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Al-Ni-Sm (Aluminum-Nickel-Samarium)

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Recently, [2008Del] determined an isothermal section for this system at 500 °C in the 40-100 at.% Al region, which depicts six ternary compounds.

Binary Systems

The Al-Ni phase diagram [1993Oka] shows five intermediate phases: $NiAl_3$ ($D0_{11}$, Fe_3C-type orthorhombic), Ni_2Al_3 ($D5_{13}$-type hexagonal, denoted δ), NiAl ($B2$, CsCl-type cubic, denoted β), Ni_5Al_3 (Ga_3Pt_5-type orthorhombic), and Ni_3Al ($L1_2$, $AuCu_3$-type cubic, denoted γ′). The Al-Sm phase diagram [Massalski2, 2007Del] depicts the following intermediate phases: Sm_3Al_{11} ($D1_3$, Al-deficient Al_4Ba-type tetragonal), $SmAl_3$ ($D0_{19}$, Ni_3Sn-type hexagonal), $SmAl_2$ ($C15$, $MgCu_2$-type cubic), SmAl (ErAl-type orthorhombic), and Sm_2Al ($C23$, Co_2Si-type orthorhombic). The Ni-Sm phase diagram [Massalski2] depicts a number of intermediate phases, none of which are relevant to the equilibria in Al-rich alloys discussed here.

Ternary Compounds

In addition to the four previously-known ternary compounds, $Sm_4Ni_6Al_{23}$ (τ_1), $SmNiAl_4$ (τ_2), $SmNiAl_2$ (τ_5), and SmNiAl (τ_6), [2008Del] found two new ternary compounds, $SmNiAl_3$ (τ_3) and $SmNi_2Al_3$ (τ_4). The structural details of these compounds are listed in Table 1. The notations τ_1, τ_2, etc. given above in brackets correspond to the numbers 1, 2, etc. used by [2008Del]. Along the line of constant Sm equal to 16.7 at.%, an additional phase $SmNi_4Al$ ($CaCu_5$-type) was reported by [1978Tak], see Table 1. This phase, however, was not found by [2008Del] at 500 °C. [2008Del] pointed out that, in $RNi_{5-x}Al_x$ (R = rare earth), $CaCu_5$-type of structure forms for $x < 2$ and the $HoNi_{2.6}Ga_{2.4}$-type of structure is found for $x \geq 2$.

Isothermal Section

With starting metals of 99.999% Al, 99.99% Ni, and 99.9% Sm, [2008Del] induction-melted 47 alloy samples in

Table 1 Al-Ni-Sm crystal structure and lattice parameter data [2008Del]

Phase	Composition, at.%	Pearson symbol	Space group	Prototype	Lattice parameter, nm
$Sm_4Ni_6Al_{23}$ (τ_1)	69.7 Al	*mC*66	*C*2/*m*	$Y_4Ni_6Al_{23}$	a = 1.5939
	18.2 Ni				b = 0.40967
	12.1 Sm				c = 1.8320
					β = 113.09°
$SmNiAl_4$ (τ_2)	64.7-66.7 Al	*oC*24	*Cmcm*	$YNiAl_4$	a = 0.40948
	18.7-16.7 Ni				b = 1.5582
	16.7 Sm				c = 0.6610
$SmNiAl_3$ (τ_3)	60 Al	*oP*20	*Pnma*	$YNiAl_3$	a = 0.8197
	20 Ni				b = 0.4087
	20 Sm				c = 1.0713
$SmNi_2Al_3$(τ_4)	49-52.5 Al	*hP*18	*P*6/*mmm*	$HoNi_{2.6}Ga_{2.4}$	a = 0.9141
	34.3-30.8 Ni				c = 0.4039
	16.7 Sm				
$SmNiAl_2$ (τ_5)	50 Al	*oC*16	*Cmcm*	$CuMgAl_2$	a = 0.4058
	25 Ni				b = 1.0519
	25 Sm				c = 0.6903
SmNiAl (τ_6)	33.3 Al	*hP*9	$P\bar{6}2m$	ZrNiAl	a = 0.6986
	33.3 Ni				c = 0.4008
	33.3 Sm				
$SmNi_4Al$	16.7 Al	*hP*6	*P*6/*mmm*	$CaCu_5$	a = 0.4980
	66.7 Ni				c = 0.4050
	16.7 Sm				

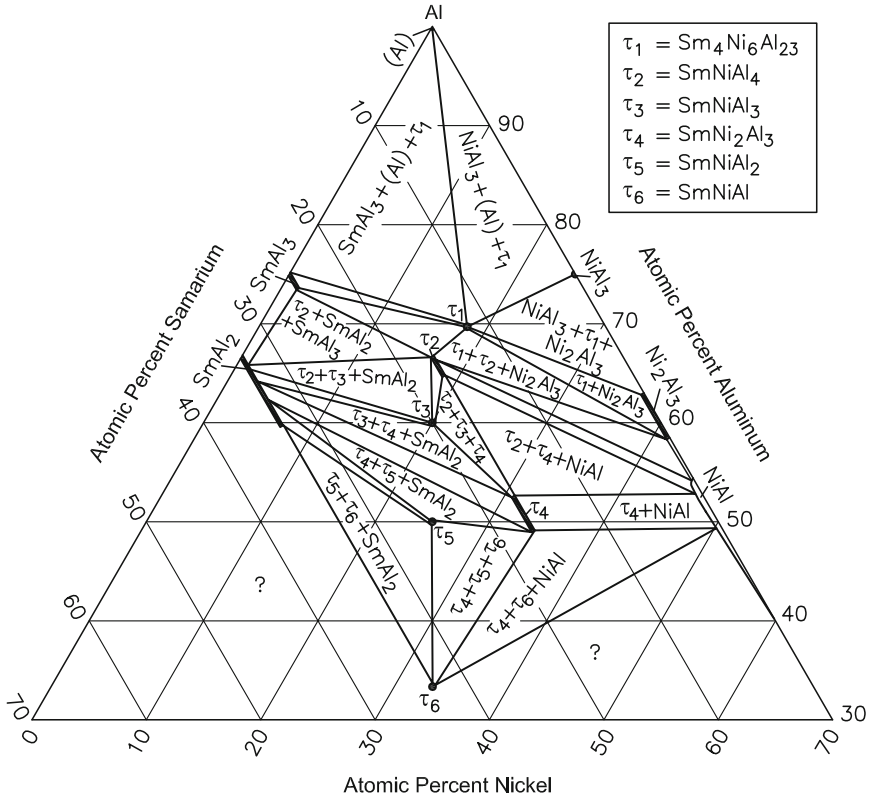

Fig. 1 Al-Ni-Sm isothermal section at 500 °C in the 40-100 at.% Al range [2008Del]

the range of 40-100 at.% Al. The alloys were annealed at 500 °C for 20 d and quenched in water. The phase equilibria were studied with x-ray powder diffraction, optical microscopy and a scanning electron microscope equipped with energy dispersive x-ray analyzer. The measured compositions of the coexisting phases were listed. The isothermal section at 500 °C constructed by [2008Del] is shown in Fig. 1. The six ternary phases τ_1 through τ_6 are present. The phases $SmNiAl_4$ (τ_2) and $SmNi_2Al_3$ (τ_4) show a homogeneity range of about 2 and 3.5 at.% Al (or Ni) respectively at constant Sm content. The binary phases $SmAl_2$ and $SmAl_3$ dissolve up to 7 and 1.5 at.% Ni at constant Sm content. NiAl dissolves up to 1 at.% Sm.

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