pa\bar{3}$	FeS_2 (pyrite)
(βS)	100	*mP*48	$P2_1/a$	···
(αS)	100	*oF*128	*Fddd*	αS

P. Waldner and A.D. Pelton, *Z. Metallkd.*, Vol 95 (No. 8), 2004, p 672–681

Ni-Sb (Nickel-Antimony)

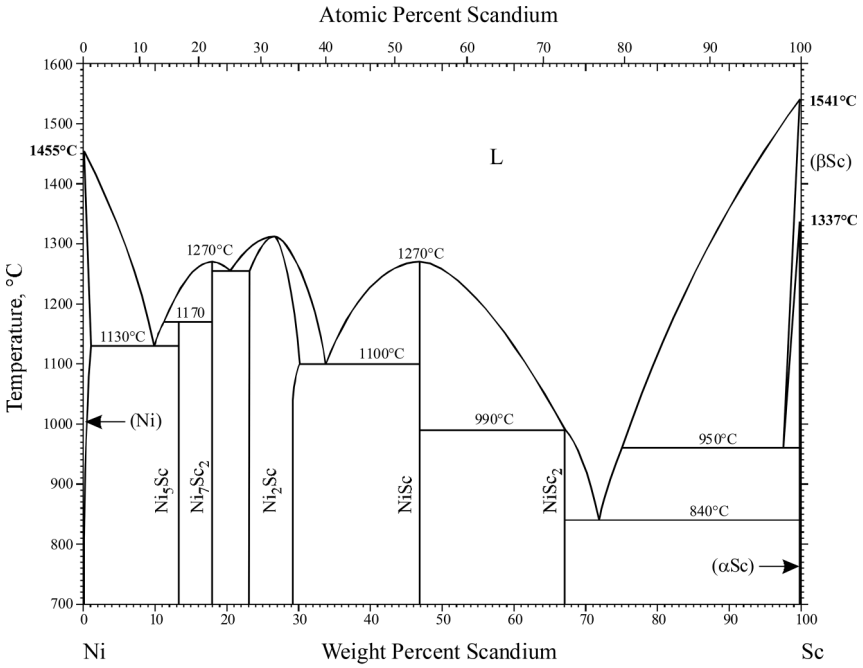


Ni-Sb crystallographic data

Phase	Composition, wt% Sb	Pearson symbol	Space group	Prototype
(Ni)	0 to 19.4	*cF*4	$Fm\bar{3}m$	Cu
Ni_3Sb	40.9	*oP*8	*Pmmn*	$\beta TiCu_3$
Ni_5Sb_2	41.5 to 44.5	*mC*28	···	···
Ni_7Sb_3	45	*t***	···	···
NiSb	61.7 to 71	*hP*4	$P6_3/mmc$	NiAs
$NiSb_2$	80.6	*oP*6	*Pnnm*	FeS_2 (marcasite)
(Sb)	100	*hR*2	$R\bar{3}m$	αAs

Z. Cao, Y. Takaku, I. Ohnuma, R. Kainuma, H. Zhu, and K. Ishida, *Rare Metals*, Vol 27 (No. 4), 2008, p 384–392

Ni-Sc (Nickel-Scandium)

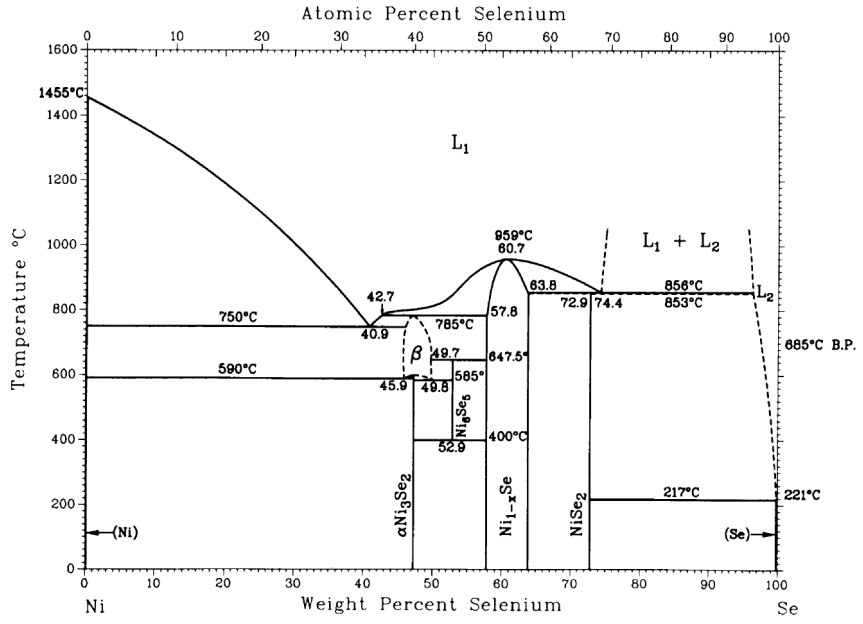


Ni-Sc crystallographic data

Phase	Composition, wt% Sc	Pearson symbol	Space group	Prototype
(Ni)	0 to 1.2	*cF*4	$Fm\bar{3}m$	Cu
Ni_5Sc	13.3	*hP*6	*P*6/*mmm*	$CaCu_5$
Ni_7Sc_2	18.0	*hP*36	*P*6/*mmm*	Ce_2Ni_7
Ni_2Sc	23 to 30	*cF*24	$Fd\bar{3}m$	Cu_2Mg
NiSc	46.8	*cP*2	$Pm\bar{3}m$	CsCl
$NiSc_2$	67.1	*cF*96	$Fd\bar{3}m$	Ti_2Ni
(βSc)	98 to 100	*cI*2	$Im\bar{3}m$	W
(αSc)	100	*hP*2	$P6_3/mmc$	Mg

H. Okamoto, *J. Phase Equilib.*, Vol 21 (No. 1), 2000, p 110

Ni-Se (Nickel-Selenium)

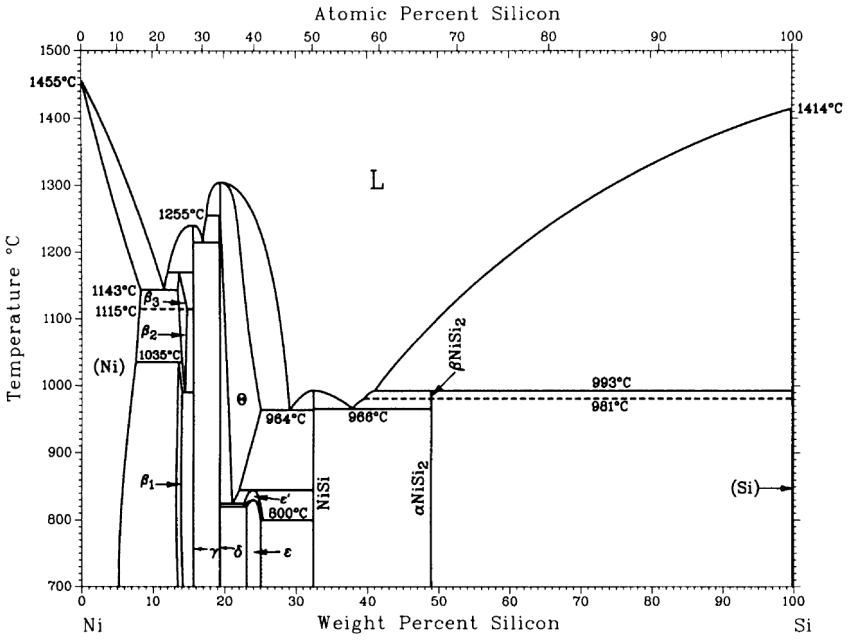


Ni-Se crystallographic data

Phase	Composition, wt% Se	Pearson symbol	Space group	Prototype
(Ni)	~0	*cF*4	$Fm\bar{3}m$	Cu
$\beta Ni_{3\pm x}Se_2$	45.9 to 49.8	*c***	...	...
αNi_3Se_2	47	*hR*5	*R*32	Bi_2STe_2
Ni_6Se_5	52.9	*oP*88	$Pca2_1$	...
		*oC*48	*Cmcm*	...
$Ni_{1-x}Se$	57.8 to 63.8	*hP*4	$P6_3/mmc$	NiAs
$NiSe_2$	72.9	*cP*12	*Pa*3	FeS_2 (pyrite)
(Se)	~100	*hP*3	$P3_121$	Se

S.Y. Lee and P. Nash, *Phase Diagrams of Binary Nickel Alloys*, P. Nash, Ed., ASM International, 1991, p 293–298

Ni-Si (Nickel-Silicon)

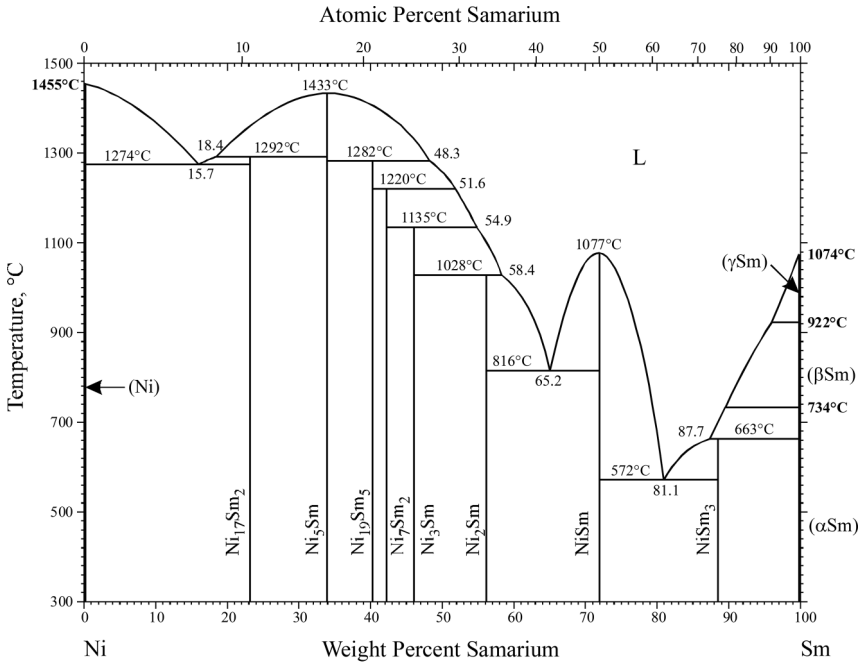


Ni-Si crystallographic data

Phase	Composition, wt% Si	Pearson symbol	Space group	Prototype
(Ni)	0 to 8.2	*cF*4	$Fm\bar{3}m$	Cu
β_1 (Ni_4Si)	12.4 to 13.4	*cP*4	$Pm\bar{3}m$	$AuCu_3$
β_3 (Ni_3Si)	~13.4 to 14.1	*mC*16	···	···
β_2 (Ni_3Si)	~13.4 to 14.1	*mC*16	···	···
γ ($Ni_{31}Si_{12}$)	15.6	*hP*14	···	···
θ (Ni_2Si)	19.4 to 25	*hP*6	···	···
δ (Ni_2Si)	19.3	*oP*12	···	Co_2Si
ε (Ni_3Si_2)	23 to 25	*oP*80	···	···
NiSi	32.4	*oP*8	*Pnma*	MnP
$\beta NiSi_2$	48.9	?	···	···
$\alpha NiSi_2$	48.9	*cF*12	$Fm\bar{3}m$	CaF_2
(Si)	~100	*cF*8	$Fd\bar{3}m$	C (diamond)

P. Nash and A. Nash, *Phase Diagrams of Binary Nickel Alloys*, P. Nash, Ed., ASM International, 1991, p 299–306

Ni-Sm (Nickel-Samarium)

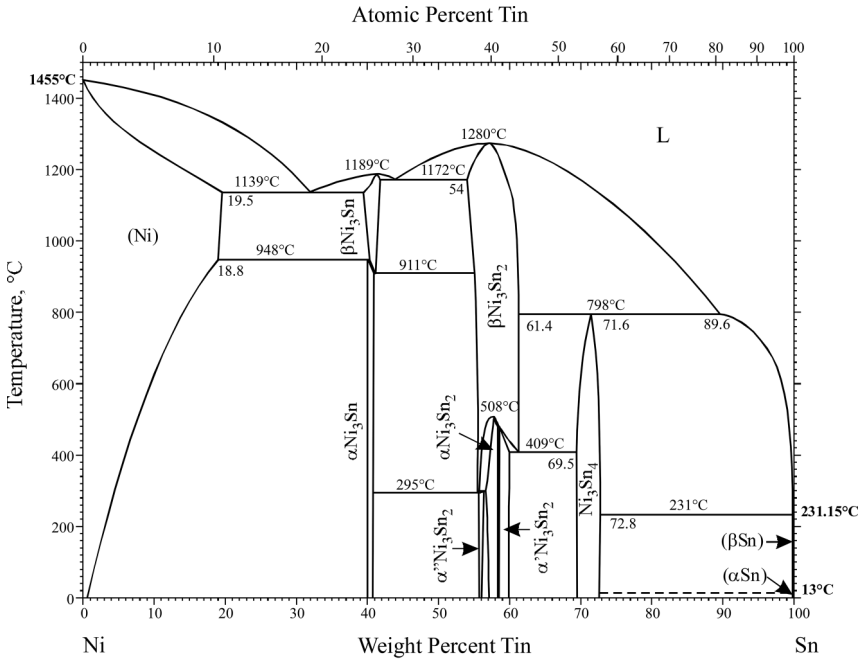


Ni-Sm crystallographic data

Phase	Composition, wt% Sm	Pearson symbol	Space group	Prototype
(Ni)	0	*cF*4	$Fm\bar{3}m$	Cu
$Ni_{17}Sm_2$	23.2	*hP*38	$P6_3/mmc$	$Ni_{17}Th_2$
Ni_5Sm	33.9	*hP*6	*P*6/*mmm*	$CaCu_5$
$Ni_{19}Sm_5$	40.3	*hR**	$R\bar{3}m$	···
Ni_7Sm_2	42.3	*hP*36	$P6_3/mmc$	Ce_2Ni_7
		*hR*54	$R\bar{3}m$	Co_7Gd_2
Ni_3Sm	46.1	*hR*24	$R\bar{3}m$	$PuNi_3$
Ni_2Sm	56.2	*cF*24	$Fd\bar{3}m$	Cu_2Mg
NiSm	71.9	*oC*8	*Cmcm*	CrB
$NiSm_3$	88.5	*oP*16	*Pnma*	Fe_3C
(γSm)	100	*cI*2	$Im\bar{3}m$	W
(βSm)	100	*hP*2	$P6_3/mmc$	Mg
(αSm)	100	*hR*3	$R\bar{3}m$	αSm

X. Su, W. Zhang, and Z. Du, *J. Alloy. Compd.*, Vol 278, 1998, p 182–184

Ni-Sn (Nickel-Tin)

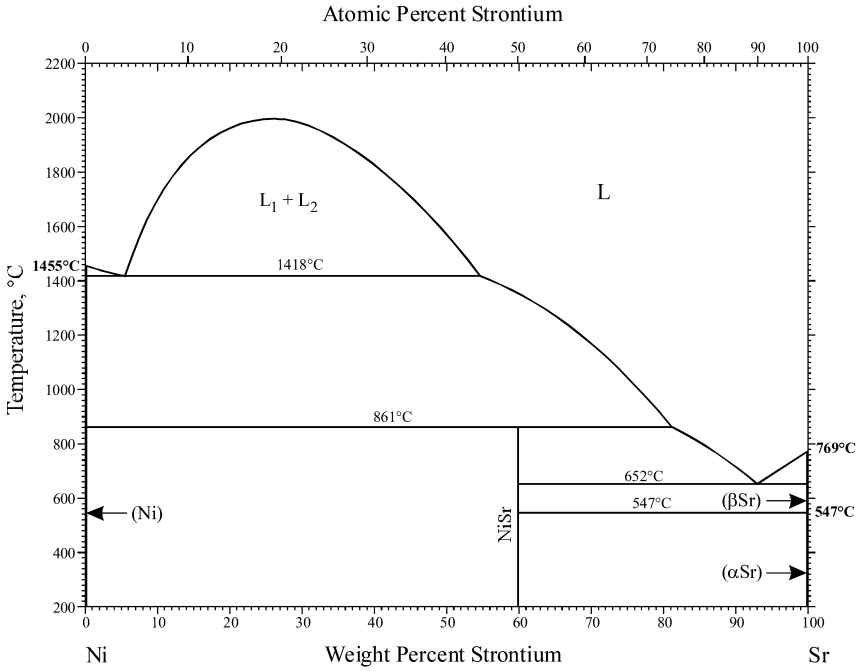


Ni-Sn crystallographic data

Phase	Composition, wt% Sn	Pearson symbol	Space group	Prototype
(Ni)	0 to 19.5	*cF*4	$Fm\bar{3}m$	Cu
βNi_3Sn	39.1 to 41.9	*cF*16	$Fm\bar{3}m$	BiF_3
αNi_3Sn	40 to 40.9	*hP*8	$P6_3/mmc$	Ni_3Sn
βNi_3Sn_2	54 to 61.4	*hP*6	$P6_3/mmc$	Ni_2In
α″Ni_3Sn_2	55.7 to 56.4	···	*Cmcm*	···
αNi_3Sn_2	56.7 to 58.5	*oP*20	*Pnma*	···
α′Ni_3Sn_2	58.6 to 60.1	···	*Cmcm*	···
Ni_3Sn_4	69.5 to 72.8	*mC*14	*C*2/*m*	···
(βSn)	100	*tI*4	$I4_1/amd$	βSn
(αSn)	100	*cF*8	$Fd\bar{3}m$	C (diamond)

C. Schmetterer, H. Flandorfer, K.W. Richter, U. Saeed, M Kauffman, P. Roussel, and H. Ipser, *Intermetallics*, Vol 15 (No. 7), 2007, p 869–884

Ni-Sr (Nickel-Strontium)

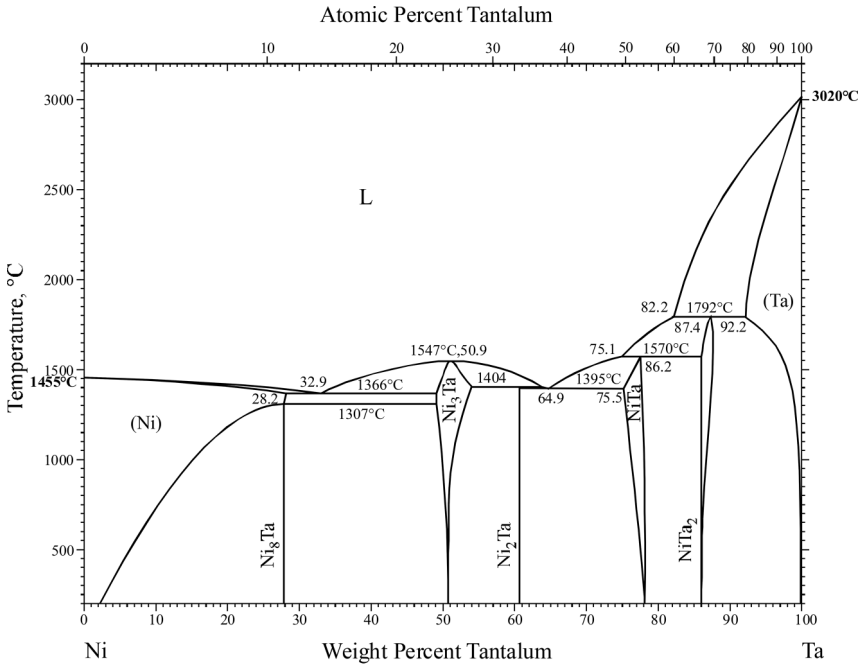


Ni-Sr crystallographic data

Phase	Composition, wt% Sr	Pearson symbol	Space group	Prototype
(Ni)	0	*cF*4	$Fm\bar{3}m$	Cu
NiSr	59.9	*hP**	···	···
(βSr)	100	*cI*2	$Im\bar{3}m$	W
(αSr)	100	*cF*4	$Fm\bar{3}m$	Cu

Y. Peng, D. Zhao, B. Hu, L. Zhou, Y. Du, T. Gang, S. Liu, and K. Chang, J. Phase Equilib. Diffus., 32(1), 42–47 (2011)

Ni-Ta (Nickel-Tantalum)

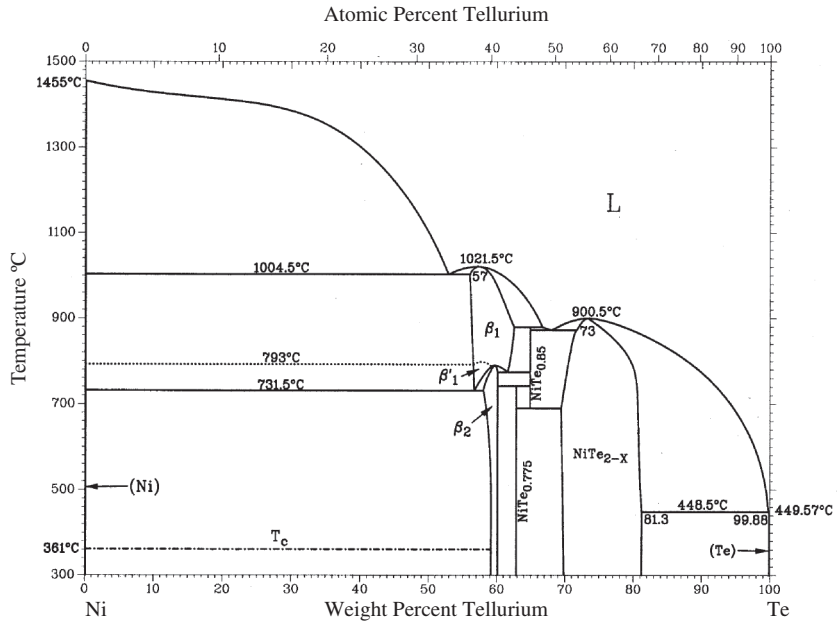


Ni-Ta crystallographic data

Phase	Composition, wt% Ta	Pearson symbol	Space group	Prototype
(Ni)	0 to 28.2	*cF*4	$Fm\bar{3}m$	Cu
Ni_8Ta	27.8	*tI**	···	$NbNi_8$
Ni_3Ta	48.9 to 53.5	*mP*48	$P2_1/m$	Pt_3Ta
Ni_2Ta	60.7	*tI*6	*I*4/*mmm*	$MoSi_2$
NiTa	75.5 to 78.1	*hR*13	$R\bar{3}m$	Fe_7W_6
$NiTa_2$	86 to 87.8	*tI*12	*I*4/*mcm*	Al_2Cu
(Ta)	92.2 to 100	*cI*2	$Im\bar{3}m$	W

Y. Cui and Z. Jin, *Z. Metallkd.*, Vol 90 (No. 3), 1999, p 233–241

Ni-Te (Nickel-Tellurium)

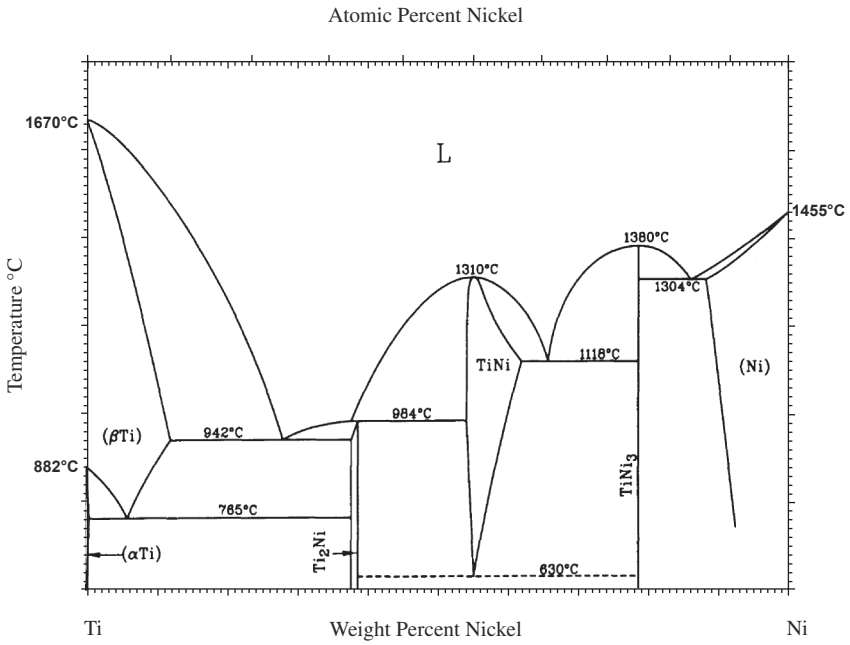


Ni-Te crystallographic data

Phase	Composition, wt% Te	Pearson symbol	Space group	Prototype
(Ni)	~0	*cF*4	$Fm\bar{3}m$	Cu
β_1	55.9 to 62.4	*cF**	···	···
β_2	58.0 to 59.7	*m***	···	···
	59.7 to 60.1	*o***	···	···
	60.0 to 60.4	*t***	···	···
β_1'	56.5 to 58	···	···	···
$NiTe_{0.775}$	62.7	*o***	···	···
$NiTe_{0.85}$	64.8	···	···	···
$NiTe_{2-x}$	69.4 to 81.3	*hP*4	$P6_3/mmc$	NiAs
		*hP*3	$P\bar{3}m1$	CdI2
(Te)	~100	*hP*3	$P3_121$	γSe

S.Y. Lee and P. Nash, *Phase Diagrams of Binary Nickel Alloys*, P. Nash, Ed., ASM International, 1991, p 330–338

Ni-Ti (Nickel-Titanium)

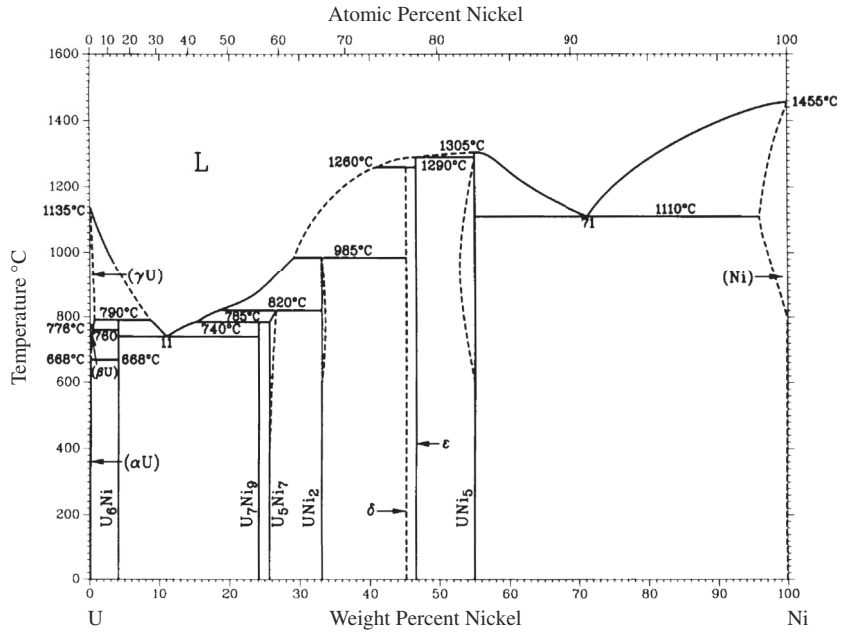


Ni-Ti crystallographic data

Phase	Composition, wt% Ni	Pearson symbol	Space group	Prototype
(βTi)	0 to 12	*cI*2	$Im\bar{3}m$	W
(αTi)	0 to 0.3	*hP*2	$P6_3/mmc$	Mg
Ti_2Ni	38.0	*cF*96	$Fd\bar{3}m$	···
TiNi	54.6 to 62	*cP*2	$Pm\bar{3}m$	CsCl
$TiNi_3$	79	*hP*16	$P6_3/mmc$	Ni_3Ti
(Ni)	88.4 to 100	*cF*4	$Fm\bar{3}m$	Cu

J.L. Murray, *Phase Diagrams of Binary Titanium Alloys*, J.L. Murray, Ed., ASM International, 1987, p 197–211

Ni-U (Nickel-Uranium)



Ni-U crystallographic data

Phase	Composition, wt% Ni	Pearson symbol	Space group	Prototype
(γU)	0 to 0.5	*cI*2	$Im\bar{3}m$	W
(βU)	0 to 0.2	*tP*30	$P4_2/mnm$	βU
(αU)	0	*oC*4	*Cmcm*	αU
U_6Ni	4.0	*tI*28	*I*4/*mcm*	MnU_6
U_7Ni_9	24.0	···	···	···
U_5Ni_7	25.6 to 26.6	···	···	···
UNi_2	33.1 to 33.4	*hP*12	$P6_3/mmc$	$MgZn_2$
δ	45.2	···	···	···
ε	46.6	···	···	···
η[(a)]	52.9	···	···	···
UNi_5	53.8 to 55.2	*cF*24	$F\bar{4}3m$	$AuBe_5$
(Ni)	93.1 to 100	*cF*4	$Fm\bar{3}m$	Cu

(a) Existence tentative

D.E. Peterson, *Phase Diagrams of Binary Nickel Alloys*, P. Nash, Ed., ASM International, 1991, p 358–361