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Al-Ni-V (Aluminum-Nickel-Vanadium)

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The compilation by [1995Vil] of the phase diagram data on this system includes a liquidus projection, three isothermal sections at 1100, 1000, and 800 °C from [1977Mya], a partial isothermal section at 800 °C from [1965Ram], and two vertical sections along the $NiAl_3$-VAl_3 and Ni_2Al_3-V_5Al_8 joins from [1971Mya]. Two more isothermal sections were reported, one at 1300 °C by [1991Cot] and the other at 1200 °C by [1997Pri]. [1988Hon] determined the (Ni)/[(Ni) + Ni_3Al)] phase boundary as a function of temperature in ternary alloys and a pseudobinary section along the Ni_3Al-Ni_3V join.

Binary Systems

The Al-Ni phase diagram [1993Oka] has five intermediate phases: $NiAl_3$ (Fe_3C-type orthorhombic); Ni_2Al_3 ($D5_{13}$-type hexagonal); NiAl ($B2$, CsCl-type cubic); Ni_5Al_3 (Ga_3Pt_5-type orthorhombic); and Ni_3Al ($L1_2$, $AuCu_3$-type cubic; also denoted γ'). Recently, the liquidus and solidus in the (Ni) region were redetermined by [2001Miu1]. The phase boundary between (Ni) and (Ni) + Ni_3Al was determined by [2003Ma] between 600 and 1200 °C. The Al-V diagram [2000Ric] depicts five intermetallic compounds: V_5Al_8 ($D8_2$, Cu_5Zn_8-type cubic); VAl_3 ($D0_{22}$, $TiAl_3$-type tetragonal); V_4Al_{23} (hexagonal); V_7Al_{45} (monoclinic); and V_2Al_{21} (cubic). The results of [2000Ric] gave lower peritectic formation temperatures of 1408 °C (1670 °C in [Massalski2]) for V_5Al_8 and 1270 °C (1360 °C in [Massalski2]) for VAl_3. The Ni-V phase diagram [1982Smi] depicts four intermediate phases: Ni_8V ($NbNi_8$-type tetragonal); Ni_3V ($D0_{22}$, $TiAl_3$-type tetragonal); Ni_2V ($MoPt_2$-type orthorhombic); σ ($D8_b$, σCrFe-type tetragonal); σ′ (an ordered version of σ); and NiV_3 ($A15$, Cr_3Si-type cubic).

Ternary Phase Equilibria

With starting metals of 99.99% Al, 99.95% Ni, and 99.9% V, [1991Cot] arc-melted six alloy compositions with V contents up to 20 at.% under an Ar atmosphere and annealed them at 1300 °C for 24 h. The phase equilibria were studied by optical and transmission electron microscopy, x-ray diffraction, and electron probe microanalysis. Differential thermal analysis was done at a heating/cooling rate of 10 °C/min. A pseudobinary eutectic phase between NiAl and (V) was found at ~1370 °C. The partial isothermal section constructed by [1991Cot] at 1300 °C is redrawn in Fig. 1 to agree with the accepted binary data. The solubility of V in NiAl is at least 14 at.%.

With starting metals of high purity, [1997Pri] arc-melted about five alloy compositions with 50 to 65 at.% V and annealed them at 1200 °C for 20 to 40 h. The phase equilibria were studied with optical microscopy, x-ray diffraction, and electron probe microanalysis. The partial isothermal section constructed by [1997Pri] at 1200 °C is redrawn in Fig. 2 to agree with the accepted binary data. The homogeneity range of NiAl is considerably larger at 1200 °C (Fig. 2) than at 1300 °C (Fig. 1).

At the Ni-rich end, [1988Hon] arc-melted ternary alloy compositions from high-purity metals. With a combination

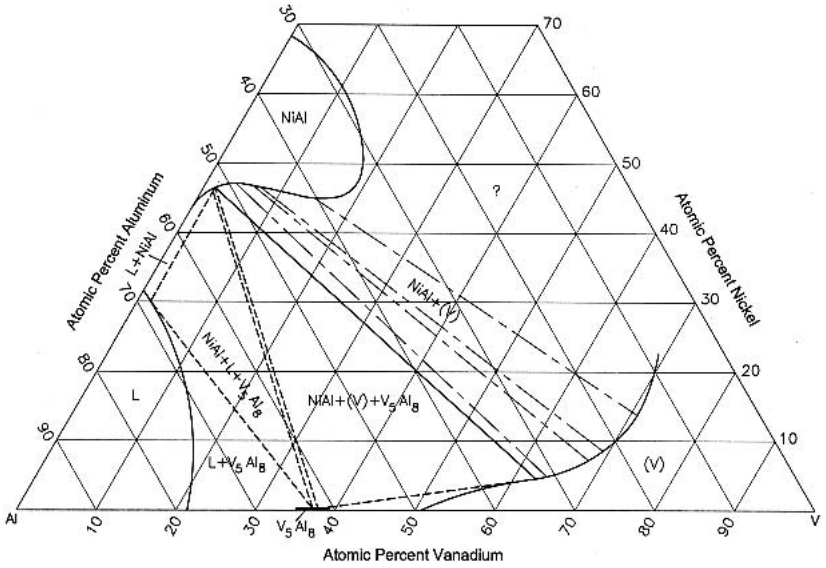

Fig. 1 Al-Ni-V partial isothermal section at 1300 °C [1991Cot]

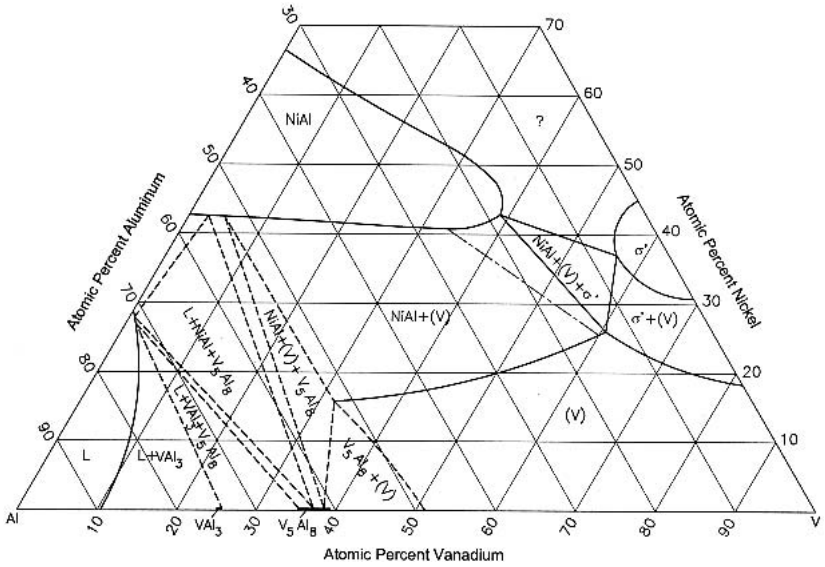

Fig. 2 Al-Ni-V partial isothermal section at 1200 °C [1997Pri]

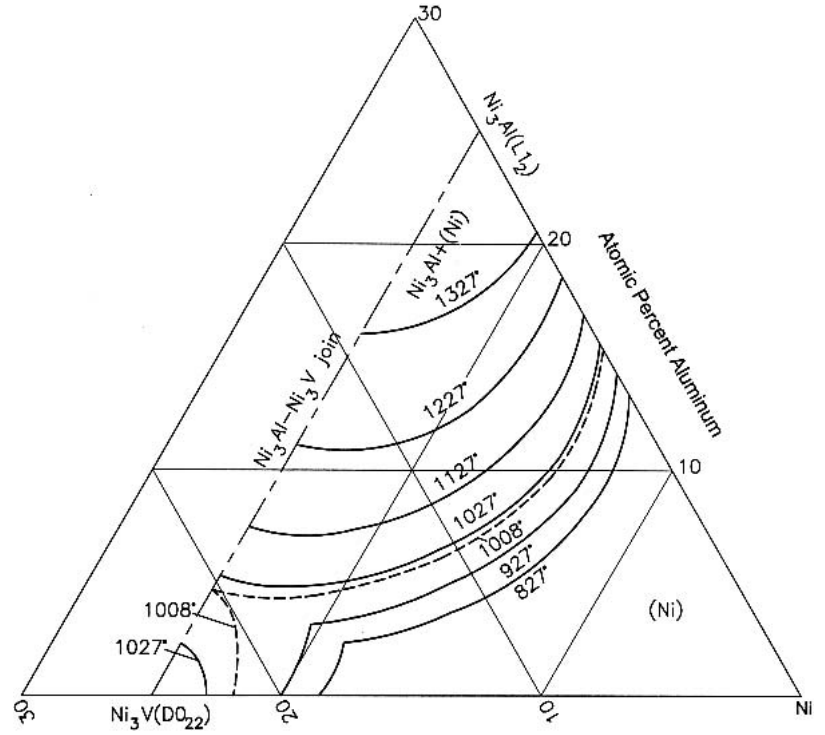

Fig. 3 Al-Ni-V: the (Ni)/[(Ni)+Ni_3V] phase boundaries at the indicated temperatures [1988Hon]

of differential thermal analysis and energy-dispersive x-ray spectroscope, they determined the (Ni)/[(Ni) + Ni_3Al] phase boundary at a series of temperatures. This is shown in Fig. 3. Also, [1988Hon] constructed a pseudobinary section along the Ni_3Al-Ni_3V join (Fig. 4).

[2001Zap] used a three-dimensional atom probe technique to measure the composition of coexisting phases in a Ni-7at.%Al-14.5at.%V alloy The apex compositions of the tie-triangle (Ni) + Ni_3Al + Ni_3V at 800 °C were found to be 2.7at.%Al-16.2at.% V, 11.3at.%Al-12at.%V, and 1.7at.%Al-21.4at.%V, respectively. The compositions of (Ni) and Ni_3V are in satisfactory agreement with earlier work, but Ni_3Al is seen to dissolve much more V (12% versus 5% in [1977Mya]). The phase equilibria were also analyzed by [2001Zap] using a mean-field model and by [2001Par] using a Monte Carlo simulation.

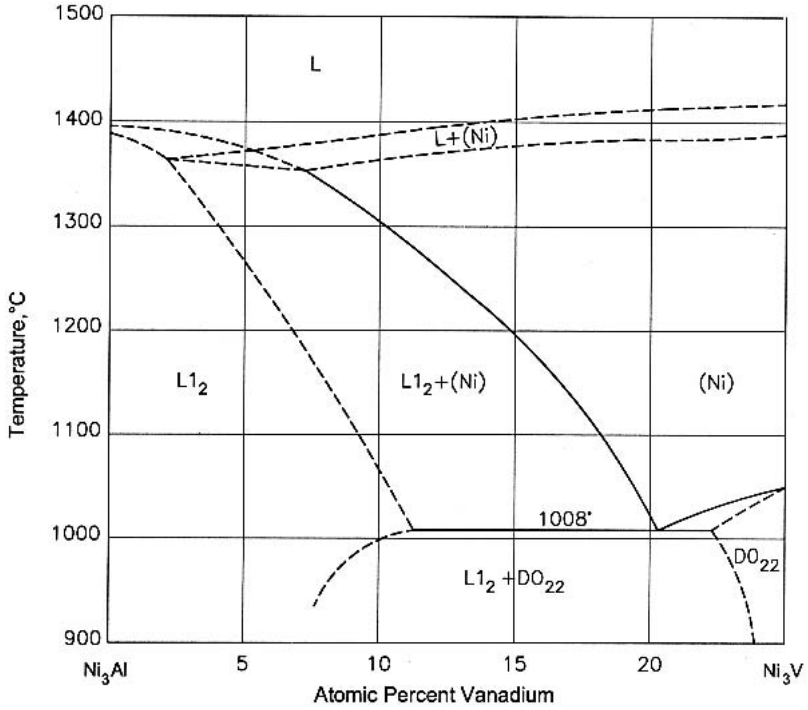

Fig. 4 Al-Ni-V pseudobinary section along the Ni_3Al-Ni_3V join [1988Hon]

[2001Miu2] determined the liquidus and solidus temperatures in the region of the primary crystallization of (Ni) as a function of Al and V, as well as the solvus temperatures of (Ni).

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