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Fe-Ni-Pd (Iron-Nickel-Palladium)

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The previous review of this system by [1992Rag] presented a liquidus surface. The predominant phase of primary crystallization on this surface is the continuous face-centered cubic (fcc) solid solution γ. Recently, [2005Hor] combined the cluster variation method with the Lennard-Jones type of pairwise atomic interaction energies, to compute the phase equilibria in the region of the ordered $L1_0$ phase.

Binary Systems

The Fe-Ni phase diagram [1991Swa] is characterized by a very narrow solidification range. A continuous solid solution denoted γ between face-centered cubic (fcc) Fe and Ni is stable over a wide range of temperature. At 517 °C, an ordered phase $FeNi_3$ ($L1_2$, $AuCu_3$-type cubic) forms congruently from γ. Two other ordered phases FeNi ($L1_0$, AuCu-type tetragonal) and Fe_3Ni ($L1_2$, $AuCu_3$-type cubic) are known and considered to be metastable [1991Swa]. The first-principle calculations of [2004Moh], however, suggested that $L1_0$ is a stable phase. In the Fe-Pd system [1993Oka], a continuous fcc solid solution γ forms between fcc Fe and Pd in the temperature range of 1300 to 900 °C. Two superstructures, FePd (AuCu-type tetragonal) and $FePd_3$ ($AuCu_3$-type cubic), form congruently from γ at 790 and 820 °C, respectively. They have appreciable homogeneity ranges at lower temperatures. The Ni-Pd system is an isomorphous one, with the fcc phase γ present at all subsolidus temperatures.

Ternary Isothermal Sections

[2005Hor] calculated and listed the Lennard-Jones type pairwise atomic interaction energies for the six pairs of atoms (Fe-Fe, Fe-Ni, etc.) of this ternary system. The tetragonality of the $L1_0$ structure was taken into account in determining the interatomic distances. The entropy term was estimated by the tetrahedron approximation of the cluster variation method. The free energy minimization was carried out by the Kikuchi iteration procedure. The partial isothermal sections calculated by [2005Hor] in the region of the $L1_0$ phase at 650, 590, and 550 °C are shown in Fig. 1.

The calculations were checked with a limited number of experiments using an Fe-5 at.% Pd-5 at.% Ni alloy. The alloy in the martensitic condition was aged at 590 °C just below the solvus of the $L1_0$ phase in the Fe-Pd system to allow its precipitation. The composition of the matrix and the precipitate analyzed with the energy dispersive spectroscopy indicated that Ni preferentially substitutes for Pd in the $L1_0$ phase.

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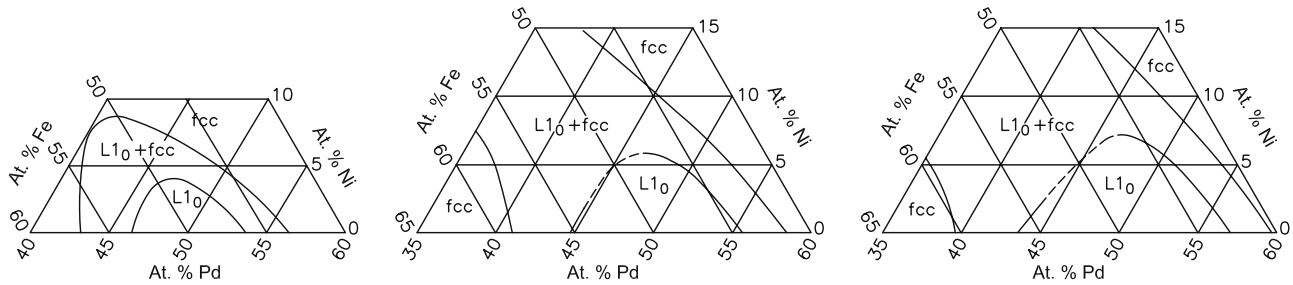

Fig. 1 Fe-Ni-Pd computed partial isothermal sections at (a) 650, (b) 590, and (c) 550 °C [2005Hor]