

The Er-Y (Erbium-Yttrium) System

167.26

88.9059

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Phase Diagram

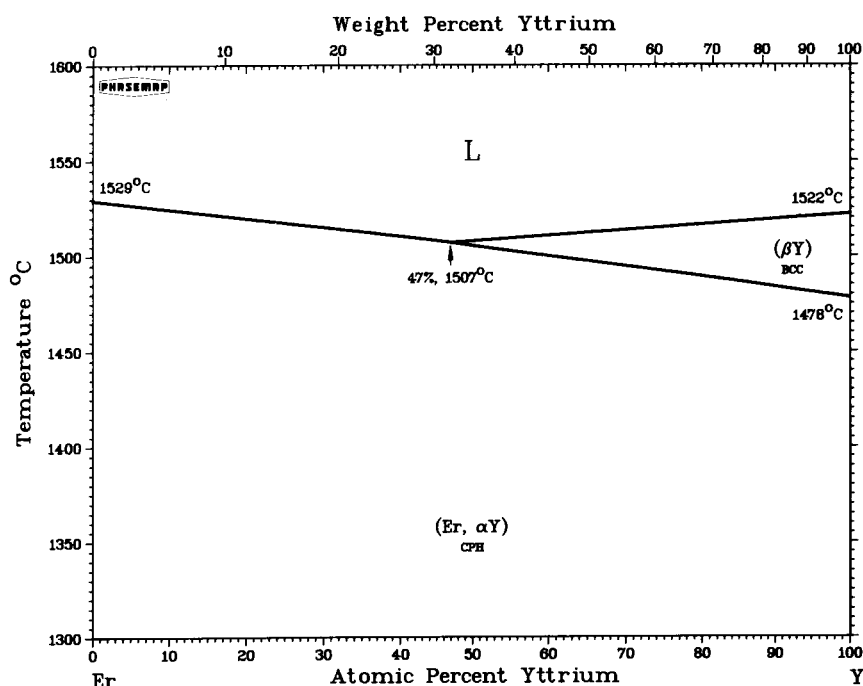
Investigations of phase equilibria in the Er-Y system were conducted by Markova *et al.* [64Mar] and Spedding *et al.* [73Spe]. The first group used distilled Y metal of 99.6 (wt.?)% purity and Er metal of about 98 (wt.?)% purity. The principal impurities included Ca, Fe, Cu, Ta, and other rare-earth metals. The alloys were arc melted under purified helium and studied in the annealed state. Microscopy, differential thermal analysis, and X-ray methods were utilized, and measurements of hardness and electrical resistivity were performed on the alloy specimens. The main difficulty experienced in their thermal analysis was the narrow temperature interval between the melting of their alloys and the polymorphic transformations.

The investigation of this system by Spedding *et al.* was performed using metals of higher purity. The impurities found in their Er metal were (in ppm atomic): 368 O; 331 H; 145 Cu; 97 C; 60 Ta; 28 Y; 26 F; 15 each Dy and Ho; 13 Cr; 12 each N, Al, and Fe; 11 each Si and Sc; and even smaller amounts of Mg, Ca, Ni, La, Ce, Pr, Nd, Sm, Gd, Tb, Tm, Yb, and Lu. Impurities in their Y metal (also in ppm atomic) were: 1251 O; 880 H; 421 F; 333 C; 49 Sc; 30 Al; 19 Si; 15 Ni; 14 Cu; 13 each N, Fe, and Ce; and smaller amounts of Mg, Ca, Cr, La, Pr, Nd, Sm, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, and Ta. Great care was taken in the design of experimental equipment and methods to avoid errors in

the measurements of melting points and transition temperatures. Differential thermal analysis, X-ray diffraction, and metallographic observations were used by Spedding *et al.* in the determination of the Er-Y phase diagram that is reproduced in Fig. 1.

The thermal data points obtained by Spedding *et al.* were shown as single points for the melting temperatures and for the transition temperatures because the start and the stop of the thermal arrests on both heating and cooling curves were within 1.5 °C, the same as for pure metals. The addition of Er to Y or Y to Er lowered the melting point to a minimum of 1507 °C at 47 at.% Y. Alloys containing less than 53 at.% Er solidify to the bcc structure, which transforms at lower temperatures to cph structure. Alloys with more than 53 at.% Er crystallize directly to the cph solid solution. The authors concluded that the wide separation between the liquidus and solidus lines for these alloys, reported in some earlier papers, was due, not to the enrichment of one rare earth over the other during freezing, but to the presence of impurities, particularly non-metallic impurities. They also stated their belief that the pronounced minima in the melting point or transition temperature of the heavy lanthanide alloy series that have been reported, do not occur when the component rare-earth metals are pure, but may well result if considerable impurities are present.

Fig. 1 Er-Y Phase Diagram



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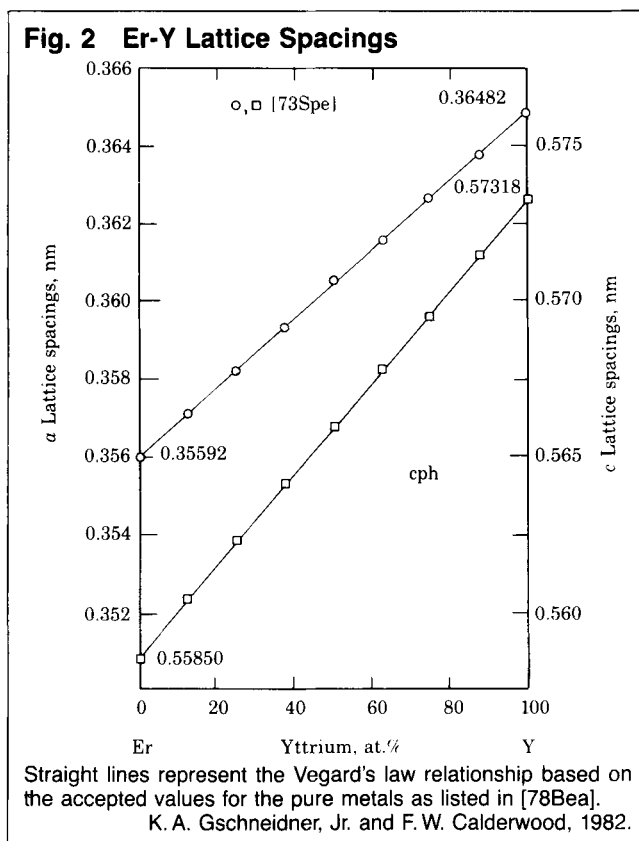
The phase diagram presented by Markova *et al.* showed melting temperatures for the pure metals that were lower than the accepted values listed in [78Bea] (Er: 1490 vs 1529 °C, Y: 1515 vs 1522 °C). When their thermal analysis data are adjusted for the differences in the melting points of the pure metals, they generally agree quite well with that of Spedding *et al.*

Lattice Spacings

Spedding *et al.* [73Spe] obtained lattice spacing data for the Er-Y system by applying a least-squares fit to the extrapolation of back reflection X-ray data. In addition to their plot of the lattice spacing data, which is shown in Fig. 2, they compared their measured parameters to calculated values based on the spacings for the pure metals. They observed a slight positive deviation from linearity (Vegard's law) in both the *a* and *c* spacings, but this is hardly, if at all, evident in Fig. 2.

Cited References

- 64Mar:** Markova, I. A., Terekhova, V. F., and Savitskii, E. M., *Zhur. Neorg. Khim.*, 9, 2034 (1964); TR: *Russ. J. Inorg. Chem.*, 9, 1098 (1964).
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78Bea: Beaudry, B. J. and Gschneidner, K. A., Jr., in *Handbook on the Physics and Chemistry of Rare Earths*, Vol. 1—*Metals*, Gschneidner, K. A., Jr. and Eyring, L., Ed., North-Holland Publishing Co., Amsterdam, 215 (1978).



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The Eu-Sc (Europium-Scandium) System

151.96

44.9559

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Phase Relationships

No experimental data for the Eu-Sc phase diagram were found. However, Miedema [76Mie], using Gschneidner's value [69Gsc] for the energy difference between divalent and trivalent Eu (96 kJ/mol), found his method would account for the known information on the valence state of Eu in intermetallic compounds. The application of his thermodynamic calculations to the Eu-Sc alloy system predicted that no stable compounds exist in this system.

A complicating factor in an investigation of the Eu-Sc alloy system is the fact that the melting point of Sc

(1541 °C [78Bea]) is 12 °C higher than the boiling point of Eu (1529 °C [78Bea]).

Cited References

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76Mie: Miedema, A. R., *J. Less-Common Met.*, 46, 176 (1976).
78Bea: Beaudry, B. J. and Gschneidner, K. A., Jr., in *Handbook on the Physics and Chemistry of Rare Earths*, Vol. 1—*Metals*, Gschneidner, K. A., Jr. and Eyring, L., Ed., North-Holland Publishing Co., Amsterdam, 215 (1978).

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