JPEDAV (2004) 25:77–78
DOI: 10.1361/10549710417704
1547-7037/$19.00 ©ASM International

As-Fe-Ga (Arsenic-Iron-Gallium)

V. Raghavan

The previous review of this ternary system [1992Rag] presented data on the solubility of Fe in GaAs as a function of temperature and on the liquidus surface where GaAs crystallizes as the primary phase. Recently, Deputier et al. [1997Dep, 1998Dep] determined an isothermal section for this system at 600 °C.

Binary Systems

The As-Fe phase diagram reviewed by [1991Oka] depicts three established phases: the Cu_2Sb type tetragonal phase Fe_2As, the MnP type orthorhombic phase FeAs, and the FeS_2 (marcasite) type orthorhombic phase $FeAs_2$. The As-Ga phase diagram [Massalski2] shows the stoichiometric compound GaAs forming congruently from the melt at 1238 °C. GaAs has the cubic ZnS (sphalerite) type structure. The mutual solubility between As and Ga is negligible. The Fe-Ga system [1993Oka] 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 BiF_3 type cubic 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 [1993Oka] and [Pearson3].

Ternary Phases

The structural details of the ferromagnetic ternary phase $Fe_3Ga_{2-x}As_x$ (denoted τ here) were summarized by [1992Rag] from the studies of [1989Har]. More recent work on this ternary phase is reviewed by [1998Dep]. It crystallizes in hexagonal symmetry and is structurally derived from the $B8_1$, NiAs type structure. The solid solution is fully disordered in the range $x = 0.85$ to 1.125 and ordered for $x = 0.20$ to 0.85. The lattice parameters for the disordered form are: $a = 0.4009$ nm and $c = 0.5046$ nm at $x = 1.0$ and for the ordered form $a = 0.8133$ nm and $c = 0.5010$ nm at $x = 0.6$ [1998Dep]. Any existence of a two-phase field in the narrow range around $x = 0.85$ could not be detected, and [1998Dep] presented the entire composition range as a single phase.

The Ternary Isothermal Section

With starting materials of purity of ≥99.99%, [1998Dep] heated about 15 alloy compositions in evacuated silica tubes

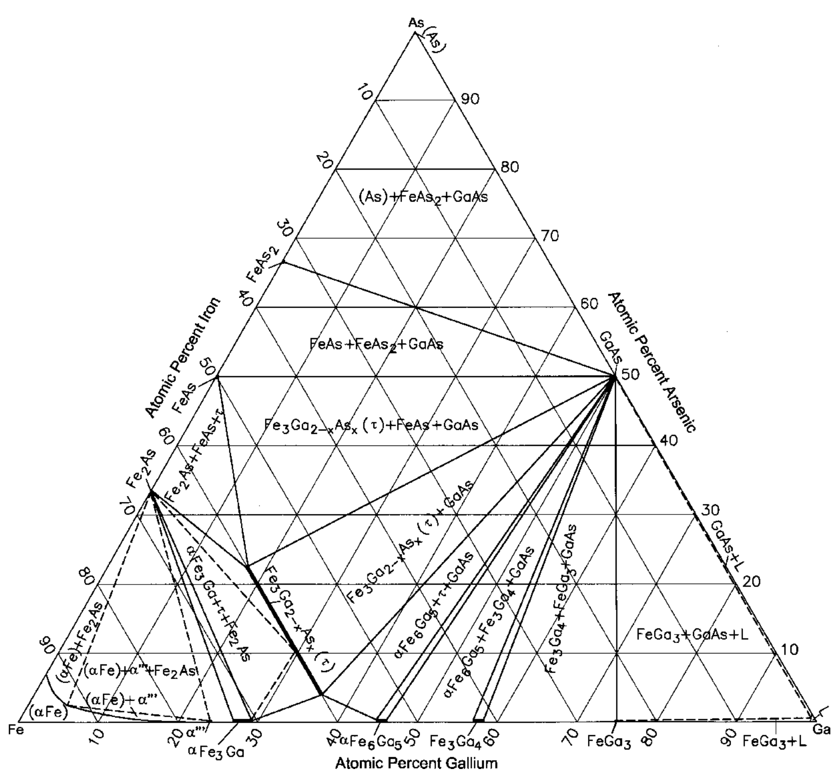

Fig. 1 As-Fe-Ga isothermal section at 600 °C [1998Dep]; narrow two-phase regions around tie-triangles are omitted.

to 1000 °C. After cooling, the samples were ground to powder, compacted, and given a final anneal at 600 °C for 10 d and quenched in ice-water mixture. The phase equilibria were studied mainly by x-ray powder diffraction. Electron probe microanalysis was done on some samples. The isothermal section at 600 °C constructed by [1998Dep] is redrawn in Fig. 1 to agree with the accepted binary data. The presence of the BiF_3 type ordered form (α''') omitted by [1998Dep] is schematically indicated. The main feature of this isothermal section is the formation of tie lines between the ternary phase $Fe_3Ga_{2-x}As_x$ (τ) and GaAs [1997Dep, 1998Dep]. This suggests that solid-state interdiffusion, which occurs during annealing of a Fe/GaAs contact, can lead to a ferromagnetic, epitaxial and stable Fe_3GaAs/GaAs heterostructure [1998Dep, 1999Lal]. This feature is not found in other M/III-V systems such as Ni-Ga-As, Fe-Ga-Sb, and Ni-Ga-Sb [2002Dep].

References

1989Har: I.R. Harris, N.A. Smith, E. Delvin, B. Cockayne, W.R. Macewan, and G. Longworth: "Structural, Magnetic and Constitutional Studies of a New Family of Ternary Phases Based on Fe_3GaAs," *J. Less Common Met.,* 1989, *146,* pp. 103-19.

1991Oka: H. Okamoto: "The As-Fe (Arsenic-Iron) System," *J. Phase Equilibria,* 1991, *12*(4), pp. 457-61.

1992Rag: V. Raghavan: "The As-Fe-Ga (Arsenic-Iron-Gallium) System," *Phase Diagrams of Ternary Iron Alloys,* Ind. Inst. Metals, Calcutta, 1992, pp. 250-52.

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

1997Dep: S. Deputier, R. Guerin, B. Lepine, A. Guivarc'h, and G. Jezequel: "The Ternary Compound $Fe_3Ga_{2-x}As_x$: a Promising Candidate for Epitaxial and Thermodynamically Stable Contacts on GaAs," *J. Alloys Compd.,* 1997, *262-263,* pp. 416-22.

1998Dep: S. Deputier, R. Guerin, and A. Guivarc'h: "Solid State Phase Equilibria in the Fe-Ga-As System," *Eur. Phys. J., Appl. Phys.,* 1998, *2*(2), pp. 127-33.

1999Lal: C. Lallaizon, B. Lepine, S. Ababou, A. Guivarc'h, S. Deputier, F. Abel, and C. Cohen: "Ion Channeling and X-ray Diffraction Studies of Epitaxial Fe on GaAs (001)," *J. Appl. Phys.,* 1999, *86*(10), pp. 5515-19.

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*(1-2)*,* pp. 132-140.