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Fe-Pt-S (Iron-Platinum-Sulfur)

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The previous review of this ternary system by [1988Rag] presented a liquidus projection from the work of [1987Bry] and an isothermal section at 1000 °C from [1976Ski]. A reaction sequence was also given from the liquid range down to 950 °C. More recently, three more isothermal sections at 1100 °C [2002Maj] and at 900 and 500 °C [1988Mak] have been reported.

Binary Systems

The Fe-Pt phase diagram [1993Oka] depicts a continuous solid solution (denoted γ) between the Fe-based face-centered cubic (fcc) phase and fcc Pt. The transformation of Fe from γ to body-centered cubic (bcc) α is lowered by the addition of Pt. Three ordered structures, cubic $AuCu_3$ type Fe_3Pt, tetragonal AuCu type FePt and cubic $AuCu_3$ type $FePt_3$, form congruently from the γ solid solution at ~840, ~1300, and ~1350 °C, respectively. The boundaries of these ordered phases are uncertain [1993Oka]. There are two intermediate phases in the Fe-S system [1982Kub]. The monosulfide pyrrhotite $Fe_{1-x}S$ (hexagonal NiAs type) is stable at Fe-deficient (S-rich) compositions with a range of 50-55 at.% S. $Fe_{1-x}S$ at 52 at.% S melts congruently at 1188 °C. In the Fe-FeS region, the solidification is through a eutectic reaction at 988 °C. In the FeS-S region, a monotectic reaction at 1082 °C yields $Fe_{1-x}S$ of 54.2 at.% S and a sulfur-rich liquid $(S)_l$. At 743 °C, cubic FeS_2 (pyrite) forms peritectically and undergoes a transition to orthorhombic FeS_2 (marcasite) at 425 °C. The phase relations below 350 °C in the pyrrhotite region are complex with the occurrence of several ordered forms. In the Pt-S system, there are two intermediate phases. PtS (mineral name: cooperite) has the *B*17 type tetragonal structure and PtS_2 has the *C*6 type hexagonal structure. The phase relationships in the condensed form are known only partially [Massalski2].

Ternary Isothermal Sections

In addition to the isothermal section at 1000 °C determined by [1976Ski] (reviewed in [1988Rag]), three more sections at 1100 °C [2002Maj] and at 900 and 500 °C [1988Mak] respectively have been reported. Starting with pure materials, Majzlan et al. [2002Maj] melted 36 alloy compositions in evacuated silica tubes, which were given a final anneal at 1100 °C for a week. The phase equilibria were studied by reflected-light microscopy and electron probe microanalysis. The compositions of the coexisting phases were listed. The isothermal section at 1100 °C con-

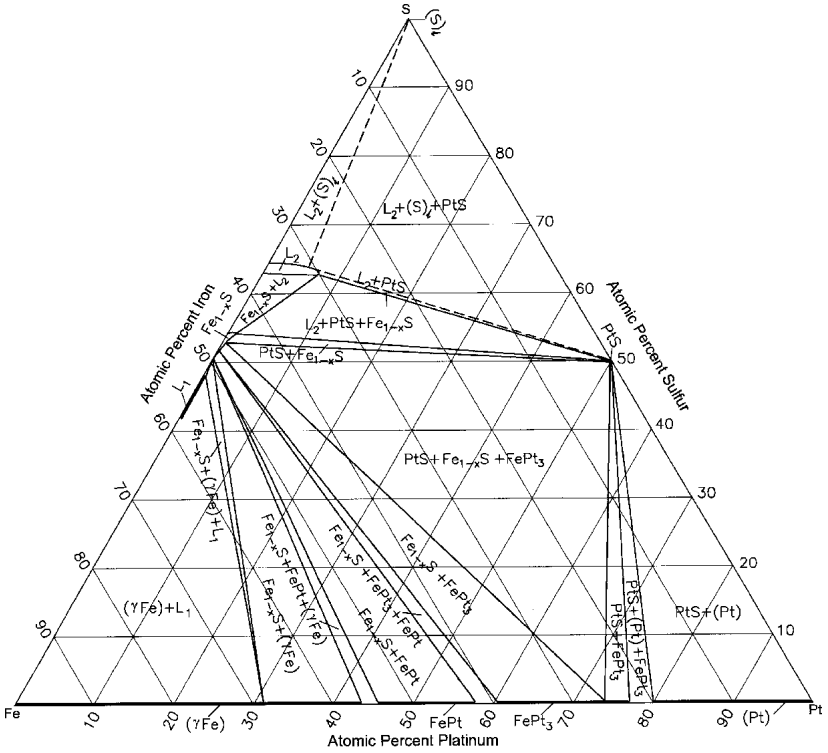

Fig. 1 Fe-Pt-S isothermal section at 1100 °C [2002Maj]

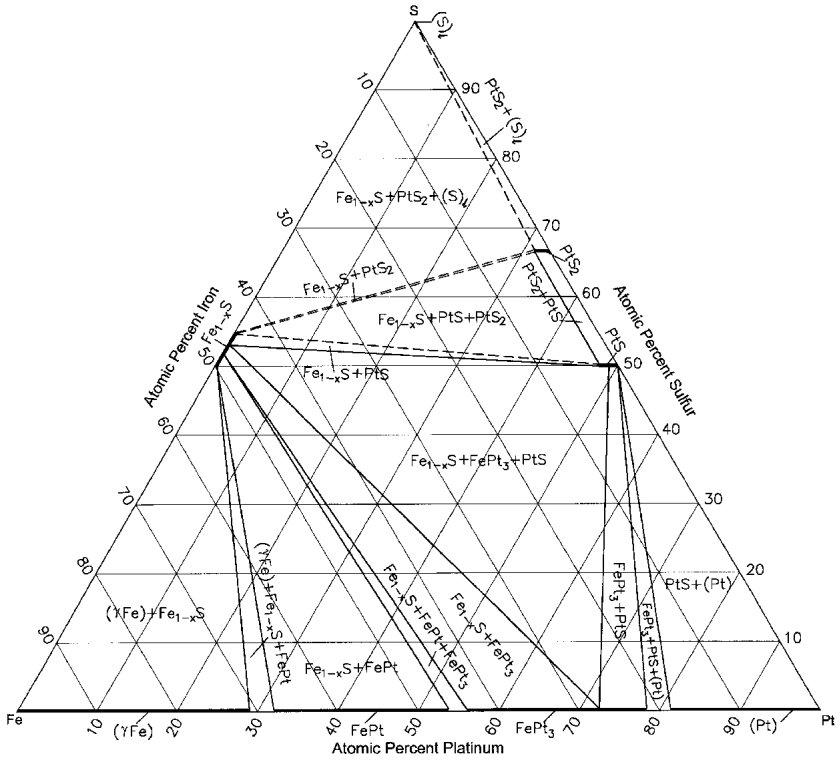

Fig. 2 Fe-Pt-S isothermal section at 900 °C [1988Mak]

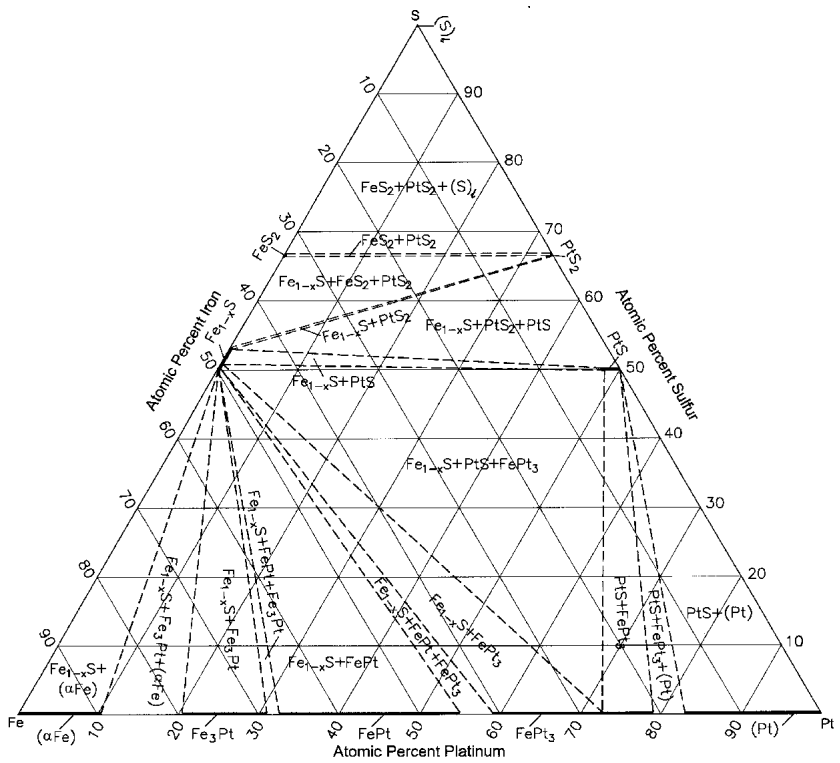

Fig. 3 Fe-Pt-S isothermal section at 500 °C [1988Mak]

structed by them is redrawn in Fig. 1. The composition ranges (in at.% Pt) of the phases along the Fe-Pt side are (γFe) (0-43.5), FePt (45.5-57.7), $FePt_3$ (60.4-77) and (Pt) (80-100), with little or no solubility of S. Along the Fe-S side, two liquids L_1 and L_2 are stable on either side of $Fe_{1-x}S$. Along the Pt-S side, only PtS is stable at this tem-

perature (and at 1000 °C [1976Ski]). The solubility of Pt in $Fe_{1-x}S$ varies from 0 at the S-poor end to 1.1 at.% at the S-rich end. The liquid phase L_2 dissolves a maximum of 7.4 at.% Pt. PtS dissolves about 0.5-0.8 at.% Fe. [1987Bry] (reviewed in [1988Rag]) postulated a ternary eutectic reaction at 1050 °C, which yields $Fe_{1-x}S$ + $FePt_3$ + PtS. However, [2002Maj] did not find this eutectic liquid at 1100 °C. The above three-phase equilibrium, however, is present in Fig. 1 at 1100 °C, which indicates that the temperature of the ternary eutectic reaction could be above 1100 °C.

[1986Mak, 1988Mak] used high purity elements to melt alloy compositions in evacuated tubes, which were given a final anneal of 1-2 months at the desired temperature. The phase equilibria were studied by reflected-light microscopy and electron probe microanalysis. The isothermal sections constructed by them at 900 and 500 °C are redrawn in Fig. 2 and 3. At 900 °C (Fig. 2), the composition ranges (in at.% Pt) of phases along the Fe-Pt side are: (γFe) (0-29), FePt (32-53.8), $FePt_3$ (56-78.4), and (Pt) (81.4-100), with little or no dissolved S. Pyrrhotite ($Fe_{1-x}S$) dissolves up to 0.6 at.% Pt at its S-richest compositions, associated with the three-phase equilibrium of $Fe_{1-x}S$, PtS_2 and PtS. In the three-phase equilibrium of $Fe_{1-x}S$, PtS and $FePt_3$, $Fe_{1-x}S$ contains 0.13 at.% Pt, PtS dissolves 1.1 at.% Fe and $FePt_3$ has 72.5 at.% Pt. At 500 °C (Fig. 3), the third component solubility in the binary compounds is negligible, except in PtS. PtS dissolves up to 1.9 at.% Fe. No S dissolves in Fe-Pt alloys. Along the Fe-Pt side, the composition ranges shown for FePt, $FePt_3$ and (Pt) are those determined by [1988Mak]. FeS_2 (pyrite) is stable at this temperature. The phase relationships shown near the Fe corner (not studied by [1988Mak]) are schematic and are based on extrapolations of uncertain binary data [1993Oka].

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