Al-Nb-Ti (Aluminum-Niobium-Titanium)

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The phase equilibria in this system were reviewed earlier by [1993Gam], [2005Rag] and [2005Tre]. More recent results were updated by [2010Rag]. Additional new data from two recent publications [2009Leo, 2009Rio] will be summarized here.

New Results on the Ternary Phase Equilibria

In the earlier literature on this ternary system, the nature of the invariant reaction involving liquid (L), TiAl (γ), Nb₂Al (σ) and TiAl₃ (η) has been interpreted either as a U-type transition reaction or as a ternary eutectic reaction, see the reviews listed above. [2009Rio] arc-melted under Ar atm two ternary alloys of composition (in at.%): 57.2Al-35.7Nb-7.1Ti and 51.4Al-39.8Nb-8.8Ti. The alloys were annealed at 1510 °C or 1410 °C for 3-4 h and quenched in water. The phase equilibria were investigated with scanning and transmission electron microscopy, x-ray powder diffraction and differential thermal analysis. After a detailed analysis of the microstructures and the measured compositions of the coexisting phases, [2009Rio] concluded that the invariant reaction is of the ternary eutectic type: $L \leftrightarrow \text{TiAl } (\gamma) + \text{Nb}_2\text{Al } (\sigma) + \text{TiAl}_3 (\eta)$, with the eutectic composition at 56Al-37.2Nb-6.8Ti (at.%) and the eutectic temperature at 1532 °C.

[2009Leo] studied the decomposition of the B2 (β) phase on ageing in three alloys of nominal composition Nb₂₄Ti₄₀Al, Nb₃₀Ti₄₀Al and Nb₃₆Ti₄₀Al. The alloys were aged at 700 °C for 720, 1080 or 3600 h and quenched in water. The phase structures were studied by x-ray powder diffraction, optical and transmission electron metallography

and by selected-area and convergent-beam electron diffraction. Formation of the ω -related $P6_3/mcm$, $hP18$ phase was observed in all the three alloys. For the Nb₂₄Ti₄₀Al alloy, the measured lattice parameters were: $a = 0.796$ nm and $c = 0.557$ nm, with the relationship $a = a_{\beta}\sqrt{6}$ and $c = a_{\beta}\sqrt{3}$. The addition of Nb appears to stabilize the Ti₅Ga₄-type $hP18$ structure, in preference to the Mn₅Si₃-type $hP16$ structure. Ab initio calculations confirmed the stabilizing effect of Nb, with the calculated cohesive energies in Ti₅Al₃, Ti₅Al₄ and Ti₅Al₃Nb equal to 6.449, 6.215 and 6.927 eV per atom respectively [2009Leo].

References

- 1993Gam:** S. Gama, Aluminum-Niobium-Titanium, *Ternary Alloys*, Vol 7, G. Petzow and G. Effenberg, Ed., VCH Verlagsgesellschaft, Weinheim, Germany, 1993, p 382-398
- 2005Rag:** V. Raghavan, Al-Nb-Ti (Aluminum-Niobium-Titanium), *J. Phase Equilib. Diffus.*, 2005, **26**(4), p 360-368
- 2005Tre:** L. Tretyachenko, Aluminum-Niobium-Titanium, *Landolt-Bornstein New Series IV*, Vol 11A3, G. Effenberg and S. Ilyenko, Ed., 2005, p 334-379
- 2009Leo:** K.J. Leonard, R. Tewari, A. Arya, J.C. Mishurda, G.K. Dey, and V.K. Vasudevan, Decomposition of the β_0 Phase to the $P6_3/mcm$, $hP18$ Structure in Nb-(24-36)Ti-40Al Alloys, *Acta Mater.*, 2009, **57**, p 4440-4453
- 2009Rio:** O. Rios, D.M. Cupid, H.J. Seifert, and F. Ebrahimi, Characterization of the Invariant Reaction Involving the L, η , γ and σ Phases in the Ti-Al-Nb System, *Acta Mater.*, 2009, **57**, p 6243-6250
- 2010Rag:** V. Raghavan, Aluminum-Niobium-Titanium, *J. Phase Equilib. Diffus.*, 2010, **31**(1), p 47-52