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Al-Er-Mg (Aluminum-Erbium-Magnesium)

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Recently, this ternary system was investigated experimentally by [2002Sac] and assessed thermodynamically by [2002Cac]. To minimize the number of experiments required, an iterative procedure was adopted, where additional critical experiments were designed on the basis of preliminary calculations. Two computed isothermal sections at 400 and 900 °C and two computed vertical sections are given in this review from the above studies.

Binary Systems

The Al-Er phase diagram [2002Sac, 2002Cac] depicts the following intermediate phases: $ErAl_3$ ($L1_2$, $AuCu_3$-type cubic), $ErAl_2$ ($C15$, $MgCu_2$-type cubic), ErAl (ErAl-type orthorhombic), Er_3Al_2 (Zr_3Al_2 -type tetragonal), and Er_2Al ($C23$, Co_2Si-type orthorhombic). The Al-Mg phase diagram [1998Lia] has the following intermediate phases: Mg_2Al_3 (cubic, denoted β), R or ε (rhombohedral) and $Mg_{17}Al_{12}$ ($A12$, αMn-type cubic, denoted γ). In the Er-Mg system [1992Sac], two intermediate phases have significant ranges of homogeneity. The phase containing 18-43 at.% Mg is bcc and labeled $A2$ here. The other phase with 48-57 at.% Mg is CsCl-type cubic and is labeled $B2$. $ErMg_2$ has the $C14$, $MgZn_2$-type hexagonal structure. Er_5Mg_{24} has the $A12$, αMn-type structure.

Ternary Phase Equilibria

With starting metals of 99.999 mass% Al, 99.9 mass% Er, and 99.9 mass% Mg, [2002Sac] induction-melted under Ar atm 33 ternary alloys, covering the entire composition range. The alloys were annealed at 400 °C for 500-850 h and quenched in water. The phase equilibria were studied with x-ray powder diffraction, optical and scanning electron microscopy and electron probe microanalysis. Before annealing, the alloys were investigated with differential thermal analysis (DTA) at a heating/cooling rate of 10 °C/min. The isothermal section at 400 °C computed by [2002Cac] based on the above experimental results is shown in Fig. 1. A ternary compound labeled τ is present at the composition $Al_{66.7}Er_{10}Mg_{23.3}$. It has the $C14$, $MgZn_2$-type hexagonal structure, with a = 0.5468-0.5476 nm and

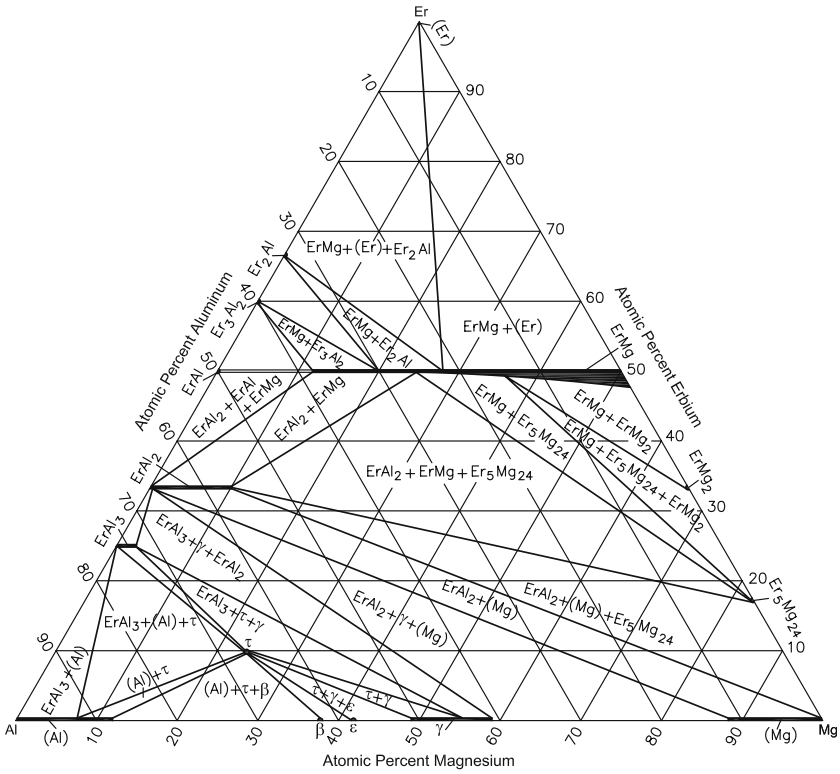

Fig. 1 Al-Er-Mg computed isothermal section at 400 °C [2002Cac]. Thin two-phase regions are omitted

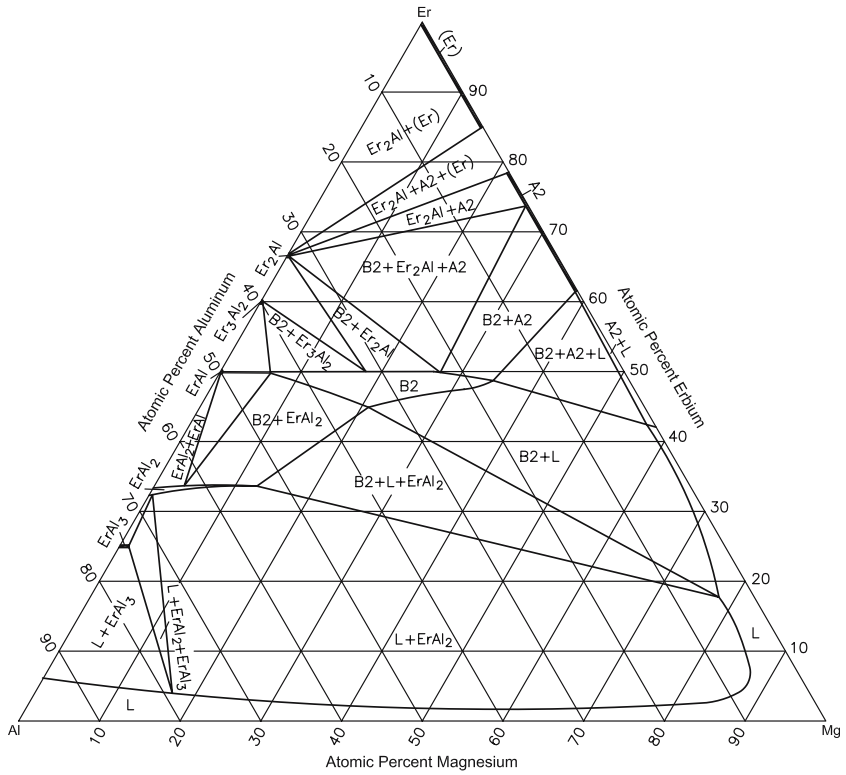

Fig. 2 Al-Er-Mg computed isothermal section at 900 °C [2002Cac]

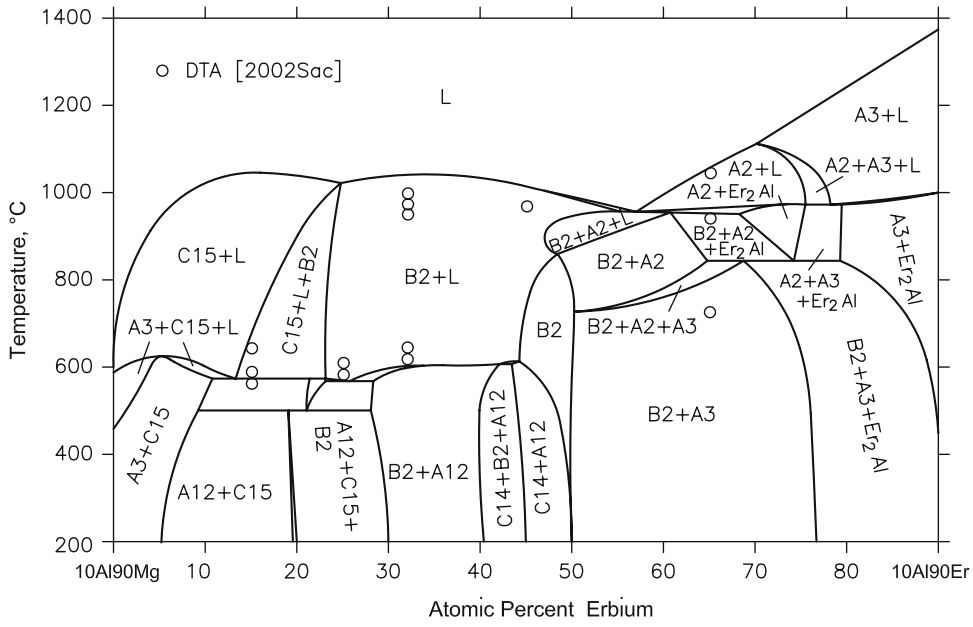

Fig. 3 Al-Er-Mg computed vertical section at 10 at.% Al [2002Cac]

c = 0.8836-0.8821 nm [2002Sac]. The DTA results show that it forms peritectically at 530 °C. The solubility of Al in the *B*2 Er-Mg compound extends up to 39 at.%. $ErMg_2$ and Er_5Mg_{24} dissolve up to 1 at.% Al. Among the Er-Al binary compounds, $ErAl_2$ dissolves up to 10 at.% Mg, with the other compounds showing a smaller solubility. The Al-Mg compounds do not dissolve any measurable amount of Er.

In their thermodynamic assessment of this system, [2002Cac] modeled the liquid and solid solution phases with a single lattice. For the binary compounds, the third

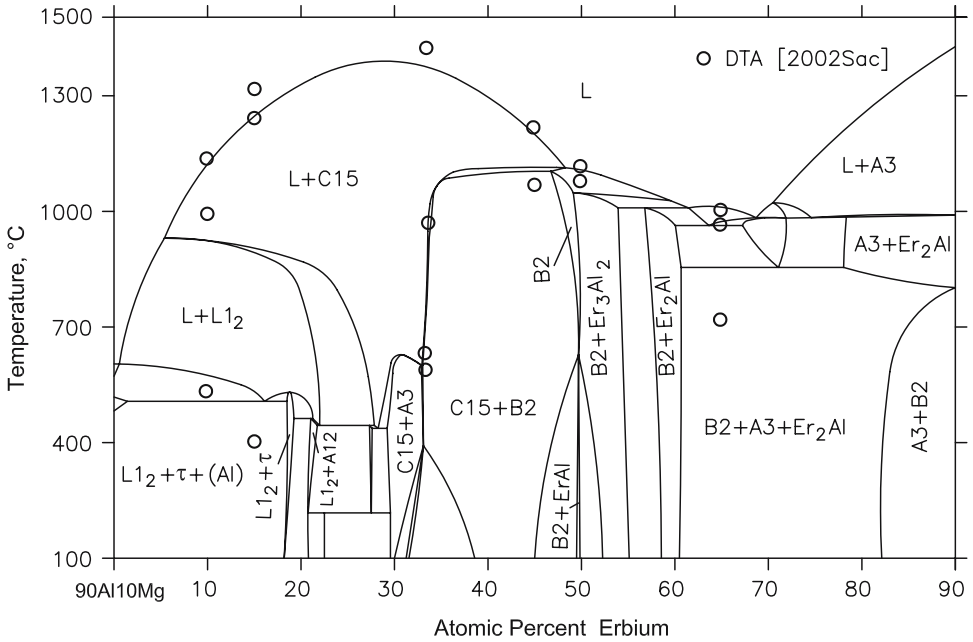

Fig. 4 Al-Er-Mg computed vertical section at 10 at.% Mg [2002Cac]

component solubility was taken into account as applicable. The binary phases Er_3Al_2, Er_2Al, β(Al-Mg), ε(Al-Mg) and the ternary phase τ were treated as stoichiometric phases. The computed isothermal section at 400 °C, shown in Fig. 1, agrees well with the experimental results. [2002Cac] computed two more isothermal sections at 700 and 900 °C. The computed section at 900 °C is shown in Fig. 2. The ternary compound τ, which is stable only below 530 °C, is not present in Fig. 2. The *B*2 phase exists only in the ternary region.

For comparison of the DTA data, [2002Cac] computed three vertical sections at a constant 10 at.% of Al, Mg or Er and a fourth section at a constant Er content of 50 at.%. Fig. 3 and 4 show the vertical sections at 10 at.% Al and 10 at.% Mg, respectively. [2002Cac] also presented a computed liquidus projection and a reaction scheme.

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