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Al-Fe-Pd (Aluminum-Iron-Palladium)

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The review of this system by [1992Rag] presented an isothermal section at 500 °C, which depicted no ternary compounds. The update by [2005Rag] reviewed the results of Balanetskyy et al. [2004Bal1, 2], who found three cubic ternary phases and two orthorhombic phases in Al-rich alloys in the temperature range of 1020-750 °C. Recently, Balanetskyy et al. made a detailed study of the solidification characteristics of ternary alloys in the range of 50-100 at.% Al [2005Bal1].

Binary Systems

The Al-Fe phase diagram [1993Kat] shows the face-centered cubic (fcc) solid solution based on Fe is restricted by a γ loop. The body-centered cubic (bcc) solid solution exists in the disordered *A*2 form as well as ordered *B*2 and *D*0_3 forms. Apart from the high-temperature phase ε (58-65 at.% Al; stable between 1232 and 1102 °C), three other intermediate phases exist: $FeAl_2$ (triclinic), Fe_2Al_5 (orthorhombic), and $FeAl_3$ or Fe_4Al_{13} (monoclinic). In the Al-Pd system [1986McA], the intermediate phases in the 50-100 at.% Al range are: Al_4Pd (hexagonal), Al_5Pd_2 (orthorhombic), Al_3Pd_2 ($D5_{13}$, Al_3Ni_2-type hexagonal), and AlPd (*B*2, CsCl-type cubic; denoted β). In the Fe-Pd system, a continuous fcc solid solution γ forms between fcc Fe and Pd in the temperature range of 1300-900 °C. At lower temperatures, two superstructures are known: FePd (AuCu-type tetragonal) and $FePd_3$ ($AuCu_3$-type cubic).

Ternary Phases

Recent work of [2004Bal1] and [2004Bal2] (reviewed in [2005Rag]) have revealed the presence of a number of Al-rich ternary phases in the temperature range of 1020-750 °C. Three cubic phases are designated as $C(Pm\bar{3})$, $C_1(Im\bar{3})$, and $C_2(Fm\bar{3})$, each with a significant homogeneity range. The *O* and *N* phases are of orthorhombic symmetry. A decagonal phase *D* with ~1.6 nm periodicity forms from the liquid in alloys between 73-82 at.% Al and 10-17 at.% Pd. This phase was found to be metastable [2005Bal2].

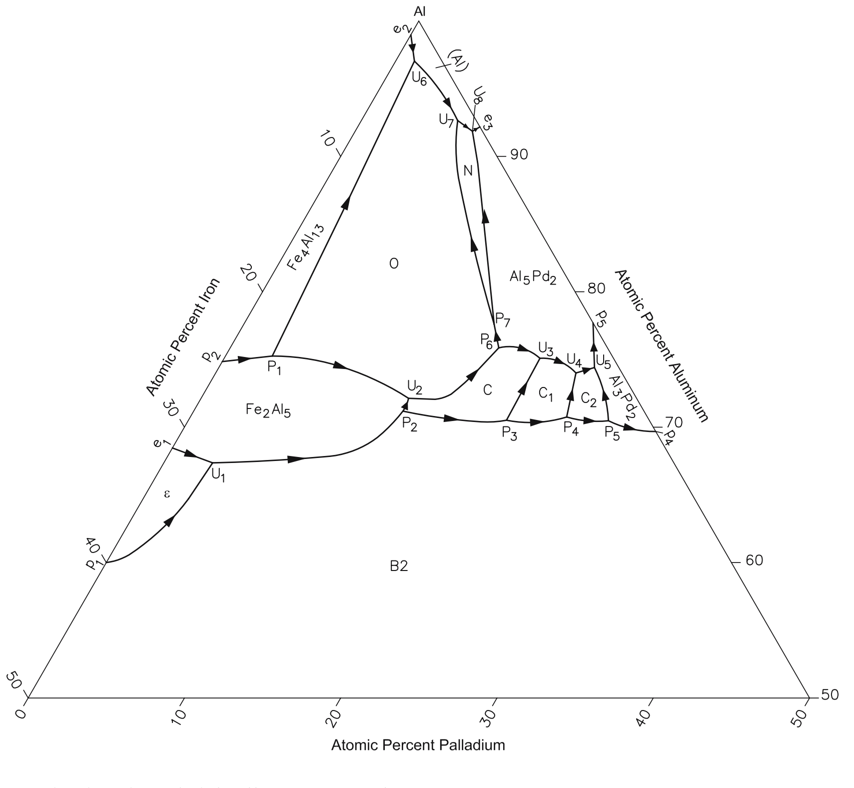

Fig. 1 Al-Fe-Pd liquidus projection for Al-rich alloys [2005Bal1]

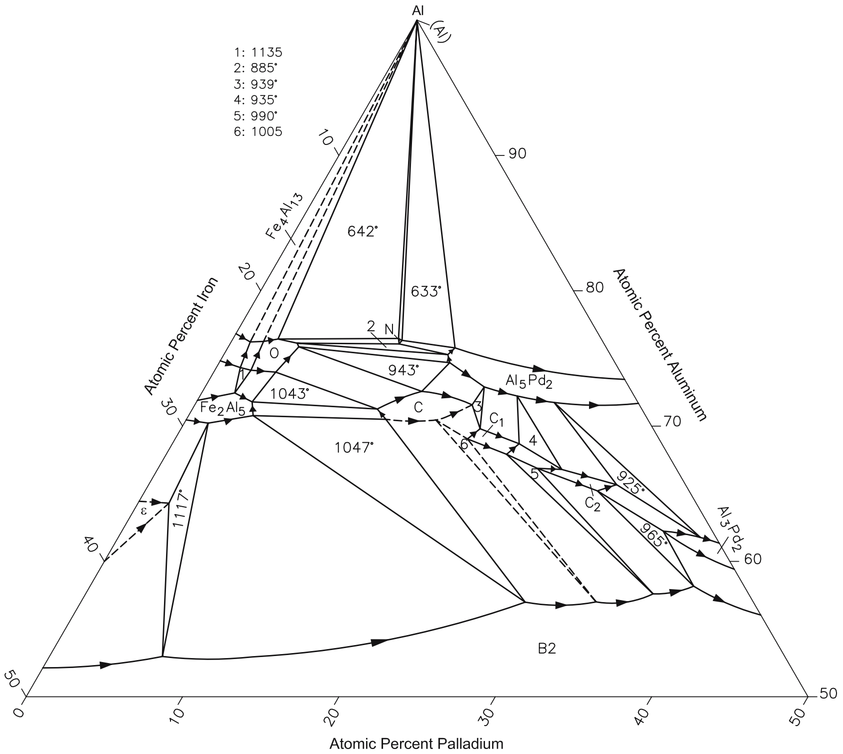

Fig. 2 Al-Fe-Pd solidus projection for Al-rich alloys [2005Bal1]

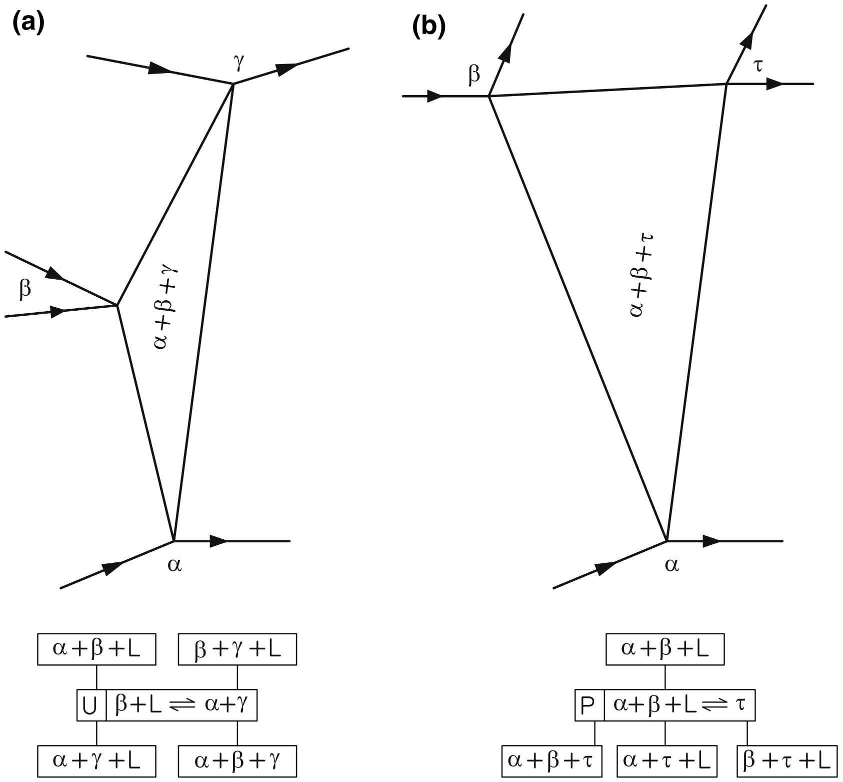

Fig. 3 Schematic illustration of the solidus surface near the invariant reactions (a) U and (b) P

Liquidus and Solidus Projections

[2005Bal1] carried out differential thermal analysis at a heating/cooling rate of 2-20 °C per min on the same 69 alloys that were used for the determination of the isothermal sections by [2004Bal1]. The phase structure was studied by scanning and transmission electron microscopy, energy dispersive x-ray analysis, and x-ray powder diffraction. The liquidus projection constructed by [2005Bal1] for the 50-100 at.% Al region is redrawn in Fig. 1. The univariant and invariant reactions in Fig. 1 are numbered the same way as in [2005Bal1]. The phases of primary crystallization are marked. The ternary phases O, C, C_1, C_2, and N form through ternary peritectic reactions P_1, P_2, P_3, P_4, and P_7 at 1135, 1047, 1005, 990, and 885 °C, respectively. The binary phases Al_3Pd_2 (denoted δ by [2005Bal1]) and Al_5Pd_2 (denoted ε by [2005Bal1]) nucleate in the ternary region through the reactions P_5 and P_6 at 965 and 943 °C, respectively. The $B2$ (β) phase is present over a large area as a primary phase. The N phase was not observed experimentally as a primary phase and its formation through P_7 shown in Fig. 1 is tentative. [2005Bal1] listed the compositions of the phases taking part in the invariant reactions.

The projection of the solidus surface determined by [2005Bal1] for the 50-100 at.% Al region is shown in Fig. 2. The temperature decreases in the direction of the arrow on a curve that traces the composition of that solid phase. The tie-triangles give the compositions of the co-existing solid phases immediately after solidification. These three-phase equilibria emerge from the invariant four-phase reactions shown on the liquidus surface in Fig. 1. The invariant-reaction temperatures are shown inside the tie-triangles. As illustrated schematically in Fig. 3, two types of topology are seen corresponding to the invariant reaction U or P.

[2005Bal1] also presented a reaction scheme that is consistent with the liquidus surface and the isothermal sections of [2004Bal1, 2].

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