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Al-Mg-Pr (Aluminum-Magnesium-Praseodymium)

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Recently, [1988Odi] determined a full isothermal section for this system at 400 °C. [1996Odi] constructed a liquidus projection and several pseudobinary sections in the Al-Mg-$PrAl_2$ region.

Binary Systems

The Al-Mg phase diagram [1998Lia] has the following intermediate phases: Mg_2Al_3 (cubic, labeled β), R or ε (rhombohedral), and $Mg_{17}Al_{12}$ ($A12$, αMn-type cubic, denoted γ). The Al-Pr phase diagram [2002Oka] shows the following intermediate compounds: αPr_3Al ($D0_{19}$, Ni_3Sn-type hexagonal), βPr_3Al ($L1_2$, $AuCu_3$-type cubic), Pr_2Al ($C23$, Co_2Si-type orthorhombic), αPrAl (ErAl-type orthorhombic), βPrAl (CeAl-type orthorhombic), $PrAl_2$ ($C15$, $MgCu_2$-type cubic), $PrAl_3$ (Ni_3Sn-type hexagonal), $PrAl_4$ or βPr_3Al_{11} ($D1_3$, Al_4Ba-type tetragonal), and αPr_3Al_{11} (αLa_3Al_{11}-type orthorhombic). The Mg-Pr phase diagram [2005Guo] depicts the following intermediate phases: $Mg_{12}Pr$ ($D2_b$, $ThMn_{12}$-type tetragonal), $Mg_{41}Pr_5$ ($Mg_{41}Ce_5$-type tetragonal), Mg_3Pr ($D0_3$, BiF_3-type cubic), Mg_2Pr ($C15$, $MgCu_2$-type cubic), and MgPr ($B2$, CsCl-type cubic).

Ternary Phase Equilibria

With starting metals of 99.995% Al, 99.95% Mg, and 99.78% Pr, [1988Odi] arc-melted about 150 alloys and annealed them at 400 °C for 480 h. The phase equilibria were studied by metallography and x-ray powder diffraction. The isothermal section at 400 °C constructed by [1988Odi] is redrawn in Fig. 1 to comply with the accepted binary data. [1988Odi] indicated in the ternary region (along the 33.3 at.% Pr line) a phase based on Mg_2Pr. This phase is labeled λ here. It may be noted that Mg_2Pr is not stable at 400 °C. A ternary compound $Al_2Mg_{0.88}Pr_{0.12}$ (denoted τ here and as λ_1 by [1996Odi]) is stable at this temperature. It has the $MgZn_2$-type hexagonal structure, with the lattice parameters of $a = 0.55186$ nm and $c = 0.8920$ nm [1988Odi].

[1996Odi] prepared 153 alloys from the same starting metals as used by [1988Odi]. The phase equilibria were

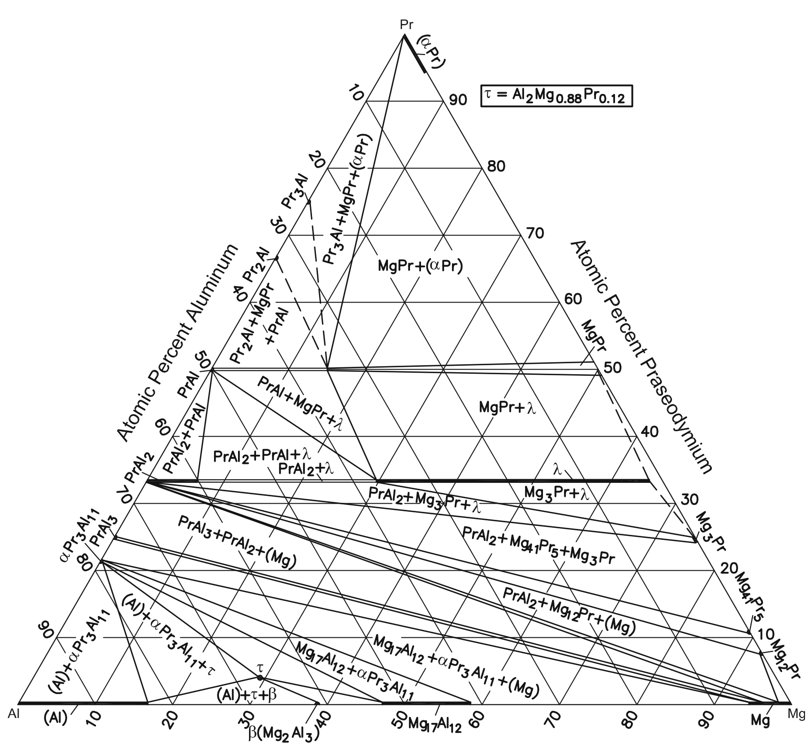

Fig. 1 Al-Mg-Pr isothermal section at 400 °C [1988Odi]. Narrow two-phase regions are omitted

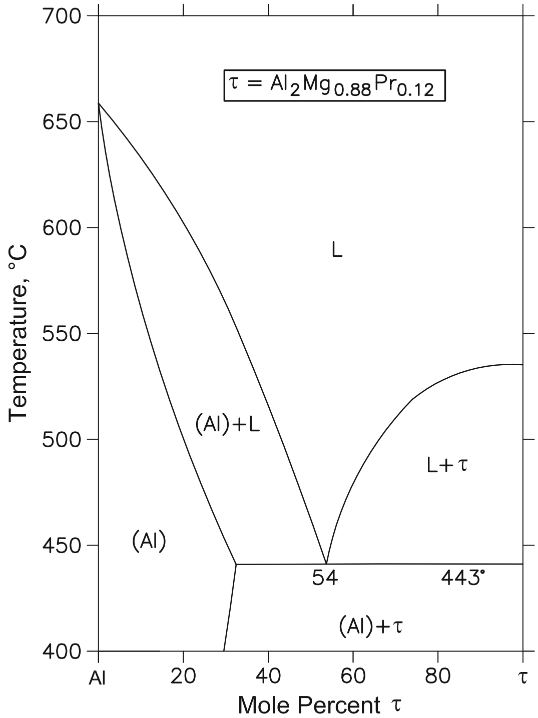

Fig. 2 Al-Mg-Pr pseudobinary section along the Al-τ join [1996Odi]

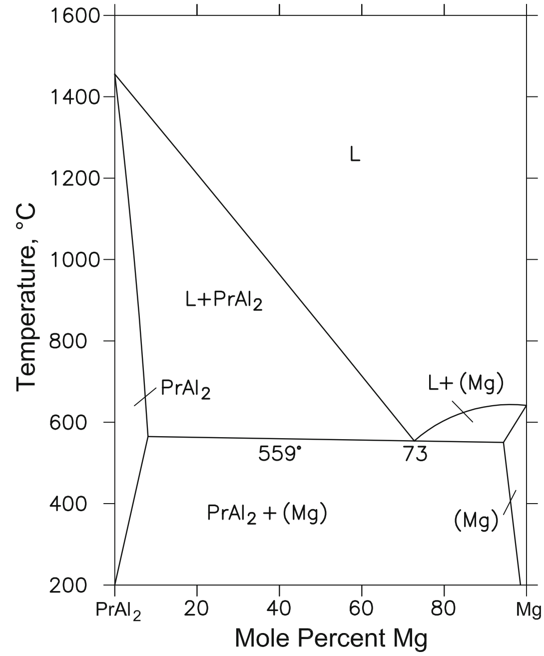

Fig. 3 Al-Mg-Pr pseudobinary section along the $PrAl_2$-Mg join [1996Odi]

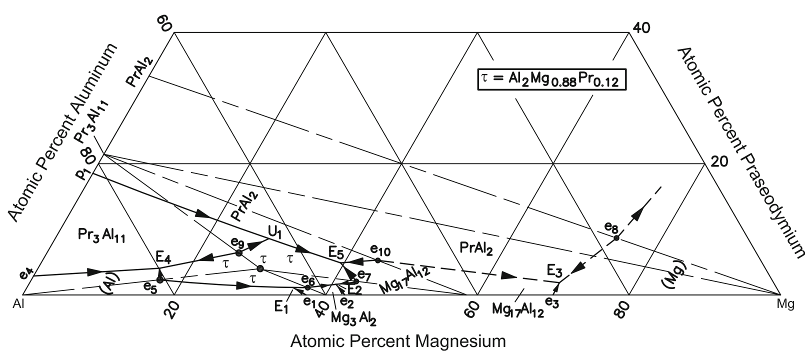

Fig. 4 Al-Mg-Pr liquidus projection in the Al-Mg-$PrAl_2$ region [1996Odi]

studied with metallography, differential thermal analysis, and x-ray powder diffraction. Four pseudobinary sections of the simple eutectic type were determined by [1996Odi] along Al-τ, τ-Mg_2Al_3, τ-$Mg_{17}Al_{12}$, and $PrAl_2$-Mg joins. The sections along Al-τ and $PrAl_2$-Mg joins are redrawn in Fig. 2 and 3. The eutectic temperatures for the τ-Mg_2Al_3 and τ-$Mg_{17}Al_{12}$ sections (not shown here) are 438 and 450 °C, respectively, and the eutectic compositions are 60 mol% Mg_2Al_3 and 45 mol% $Mg_{17}Al_{12}$.

The liquidus projection determined by [1996Odi] for the Al-Mg-$PrAl_2$ region is redrawn in Fig. 4. The final solidification in the Al-Mg_2Al_3-τ, Mg_2Al_3-$Mg_{17}Al_{12}$-τ, $Mg_{17}Al_{12}$-Mg-Pr_3Al_{11}, Al-Pr_3Al_{11}-τ, and $Mg_{17}Al_{12}$-Pr_3Al_{11}-τ subregions are through ternary eutectic reactions E_1, E_2, E_3, E_4, and E_5, respectively, all occurring between 434 and 440 °C.

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