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Interaction of Components in the Ni–Zn–Si System at 570 K

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The interaction of nickel with zinc and silicon over the whole range of concentrations has not yet been studied. The Ni–Zn–Si system was investigated early at 1070 K [1]. Three ternary compounds: Ni_2ZnSi, Ni_2Zn_3Si and Ni_3ZnSi_2 exist at this temperature. Phase diagrams of the binary systems Ni–Zn and Ni–Si have been accepted as given in [2]. Crystallographic characteristics for the binary compounds of the Ni–Zn and Ni–Si systems according to [3] are listed in Table 1.

Results of investigation of the isothermal section of Ni–Zn–Si system at 570 K are presented in this paper. Isothermal section of the phase diagram of Ni–Zn–Si system has been constructed by X-ray phase analysis of 56 alloys. Purity of the elements were: nickel 99.99 wt.%, zinc 99.9 wt.% and silicon 99.999 wt.%. The samples were arc melted in an argon atmosphere and then annealed at 570 K for 400 h. X-ray powder diffraction were obtained using a DRON-2.0 powder diffractometer with FeK_α-radiation and powder diffractometer DRON-3M (CuK_α-radiation, 0.05° step of scanning, 20–30 sec./one point speed of scanning). Indexing of the diffractograms was made by using the program TREOR-90. The cell constants were refined using the program LATCON. The crystal structure was refined from powder patterns with the program DBW-3.2S [4]. A differential scanning calorimeter (DSC) "Netzsch STA 409" was used for the determination of the melting temperatures of the synthesized phases and for detecting possible phase transition.

Table 1. Crystallographic parameters for the binary compounds of the Ni–Zn and Ni–Si systems [3].

Compound	Str. type	Space group	a, nm	b, nm	c, nm
NiZn	In	I4/mmm	0.27468		0.31783
NiZn	CsCl	$Pm\bar{3}m$	0.29143		
NiZn(β_1)	AuCu	P4/mmm	0.3885		0.2965
$NiZn_3$	$NiZn_3$	Abm2	3.3326	1.2499	0.8869
Ni_2Zn_{11}	Cu_5Zn_8	$I\bar{4}3m$	0.89228		
Ni_3Zn_{22}	Ni_3Zn_{22}	C2/m	1.337	0.747 $\beta = 113.3°$	0.765

Table 1 (continuation)

NiSi	MnP	Pnma	0.518	0.334	0.562
NiSi	FeSi	$P2_13$	0.4446		
$NiSi_2$	CaF_2	$Fm\bar{3}m$	0.5406		
Ni_2Si	Ni_2Si	$P6_3/m$	0.3805		0.4890
Ni_2Si	Co_2Si	Pnma	0.500	0.373	0.704
Ni_3Si	$AuCu_3$	$Pm\bar{3}m$	0.3504		
Ni_3Si	CsCl	$Pm\bar{3}m$	0.2808		
Ni_3Si	Cu	$Fm\bar{3}m$	0.35826		
Ni_3Si_2	Ni_3Si_2	$Cmc2_1$	1.2229	1.0805	0.6924
$Ni_{31}Si_{12}$	$Ni_{31}Si_{12}$	P321	0.6671		1.2288

The phase diagram of the Ni–Zn–Si ternary system at 570 K is shown in Figure 1. The existence of Ni_2ZnSi, Ni_2Zn_3Si and Ni_3ZnSi_2 compounds was confirmed at 570 K. A new ternary compound $Ni_3Zn_{0.33}Si_{0.67}$ was found at this temperature. Crystallographic characteristics of the ternary compounds are listed in Table 2. Compound $Ni_3Zn_{0.33}Si_{0.67}$ crystallizes in structure type Al_3Ti. Atoms Zn and Si are statistically arranged in positions 2b. The atomic parameters for the $Ni_3Zn_{0.33}Si_{0.67}$ were refined to R = 0.024 and the corresponding values are listed in Table 3. It was found that the binary NiSi and Ni_3Si phases exhibit small solid solution ranges (< 10% Zn) in the Ni–Zn–Si system. Thermal analysis of the $Ni_{0.8}Zn_{0.2}Si$ alloy was carried out (Fig. 2). Deviations between values of melting temperature of NiSi [2] compound and the alloy from solid solution of Zn in the NiSi was observed (Table 4). The peak corresponded to the eutectic transformation $L \Leftrightarrow NiSi + \alpha NiSi_2$, being a result of shifting composition from NiSi to the field between NiSi and $NiSi_2$ (Table 4). No polymorphic transformations are observed for NiSi compound, contrary to [3], where the existence of two modifications of this compound was indicated. The existence of the NiSi com-

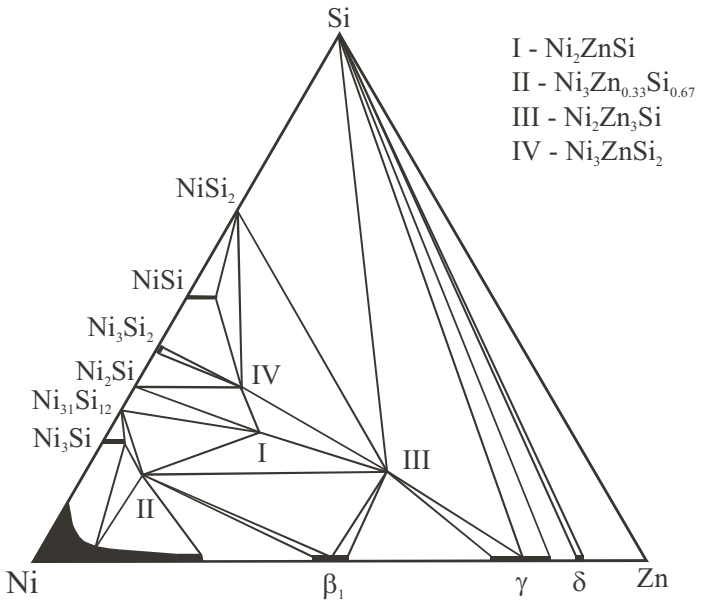

Figure 1. Isothermal section of the Ni–Zn–Si system at 570 K.

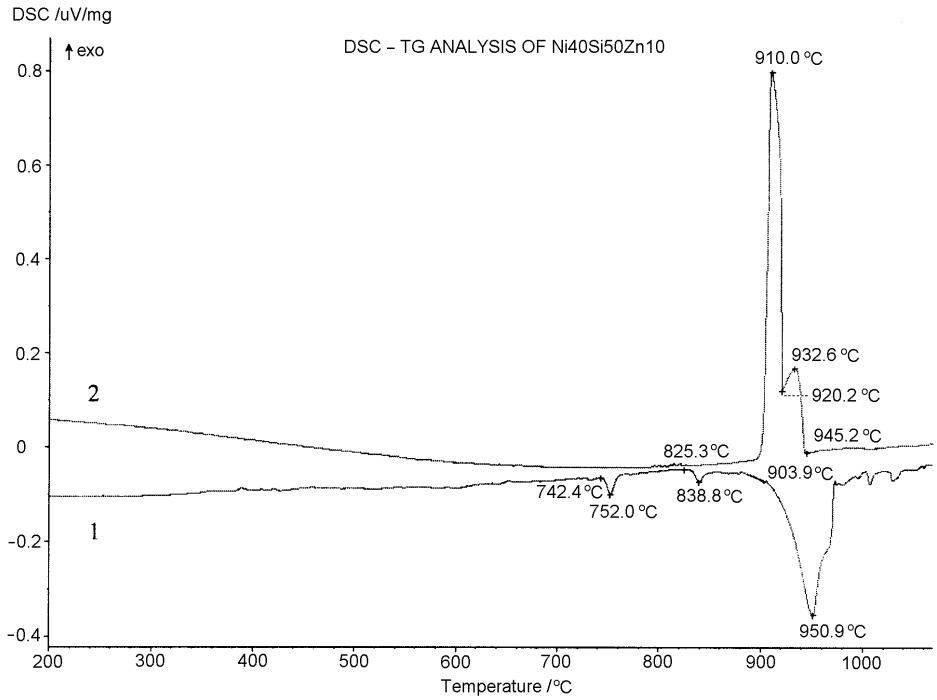

Figure 2. Heating and cooling curves for the $Ni_{0.8}Zn_{0.2}Si$ alloy (1 – heating curve, 2 – cooling curve).

pound with FeSi structure type was not confirmed by us. Solubility of Zn in the NiSi binary compound is the reason for temperature decreases of eutectic and congruent transformations.

Table 2. Crystallographic characteristics of the ternary compounds of the Ni–Zn–Si system.

Compounds	Structure type	Space group	a, nm	c, nm	References
Ni_2ZnSi	BiF_3	$Fm\bar{3}m$	0.569		3
Ni_2Zn_3Si	Ti_2Ni	$Fd\bar{3}m$	1.0718		3
Ni_3ZnSi_2	FeSi	$P2_13$	0.4535		3
$Ni_3Zn_{0.33}Si_{0.67}$	Al_3Ti	I4/mmm	0.35072(6)	0.7065(3)	authors data

Table 3. The atomic parameters of $Ni_3Zn_{0.33}Si_{0.67}$.

Atom	x/a	y/b	z/c	B_i
(Zn+Si)	0	0	1/2	1.8
Ni1	0	0	0	1.2
Ni2	0	1/2	1/4	1.9

Table 4. Temperatures of some special points.

Reaction	Reaction type	Temperature, °C	
		NiSi ([2])	$Ni_{0.8}Zn_{0.2}Si$ (exp)
L ⇔ NiSi	Congruent	992	932.6
L ⇔ NiSi+α$NiSi_2$	Eutectic	966	910.0

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