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Al-Mn-Ni-Ti (Aluminum-Manganese-Nickel-Titanium)

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Recently, [2004Ish] studied the phase relationships at 1300, 1200, and 1000 °C between the $B2$- and $L2_1$-type ordered structures on the NiAl-NiTi-NiMn plane of the composition tetrahedron.

Binary Systems

Brief descriptions of the Al-Mn, Al-Ti, and Mn-Ti phase diagrams are given in the Al-Mn-Ti update in this issue. For Al-Ni and Ni-Ti descriptions, see the Al-Ni-Ti update. In the Mn-Ni phase diagram [1991Gok], Ni and γMn (both face-centered cubic) form a continuous solid solution (denoted γ) at subsolidus temperatures. At 911 °C, the η phase (45 to 52 at.% Ni; CsCl-type cubic) forms congruently from γ. At 775 °C, a peritectoid reaction between γ and η yields η′ (47 to 55.5 at.% Ni; $L1_0$, AuCu-type tetragonal). At the Ni-rich end, another peritectoid reaction at 520 °C yields γ′ ($L1_2$, $AuCu_3$-type cubic). A number of other intermediate phases, which have not been fully characterized, are known in this system [1991Gok].

Ternary Systems

Updates on the Al-Mn-Ti and Al-Ni-Ti ternary systems appear in this issue. The compilation by [1995Vil] on the Al-Mn-Ni system contains partial liquidus projections, partial isothermal sections at 1000, 630, 600, and 500 °C, and vertical sections at 10 and 15 wt.% Al and at 20 and 40 wt.% Mn, and also along the Ni_3Al-Ni_3Mn and the AlNi-Mn joins. An update of the Mn-Ni-Ti system by [2003Gup] gives a pseudobinary section along the Ni_3Mn-Ni_3Ti join.

Quaternary Phase Equilibria

With starting materials of purity Al >99.99%, Mn >99.9%, Ni >99.95%, and Ti >99.5%, [2004Ish] arc-melted a limited number of alloy compositions that lie on the NiAl-Ni_2AlTi-Ni_2AlMn triangle, which forms part of the NiAl-NiTi-NiMn plane in the composition tetrahedron. The samples were annealed at 1300, 1200, and 1000 °C for 1, 14, and 28 days, respectively, and were quenched in an ice-water mixture. 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. 1. The $B2 \leftrightarrow L2_1$ transition is a second-order transition along the Ni_2AlTi-Ni_2AlMn side. As the Al 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.%.

References

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1995Vil: P. Villars, A. Prince, and H. Okamoto, Al-Mn-Ni, *Handbook of Ternary Alloy Phase Diagrams,* ASM International, Vol 4, 1995, p 3989-4000

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2004Ish: K. Ishikawa, I. Ohnuma, R. Kainuma, K. Aoki, and K. Ishida, Phase Equilibria and Stability of Heusler Type Aluminides in the NiAl-Ni_2AlTi-Ni_2AlY (Y: V, Cr or Mn) Systems, *J. Alloys Compd.,* Vol 367, 2004, p. 2-9

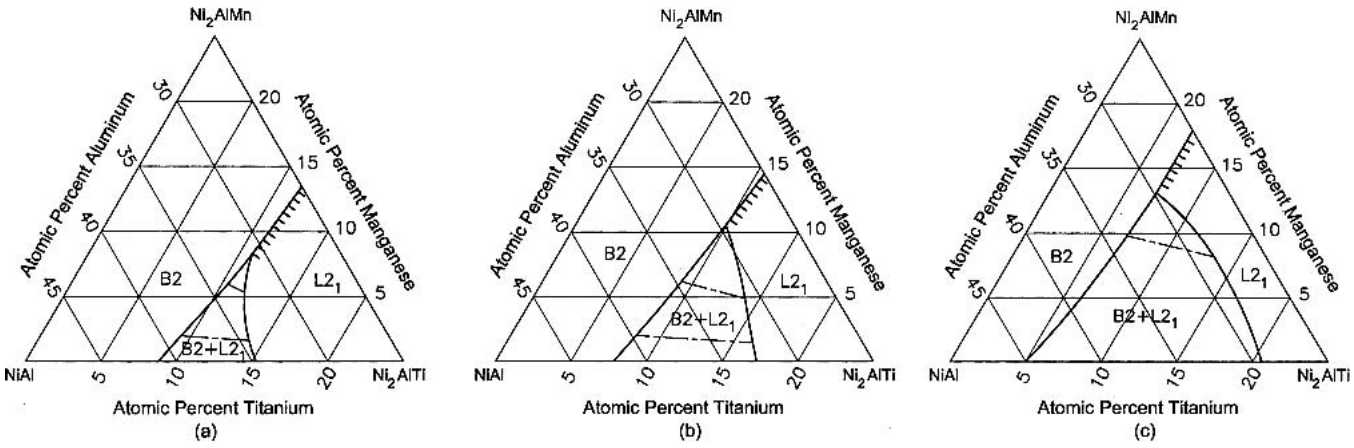

Fig. 1 Al-Mn-Ni-Ti $B2$-$L2_1$ equilibria on the NiAl-Ni_2AlTi-Ni_2AlMn plane at (a) 1300 °C, (b) 1200 °C, and (c) 1000 °C [2004Ish]