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Fe-Ga-Ni (Iron-Gallium-Nickel)

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Recently, [2008Duc] determined the phase equilibria among the face-centered cubic (fcc) and the ordered and disordered forms of body-centered cubic (bcc) phases in this system.

Binary Systems

The Fe-Ga phase diagram [2004Oka, Massalski2] has the following intermediate phases: α′ (*B*2, CsCl-type cubic), α″ ($D0_3$, BiF_3-type cubic), βFe_3Ga ($D0_{19}$, Ni_3Sn-type hexagonal), αFe_3Ga ($L1_2$, $AuCu_3$-type cubic), βFe_6Ga_5 (Al_8Cr_5-type rhombohedral), αFe_6Ga_5(Fe_6Ge_5-type monoclinic), Fe_3Ga_4 (monoclinic) and $FeGa_3$ ($CoGa_3$-type tetragonal). In the Fe-Ni phase diagram, a continuous face-centered cubic solid solution (denoted γ) forms between γFe and Ni and is stable over a wide range of temperature. At 517 °C, an ordered phase $FeNi_3$ ($L1_2$, $AuCu_3$-type cubic) forms congruently from γ. The Ga-Ni phase diagram [2007Duc, Massalski2] shows the following intermediate phases: Ga_4Ni ($D8_2$, Cu_5Zn_8-type cubic), Ga_3Ni_2 ($D5_{13}$, Ni_2Al_3-type hexagonal), β (42-69.4 at.% Ni; *B*2, CsCl-type cubic), Ga_2Ni_3 (denoted ε), Ga_7Ni_{13} (62.5-65 at.% Ni; $B8_1$, NiAs-type hexagonal), Ga_3Ni_5 (denoted δ; Ga_3Pt_5-type orthorhombic), and $GaNi_3$ ($L1_2$, $AuCu_3$-type cubic, denoted γ′).

Ternary Phase Equilibria

Partial isothermal sections at 1200, 1000, and 800 °C depicting the fcc-*B*2 equilibrium were determined by [2007Oik]. Extending this work, [2008Duc] used starting metals of 99.9% Fe, 99.9999% Ga, and 99.9% Ni to prepare diffusion couples and triples. Initially, a diffusion couple was prepared between Fe and Ni and given a diffusion-anneal to form a continuous diffusion zone. Holes were drilled near the diffusion zone to insert Ga chips. The final anneal of the diffusion triple was done at 1000, 900, and 850 °C for annealing times of 10-96 h. Microstructural analysis was done in the back scattering electron mode in the scanning electron microscope and the local composition was determined by electron probe microanalysis. The isothermal sections for Ga-lean alloys constructed by [2008Duc] at 1000, 900, and 850 °C are shown in Fig. 1-3. The phase distribution is similar at all the three temperatures. The fcc-bcc or fcc-*B*2 two-phase region narrows, on moving towards the Fe corner. The $L1_2$ (Ni_3Ga) phase dissolves 14-18 at.% Fe. The Ni-Ga binary phase $Ni_{13}Ga_7$ indicated in Fig. 2 and 3 has very limited extension into the ternary region.

[2008Duc] constructed two partial vertical sections between 600 and 1100 °C along the Ni_3Ga-Fe_3Ga line and at a constant Ni content of 50 at.%, respectively. These are shown in Fig. 4 and 5. In Fig. 4, the $B2 \leftrightarrow L2_1$ second-order transition temperature increases slightly with

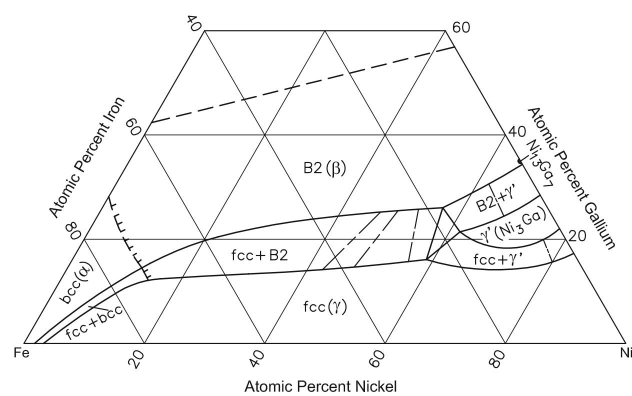

Fig. 2 Fe-Ga-Ni isothermal section at 900 °C [2008Duc]

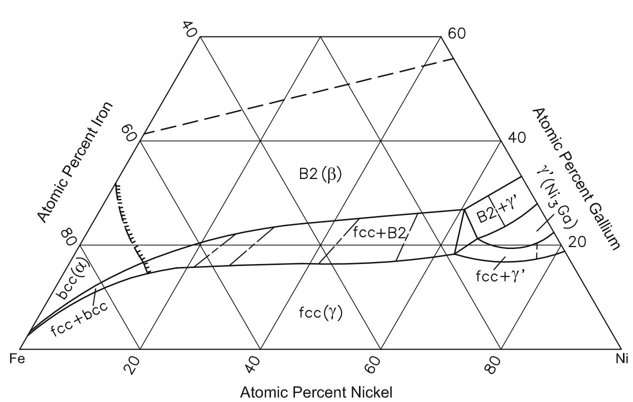

Fig. 1 Fe-Ga-Ni isothermal section at 1000 °C [2008Duc]

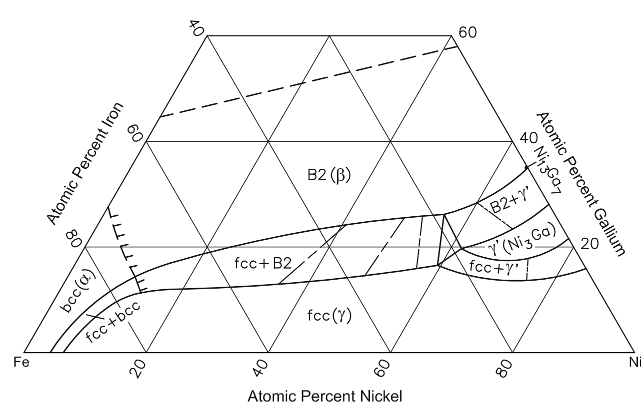

Fig. 3 Fe-Ga-Ni isothermal section at 850 °C [2008Duc]

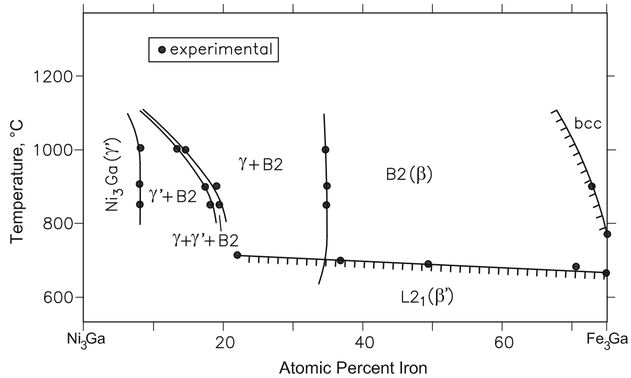

Fig. 4 Fe-Ga-Ni partial vertical section along the Ni_3Ga-Fe_3Ga join [2008Duc]

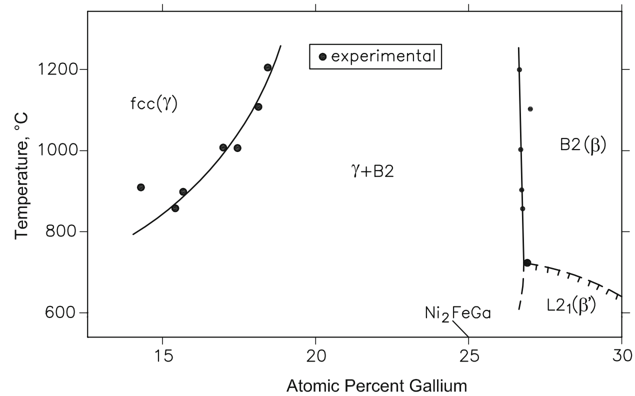

Fig. 5 Fe-Ga-Ni partial vertical section at 50 atomic percent Ni [2008Duc]

increasing Ni content. In Fig. 5, the solubility of Ga in fcc (γ) decreases with decreasing temperature. The solubility of Ga in the *B*2 (β) phase is almost independent of temperature [2008Duc, 2004Omo].

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