

Al – Ni (Aluminum – Nickel)

Phase diagram

Huang et al. [98 Hua] have calculated the phase equilibria in the Al-Ni system. The results are reproduced by [99 Lu], too. They are given in Fig. 1.

To describe the thermodynamic properties and the phase equilibria Ansara et al. [97 Ans] have used a sub-lattice model. On the basis of this model and all thermodynamic data for the Al-Ni-system present in the literature the above mentioned authors have calculated an assessed phase diagram (Fig. 1). Fig. 2 gives the part around 75 at% Ni in an enlarged version.

As can be seen from Fig. 2 near 75 at% Ni a stable and a metastable eutectic can be obtained [94 Lee]. It should be mentioned that in the literature concerning superalloys, AlNi_3 is called γ' , whereas the Ni-rich solid solution (Ni) is noted γ and the Ni-poor NiAl- compound named β . The solid phases of the metastable eutectic thus consist of β and γ . The stable one is occurring at 79.4 at% Ni, the metastable eutectic in the concentration range from 79.5 at% Ni to 79.6 at% Ni. Impurities of Cr, Fe or Si accelerate the formation of the metastable eutectic.

Some of the results have been obtained by diffusion couple experiments as well as directional solidification studies [94 Lee].

A short review of phase equilibria is given by Okamoto [93 Oka]. The phase diagram recommended is very similar to that given in Fig. 1.

The liquidus has been investigated by Lee et al. [94 Lee] thoroughly. The results near the stoichiometry AlNi are given in Fig. 3.

Thermodynamics

In the course of modelling mentioned above, [97 Ans] have calculated enthalpies of mixing of liquid alloys. The results served to draw Fig. 4. They are very similar to ΔH^L - values published by [Landolt-Börnstein] and also very similar to those published by [93 Sto] for the temperature of 1923 K.

Furtheron, [97 Ans] have calculated enthalpies of formation of solid alloys, referred to pure fcc Al and fcc Ni (see Fig. 5). The temperature dependence of the enthalpy of formation of AlNi_3 has been determined by Al solution calorimetry [96 Rzy]. The results are given in Table 1.

Table 1. Al–Ni. Enthalpies of formation of AlNi_3 as a function of temperature [96 Rzy].

Temperature [K]	ΔH^S [kJ g-atom ⁻¹]
300	- 41.3 ± 1.3
521	- 43.0 ± 1.1
756	- 41.6 ± 1.2
947	- 42.2 ± 1.0
1123	- 42.3 ± 1.6

A thermodynamic assessment, also, has been performed by Du et al. [96 Du] using the Calphad method. Thermodynamic activities obtained for liquid alloys at 2000 K are given in Fig. 6. At concentrations > 80 at% Ni there is a good agreement with experimentally determined activities ([90 Hil], [91 Mar]).

By mechanical alloying nanocrystalline AlNi_3 -based alloys can be prepared. On heating the nanocrystalline samples a broad exothermic transformation takes place. Surinach et al. [93 Sur] found that the released energy is much higher than that which can be stored by usual deformation.

Partial molar Gibbs enthalpies in liquid Al-Ni alloys at 1873K [93 Sto] compared with results from literature are reproduced in Fig. 7.

Figures

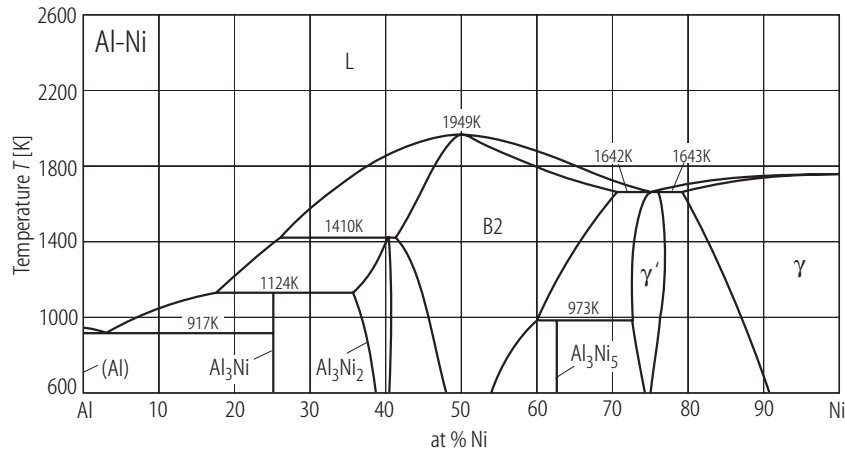


Fig. 1. Al-Ni. Assessed phase diagram [97 Ans].

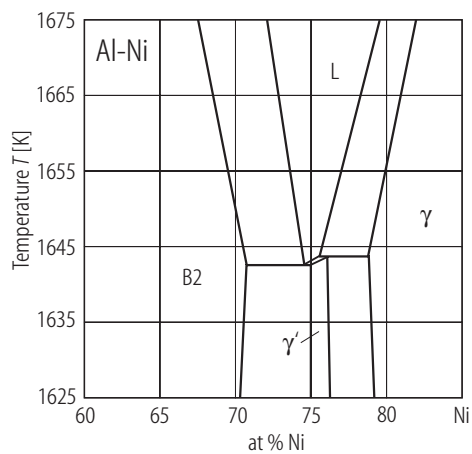


Fig. 2. Al-Ni. Phase equilibria near 75 at% Ni in more detail [94 Lee].

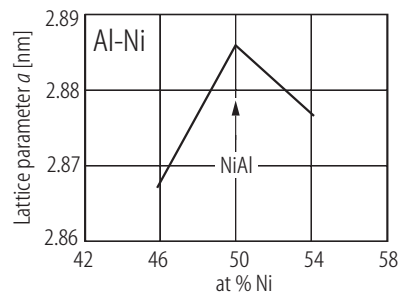


Fig. 3. Al-Ni. Liquidus near the stoichiometry NiAl [94 Lee].

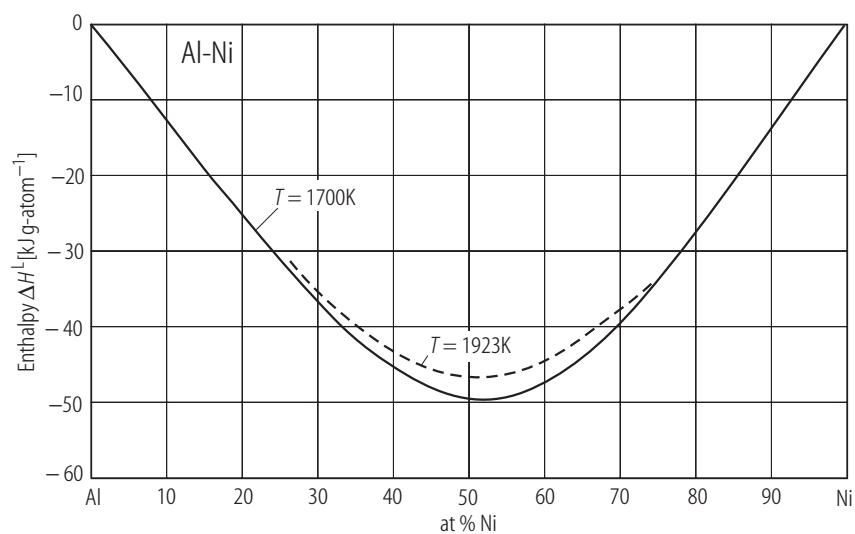


Fig. 4. Al-Ni. Calculated enthalpies of mixing of liquid alloys [97 Ans].

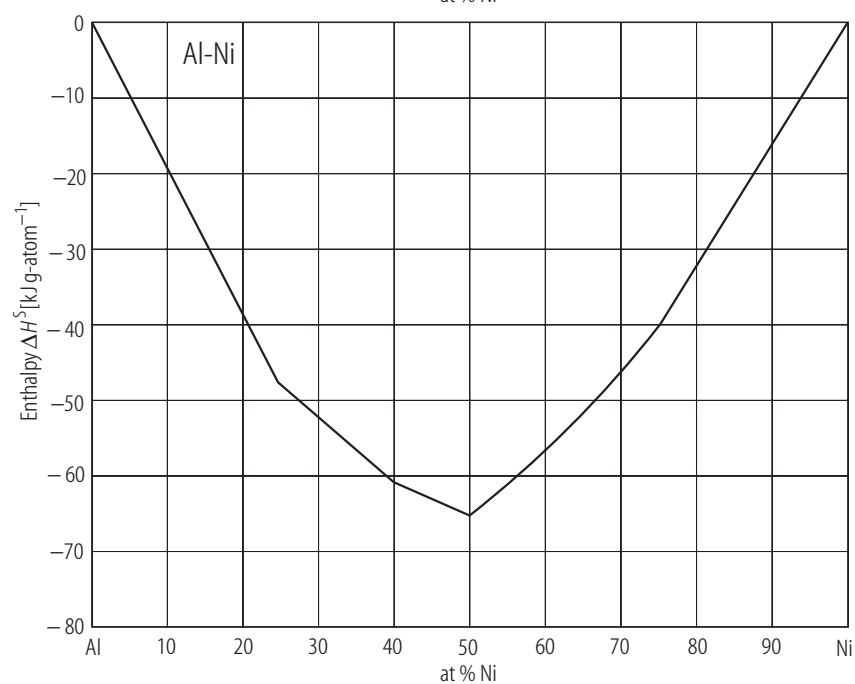


Fig. 5. Al-Ni. Calculated enthalpies of formation of solid alloys referred to pure fcc Al and fcc Ni [97 Ans].

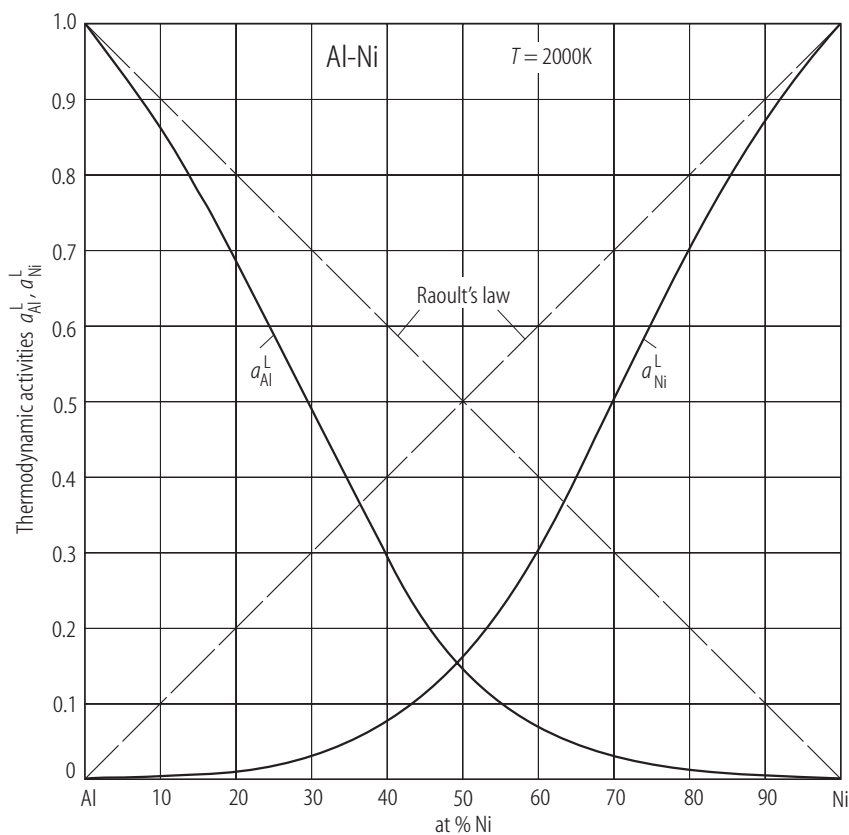


Fig. 6. Al-Ni. Calculated thermodynamic activities of liquid alloys [96 Du].

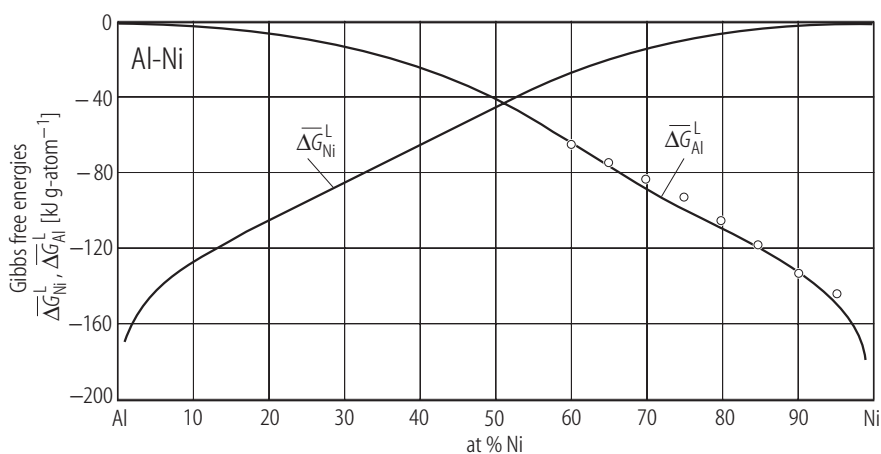


Fig. 7. Al-Ni. Calculated partial Gibbs enthalpies for liquid alloys [93 Sto]. Circles: [65 Vac].

References

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