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Al-Ho-Mg (Aluminum-Holmium-Magnesium)

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Recently, this ternary system was investigated experimentally by [2003Den] and assessed thermodynamically by [2003Cac]. To minimize the number of experiments required, an iterative procedure was adopted, where additional critical experiments were designed on the basis of the preliminary calculations. An Al-rich ternary compound τ with the $MgNi_2$-type hexagonal structure was found at 400 °C.

Binary Systems

The Al-Ho phase diagram [2003Den, 2003Cac] shows the following intermediate phases: $HoAl_3$ ($HoAl_3$-type (*hR*20) rhombohedral), $HoAl_2$ (*C*15, $MgCu_2$-type cubic), HoAl (ErAl-type orthorhombic), Ho_3Al_2 (Zr_3Al_2-type tetragonal) and Ho_2Al (*C*23, Co_2Si-type orthorhombic). The Al-Mg phase diagram [1998Lia] has the following intermediate phases: Mg_2Al_3 (cubic, labeled β), R or ε (rhombohedral) and $Mg_{17}Al_{12}$ (*A*12, αMn-type cubic, denoted γ). The Ho-Mg phase diagram [Massalski2, 2003Cac] has the following intermediate phases: Ho_5Mg_{24} (*A*12, αMn-type cubic), $HoMg_2$ (*C*14, $MgZn_2$-type hexagonal), and HoMg (*B*2, CsCl-type cubic). A body centered cubic (bcc) phase is stable above 680 °C with a homogeneity range extending from 18 to 42 at.% Mg.

Ternary Isothermal Section

With starting metals of 99.999% Al, 99.9% Ho, and 99.99% Mg, [2003Den] induction-melted seven ternary alloys. Differential thermal analysis (DTA) was carried out at a heating/cooling rate of 10 °C/min. The samples were annealed at 400 °C for 850 h and quenched in water. The phase equilibria were studied with optical and electron microscopy, x-ray powder diffraction and electron probe microanalysis. These experimental results were used in the thermodynamic optimization by [2003Cac]. The computed isothermal section at 400 °C shown in Fig. 1 agrees well with the experimental results. An Al-rich ternary phase τ is present at 400 °C. It has a composition near $Al_2Ho_{0.39}Mg_{0.61}$ and the *C*36, $MgNi_2$-type hexagonal structure, with $a = 0.5471$ nm and $c = 1.7671$ nm [2003Den]. The DTA data show that τ forms peritectically at about 450 °C.

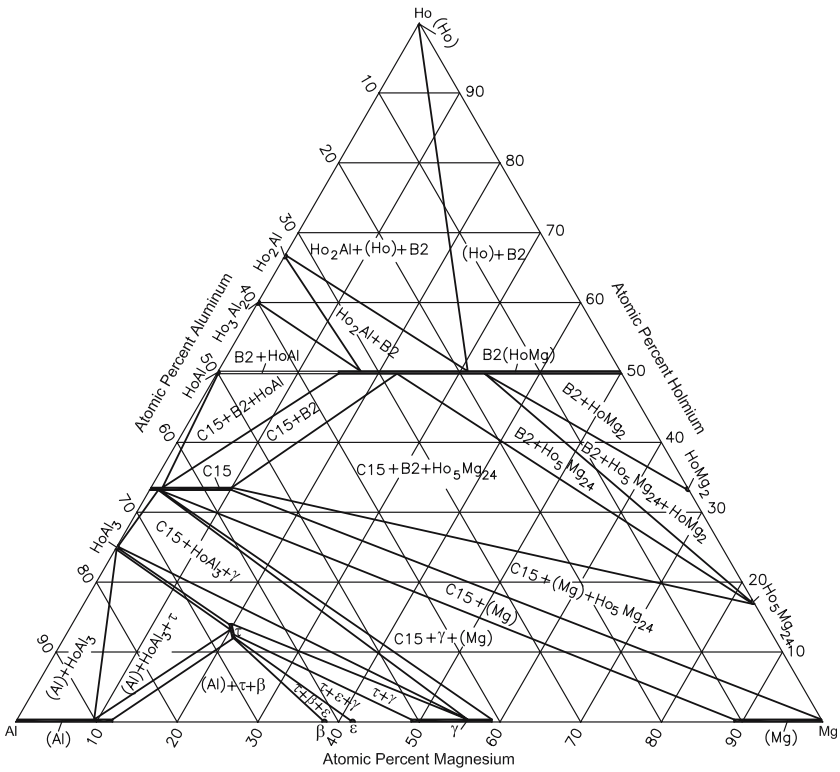

Fig. 1 Al-Ho-Mg computed isothermal section at 400 °C [2003Den, 2003Cac]. Narrow two-phase regions are omitted

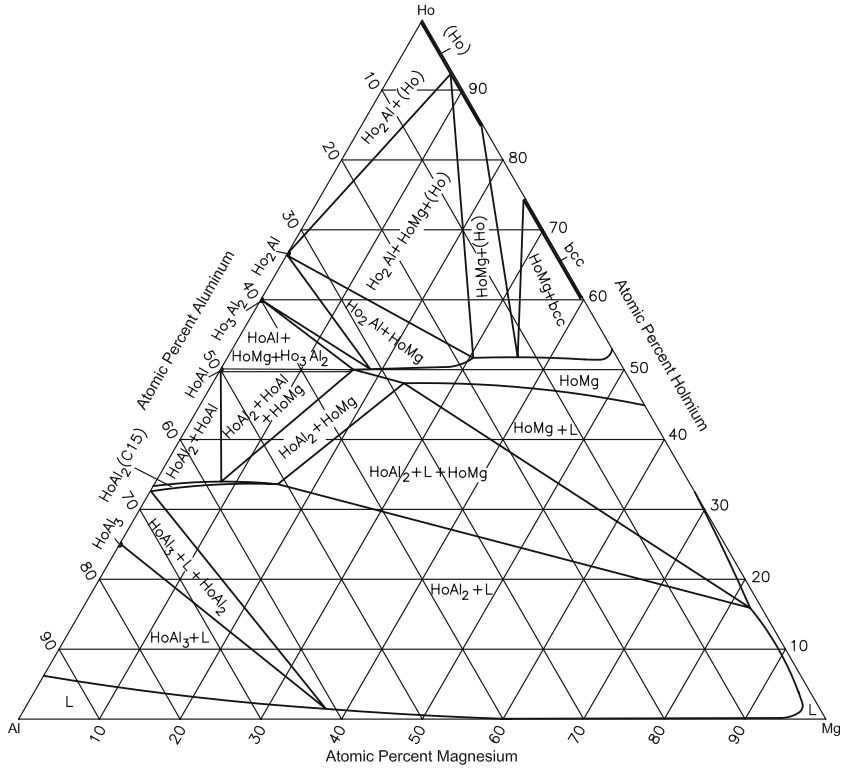

Fig. 2 Al-Ho-Mg computed isothermal section at 800 °C [2003Cac]

At 400 °C, the binary phases HoMg (denoted *B*2) and $HoAl_2$ (denoted *C*15) dissolve up to 35 at.% Al and 10 at.% Mg respectively. An isothermal section computed at 800 °C by [2003Cac] is shown in Fig. 2. The τ phase is absent at this temperature. The solubility of Mg in $HoAl_2$ is larger here, as compared to that in Fig. 1.

A liquidus projection was also computed by [2003Cac]. The extent of the primary solidification ranges of the phases in the computed projection agrees well with the metallographic observations of [2003Den]. The *C*15 phase shows a large field of primary crystallization. However, the agreement of the computed surface with DTA data was found to be not satisfactory.

References

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