The Co-Si (Cobalt-Silicon) System

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Equilibrium Diagram

The equilibrium phases in the Co-Si system are: (1) the liquid, L; (2) the Co-rich, fcc terminal solid solution, (αCo); (3) the Co-rich, cph terminal solid solution, (εCo); (4) the tetragonal phase αCo_3Si, stable between 1193 and 1214 °C; (5) Co_2Si, with two modifications—low-temperature, orthorhombic αCo_2Si, stable below ~1320 °C, and high-temperature βCo_2Si, with an unknown

Table 1 Special Points of the Assessed Co-Si Phase Diagram

Reaction	Composition of the respective phases, at.% Si			Temperature, °C	Reaction type
L↔CoSi		50		1460	Congruent
L↔βCo_2Si		33.3		1334	Congruent
L↔$CoSi_2$		66.7		1326	Congruent
L + βCo_2Si↔αCo_2Si	~31	~32.6	~33	~1320	Peritectic
L↔CoSi + $CoSi_2$	61.8	~52	66.7	1310	Eutectic
L↔βCo_2Si + CoSi	39.7	35.8	~49	1286	Eutectic
L↔$CoSi_2$ + (Si)	77.5	66.7	~100	1259	Eutectic
(αCo) + L↔(εCo)	16.5	21.4	17.6	1250	Peritectic
βCo_2Si↔αCo_2Si + CoSi	35.1	~34	49	1238	Eutectoid
L + αCo_2Si↔αCo_3Si	24.4	~32.6	25.0	1214	Peritectic
L↔(εCo) + αCo_3Si	23.1	18.4	25.0	1204	Eutectic
αCo_3Si↔(εCo) + αCo_2Si	25.0	18.1	~32.6	1193	Eutectoid

Table 2 Experimental Data on Co-Si Invariant Reactions

Reference	Reaction	Composition of the respective phases, at.% Si			Temperature, °C	Reaction type
[34Vog](a)	L↔(αCo) + αCo_3Si	23.1	14.6	25.0	1200	Eutectic
	L + αCo_2Si↔αCo_3Si	24.8	33.3	25.0	1210	Peritectic
	αCo_3Si↔(αCo) + αCo_2Si	25.0	13.7	33.3	1160	Eutectoid
	βCo_2Si↔L		33.3		1332	Congruent
	L↔βCo_2Si + CoSi	39.6	36.0	50.0	1270	Eutectic
	βCo_2Si↔αCo_2Si + CoSi	35.7	34.0	50.0	1208	Eutectoid
[37Has]	L↔(αCo) + αCo_3Si	23.1	14.0	25.0	1195	Eutectic
	L + αCo_2Si↔αCo_3Si	23.9	32.3	25.0	1212	Peritectic
	αCo_3Si↔(αCo) + αCo_2Si	25.0	13.3	32.3	1170	Eutectoid
	βCo_2Si↔L		33.3		1332	Congruent
	L↔βCo_2Si + CoSi	39.7	35.8	49.1	1286	Eutectic
	βCo_2Si↔αCo_2Si + CoSi	35.1	34.1	49.1	1238	Eutectoid
	CoSi↔L		50.0		1460	Congruent
	L↔CoSi + $CoSi_2$	61.8	52.1	66.7	1310	Eutectic
	$CoSi_2$↔L		66.7		1326	Congruent
	L↔$CoSi_2$ + (Si)	77.5	66.7	97.9	1259	Eutectic
[64Kal]	CoSi↔L		50.0		1465	Congruent
[68Kal1]	$CoSi_2$↔L		66.7		1322	Congruent
[72Boo]	L↔(αCo) + αCo_3Si	...	...	25.0	1200	Eutectic
	αCo_3Si↔(αCo) + αCo_2Si	25.0	...	33.3	1170	Eutectoid
	L + αCo_2Si↔αCo_3Si	...	33.3	25.0	1210	Eutectic
[73Kos](a)	(αCo) + L↔(εCo)	16.5	21.4	17.5	1250	Peritectic
	L↔(εCo) + αCo_3Si	23.1	18.4	25.0	1204	Eutectic
	αCo_3Si↔(εCo) + αCo_2Si	25.0	18.1	...	1193	Eutectoid
	L + αCo_2Si↔αCo_3Si	24.4	...	25.0	1214	Peritectic

(a) Data read from the figure.

structure, stable between 1238 °C and the congruent melting temperature of 1334 °C; (6) the cubic intermediate phase CoSi, stable up to its congruent melting at 1460 °C; (7) the cubic phase $CoSi_2$, stable up to its congruent melting at 1326 °C; and (8) the cubic solid solution, (Si), with negligible solid solubility of Co. The assessed phase diagram of the Co-Si system is shown in Fig. 1, and a detail of the high-temperature equilibria between 14 and 42 at.% Si is shown in Fig. 2. The special points of the assessed diagram and reported experimental data are listed in Tables 1 and 2, respectively.

Terminal Solid Solubilities

The (αCo)/(εCo) phase equilibria illustrated in Fig. 1 and 2 were determined by differential thermal analysis (DTA) [73Kos] and

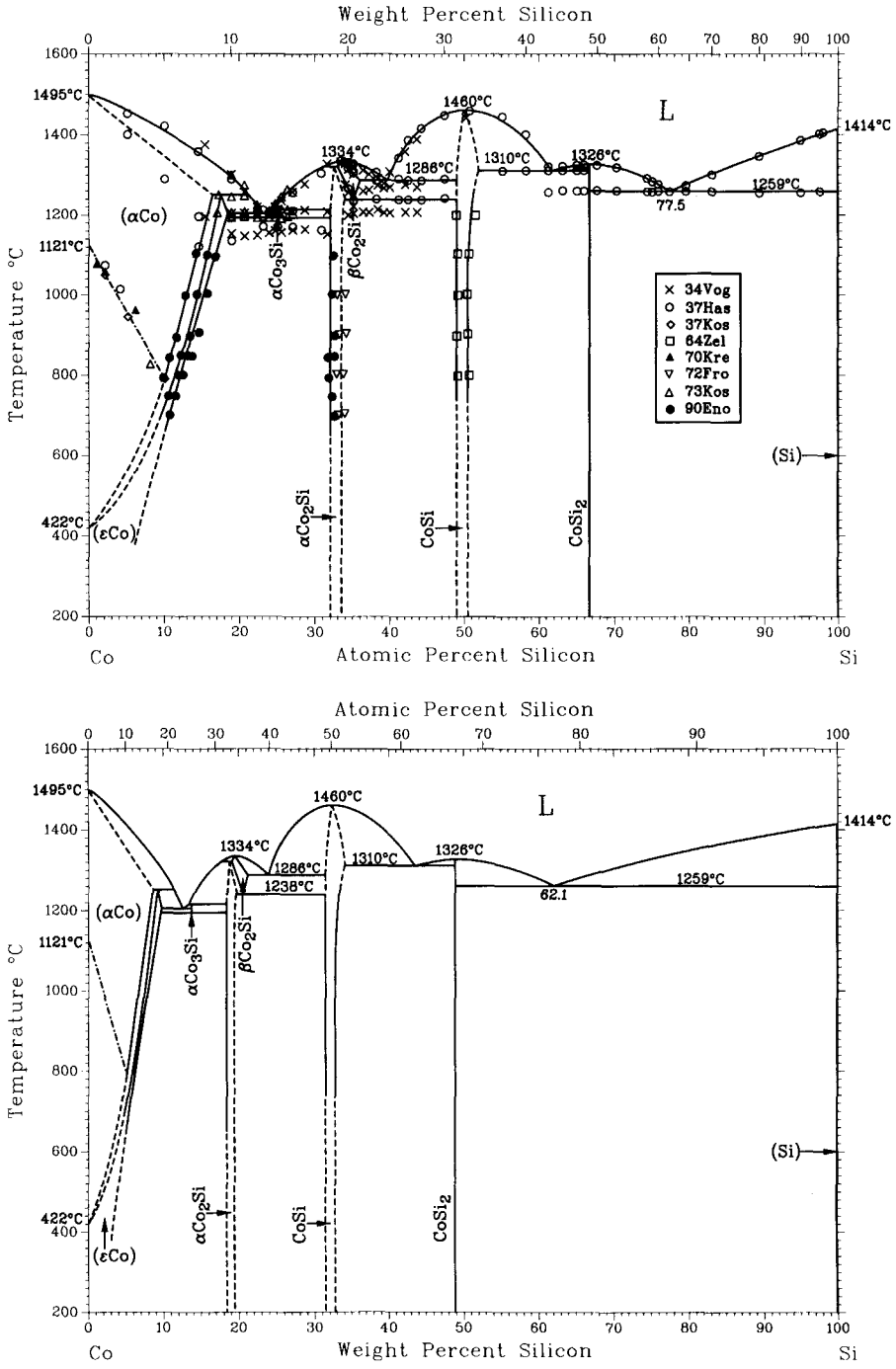

Fig. 1 Assessed Co-Si phase diagram.

electron probe microanalysis (EPMA) [90Eno], with both sets of data in good agreement at high temperatures. These studies of phase equilibria show that (εCo) is stable up to the peritectic temperature of 1250 °C, and that the maximum Si solubility in (εCo) is 18.4 at.% Si at the Co-Co_2Si eutectic temperature of 1204 °C [73Kos]. The high-temperature terminal solid solubilities shown in Fig. 1 are comparable to those reported by [63Luo], [67Pan], and [88Lik], but the exact lower-temperature solubility is less certain. Experimental data on the solid solubilities of (αCo) and (εCo) are presented in Table 3. The solid solubility of Co in (Si) is very small; data reported by [57Col] and [77Kit] are given in Table 4.

Table 3 Co-Si Solid Solubility Data

		Composition, at.% Si									
	Temperature,		(εCo)		αCo_2Si		βCo_2Si		CoSi		
Reference	°C	(αCo)	Si-poor	Si-rich	Si-poor	Si-rich	Si-poor	Si-rich	Si-poor	Si-rich	Comment
[34Vog]	1275	...	...	...	...	...	34.0	...	...	...	(a, b)
	1255	...	...	...	...	...	34.4	...	...	...	
	1221	...	...	...	...	...	35.1	...	...	...	
[64Zel]	1200	...	...	...	...	...	...	...	48.5	50.9	(c)
	800 to 1100	...	...	...	...	...	...	...	49.0	50.6	
[72Fro]	700 to 1000	...	...	...	33.0	33.6	...	...	...	...	(d)
[73Kos]	1221	...	17.2	...	...	...	...	...	...	...	(a, b)
[90Eno]	1100	14.4	15.2	...	...	...	...	...	...	...	(e)
		...	...	16.9	32.3	...	...	...	...	...	(f)
	1000	12.7	13.8	...	...	...	...	...	...	...	(e)
		...	...	15.6	32.3	...	...	...	...	...	(f)
	900	11.6	13.3	14.4	32.2	...	...	...	...	...	(e)
		...	...	14.5	32.6	...	...	...	...	...	(f)
	850	10.6	12.1	12.9	31.7	...	...	...	...	...	(e)
		...	...	13.6	32.7	...	...	...	...	...	(f)
	800	10.0	11.4	12.1	31.8	...	...	...	...	...	(e)
	750	...	10.2	11.2	32.1	...	...	...	...	...	(e)
	700	...	...	10.5	32.6	...	...	...	...	...	(e)

(a) Data read from the figure. (b) Thermal analysis. (c) X-ray data. (d) Metallography. (e) EPMA (diffusion couple). (f) EPMA (two-phase specimen).

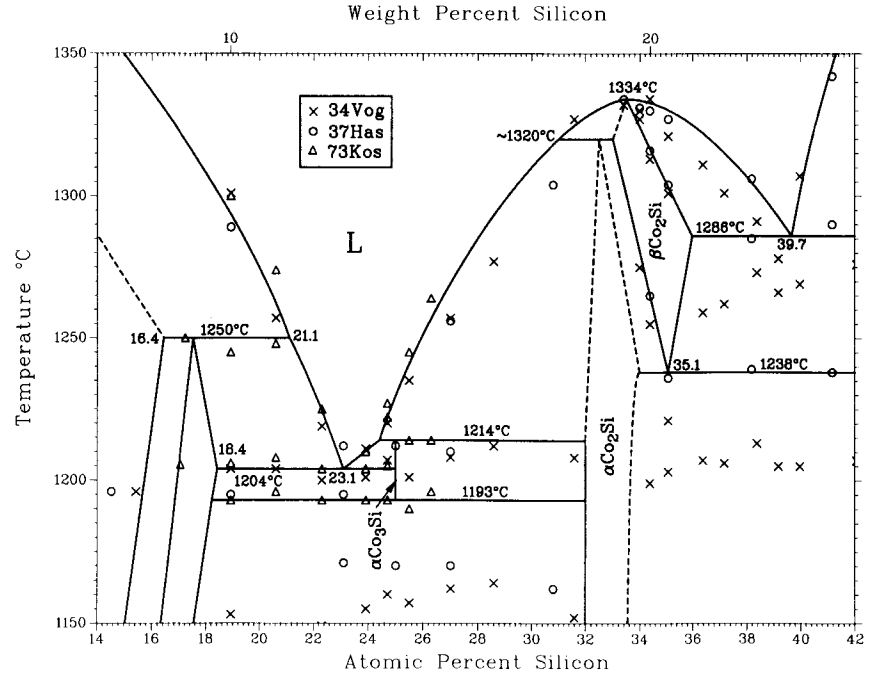

Fig. 2 Assessed Co-Si phase diagram from 14 to 42 at.% Si.

Liquidus and Solidus

Co-Si liquidus and solidus temperatures were measured by DTA in the composition ranges 15 to 50 at.% Si [34Vog], 0 to 100 at.% Si [37Has], and 17 to 26 at.% Si [73Kos]. These data are shown in Table 5.

Table 4 Solid Solubility of Co in (Si)

Reference	Temperature, °C	Solubility (N_{Co}), cm^{-3}
[57Col]	1200	10^{16}
[77Kit]	1270	1.3×10^{16}
	1250	1.1×10^{16}
	1200	6.3×10^{15}
	1200	4.7×10^{15}
	1150	3.0×10^{15}
	1100	9.9×10^{14}
	1100	1.0×10^{15}
	1000	1.3×10^{14}

Note: As measured by radiotracer method.

Intermediate Phases

αCo_3Si. The stable αCo_3Si illustrated in Fig. 1 is the subject of considerable controversy, and was not yet conclusively identified in quenched samples. The evidence for its existence relies almost solely on thermal analysis results and microstructural observation of its presumed eutectoid decomposition [34Vog, 37Has, 72Boo, 73Joh, 73Kos], which [37Kos], [63Kuz], and [67Pan] could not detect. According to the metallographic and DTA studies of [72Boo], αCo_3Si is stable between 1170 and 1210 °C, and [73Kos] ascertained the existence of αCo_3Si by DTA between 1193 and 1214 °C. One possible cause for the disagreement may lie in the purities of the material used in the particular investigation; [76Liv] showed that adding small quantities of Al, Ta, or W to a stoichiometric αCo_3Si alloy suppressed the formation of a eutectoid structure. [73Joh] examined the crystal structure of αCo_3Si quenched to room temperature by X-ray diffraction

Table 5 Co-Si Liquidus and Solidus Data from Thermal Analysis

Composition, at.% Si	Liquidus	Solidus	Invariant		
From [34Vog](a)					
15.4	1375	...	1196	...	...
18.9	1301	...	1204	1153	...
20.6	1257	...	1204	1147	...
22.3	1219	...	1200	1149	...
23.9	1211	...	1201	1155	...
24.7	1220	...	1207	1160	...
25.5	1235	...	1201	1157	...
27.0	1257	...	1208	1162	...
28.6	1277	...	1212	1164	...
31.6	1327	...	1208	1152	...
33.4	1332	...	...	...	...
34.0	1330	1327	1275	...	...
34.4	1334	1313	1255	1199	...
35.1	1321	1301	1221	1203	...
36.4	1311	...	1259	1207	...
37.2	1301	...	1262	1206	...
38.4	1291	...	1273	1213	...
39.2	1278	...	1266	1205	...
40.0	1307	...	1269	1205	...
42.1	1358	...	1276	1207	...
43.7	1388	...	1269	1207	...
50.3	1441	...	...	...	...
From [37Has]					
5.1	1452	1400	...	...	...
10.0	1421	1289	...	...	...
14.5	1358	...	1196	1121	...
18.9	1289	...	1195	1135	...
23.1	...	...	1195	1212	1171
25.0	...	...	1212	1170	...
27.0	1256	...	1210	1170	...
30.8	1304	...	1162	...	...
33.4	1334	...	...	...	...
34.0	1331	...	...	...	...
34.4	1330	1316	1265	...	...
35.1	1327	1304	1236	...	...
From [37Has](cont.)					
38.2	1307	...	1285	1239	...
41.2	1342	...	1290	1238	...
42.5	1386	...	1286	1238	...
44.3	1415	...	1285	1237	...
47.4	1447	...	1289	1241	...
50.8	1458	...	...	...	...
55.2	1444	...	1309	...	...
58.3	1400	...	1310	...	...
61.3	1320	...	1310	1256	...
63.2	1321	...	1310	1260	...
65.1	1323	...	1310	1259	...
66.0	1324	...	1310	1259	...
67.7	1323	...	1260	...	...
70.3	1318	...	1260	...	...
74.4	1291	...	1258	...	...
75.1	1283	...	1257	...	...
75.9	1276	...	1259	...	...
77.4	...	...	1258	...	...
79.6	1273	...	1259	...	...
83.1	1300	...	1258	...	...
89.4	1346	...	1255	...	...
95.0	1385	...	1255	...	...
97.6	1401	...	1258	...	...
98.1	1405	...	...	...	...
From [73Kos](a)					
17.2	...	...	1250	...	...
18.9	1300	...	1245	1206	1193
20.6	1274	...	1248	1208	1196
22.3	1225	...	1204	1193	...
23.9	1210	...	1204	1193	...
24.7	1227	...	1222	1205	1193
25.5	1245	...	1214	1190	...
26.3	1264	...	1214	1196	...

(a) Data read from the figure.

(XRD), and tentatively assigned an unspecified tetragonal structure.

Co_2Si. [34Vog] and [37Has] studied the transformation behavior of Co_2Si by thermal analysis; both data sets on the stability range of high-temperature βCo_2Si are in good agreement. However, neither investigation was able to produce retained βCo_2Si, and the calorimetric experiments of [72Fro] could not reproduce the transformation. More explicit confirmation of this phase is desirable. Low-temperature αCo_2Si melts peritectically at 1320 °C ($L + \beta Co_2Si \leftrightarrow \alpha Co_2Si$) and also participates in eutectoid reactions at 1193 and 1238 °C and the peritectoid reaction at 1214 °C. The homogeneity range of αCo_2Si was reported to be 33.0 to 33.6 at.% Si between 700 and 1000 °C from metallographic observations [72Fro].

CoSi. Cubic CoSi is stable below its congruent melting temperature of 1460 °C. The homogeneity range determined by X-ray measurements is from 49.0 to 50.6 at.% Si in the temperature range 800 to 1000 °C and from 48.5 to 50.9 at.% Si at 1200 °C [64Zel].

$CoSi_2$. Cubic $CoSi_2$, with an almost stoichiometric composition, is stable below its congruent melting temperature of 1326 °C.

Table 6 Co-Si Transformation Temperatures

Reference	Composition, at.% Si	Temperature, °C Heating	Cooling	Method
[37Has]	2.1	537	469	Dilatometric
		536	468	Magnetic
	4.1	597	524	Dilatometric
		596	525	Magnetic
	8.1	687	594	Dilatometric
		688	595	Magnetic
	11.4	738	635	Dilatometric
[37Kos](a)	2.1	482	384	Magnetic
	5.1	658	458	Dilatometric
		654	468	Magnetic
	10.0	795	550	Dilatometric
		795	555	Magnetic
	14.5	1025	982	Magnetic
[70Kra]	1.77	526	459	Dilatometric
	8.15	454	402	Dilatometric
	9.86	449	400	Dilatometric
[73Kos](a)	2.1	533	463	Dilatometric
		526	470	Thermal
	4.1	602	513	Thermal
	6.1	684	558	Dilatometric
		672	565	Thermal
	8.1	728	580	Dilatometric
		739	590	Thermal
	10.0	782	596	Dilatometric
		778	596	Thermal

(a) Data read from the figure.

Metastable Phases

[63Luo] reported that an (αCo) solid solution up to 15 at.% Si was obtained by rapid quenching from the melt, which is within the solubility limit of equilibrium (αCo). It was recognized that the formation and transformation behaviors of αCo_3Si and αCo_2Si are complex and are quite different on heating from those on cooling [72Boo, 73Joh, 73Kos, and 74Boo]. This is mainly due to suppression of the formation of αCo_3Si on cooling. The metastable eutectic reaction $L \leftrightarrow (\alpha Co) + \alpha Co_2Si$ at ~1192 °C was found by [72Boo] and was supported by [74Boo] and [75Liv], whereas [73Kos] did not detect this reaction. According to [73Joh], αCo_3Si transforms ultimately to a eutectoid structure of αCo_2Si and the Co-rich solid solution, but the reaction only was observed to proceed *via* a transition phase with an orthorhombic structure not distinguished from that of αCo_2Si. This phase appears to form by a massive transformation. [73Kos] found a metastable ordered phase of βCo_3Si with $D0_{19}$ structure, with a composition of ~8 at.% Si at temperatures below about 570 °C.

The tetragonal phase Co_2Si_3, formed at pressures >4 GPa and temperatures of 500 to 750 °C, is metastable under ordinary conditions. After annealing at 700 °C, it decomposes into $\alpha CoSi_2$ and CoSi [82Lar].

Table 7 Co-Si Crystal Structure Data

Phase	Composition, at.% Si	Pearson symbol	Space group	Strukturbericht designation	Prototype	Comment	Reference
(αCo)	0 to 16.4	*cF4*	$Fm\bar{3}m$	*A1*	Cu	422<*T*<1495 °C	[83Nis]
(εCo)	0 to 18.4	*hP2*	$P6_3/mmc$	*A3*	Mg	*T*<1245 °C	[83Nis]
αCo_3Si	25	*t***	...	...	...	1193<*T*<1214 °C	[73Joh]
αCo_2Si	~32 to ~34	*oP12*	*Pnma*	*C23*	Co_2Si	*T*<~1320 °C	[Pearson1]
βCo_2Si	~32 to 35.8	?	?	?	?	1238<*T*<1334 °C	...
CoSi	49 to ~52	*cP8*	$P2_13$	*B20*	FeSi	*T*<1460 °C	[Pearson1]
$CoSi_2$	66.7	*cF12*	$Fm\bar{3}m$	*C1*	CaF_2	*T*<1326 °C	[Pearson1]
(Si)	~100	*cF8*	$Fd\bar{3}m$	*A4*	C(diamond)	*T*<1414 °C	[King1]
Metastable phases							
βCo_3Si	~8 to 25	*hP8*	$P6_3/mmc$	$D0_{19}$	Ni_3Sn	*T*<570 °C	[73Kos]
Co_4Si	~20	?	?	?	?	Thin film	[86Apr]
γCo_2Si	~25	*o***	...	...	...	(a)	[73Joh]
Co_2Si_3	60	*tP20*	*P4c2m*	...	Ru_2Sn_3	*P*>4.0 GPa 500 < *T*<700 °C	[82Lar]

(a) Formed by massive transformation.

Table 8 Co-Si Lattice Parameter Data

Phase	Composition, at.% Si	Lattice parameters, nm a	b	c	Comment	Reference
(αCo)	0	0.35446	...	...	Pure αCo	[83Nis]
	4	0.35420	...	...	(a, b)	[63Luo]
	8	0.35395	...	...	(a, b)	[63Luo]
	11.5	3.35365	...	...	(a, b)	[63Luo]
	13	0.35355	...	...	(a, b)	[63Luo]
	15	0.35350	...	...	(a, b)	[63Luo]
(εCo)	0	0.25071	...	0.40695	Pure εCo	[83Nis]
	5.1	0.24925	...	0.4050	...	[37Has]
	10.0	0.2486	...	0.4015	...	[37Has]
	14.5	0.2474	...	0.3970	(εCo) + αCo_2Si	[37Has]
	18.9	0.2475	...	0.3970	(εCo) + αCo_2Si	[37Has]
	4	0.2500 to 0.2503	...	0.4050 to 0.4084	800 to 1200 °C	[88Lik]
αCo_3Si	25	0.842	0.3738	0.581	...	[73Joh]
αCo_2Si	33	0.4918	0.3730	0.7109	...	[Pearson1]
		0.4908	0.3725	0.7095	...	[Pearson2]
		0.4919	...	0.7104	...	[72Fro]
CoSi	50	0.4447	...	...	...	[Pearson1]
	49.1	0.44477	...	...	...	[64Zel]
	49.4	0.44467	...	...	...	[64Zel]
	49.6	0.44464	...	...	...	[64Zel]
	49.8	0.44446	...	...	...	[64Zel]
	49.9	0.44445	...	...	...	[64Zel]
	50.1	0.44444	...	...	...	[64Zel]
	50.4	0.44426	...	...	...	[64Zel]
	50	0.4448	...	...	...	[71Wal]
$CoSi_2$	66.7	0.5365	...	...	...	[Pearson1]
		0.53526	...	...	...	[87Wei]
Si	100	0.54306	...	...	...	[King1]
Metastable phases						
βCo_3Si	25	0.4976	...	0.4069	...	[73Kos]
Co_2Si_3	60	0.5234	...	0.8543	...	[82Lar]

(a) Data read from the figure. (b) Splat quenched from the melt.

Table 9 Enthalpy Coefficients and Heats of Fusion for Cobalt Silicides

Phase	Coefficients, J/mol a	b	$c \times 10^3$	$d \times 10^{-5}$	Heat of fusion
αCo_2Si(s)	−24906	70.785	4.532	2.443	54 300
Co_2Si(L)	−30708	136.74			
CoSi(s)	−15400	47.1	5.95	5.67	69 200
CoSi(L)	2920	87.4			
$CoSi_2$(s)	−25200	71.64	7.569	9.501	100 200

Table 10 Fitted Thermodynamic Parameters for Co-Si Liquid Alloys

Regular solution

$\Delta G^{ex} = -112\,073 X_{Co}X_{Si}$ ($R^2 = 0.958$)

Subregular Solution

$\Delta G^{ex} = X_{Co}X_{Si}(-92\,481X_{Co} - 133\,151X_{Si})$ ($R^2 = 0.971$)

Subsubregular solution

$\Delta G^{ex} = X_{Co}X_{Si}(-34\,179X_{Co} - 99\,958X_{Si} - 193\,065X_{Co}X_{Si})$ ($R^2 = 0.990$)

Quasiregular solution

$\Delta G^{ex} = -275\,995X_{Co}X_{Si}(1 - T/3075)$ ($R^2 = 0.971$)

Laser irradiation of thin Co films on single-crystalline Si was studied by [79Gur]. In the 0.1-μm Co film, Co_2Si, CoSi, and $CoSi_2$ were formed. $CoSi_2$ films on (111) Si substrates were obtained by solid phase epitaxy [80Sai] and by evaporation of Co onto Si [82Sor]. $CoSi_2$, CoSi, Co_2Si, and Co_4Si were obtained by solid-state reaction at 800 °C within thin bilayers of amorphous Si and Co evaporated onto SiO_2 substrates. The crystal structure of Co_4Si could not be determined [86Apr].

As with many other silicides, the fabrication of amorphous Co-Si alloys is of interest; [88Kim] showed that a minimum of 13.5 at.% Si was necessary to produce amorphous Co-Si films by sputtering. An estimate of the glass transition temperature for $Co_{1-x}Si_x$ ($x = 0.33, 0.397, 0.618, 0.775$) was reported by [79Nie].

The martensitic transformation of (αCo) ↔ (εCo) was studied by [37Has], [37Kos], [70Kra], and [73Kos]; the transformation temperatures are given in Table 6.

Table 11 Experimental and Estimated Heats of Formation of Cobalt Silicides

Reference	Heat of formation, kJ/mol αCo_2Si	CoSi	$CoSi_2$
[37Oel]	-115.4	-92.0	-102.9
[73Cha]	-113.1	-95.0	-98.7
[79Kau]	-176.7	-144.9	-201.1
[81Mac]	...	-92.0	...
[84Pas]	-99.2	-89.5	-104.2
[88Nie]	-90	-62	-45

Table 12 Co-Si Curie Temperatures

Reference	Composition, at.% Si	Curie Temperature, °C (αCo)	(εCo)
[37Has]	2.1	1074	...
	4.1	1014	...
	8.1	882	...
	11.5	754	...
[37Kos](a)	2.1	1050	...
	5.1	945	...
	10.0	790	...
	14.5	625	735
[70Kre](a)	1.0	1078	...
	2.1	1058	...
	6.1	962	...
[73Kos](a)	8.1	827	...

(a) Data read from the figure.

Crystal Structures and Lattice Parameters

The crystal structures of most of the phases in the Co-Si system are well-established; exceptions include αCo_3Si and βCo_2Si, neither of which was unambiguously identified as a stable phase. Crystal structure and lattice parameter data for the stable and metastable phases of the Co-Si system are summarized in Tables 7 and 8, respectively.

Thermodynamics

Several thermodynamic investigations of both liquid and solid alloys in the Co-Si system were reported, the first of these being the enthalpy of formation determinations made by [37Oel]. High-temperature heat capacity measurements were made for αCo_2Si [72Fro], CoSi [68Kal1], and $CoSi_2$ [64Kal]. The parameters for the standard H_T–H_{298} equation ($a + bT + cT^2 + dT^{-1}$) are given in Table 9, along with the measured heats of fusion. For αCo_2Si, the allotropic transformation had no apparent impact on the thermodynamic results. Subambient heat capacity measurements were made for CoSi [64Kal] and $CoSi_2$ [68Kal2].

Three experimental investigations of Gibbs energies of formation in molten Co-Si alloys were made. [68Mar] obtained activity coefficients of Si by equilibrating various Co-Si alloys with Ag-Si melts; their results are in substantial agreement with those of [64Sch], performed by determining the equilibria between these alloys and a calcium silicate melt. As might be expected, a strong negative deviation from ideal behavior was demonstrated, showing some asymmetry with respect to composition; this was also shown by the two activity measurements of [64Bow], obtained by equilibrating liquid alloys with an SiO_2-H_2-H_2O environment. [80Kha1] and [80Kha2] analyzed the cause of the large negative value of the entropy of mixing in the liquid state determined by [64Sch] and concluded that it is due to an electronic contribution. Regression analysis was performed against the combined results of [64Sch] and [68Mar] to determine the coefficients of some common thermodynamic model equations; these are listed in Table 10. Heats of formation of molten alloys in this system were measured by [60Gel] as well as [37Oel]; the terminal heat of solution of Co in liquid Si was more negative in the former results. The enthalpy of mixing in the liquid state was calculated by [71Pet], [83Pas], [84Pas], and [85Fro]. The work of [37Oel] also yielded ΔH^0_{298} values for the solid silicides, which are compared in Table 11 to the modeling results of [73Cha], [79Kau], [84Pas], and [88Nie].

The specific heat of CoSi was measured in the temperature range 0.5 to 9 K, and the electronic specific heat coefficient was determined to be 1.1 mJ/mol · K^2 [74Mar].

The order-disorder transition temperatures for $A2 \leftrightarrow B2$ and $B2 \leftrightarrow D0_3$ reactions in the bcc phase were evaluated by analyzing the experimental data on Fe-Co-Si alloys [79Ind]. [79Kau] presented an analytical description of thermodynamic properties of the liquid, (αCo), (εCo), (Si), and the compound phases, and from these, he computed a phase diagram.

Thermal diffusivity and conductivity of Co alloys with 0 to 6 at.% Si were measured, and deep troughs at the Curie temperature were observed by [70Kre].

Magnetism

The Curie temperature of (αCo) phase was determined by [37Has], [37Kos], [70Kre], and [73Kos]; values are listed in Table 12.

Several studies of magnetic susceptibility of cobalt silicide alloys and compounds were made, including [55Ben1], [55Ben2], [66Shi], [72Ama], and [75Dov]; the results showed that CoSi is diamagnetic, and $CoSi_2$ paramagnetic. Debye temperatures were derived by a variety of experimental techniques [64Kal, 65And, 72Ama, 74Mar, 84Hen, 86Apr, 87Nav]. For $CoSi_2$, a single value of 220 K is reported [86Apr], whereas for CoSi, reported values range between 487 and 600 K, and for $CoSi_2$ between 450 and 500 K. Saturation magnetization and intrinsic coercivity measurements were made for high-Co eutectic/eutectoid compositions by [73Joh] and [75Liv], and studies of the thermoelectric properties of CoSi were made by [64Asa] and [81Zai].

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*Indicates key paper.

#Indicates presence of a phase diagram.

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