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Al-Pd-Ru (Aluminum-Palladium-Ruthenium)

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This ternary system was investigated by [2008Pav], who reported three isothermal sections at 1100, 1050 and 1000 °C for Al-rich alloys, which were reviewed by [2009Rag]. Recently, [2009Pav] presented an extension of this study to the temperature range of 900-790 °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), $\sim PdAl_3$ (denoted ε_{28}, 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-Ru phase diagram [2003Mi] depicts six intermediate phases: $RuAl_6$ (orthorhombic, space group *Cmcm*), Ru_4Al_{13} (monoclinic, space group *C*2/*m*), Ru_2Al_5 (orthorhombic, space group *Cmcm*), $RuAl_2$ (*C*54, $TiSi_2$-type orthorhombic), Ru_2Al_3 (Os_2Al_3-type tetragonal), and RuAl (*B*2, CsCl-type cubic). The Pd-Ru phase diagram [Massalski2] is a simple peritectic system, with no intermediate phases.

Ternary Phases

In addition to the icosahedral phase I, the occurrence of three cubic phases: C (primitive cubic, $Pm\bar{3}$), C_1 (body-centered cubic, $Im\bar{3}$) and C_2 (face-centered cubic, $Fm\bar{3}$) were reported by [2008Pav], while investigating this system in the temperature range of 1100-1000 °C. All these four phases were found by [2009Pav] to be stable down to at least 790 °C. Instead of the F_{40} structure reported by [2008Pav] at the Ru-rich end of the I phase, [2009Pav] found a primitive structure labeled P_{40} (space group $Pa\bar{3}$) with the lattice parameter a = 4.0445 nm, which is essentially the same as that of F_{40}. Apart from this, an additional primitive cubic phase labeled P_{20} was found at the Pd-rich end of the I region, with a = 2.0227 nm, which is half of the lattice parameter of P_{40}. The phases P_{40} and P_{20} were found both at 900 and 790 °C even after prolonged annealing, but their thermodynamic stability is not firmly established [2009Pav]. Also, no compositional gap separating them from I could be detected

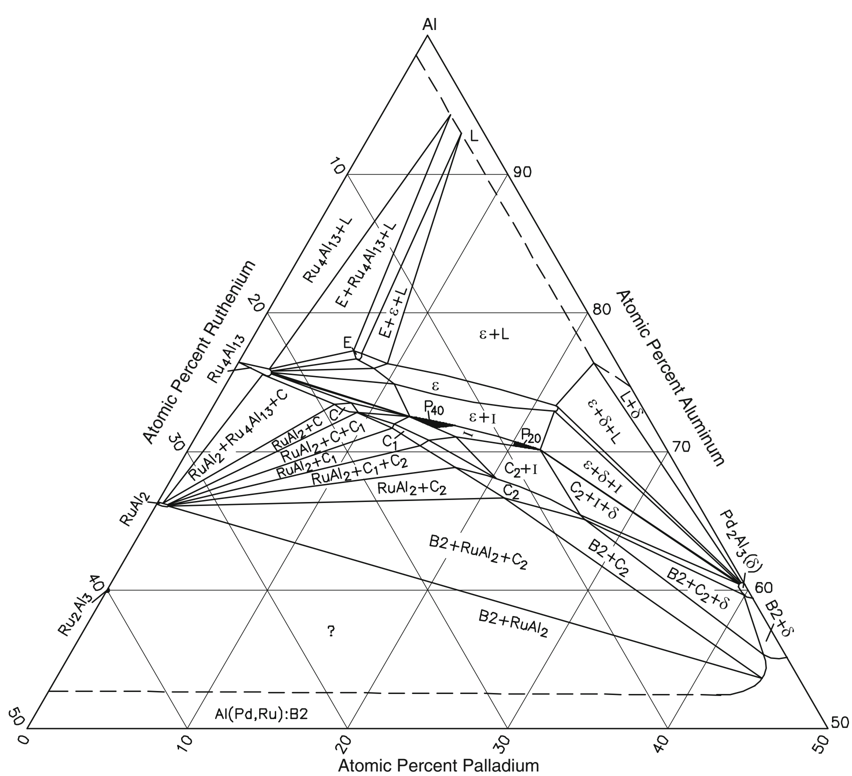

Fig. 1 Al-Pd-Ru isothermal section at 900 °C for Al-rich alloys [2009Pav]

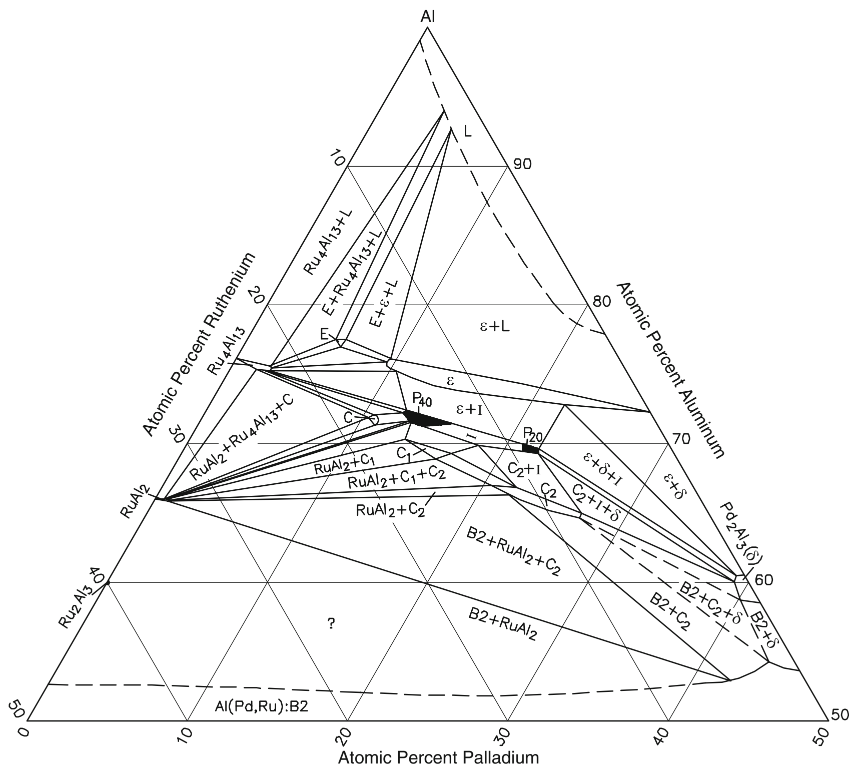

Fig. 2 Al-Pd-Ru isothermal section at 790 °C for Al-rich alloys [2009Pav]

in the experiments [2009Pav]. New complex orthorhombic structures labeled as E were found at the Ru-rich end of the ε region. The results indicated that the E phases were separated by a compositional gap from the ε region.

Isothermal Sections

With starting metals of 99.999% Al, 99.95% Pd and 99.9% Ru, [2009Pav] levitation-melted more than 60 alloys. The samples were annealed at 900 °C for 836 h or at 790 °C for 4500 h. The phase equilibria were studied by scanning and transmission electron microscopy, x-ray powder diffraction and differential thermal analysis at heating rates of 5-20 °C per min. The local composition was determined by inductively-coupled plasma optical emission spectroscopy and energy dispersive x-ray analysis. The isothermal sections constructed by [2009Pav] at 900 and 790 °C are shown in Fig. 1 and 2. The ternary phases C, C_1, C_2, I, P_{40}, P_{20} and E are present. The ε-related phases are clubbed together as ε. At 900 °C (Fig. 1), ε has a range from $Al_{72.5}Pd_{21}Ru_{6.5}$ to $Al_{77}Pd_{7.5}Ru_{15.5}$. Pd_2Al_3 (δ) dissolves 1 at.% Ru. Ru_4Al_{13} and $RuAl_2$ dissolve $<$2.5 and 1 at.% Pd respectively. At 700 °C (Fig. 2), the ε region extends up to the Al-Pd side. Pd_2Al_3 (δ) dissolves about 2 at.% Ru. The solubility of Pd in Ru_4Al_{13} and $RuAl_2$ is about the same as at 900 °C.

References

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