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Fe-Rh-Ti (Iron-Rhodium-Titanium)

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Recently, [2007Bal] determined two isothermal sections at 1000 and 800 °C for this ternary system for the entire composition range. No ternary compounds were found.

Binary Systems

The Fe-Rh phase diagram is shown in Fig. 1 from [2007Bal]. Fe and Rh form a continuous face-centered cubic (fcc) solid solution. The ordered B2 phase is stable over a wide composition range and exists both in the ferromagnetic and anti-ferromagnetic states. The bcc → B2 transition and the magnetic transition are second-order, without an intervening two-phase region. A comparison of the Fe-Ti assessments was presented by [1998Dum]. There are two intermediate phases in this system: Fe_2Ti (*C*14, $MgZn_2$-type hexagonal) and FeTi (*B*2, CsCl-type cubic). The Rh-Ti phase diagram determined by [2006Bal] is shown in Fig. 2. The intermediate phases in this system are: Rh_3Ti ($L1_2$, $AuCu_3$-type cubic), Rh_5Ti_3 (Ge_3Rh_5-type orthorhombic), βRhTi (labeled $B2_{tetra}$, $L1_0$, AuCu-type tetragonal?), αRhTi (*B*2, CsCl-type cubic) and $RhTi_2$ ($C11_b$, $MoSi_2$-type tetragonal). The βRhTi(*B*2)/(βTi)(bcc) and the βRhTi($L1_0$)/αRhTi(*B*2) boundaries are second-order boundaries.

Ternary Isothermal Sections

With starting metals of 99.95% Fe, 99.9% Rh and 99.8% Ti, [2007Bal] arc-melted about 38 alloy samples. The alloys were annealed at 1000 and 800 °C for 200-4000 h and air cooled. The phase equilibria were studied with the diffusion couple technique, electron probe microanalysis, x-ray powder diffraction, transmission electron microscopy, and differential scanning calorimetry. The diffusion couples were annealed for a duration of 1-3 weeks. The couples consisted of $Fe_{50}Ti_{50}$-$Ti_{50}Rh_{50}$, $Fe_{14}Rh_{43}Ti_{43}$-$Fe_{52}Rh_{48}$, $Fe_{52}Rh_{48}$-$Rh_{20}Ti_{80}$, $Fe_{14}Rh_{43}Ti_{43}$-Ti, and $Fe_{83}Rh_{17}$-Ti. The measured compositions for two-phase (tie-line) and three-phase (tie- triangle) equilibria were listed.

The isothermal sections constructed by [2007Bal] at 1000 and 800 °C are shown in Fig. 3 and 4. At 1000 °C (Fig. 3), the *B*2 phase that is present along all three sides forms a continuous solid solution through the ternary region. In Ti-rich alloys, it is in equilibrium with (βTi) (bcc). The bcc-*B*2 two-phase region narrows down on approaching the Rh-Ti side and probably ends at a tricritical point (marked *C* in Fig. 3), close to the binary side. In Fe-rich alloys, *B*2 is in equilibrium with Fe_2Ti, bcc Fe, and fcc Fe. Near the Rh corner, *B*2 forms tie lines with Rh_5Ti_3, Rh_3Ti, and (Rh) (fcc). At compositions marked as t, the cubic *B*2 phase undergoes the tetragonal distortion during cooling. At 800 °C (Fig. 4), the continuous *B*2 solid solution persists. The binary phase $RhTi_2$ is present and forms tie-lines with (β Ti) and *B*2 phases. The tetragonal distortion of the *B*2 phase marked t is present at the annealing temperature. The solubility of Ti in fcc Fe is 1.4 at.% at 1000 °C and 1 at.% at 800 °C. It is up to 10 at.% in fcc Rh at these temperatures. Fe_2Ti dissolves ~2 at.% Rh at 1000 °C, the solubility decreasing with decreasing temperature. Rh_5Ti_3 dissolves about 10 and 17 at.% Fe at 1000 and 800 °C

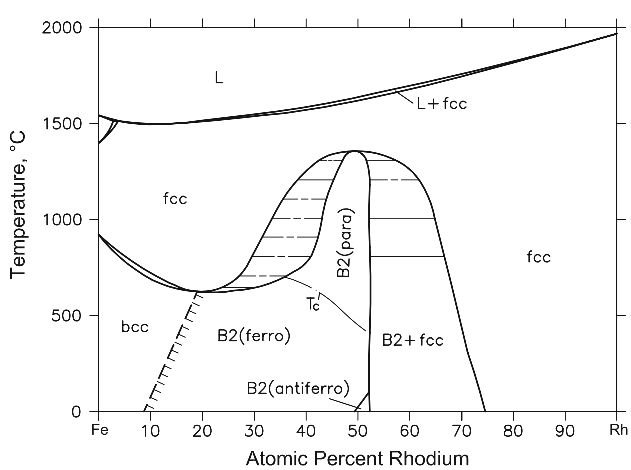

Fig. 1 Fe-Rh binary phase diagram [2007Bal]

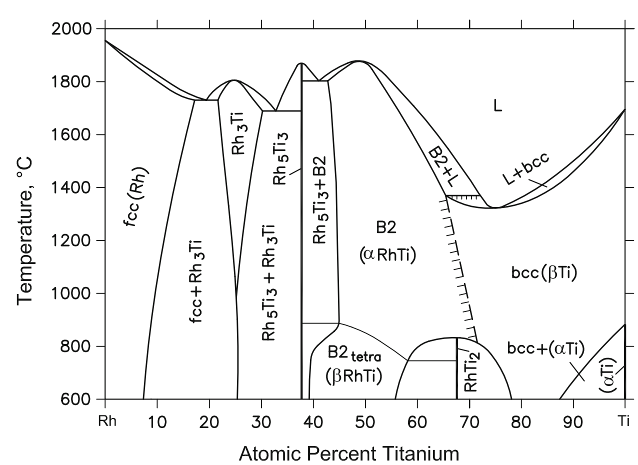

Fig. 2 Rh-Ti binary phase diagram [2006Bal]

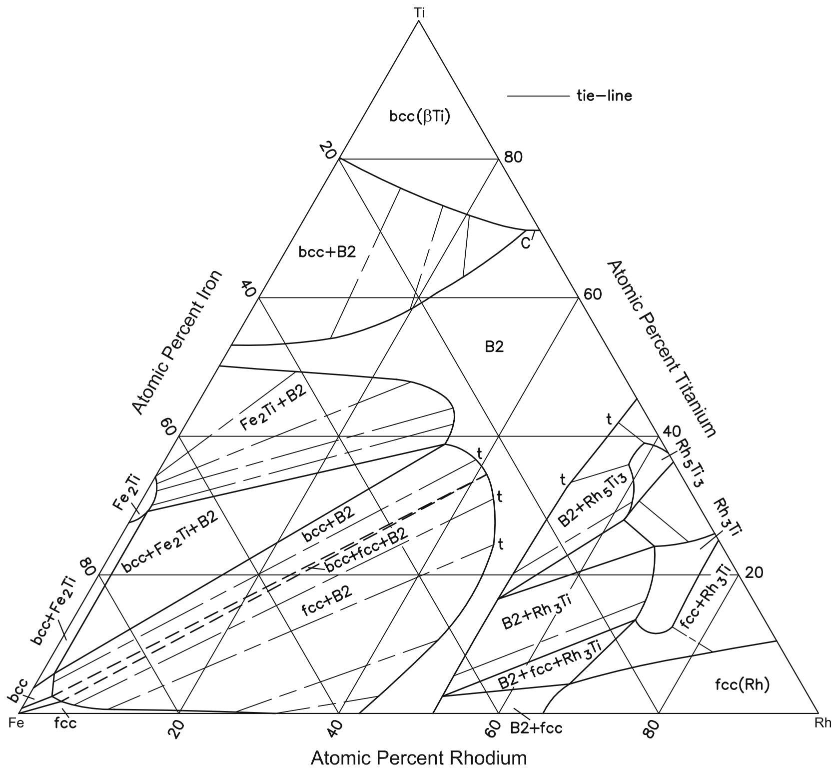

Fig. 3 Fe-Rh-Ti isothermal section at 1000 °C [2007Bal]. Phases marked t undergo the cubic-to-tetragonal transition during cooling

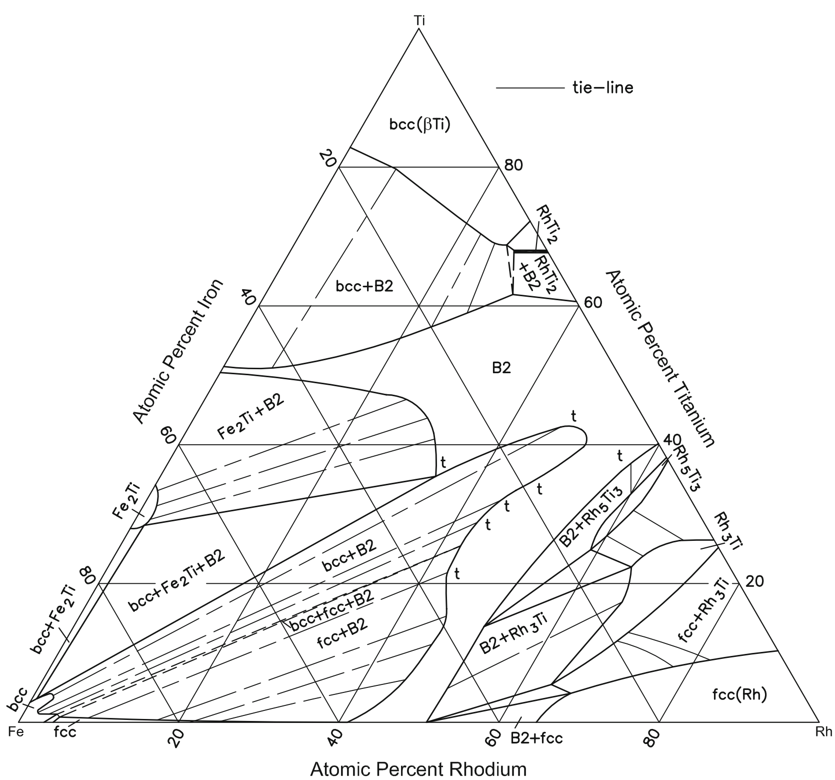

Fig. 4 Fe-Rh-Ti isothermal section at 800 °C [2007Bal]. Phases marked t represent tetragonal *B*2 at 800 °C

respectively. Rh_3Ti is estimated to dissolve about 17 at.% of Fe at 1000 °C and 30 at.% at 800 °C.

In the second part of the study of this ternary system, [2007Ele] calculated the phase equilibria between the disordered bcc and the ordered *B*2 and $D0_3$ forms by the cluster variation method (CVM), using the irregular tetrahedron approximation. The experimental data of [2007Bal] were used as inputs to derive the energy parameters. Isothermal sections, which depict the equilibria between bcc and its ordered forms, were calculated at 1200, 1000, 800, 700, 600 and 500 °C.

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