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

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The topologically close-packed intermetallics Ni_3Al, Ni_3Ti, and Ni_3V have excellent corrosion and oxidation resistance and attractive mechanical properties, with strength increasing with increasing temperature. Recently, [2004Nun] determined isothermal sections at 1000 and 1100 °C for the Ni_3Al-Ni_3Ti-Ni_3V pseudoternary system. [2004Ish] studied the phase relationships at 1300, 1200, and 1000 °C between the *B*2- and $L2_1$-type ordered structures on the NiAl-NiTi-NiV plane of the composition tetrahedron.

Binary Systems

For brief descriptions of the Al-Ni, Al-Ti, and Ni-Ti binaries, see the Al-Ni-Ti update in this issue. The Al-Ti-V update gives descriptions of the Al-V and Ti-V phase diagrams. See the Al-Ni-V update for the Ni-V phase diagram.

Ternary Systems

The Al-Ni-Ti, Al-Ni-V, and Al-Ti-V systems are updated in this issue. The review of the Ni-Ti-V system by [1991Gup] presented a schematic liquidus projection, a corresponding reaction scheme, and two partial isothermal sections, one at 1000 °C for the Ni-NiTi-V region and the other at 900 °C for the NiTi-Ti-V region based on the results of [1984Ere]. [1992Pri] reported a full isothermal section at 1000 °C, which is in agreement with [1984Ere]. Figure 1 shows a pseudobinary section along the Ni_3Ti-Ni_3V join [2004Nun]. In addition to the solid solutions based on Ni_3Ti and Ni_3V, two intermediate phases, one with rhombohedral symmetry (denoted r) and the other with $D0_{19}$ structure, are present.

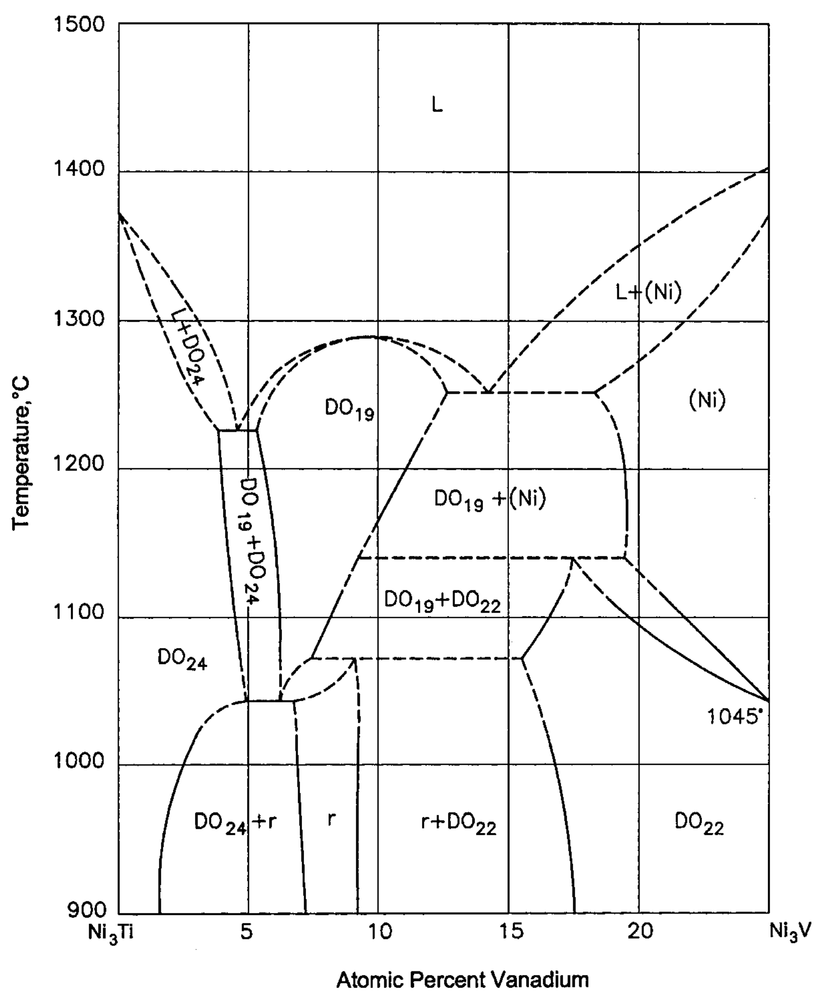

Fig. 1 Al-Ni-Ti-V pseudobinary section along the Ni_3Ti-Ni_3V join [2004Nun]

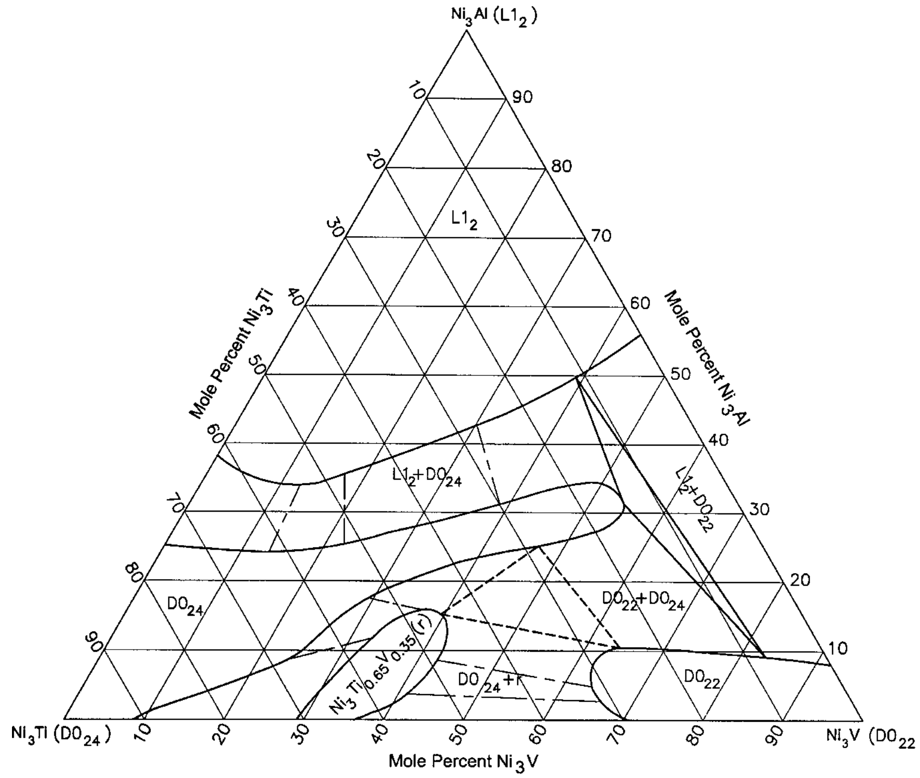

Fig. 2 Al-Ni-Ti-V pseudoternary section on the Ni_3Al-Ni_3Ti-Ni_3V plane at 1000 °C [2004Nun]

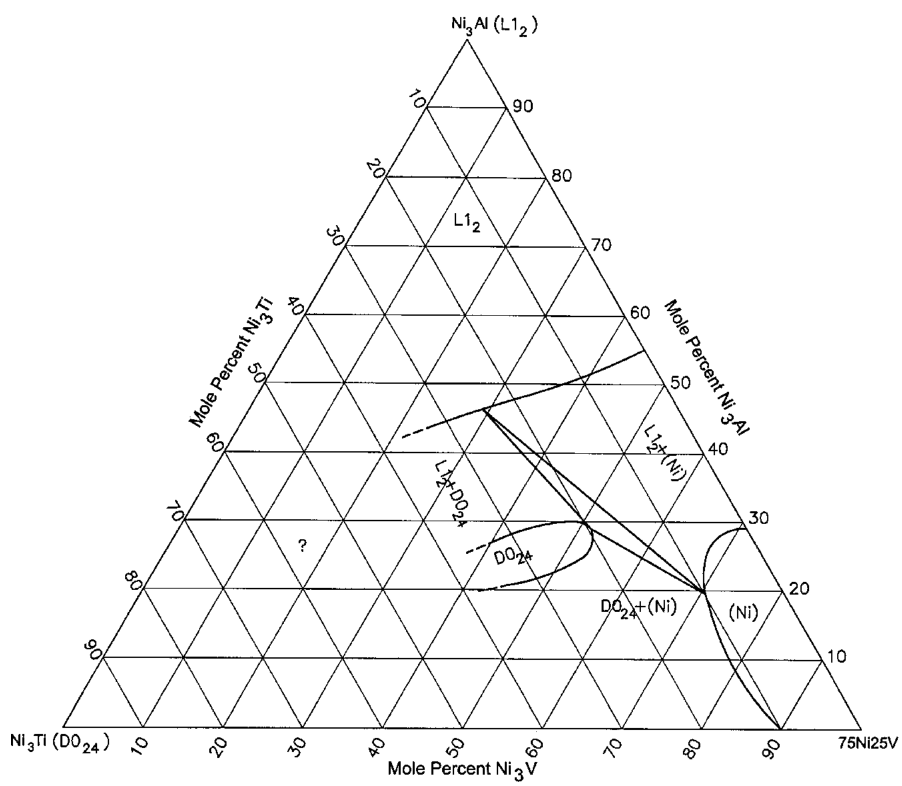

Fig. 3 Al-Ni-Ti-V partial pseudoternary section on the Ni_3Al-Ni_3Ti-Ni_3V plane at 1100 °C [2004Nun]

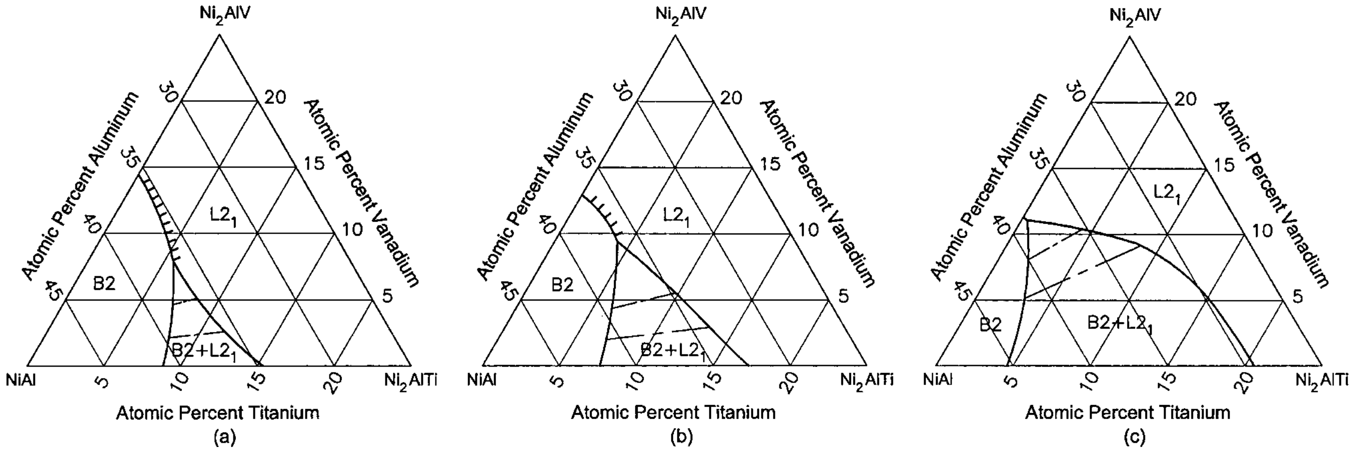

Fig. 4 Al-Ni-Ti-V $B2$-$L2_1$ equilibria on the NiAl-Ni_2AlTi-Ni_2AlV plane at (a) 1300 °C, (b) 1200 °C, and (c) 1000 °C [2004Ish]

The Ni_3Al-Ni_3Ti-Ni_3V Pseudoternary Section

With starting metals of 99.99% Al, 99.9% Ni, 99.9% Ti, and 99.9% V, [2004Nun] arc-melted 23 quaternary alloy compositions that lie on the Ni_3Al-Ni_3Ti-Ni_3V plane under an Ar atmosphere. The alloys were annealed at 1100 and 1000 °C for 5 to 7 d, followed by water quenching. The phase equilibria were studied using optical microscopy, x-ray diffraction, and scanning electron microcopy with wavelength-dispersive spectroscopy. The pseudoternary sections constructed by [2004Nun] at 1000 and 1100 °C are redrawn in Fig. 2 and 3. In Fig. 2, along the Ni_3Al-Ni_3Ti side, Ni_3Al ($L1_2$, $AuCu_3$-type) and Ni_3Ti ($D0_{24}$, Ni_3Ti-type hexagonal) are in two-phase equilibrium (refer to Fig. 4 under the Fe-Ni-Ti update in this issue). Along the Ni_3Al-Ni_3V side, Ni_3Al and Ni_3V ($D0_{22}$, $TiAl_3$-type tetragonal) are in two-phase equilibrium (refer to Fig. 4 in the Al-Ni-V update in this issue). Along the Ni_3Ti-Ni_3V side, Ni_3Ti, $Ni_3Ti_{0.65}V_{0.35}$ (a rhombohedral phase), and Ni_3V are present (Fig. 1). No quaternary compounds were found on this plane. In Ni_3Ti, most of the Ti atoms are substituted by Al and V atoms. The solubility of Al in $Ni_3Ti_{0.65}V_{0.35}$ is significant. At 1100 °C, only a partial diagram was determined by [2004Nun] (Fig. 3). At this temperature, Ni_3V has transformed to (Ni) with 25 at.% V dissolved in it. This face-centered cubic phase dissolves up to 7.5 at.% Al. [2004Nun] showed that the extent of the phase fields on the pseudoternary plane depends on the electron-to-atom ratio and the atomic sizes of the constituent atoms.

$B2$-$L2_1$ Phase Equilibria

With starting materials of purity Al >99.99%, Ni >99.95%, Ti >99.5%, and V >99.7%, [2004Ish] arc-melted a limited number of alloy compositions that lie on the NiAl-Ni_2AlTi-Ni_2AlV triangle, which forms part of the NiAl-NiTi-NiV plane in the composition tetrahedron. The samples were annealed at 1300, 1200, and 1000 °C for 1, 14, and 28 days, respectively, and quenched in ice water. The phase equilibria were studied by metallography and the diffusion-couple technique. The composition of the phases was measured by energy-dispersive x-ray spectroscopy. Isothermal sections constructed by [2004Ish] at 1300, 1200, and 1000 °C are redrawn in Fig. 4. The $B2 \leftrightarrow L2_1$ transition is a second-order transition along the NiAl-Ni_2AlV side. As the Ti content increases, the first-order transition sets in, with the appearance of the two-phase field ($B2 + L2_1$). With decreasing temperature, the width of the two-phase field increases. The measured Ni content of the $B2$ and $L2_1$ phases in all of the studied alloy compositions was ~50 at.%.

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