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Al-Ni-Re (Aluminum-Nickel-Rhenium)

V. Raghavan

[1999Hua] computed the phase equilibria of this ternary system and compared the results with the limited experimental data available.

Binary Systems

The Al-Ni phase diagram [1993Oka] shows five intermediate phases: $NiAl_3$ ($D0_{11}$, 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-Re phase diagram determined by [2001Sch], Fig. 1, shows the intermetallic compounds: $ReAl_{12}$ (WAl_{12}-type cubic), $ReAl_6$ ($D2_h$, $MnAl_6$-type orthorhombic), Re_8Al_{33-x} (triclinic), $ReAl_4$ (hexagonal), Re_4Al_{11} (Mn_4Al_{11}-type triclinic), ReAl (CuTi-type tetragonal), and Re_2Al ($C11_b$, $MoSi_2$-type tetragonal). The diagram determined by [2001Sch] differs significantly from the one proposed by [1999Cor1]. [1999Cor1] based their observations on metallography and x-ray diffraction on arc melted samples, whereas [2001Sch] used, in addition, differential thermal analysis on arc melted and annealed samples. The Ni-Re phase diagram is of the simple peritectic type [Massalski2].

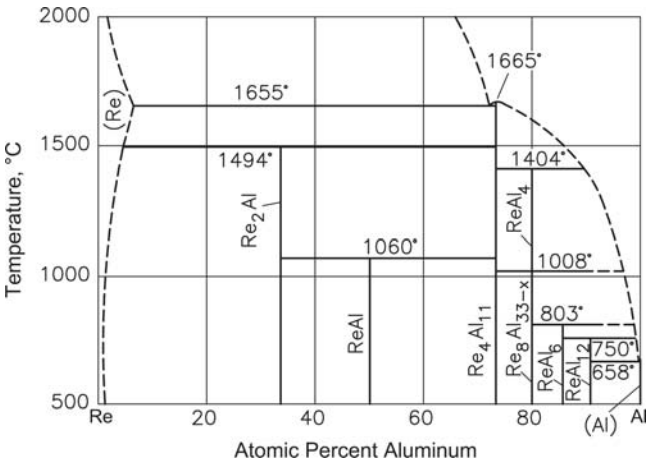

Fig. 1 Al-Re phase diagram [2001Sch]

Ternary Phase Equilibria

A liquidus projection was proposed for this ternary system by [1999Cor2]. With starting metals of purity of ≥99.9 wt.%, [1999Cor2] arc melted about 35 samples under Ar atm. The phase equilibria were studied by optical and scanning electron microscopy, energy dispersive x-ray spectroscopy (EDX), and x-ray diffraction. No differential thermal analysis could be done. Eleven ternary invariant reactions were observed or deduced. The compositions of the liquid participating in the invariant reactions were derived from the composition analysis by EDX and listed by [1999Cor2]. With starting metals of 99.999% Al, 99.9% Ni, and 99.85% Re, [2003Bar] arc melted ten ternary alloys with Al in the range of 43 to 54.5 at.%, Ni of 42.5 to 50.5 at.%, and Re of 0.2 to 14 at.% and studied the phase equilibria by differential thermal analysis, optical and scanning metallography, and electron probe microanalysis. The main finding of [2003Bar] is the existence of a maximum on the [L + NiAl + (Re)] univariant eutectic line at 2.5 at.% Re. In Fig. 2, a tentative liquidus projection is drawn up to 60 at.% Al, which is consistent with the experimental results of [1999Cor2] and [2003Bar] and the computed results of [1999Hua]. A large region of primary separation of (Re) is seen. For Al contents above 60 at.%, there is no general agreement among [1999Cor2], [1999Hua], and the Al-Re binary phase diagram of [2001Sch].

[1999Hua] modeled the liquid, face-centered cubic (fcc),

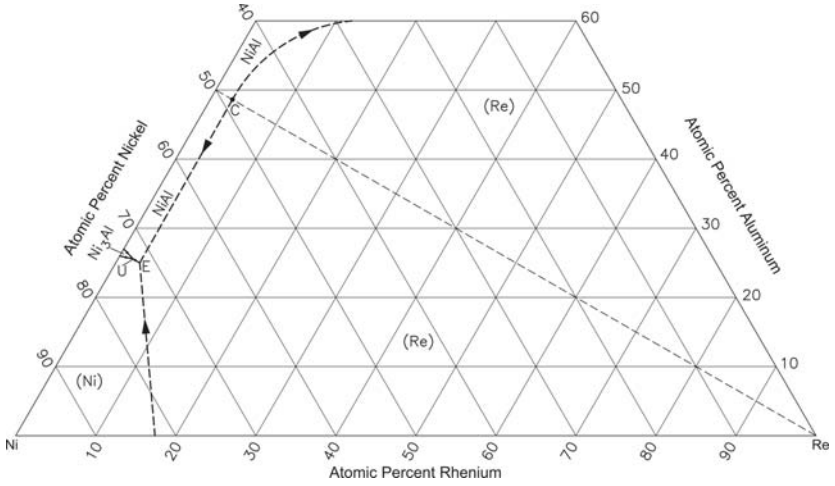

Fig. 2 Al-Ni-Re tentative liquidus projection up to Al = 60 at.% [1999Cor2, 2003Bar]

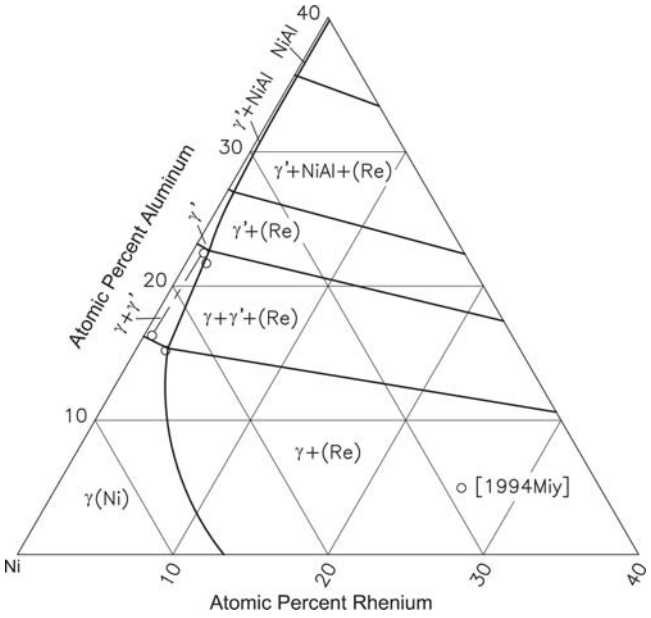

Fig. 3 Al-Ni-Re computed isothermal section at 1040 °C [1999Hua]

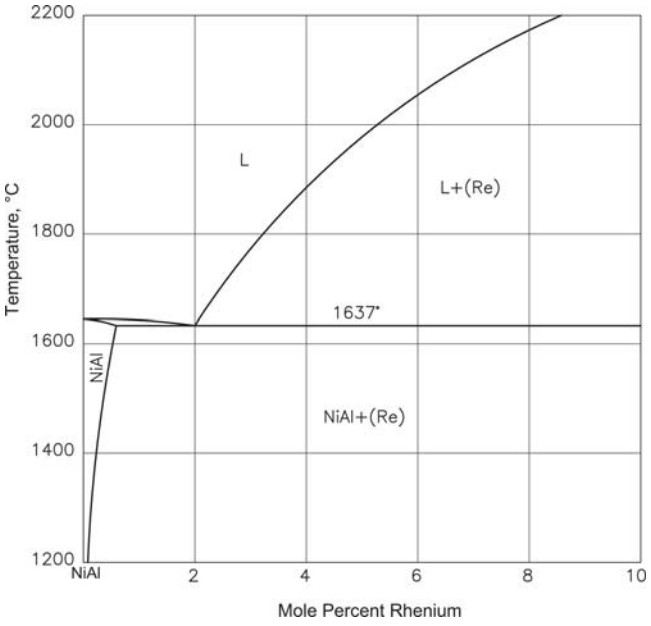

Fig. 4 Al-Ni-Re computed pseudobinary section along the NiAl-Re join [1999Hua]

and close-packed hexagonal (cph) phases as substitutional solutions with separate chemical and magnetic contributions to the excess Gibbs energy. The $L1_2$ phase was described with a two-sublattice model $(Al,Ni,Re)_{0.75}(Al,Ni,Re)_{0.25}$. The $B2$ phase was also described with a two-sublattice model $(Al,Ni,Re)_1(Ni,Re,Va)_1$. The interaction parameters obtained by optimization were listed.

In Fig. 3, the isothermal section at 1040 °C computed by [1999Hua] is redrawn with two experimental tie-lines from [1994Miy] for the γ(Ni)-γ′(Ni_3Al) equilibrium. The vertical section along the NiAl-Re join is pseudobinary, Fig. 4

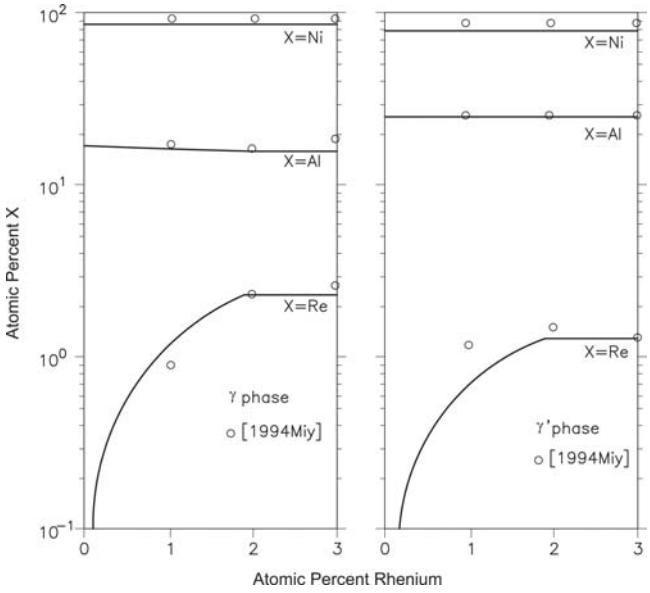

Fig. 5 Al-Ni-Re computed partitioning of Al, Ni and Re between γ and γ′ at 1040 °C with (Ni − Al) = 63 at.% [1999Hua]

[1999Hua]. The computed eutectic maximum on the NiAl-Re join occurs at 2 at.% Re and at 1637 °C.

[1994Miy] studied the partitioning of alloying elements between γ(Ni) and γ′(Ni_3Al) at 1040 °C by electron probe microanalysis. With starting metals of 99.99% Al, 99.9% Ni, and 99.96% Re, [1994Miy] prepared three alloys with Re contents of 1, 2, and 3 at.%, respectively, and a constant (Ni − Al) content of 63 at.%. Their results are compared with those computed by [1999Hua] in Fig. 5. The agreement is satisfactory. [1994Miy] also prepared six other alloys with Re content of 2 to 4 at.% to study the site preference of Re in Ni_3Al (γ′) and found that the Re atoms are located preferentially on Al sites in γ′, with an estimated occupation probability between 53 and 78%.

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