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Al-Ni-Si (Aluminum-Nickel-Silicon)

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At about the same time as a review of this ternary system by [2005Rag] appeared in print, new experimental results were reported by [2005Pan]; these supplement the reviewed results. Two full isothermal sections were reported by [2005Pan] at 850 and 750 °C. The new results are consistent with the data of Richter et al. [2003Ric, 2004Ric] reviewed by [2005Rag].

Binary Systems

The Al-Ni phase diagram [1993Oka] shows five intermediate phases: $NiAl_3$ ($D0_{11}$, Fe_3C-type orthorhombic), Ni_2Al_3 ($D5_3$-type hexagonal), NiAl ($B2$, CsCl-type cubic), Ni_5Al_3 (Ga_3Pt_5-type orthorhombic), and Ni_3Al ($L1_2$, $AuCu_3$-type cubic, denoted γ'). The Al-Si phase diagram is a simple eutectic type [Massalski2]. The Ni-Si phase diagram [1999Du] has a number of intermediate phases: Ni_3Si with three modifications, the lowest temperature form being $L1_2$, $AuCu_3$-type cubic, Ni_5Si_2 (hexagonal), δNi_2Si ($C23$, Co_2Si-type orthorhombic), θNi_2Si (hexagonal), Ni_3Si_2 (orthorhombic), NiSi ($B31$, MnP-type orthorhombic), and $NiSi_2$ ($C1$, CaF_2-type cubic).

Ternary Phases

[2005Rag] has listed the structural parameters of the ternary phases of this system. $Al_{13}Ni_{67}Si_{20}$ (τ_1) is a solid solution based on the binary compound δNi_2Si. $AlNi_2Si$ (τ_2) has the FeSi-type cubic structure. Al_6Ni_3Si (τ_3) has the Ge_7Ir_3-type cubic structure. $Al_ySi_{9-y}Ni_{13\pm x}$ (τ_4) is not distinguishable from the binary compound θNi_2Si and is clubbed together with it as θ (τ_4). $AlNi_{16}Si_9$ (τ_5) is orthorhombic and is stable below 783 °C. [2005Pan] found a new compound $Ni_5(Al,Si)_3$ (τ_6), which appears to be the stabilized form of the binary compound Ni_5Al_3.

Ternary Isothermal Sections

With starting metals of 99.97% Al, 99.9995% Si, and 99.97% Ni, [2005Pan] arc melted 53 ternary alloys under Ar atmosphere. The alloys were annealed at 850 °C for 1200 h or at 750 °C for 1440 h and water quenched. The phase equilibria were studied by scanning electron microscopy and electron probe microanalysis. The isothermal sections constructed by [2005Pan] at 850 and 750 °C are redrawn in Fig. 1 and 2 to agree with the accepted binary data. The

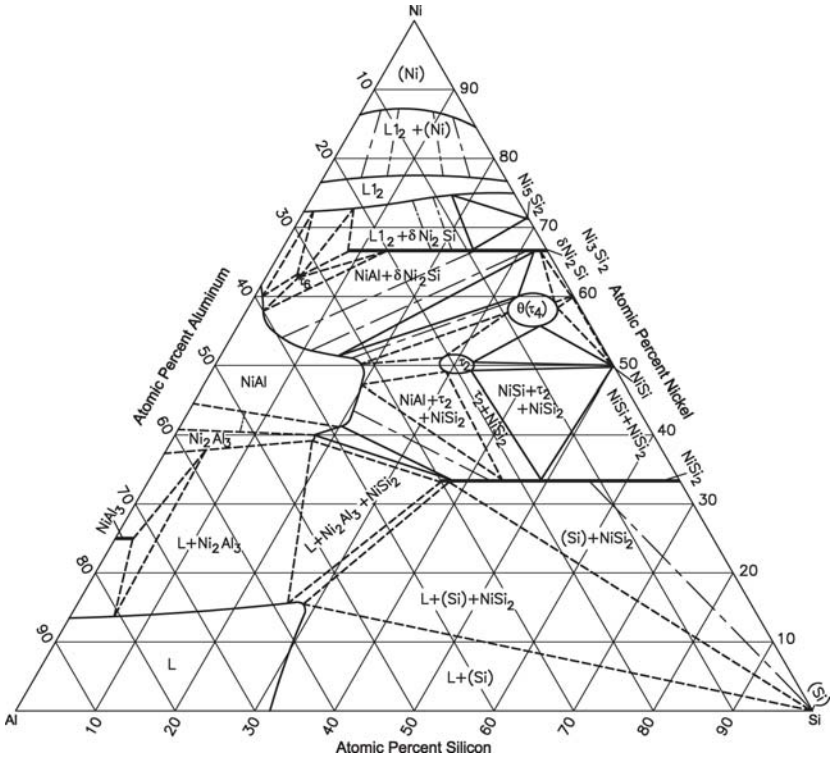

Fig. 1 Al-Ni-Si isothermal section at 850 °C [2005Pan]

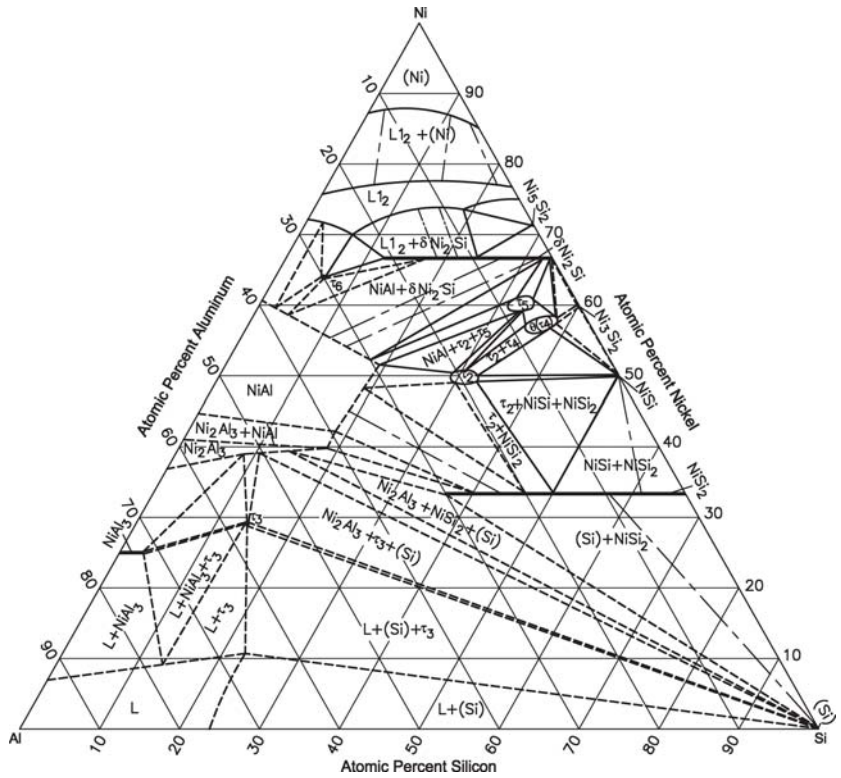

Fig. 2 Al-Ni-Si isothermal section at 750 °C [2005Pan]

ternary phase τ_6 is present at the composition ~$Ni_{63}Al_{33}Si_4$ at 850 °C and at ~$Ni_{64}Al_{30}Si_6$ at 750 °C. It appears to be the stabilized form of Ni_5Al_3, which is stable only below 700 °C in the Ni-Al binary system. Both at 850 and 750 °C, Ni_3Al and Ni_3Si form a continuous $L1_2$-type solid solution. The solubility of Al in δNi_2Si is ~25 at.% at 850 °C and ~21 at.% at 750 °C [2005Pan]. The τ_1 phase does not appear separately from δNi_2Si at either of these temperatures. The solubility of Si in NiAl and Ni_2Al_3 is 20 to 18 and 18 at.%, respectively. The solubility of Al in $NiSi_2$ is as high as 30 at.%. The above results are consistent with those of [2003Ric] and [2004Ric].

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