JPEDAV (2006) 27:405-407
DOI: 10.1361/154770306X116423
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Al-Ni-Ta (Aluminum-Nickel-Tantalum)

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The compilation of data on this ternary system by [1995Vil] presented a partial liquidus projection from [1986Wil] and partial isothermal sections from [1968Hun], [1979Nas], and [1986Wil]. This system was also reviewed by [1993Zak]. More recently, [1996Pal] determined two isothermal sections at 1250 and 1000 °C for alloys containing Ta up to 50 at.%. [2003Zho] presented a thermodynamic description for Ni-rich alloys.

Binary Systems

The Al-Ni phase diagram [1993Oka] shows five intermediate phases: $NiAl_3$ (Fe_3C-type orthorhombic), Ni_2Al_3 ($D5_{13}$-type hexagonal), NiAl ($B2$, CsCl-type cubic, also denoted β), Ni_5Al_3 (Ga_3Pt_5-type orthorhombic), and Ni_3Al ($L1_2$, $AuCu_3$-type cubic; also denoted γ′). The Al-Ta phase diagram [1990Sub] depicts four intermediate phases. Ta_2Al (σ) has the $D8_b$, σCrFe-type tetragonal structure, with a homogeneity range of 20 to 47 at.% Al. TaAl (monoclinic), $TaAl_2$ (complex bcc) and $TaAl_3$ ($D0_{22}$, $TiAl_3$-type tetragonal) are line compounds. The Ni-Ta system [2000Oka] has five intermediate phases: Ni_8Ta (Ni_8Nb-type tetragonal), Ni_3Ta (Pt_3Nb-type monoclinic), Ni_2Ta ($C11_b$, $MoSi_2$-type tetragonal), NiTa ($D8_5$, Fe_7W_6-type rhombohedral), and $NiTa_2$ ($C16$, $CuAl_2$-type tetragonal).

Ternary Phases

Three ternary phases are known in this system. NiAlTa (τ_1) is a $C14$, $MgZn_2$-type hexagonal Laves phase. Its ho-

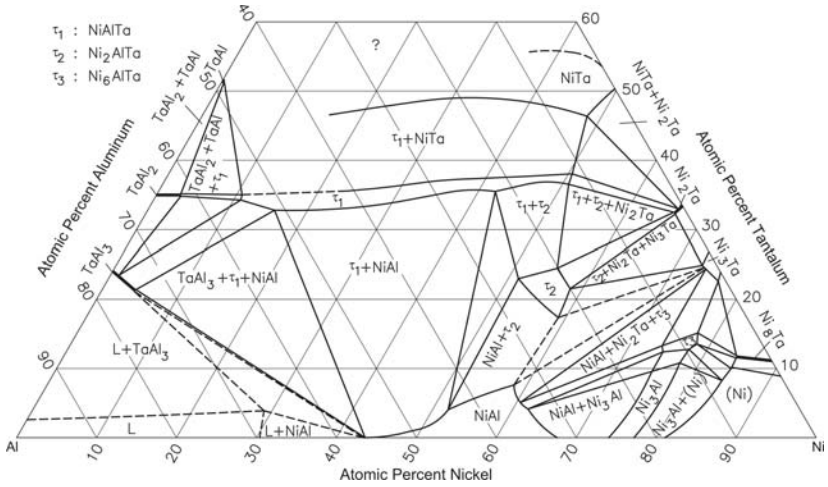

Fig. 1 Al-Ni-Ta isothermal section at 1250 °C [1996Pal]

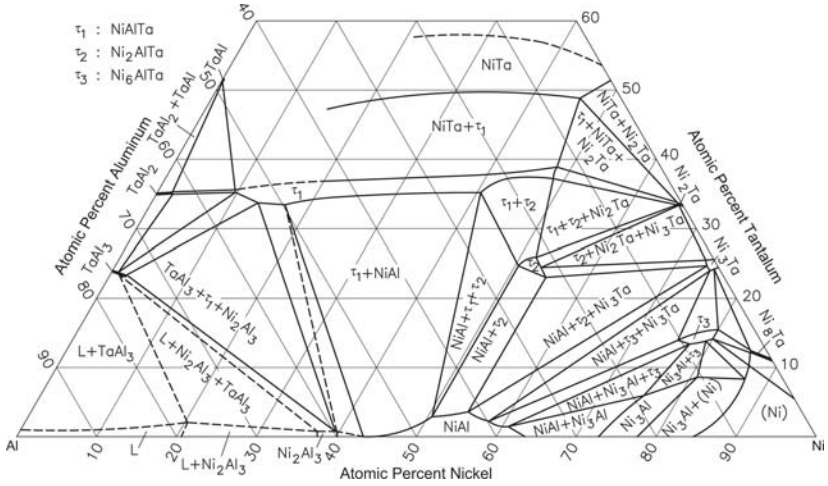

Fig. 2 Al-Ni-Ta isothermal section at 1000 °C [1996Pal]

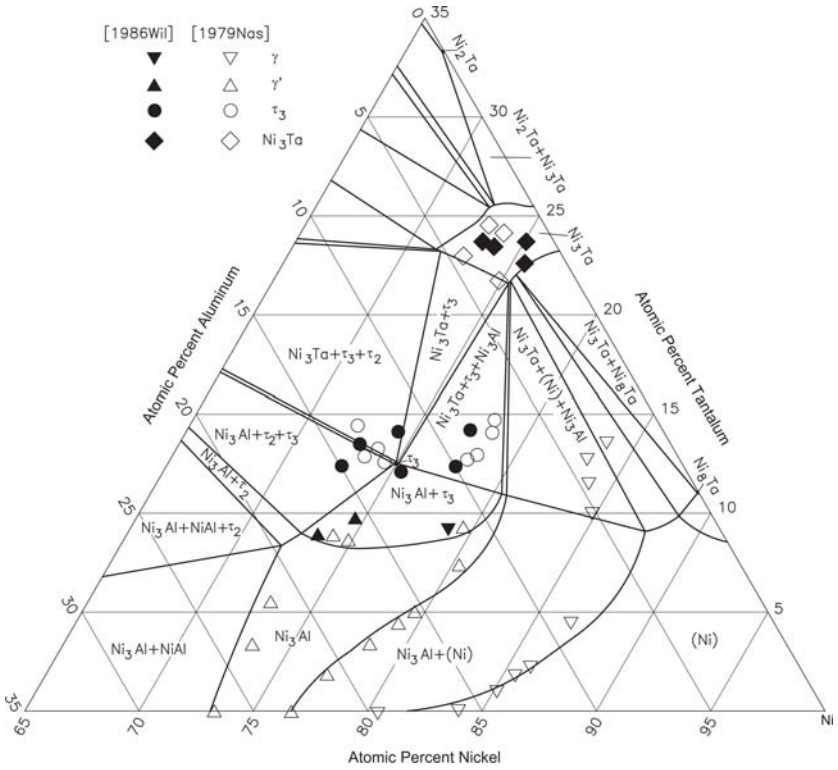

Fig. 3 Al-Ni-Ta computed isothermal section at 1250 °C [2003Zho]

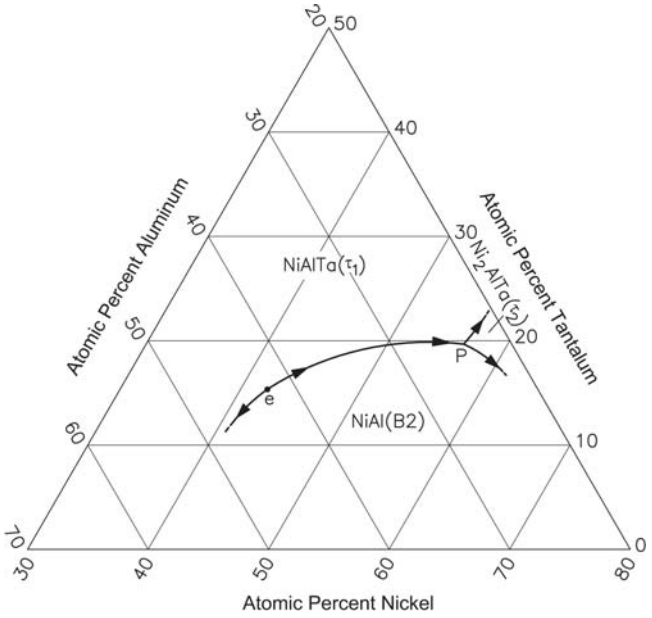

Fig. 4 Al-Ni-Ta partial liquidus projection [1994Joh]

mogeneity extends approximately along the line of constant content of 33.3 at.% Ta, from 10 to 50 at.% Ni [1996Pal]. Ni_2AlTa (τ_2) is a $L2_1$-type Heusler phase. Ni_6AlTa (τ_3, denoted π by [2003Zho]) is a $D0_{24}$, Ni_3Ti-type hexagonal phase. The homogeneity regions of τ_2 and τ_3 are limited. The other reported ternary phases $Ni_2Al_3Ta_5$ (τ_4), Ni_2Al_2Ta, and $NiAl_2Ta$ [1995Vil] were not found by [1996Pal].

Ternary Phase Equilibria

With starting metals of Al (99.99 wt.%), Ni (99.95 wt.%), and Ta (99.97 wt.%), [1996Pal] melted 32 ternary alloys in a levitation furnace. The samples were annealed at 1250 °C for 100 to 120 h or at 1000 °C for 168 h and water quenched. The phase equilibria were studied by metallography, x-ray powder diffraction, and electron probe microanalysis. On the basis of their experimental data, [1996Pal] constructed isothermal sections at 1250 and 1000 °C. At 1250 °C (Fig. 1), the three ternary phases τ_1, τ_2, and τ_3 are present. The Laves phase τ_1 has a wide range of Ni content from ~10 to 50 at.%, with Ni and Al substituting for each other at approximately constant Ta content. Ni_2AlTa (τ_2) has a significant homogeneity range, with a slight shift from the stoichiometric composition to lower Ta and higher Ni contents. Ni_6AlTa (τ_3) has a more limited variation in composition, with a Ni (or Al) range of ~5 at.%. At 1000 °C (Fig. 2), the phase distribution is the same as at 1250 °C (Fig. 1), except for the appearance of Ni_2Al_3 along the Al-Ni axis [1996Pal]. At 1000 °C, τ_2 has a more restricted composition range.

In a thermodynamic analysis of the Ni-rich part of this system, [2003Zho] modeled the (Ni) (fcc, γ) and Ni_3Al ($L1_2$, γ') phases with a single Gibbs energy function taking into account the ordering contribution to the Gibbs energy. The ternary phase Ni_6AlTa (τ_3, denoted π by [2003Zho]) was modeled as a compound of fixed stoichiometry. The third component solubility in Ni_3Al and Ni_3Ta were modeled. The ternary interaction parameters obtained by opti-

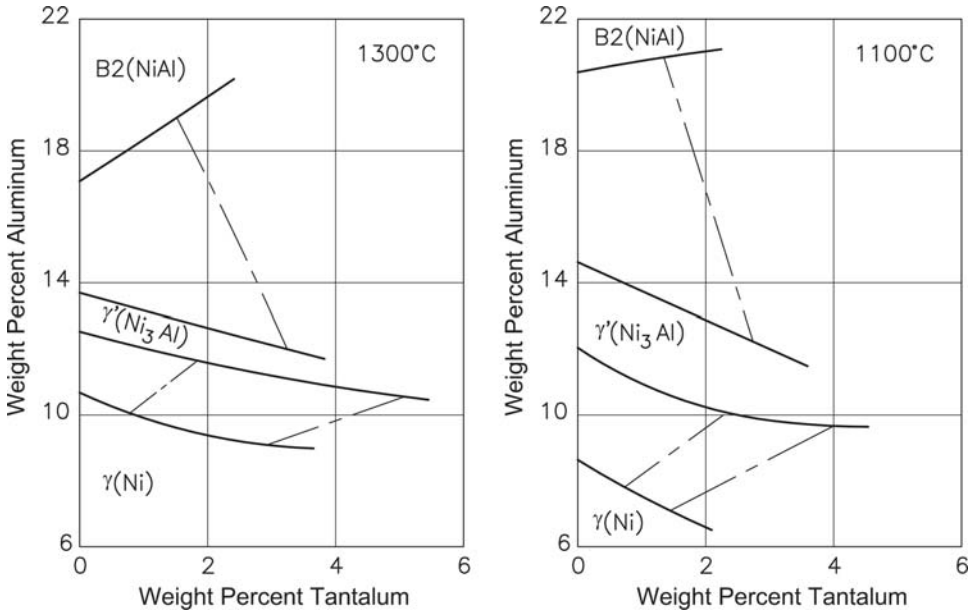

Fig. 5 Al-Ni-Ta partial isothermal sections at 1300 and 1100 °C [1994Jia]

mization for the liquid and fcc phases were listed. However, [2003Zho] did not include input data from the more recent experimental results of [1992Tia] and [1994Jia] on the tie-lines between γ and γ′. An isothermal section at 1250 °C for the Ni-rich region, two vertical sections at constant Ni contents of 85 and 82 at.%, respectively and a liquidus projection were computed. As an example, the computed isothermal section at 1250 °C is redrawn in Fig. 3 including the comparison with the experimental data of [1986Wil] and [1979Nas]. The triangulations here are quite different from those in Fig. 1 (experimental section of [1996Pal]) and from those in the isothermal section of [1986Wil] at 1250 °C. The difference arises at least partly from the modeling of τ_3 by [2003Zho] as a compound of fixed stoichiometry.

A partial liquidus surface for the Ni-rich region was reported by [1986Wil] (given in [1995Vil]). [1994Joh] determined the liquidus lines that meet at the ternary point *P* corresponding to the reaction: L + NiAl + NiAlTa (τ_1) ↔ Ni_2AlTa (τ_2). This is shown in Fig. 4. A complete characterization of the liquidus surface including the Al-rich region is not available. Liquidus and solidus temperatures of Ni-based solid solution containing Al and Ta were determined by [2001Miu]. The solvus temperatures of Ni_3Al (γ′) were earlier determined by [1989Hon] as a function of Al and Ta.

The γ/γ′ and γ′/*B*2 equilibria at 1300 and 1100 °C determined by [1994Jia] are shown in Fig. 5.

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