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Al-Pd-Rh (Aluminum-Palladium-Rhodium)

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Recently, [2006Prz] reported four partial isothermal sections for Al-rich alloys of this system at 1100, 1000, 900, and 790 °C.

Binary Systems

The Al-Pd phase diagram [2001Yur] depicts the following intermediate phases: $PdAl_4$ (hexagonal, space group $P6_322$), $PdAl_3$ (denoted ε_6, orthorhombic), ε_{28} ($\sim PdAl_3$, orthorhombic), Pd_8Al_{21} (Pt_8Al_{21}-type tetragonal), Pd_2Al_3 (denoted δ, $D5_{13}$, Ni_2Al_3-type hexagonal), PdAl (*B*2-type cubic and two low-temperature forms: rhombohedral and *B*20-type cubic), Pd_5Al_3 (Rh_5Ge_3-type orthorhombic), Pd_2Al (*C*23, Co_2Si-type orthorhombic), and Pd_5Al_2 (Pd_5Ga_2-type orthorhombic). The Al-Rh phase diagram, shown in Fig. 1 [2006Kho], depicts the following intermediate phases: Rh_2Al_9 ($D8_d$, Co_2Al_9-type monoclinic), $Rh_{1-x}Al_3$ (orthorhombic, denoted O_1 or ε_{16}), $RhAl_3$ (orthorhombic, denoted O_2 or ε_6), Rh_2Al_5(c) (space group $Pm\bar{3}$, cubic, denoted C), Rh_2Al_5(h) ($D8_{11}$, Co_2Al_5-type hexagonal, denoted H), Rh_3Al_7 (monoclinic, denoted V), and RhAl (*B*2, CsCl-type cubic). Pd and Rh form a continuous face-centered cubic (fcc) solid solution, with a miscibility gap below 845 °C [Massalski2].

Ternary Isothermal Sections

[2006Prz] melted a number of Al-rich ternary alloys in an induction furnace under Ar atm. The alloys were annealed at 1100-790 °C for 24-2610 h and quenched in water. The phase structures were studied by scanning and transmission electron microscopy and x-ray diffraction. Local composition analysis was done with electron probe microanalysis and with inductively-coupled plasma optical emission spectroscopy. Differential thermal analysis was carried out at heating/cooling rates of 10-50 °C per min.

Results of a limited number of experiments indicated a continuous solid solution between the isostructural binary compounds PdAl and RhAl. The ε-family of orthorhombic phases exhibit the same lattice parameters along two axes and a varying parameter along the third. Metallographic examination of phases in the ε-range did not indicate any compositional contrast. [2006Prz] clubbed all ε variants together and labeled them as a single solid solution labeled ε. [2006Prz] found two ternary cubic phases structurally related to C. One of them denoted C_2 has a lattice parameter $a \sim 1.5483$ nm, which is approximately twice that of C. The C_2 phase occurs over a range of Pd content of 4-27 at.% and is stable in the investigated temperature range of 1100-790 °C. The melting point and the lattice parameter of C_2 decrease with the increase in Pd content. At 900 °C, another ternary phase C_3 with hexagonal parameters $a = 1.0916$ nm and $c = 1.3386$ nm appears and is structurally related to C. C_3 forms in the solid state between 925 and 831 °C, as the Pd content varies from 4 to 13 at.%.

The four isothermal sections for Al-rich alloys at 1100, 1000, 900, and 790 °C are shown in Fig. 2-5 [2006Prz]. At 1100 °C (Fig. 2), the maximum solubility of Al in (Pd,Rh)Al reaches 58 at.%. The Rh_2Al_5(c), ε, and V phases dissolve 11, 9, and 3 at.% Pd, respectively. The composition range of C_2 extends from $Al_{66}Pd_4Rh_{30}$ to $Al_{64}Pd_{20.5}Rh_{15.5}$. At 1000 °C

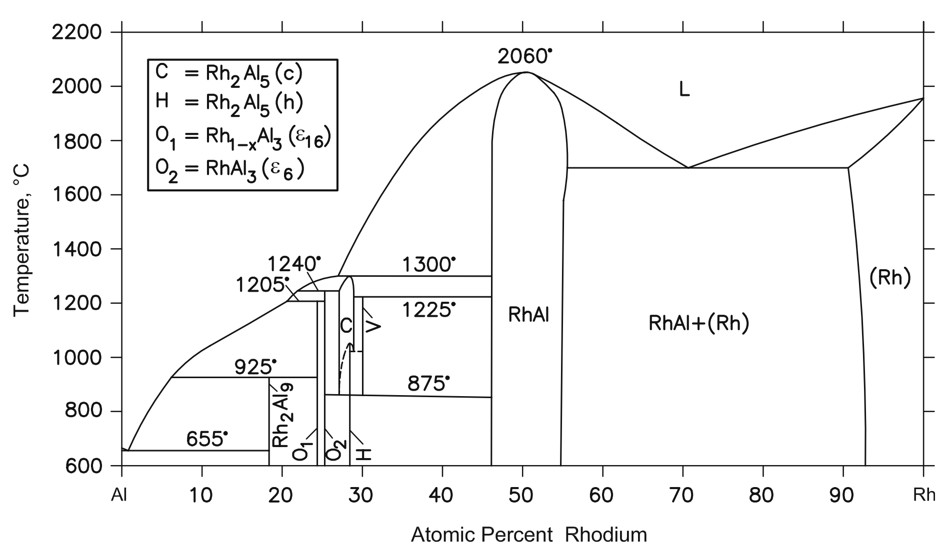

Fig. 1 Al-Rh phase diagram [2006Prz]

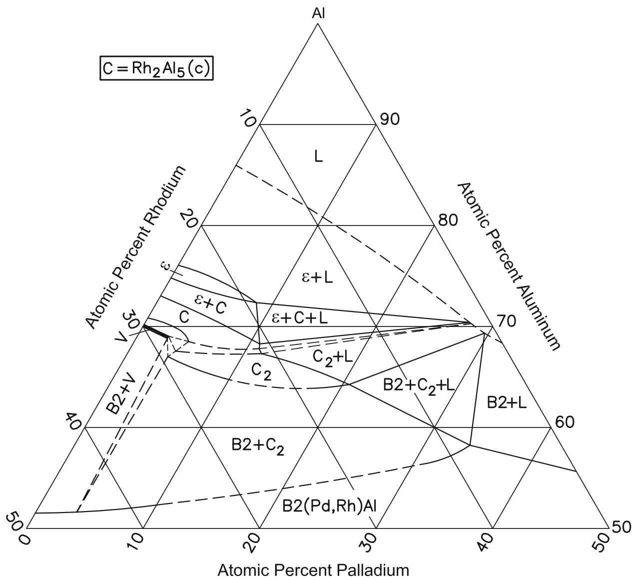

Fig. 2 Al-Pd-Rh isothermal section at 1100 °C [2006Prz]

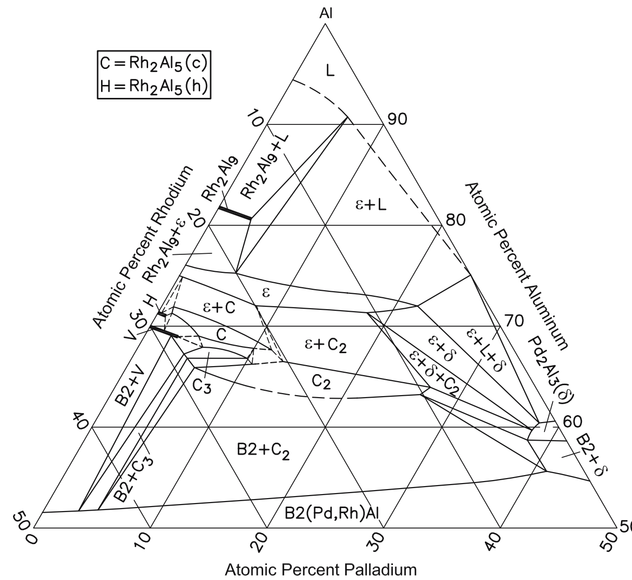

Fig. 4 Al-Pd-Rh isothermal section at 900 °C [2006Prz]

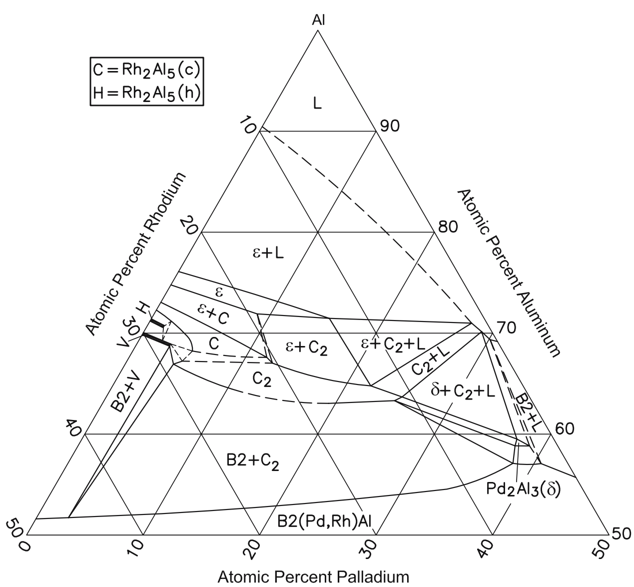

Fig. 3 Al-Pd-Rh isothermal section at 1000 °C [2006Prz]

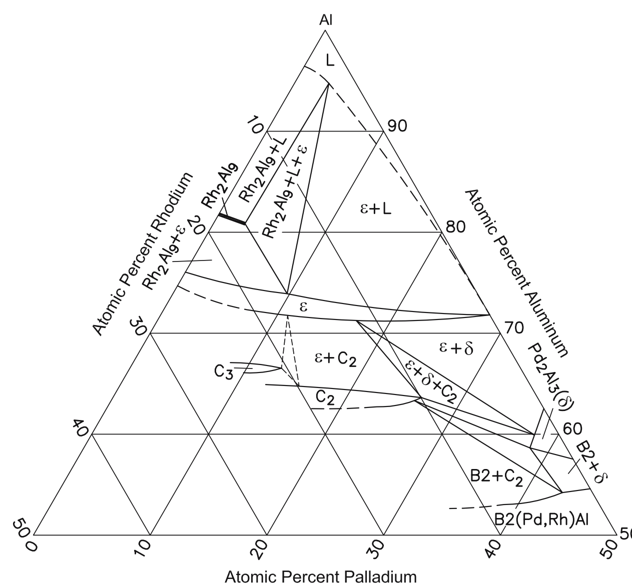

Fig. 5 Al-Pd-Rh partial isothermal section at 790 °C [2006Prz]

(Fig. 3), the C_2 phase extends further up to 25 at.% Pd. The H, C, ε and V phases dissolve up to 2, 13, 15, and 3 at.% Pd respectively. Pd_2Al_3 (δ) is present in the ternary region. At 900 °C (Fig. 4), Rh_2Al_9 is present and dissolves up to 3.5 at.% Pd. The ε, H and V phases dissolve up to 22, 1, and 3 at.% Pd. Pd_2Al_3 (δ) extends up to the binary side and dissolves 3 at.% Rh. The maximum solubility of Al in (Pd,Rh)Al has decreased to 55 at.% [2006Prz]. At 790 °C (Fig. 5), the ε phases form a continuous solid solution. The solubility of the third component in the binary phases is about the same as at 900 °C.

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