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Fe-Ga-Sb (Iron-Gallium-Antimony)

V. Raghavan

Recently, Deputier et al. [2002Dep] determined an isothermal section for this system at 600 °C, which depicts an extensive solubility of Ga in the Fe_3Sb_2 (ε) binary phase.

Binary Systems

The Fe-Ga system [1993Oka1] is characterized by the presence of a closed γ loop and several ordered forms of the bcc Fe based solid solution (αFe). α' has the CsCl type ordered structure. The structure of α'' is not known. α''' has the cubic BiF_3 type structure. The intermediate phases of the system are: Fe_3Ga, Fe_6Ga_5, Fe_3Ga_4, and $FeGa_3$. The first two have high- and low- temperature modifications. For crystal structure data, see [1993Oka1] and [Pearson3]. The Fe-Sb phase diagram [1993Oka2] depicts two intermediate phases. The NiAs-type $B8_1$ phase Fe_3Sb_2 (ε) has a homogeneity range of 40-47 at.% Sb. The other intermediate phase $FeSb_2$ is stoichiometric and has orthorhombic symmetry. [Pearson3] lists two orthorhombic types for this phase: FeS_2-type (*Pnnm*) and $FeSb_2$-type (*Pnn*2). The Ga-Sb phase diagram [1988Nga] is characterized by the presence of the congruently-melting intermediate phase GaSb. It is stoichiometric and has the cubic ZnS (sphalerite) type structure. The mutual solubility between Ga and Sb is very limited.

Ternary Isothermal Section

With starting materials of purity of ≥99.99%, [2002Dep] heated about 30 alloy compositions to 1000 °C for 72 h in evacuated silica tubes. The cooled samples were ground to powder and annealed at 600 °C for a long time to ensure homogeneity and then quenched in ice-water mixture. The phase equilibria were studied by x-ray powder diffraction and by energy dispersive spectroscopy attached to a scanning electron microscope (SEM-EDS). The isothermal section at 600 °C constructed by [2002Dep] is redrawn in Fig. 1 to agree with the accepted binary data. The ordered form of bcc Fe (α''') and the Sb-rich liquid, omitted by [2002Dep], are schematically indicated.

The main feature of the section in Fig. 1 is the large solubility of Ga in the Fe_3Sb_2 (ε) phase, with Ga substituting for Sb. The Ga-rich end has the composition range of $Fe_tGa_{0.8}Sb_{1.2}$ ($2.15 \leq t \leq 2.80$), that corresponds to an Fe

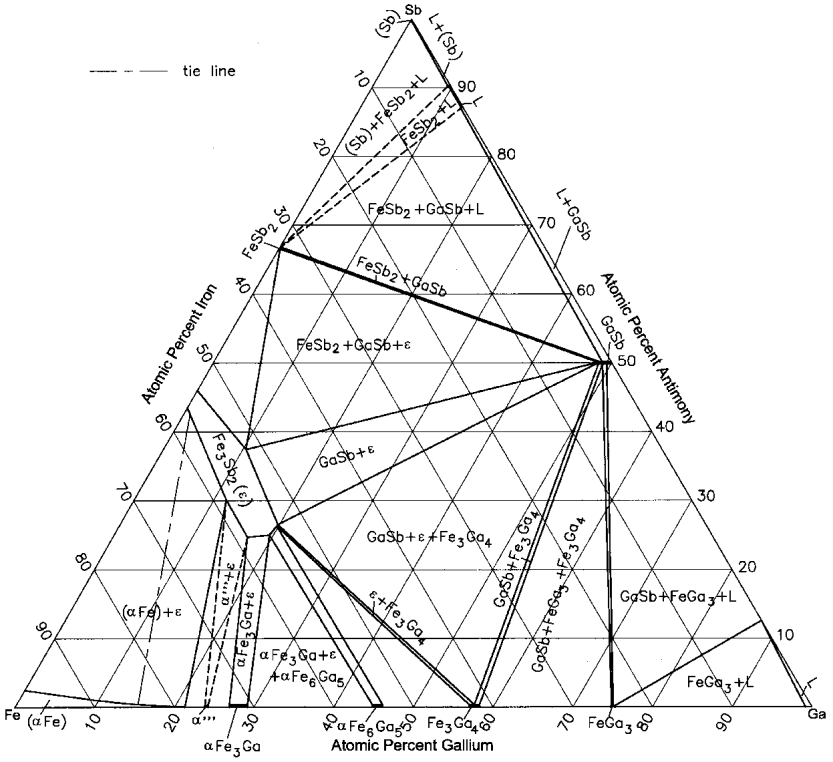

Fig. 1 Fe-Ga-Sb isothermal section at 600 °C [2002Dep]

range of 52-58 at.%. This range does not cover the composition Fe_tGaSb found at 800 °C by [1994Moz]. $Fe_tGa_{0.8}Sb_{1.2}$ has hexagonal symmetry and a structure intermediate between $B8_1$ and $B8_2$ types. No extra lines are seen in the x-ray powder patterns, indicating that Ga and Sb atoms are randomly distributed in the non-metal sublattice. In NiAs ($B8_1$), there are two types of interstitial sites which are vacant. In Ni_2In ($B8_2$), both the interstitial sites are occupied by Ni atoms. In $Fe_tGa_{2-x}Sb_x$ (ε), the extra Fe atoms (as compared to the NiAs structure) are distributed randomly over the two interstitial sites. This phase can be considered either as a partially-filled NiAs type structure or a metal-deficient Ni_2In type structure [2002Dep].

In Fig. 1, in addition to $Fe_tGa_{2-x}Sb_x$, GaSb forms tie lines with several other binary phases. This means that annealing at lower temperatures (<500 °C) a Fe/GaSb contact does not result in a stable, monophasic, epitaxial heterostructure as is found in the As-Fe-Ga system [2002Dep].

References

1988Nga: T.L. Ngai, R.C. Sharma, and Y.A. Chang: "The Ga-Sb (Gallium-Antimony) System," *Bull. Alloy Phase Diagrams,* 1988, *9*(5), pp. 586-91.

1993Oka1: H. Okamoto: "Fe-Ga (Iron-Gallium)" in *Phase Diagrams of Ternary Iron Alloys,* H. Okamoto, ed., ASM International, Materials Park, OH, 1993, pp. 147-51.

1993Oka2: H. Okamoto: "Fe-Sb (Iron-Antimony)" in *Phase Diagrams of Ternary Iron Alloys,* H. Okamoto, ed., ASM International, Materials Park, OH, 1993, pp. 366-70.

1994Moz: O. Moze, A. Paoluzi, L. Pareti, G. Turilli, F. Bouree-Vigneron, B. Cockayne, W.R. Macewan, C. Greaves, N.A. Smith, and I.R. Harris: "Magnetic and Crystal Structure and Magnetocrystalline Anisotropy of Hexagonal $Fe_{60}Ga_{40-x}As_x$ (x = 6, 23) and $Fe_{60}Ga_{23}Sb_{17}$ Compounds," *IEEE Trans. Magn.*, 1994, *30*(2), pp. 1039-41.

2002Dep: S. Deputier, N. Barrier, R. Guerin, and A. Guivarc'h: "Solid State Phase Equilibria in the Fe-Ga-Sb Ternary System at 600 °C," *J. Alloys Compd.*, 2002, *340,* pp. 132-40.