JPEDAV (2011) 32:64–66
DOI: 10.1007/s11669-010-9800-y
1547-7037 ©ASM International

Al-Ni-Pt (Aluminum-Nickel-Platinum)

V. Raghavan

The previous review of this ternary system by [2006Rag] presented a partial isothermal section at 1150 °C from the studies of [2005Hay]. Recently, new thermodynamic descriptions of this system were reported by [2009Lu] and [2010Zhu].

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; denoted γ′). The Al-Pt phase diagram [1986McA] depicts nine intermetallic phases: Pt_5Al_{21} (cubic), Pt_8Al_{21} (tetragonal), $PtAl_2$ ($C1$, CaF_2-type cubic), Pt_2Al_3 (hexagonal), PtAl ($B20$, FeSi-type cubic), β (52-56 at.% Pt; $B2$-type cubic), Pt_5Al_3 (Ge_3Rh_5-type orthorhombic), Pt_2Al ($PbCl_2$-type orthorhombic above 1060 °C and Pt_2Ga-type orthorhombic below 1060 °C), and Pt_3Al ($L1_2$, $AuCu_3$-type cubic and low-temperature Pt_3Ga-type tetragonal). The Ni-Pt phase diagram [2009Lu] depicts a large region of the continuous face-centered cubic (fcc) solid solution of Ni and Pt. At low temperatures, three ordered phases appear Ni_3Pt ($L1_2$, $AuCu_3$-type cubic), NiPt ($L1_0$, AuCu-type tetragonal) and $NiPt_3$ ($L1_2$, $AuCu_3$-type cubic).

Computed Ternary Phase Equilibria

Using selected data on the experimental phase equilibria and the thermodynamic properties, [2009Lu] first assessed the Ni-Pt binary system with particular reference to the stability region of the three ordered structures Ni_3Pt, NiPt and $NiPt_3$. All the four fcc-based phases: the disordered fcc solid solution, Ni_3Pt ($L1_2$), NiPt ($L1_0$) and $NiPt_3$ ($L1_2$) were described using a four sublattice model. First-principles calculations were also performed to estimate the ground-state energies of the ordered compounds. The assessment of [2000Wu] of the Al-Pt system was modified by [2009Lu], using the four sublattice model for the fcc-based structures.

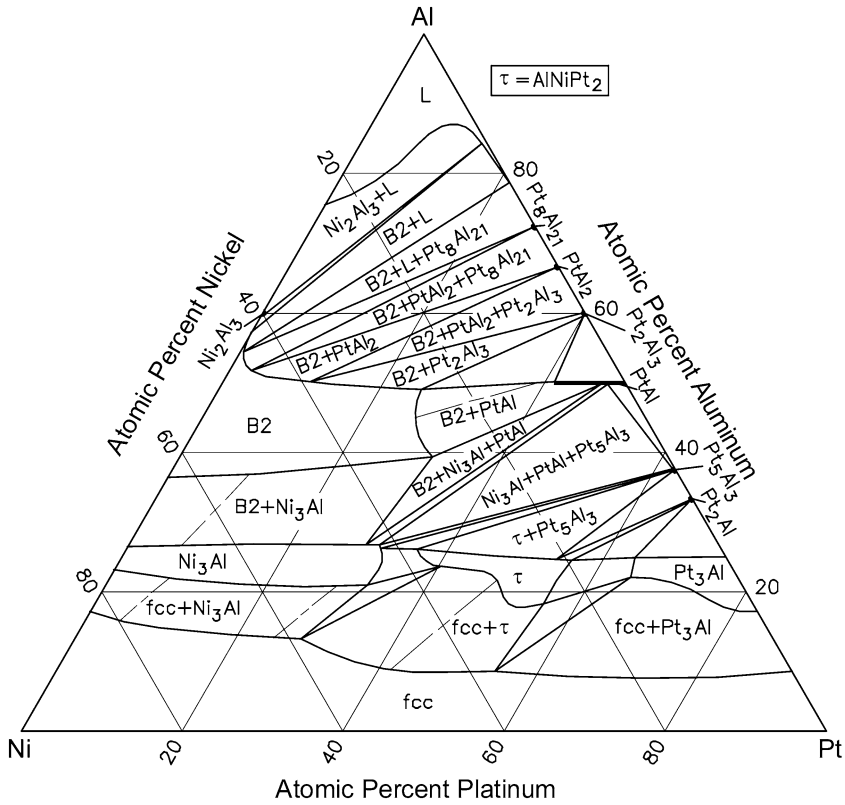

Fig. 1 Al-Ni-Pt computed isothermal section at 1100 °C [2009Lu]

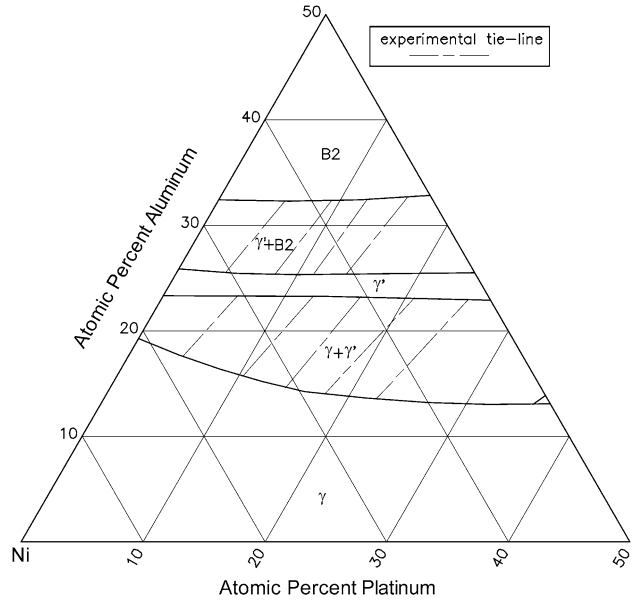

Fig. 2 Al-Ni-Pt computed isothermal section at 1250 °C for Ni-rich alloys [2010Zhu]

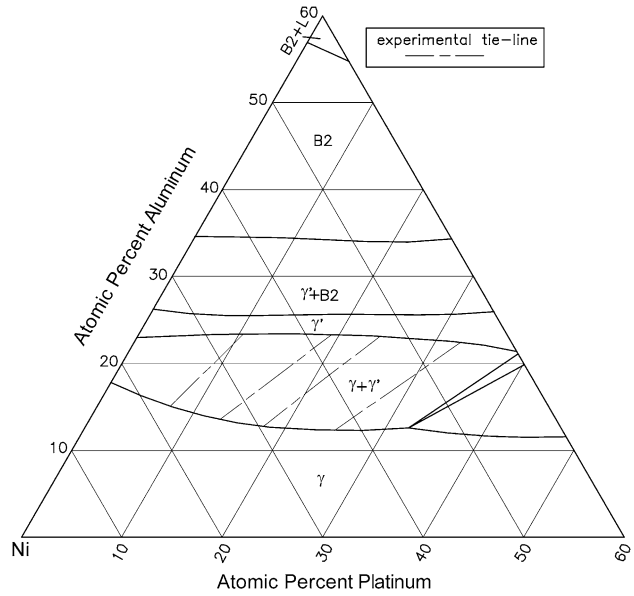

Fig. 3 Al-Ni-Pt computed isothermal section at 1160 °C for Ni-rich alloys [2010Zhu]

First principles calculations were also carried out to determine the formation energies of the fcc-based structures as well as the *B*2 and *B*20 phases. The Al-Ni description by [2003Sun] was adopted by [2009Lu].

As in the binary systems, a four sublattice model was used to describe the fcc-based phase that forms within the ternary region or those that extend into the ternary region from the binary sides. The isothermal section at 1100 °C computed by [2009Lu] is shown in Fig. 1. The ternary

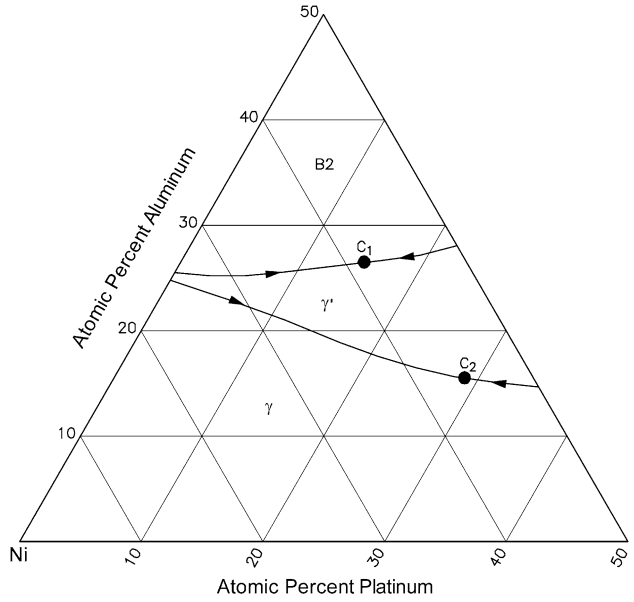

Fig. 4 Al-Ni-Pt computed liquidus projection for Ni-rich alloys [2010Zhu]

phase $AlNiPt_2$ (τ) [2005Hay] is present. The computed section was found to be in good agreement with the literature experimental data.

With starting metals of purity of 99.95% or better, [2010Zhu] made 14 Ni-rich ternary alloys that fall in the two-phase region of (γ + γ′) or (γ′ + *B*2). The alloys were annealed at 1250 or 1160 °C for 30 days. The phase equilibria were studied with scanning electron microscopy and x-ray powder diffraction. The compositions of the co-existing phases were measured with an electron probe microanalyzer.

The cluster/site approximation was used to evaluate the thermodynamic parameters of the fcc-based phases. The liquid was described as a substitutional solution, taking into consideration the ternary interaction. The *B*2 phase was modeled using two sublattices, with all three elements residing in both sublattices. The optimized interaction parameters were listed. Two isothermal sections at 1250 and 1160 °C were calculated for Ni-rich alloys. These are shown in Fig. 2 and 3, along with experimental tie-lines [2010Zhu]. The agreement is satisfactory. The computed liquidus projection is shown in Fig. 4. The two liquidus lines depict a saddle-point minimum marked C_1 and C_2. There are no invariant reactions in this region of the system.

References

1986McA: A.J. McAlister and D.J. Kahan, The Al-Pt (Aluminum-Platinum) System, *Bull. Alloy Phase Diagr.*, 1986, **7**(1), p 47-51

1993Oka: H. Okamoto, Al-Ni (Aluminum-Nickel), *J. Phase Equilib.*, 1993, **14**(2), p 257-259

2000Wu: K. Wu and Z. Jin, Thermodynamic Assessment of the Al-Pt Binary System, *J. Phase Equilib.*, 2000, **21**(3), p 221-226

2003Sun: B. Sundman and N. Dupin, *JEEP Conference*, Lyon, 2003, quoted by [2009Lu]

2005Hay: S. Hayashi, S.I. Ford, D.J. Young, D.J. Sordelet, M.F. Besser, and B. Gleeson, α-NiPt(Al) and Phase Equilibria in the Ni-Al-Pt System at 1150 °C, *Acta Mater.*, 2005, **53**, p 3319-3328

2006Rag: V. Raghavan, Al-Ni-Pt (Aluminum-Nickel-Platinum), *J. Phase Equilib. Diffus.*, 2006, **27**(5), p 497-498

2009Lu: X.G. Lu, B. Sundman, and J. Agren, Thermodynamic Assessments of the Ni-Pt and Al-Ni-Pt Systems, *CALPHAD*, 2009, **33**, p 450-456

2010Zhu: J. Zhu, C. Zhang, D. Ballard, P. Martin, J. Fournelle, W. Cao, and Y.A. Chang, Study of the Ni-Rich Multi-Phase Equilibria in Ni-Al-Pt Alloys Using the Cluster/Site Approximation for the Face-Centered Cubic Phases, *Acta Mater.*, 2010, **58**, p 180-188