

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

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Recently, [2008Pav] determined three isothermal sections for Al-rich alloys of this system at 1100, 1050, and 1000 °C, which depict the three ternary cubic phases and the quasicrystalline icosahedral phase I.

CsCl-type cubic). The Pd-Ru phase diagram [Massalski2] is a simple peritectic system, with no intermediate phases.

Binary Systems

The Al-Pd phase diagram [2001Yur] depicts the following intermediate phases: PdAl₄ (hexagonal, space group *P*6₃22), PdAl₃ (denoted ε₆, orthorhombic), ~PdAl₃ (denoted ε₂₈, orthorhombic), Pd₈Al₂₁ (Pt₈Al₂₁-type tetragonal), Pd₂Al₃ (denoted δ, *D*5₁₃, Ni₂Al₃-type hexagonal), PdAl (*B*2-type cubic and two low-temperature forms: rhombohedral and *B*20-type cubic), Pd₅Al₃ (Rh₅Ge₃-type orthorhombic), Pd₂Al (*C*23, Co₂Si-type orthorhombic), and Pd₅Al₂ (Pd₅Ga₂-type orthorhombic). The Al-Ru phase diagram [2003Mi] depicts six intermediate phases: RuAl₆ (orthorhombic, space group *Cmcm*), Ru₄Al₁₃ (monoclinic, space group *C*2/*m*), Ru₂Al₅ (orthorhombic, space group *Cmcm*), RuAl₂ (*C*54, TiSi₂-type orthorhombic), Ru₂Al₃ (Os₂Al₃-type tetragonal), and RuAl (*B*2,

Ternary Phase Equilibria

Three ternary cubic phases were identified by [2008Pav] in the temperature range of 1100-1000 °C: the primitive cubic phase (*Pm* $\bar{3}$; denoted C) melts at 1326 °C and has a composition range of ~Al₇₃Pd₅Ru₂₂-Al_{70.5}Pd₁₅Ru_{14.5}. The lattice parameter at the Al_{74.4}Pd_{7.5}Ru_{18.1} is $a = 0.77568$ nm [2008Pav]. The body-centered cubic phase C₁ (*Im* $\bar{3}$) forms below 1000 °C. The lattice parameter is twice as large as that of C, equal to 1.5532 nm at the composition Al₇₁Pd_{12.5}Ru_{16.5} in samples annealed at 900 °C. The face-centered cubic phase C₂ (*Fm* $\bar{3}$) forms at 1184 °C and has a compositional range of ~Al_{69.5}Pd_{14.5}Ru₁₆-Al₆₈Pd₂₃Ru₉. The lattice parameter $a = 1.55695$ nm at Al_{67.7}Pd_{19.7}Ru_{12.6} [2008Pav]. [2008Pav] did not confirm the existence of the cubic phase at the composition Al₆₈Pd₂₀Ru₁₂ reported earlier by [1996Mah].

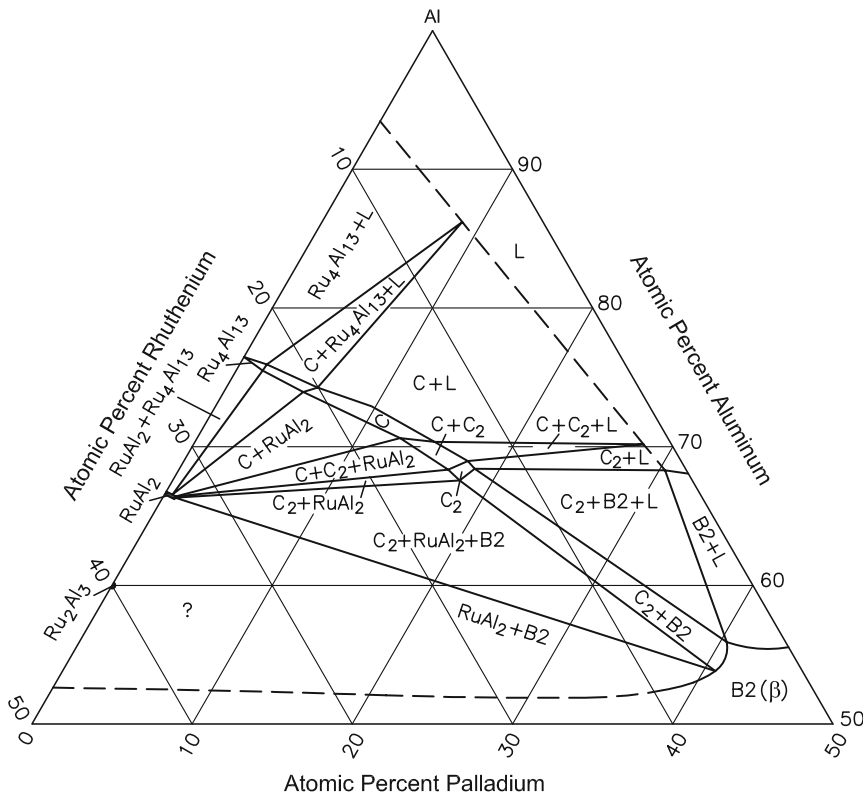


Fig. 1 Al-Pd-Ru partial isothermal section at 1100 °C for Al-rich alloys [2008Pav]

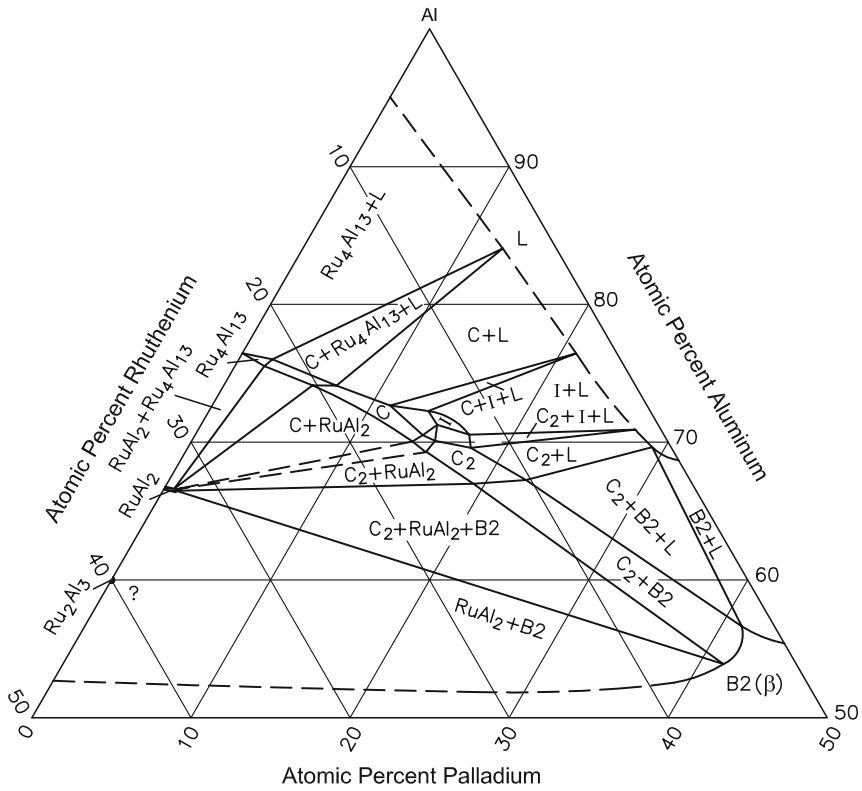


Fig. 2 Al-Pd-Ru partial isothermal section at 1050 °C for Al-rich alloys [2008Pav]

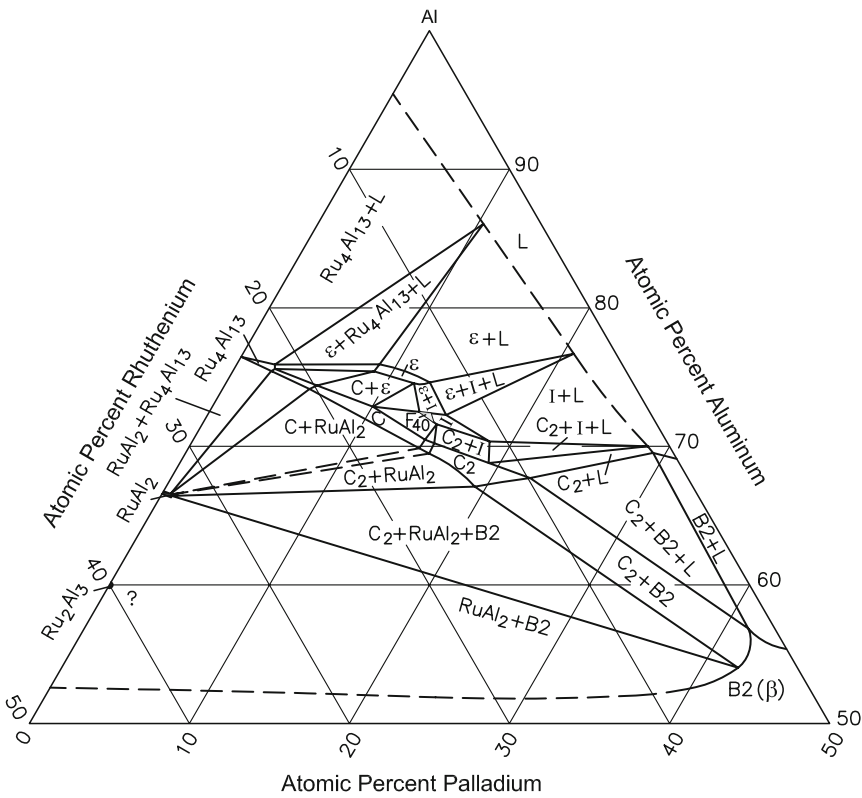


Fig. 3 Al-Pd-Ru partial isothermal section at 1000 °C for Al-rich alloys [2008Pav]

Section II: Phase Diagram Evaluations

The icosahedral phase I forms at 1080 °C and has a homogeneity range of $\sim \text{Al}_{72.5}\text{Pd}_{13}\text{Ru}_{14.5}$ - $\text{Al}_{70}\text{Pd}_{19.5}\text{Ru}_{10.5}$. A face-centered cubic phase that is structurally-related to the I phase is found at 1000 °C at the Pd-poor end of the composition of I. It has a lattice parameter of $a \approx 3.96$ nm and was designated as F_{40} by [2008Pav].

With starting metals of 99.999% Al, 99.95% Pd, and 99.9% Ru, [2008Pav] prepared Al-rich alloys by levitation induction melting under Ar atm. The samples were annealed at 1100, 1050, and 1000 °C up to 50, 160, and 165 h, respectively. The phase equilibria were studied with x-ray and electron diffraction. The phase compositions were determined by inductively coupled plasma optical emission spectroscopy and by energy dispersive x-ray analysis in a scanning electron microscope. Differential thermal analysis was carried out at a rate of 5-20 °C per min. The isothermal sections constructed by [2008Pav] for Al-rich alloys at 1100, 1050, and 1000 °C are shown in Fig. 1-3.

At 1100 °C (Fig. 1), the ternary cubic phases C and C_2 are present, with C having a wider composition range than C_2 . The binary phases $\text{Ru}_4\text{Al}_{13}$ and RuAl_2 dissolve about 2 and 1 at.% Pd. AlPd and AlRu form a continuous solid solution. At 1050 °C (Fig. 2), in addition to C and C_2 , the

icosahedral phase I is present. The homogeneity range of C_2 is significantly larger than at 1100 °C. At 1000 °C (Fig. 3), the Al-Pd binary ϵ -related orthorhombic phases are present in the ternary region and are clubbed together as ϵ . The ϵ -range is $\sim \text{Al}_{76}\text{Pd}_{8.5}\text{Ru}_{15.5}$ - $\text{Al}_{75}\text{Pd}_{12}\text{Ru}_{13}$. The complex cubic phase F_{40} is indicated contiguously with I phase at its Pd-poor end.

References

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