

# Fe-Ga-Nd (Iron-Gallium-Neodymium)

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Recently, [2009Li] determined an isothermal section for this ternary system at 500 °C, which depicts three ternary compounds.

NdFe<sub>2</sub>Ga<sub>8</sub> (denoted as  $\alpha$  by [2009Li] and as  $\tau_1$  here), NdFe<sub>5</sub>Ga<sub>7</sub> ( $\beta$  or  $\tau_2$ ), and Nd<sub>6</sub>Fe<sub>13</sub>Ga ( $\gamma$  or  $\tau_3$ ). The structural details with homogeneity ranges are shown in Table 1. The atomic coordinates were determined and listed for  $\tau_2$  and  $\tau_3$  phases by [2009Li].

## Binary Systems

The Fe-Ga phase diagram [2004Oka, Massalski2] has the following intermediate phases:  $\alpha'$  (B2, CsCl-type cubic),  $\alpha''$  (D0<sub>3</sub>, BiF<sub>3</sub>-type cubic),  $\beta$ Fe<sub>3</sub>Ga (D0<sub>19</sub>, Ni<sub>3</sub>Sn-type hexagonal),  $\alpha$ Fe<sub>3</sub>Ga(L1<sub>2</sub>, AuCu<sub>3</sub>-type cubic),  $\beta$ Fe<sub>6</sub>Ga<sub>5</sub> (Al<sub>8</sub>Cr<sub>5</sub>-type rhombohedral),  $\alpha$ Fe<sub>6</sub>Ga<sub>5</sub> (Fe<sub>6</sub>Ge<sub>5</sub>-type monoclinic), Fe<sub>3</sub>Ga<sub>4</sub> (monoclinic) and FeGa<sub>3</sub> (CoGa<sub>3</sub>-type tetragonal). The Fe-Nd phase diagram depicts two intermediate phases: Fe<sub>17</sub>Nd<sub>2</sub> (Th<sub>2</sub>Zn<sub>17</sub>-type rhombohedral) and Fe<sub>17</sub>Nd<sub>5</sub> (hexagonal, space group *P6<sub>3</sub>/mcm*). The Ga-Nd phase diagram [Massalski2, 2009Li] depicts the following intermediate phases: Nd<sub>9</sub>Ga<sub>4</sub> (Sm<sub>9</sub>Ga<sub>4</sub>-type tetragonal), Nd<sub>5</sub>Ga<sub>3</sub> (D8<sub>1</sub>, Cr<sub>5</sub>B<sub>3</sub>-type tetragonal), NdGa (*B<sub>f</sub>*, CrB-type orthorhombic), NdGa<sub>2</sub> (C32, AlB<sub>2</sub>-type hexagonal),  $\beta$ NdGa<sub>6</sub>, and  $\alpha$ NdGa<sub>6</sub> (tetragonal, space group *P4/nbm*).

## Ternary Isothermal Section

With starting metals of 99.99% Fe, 99.99% Ga and 99.9% Nd, [2009Li] arc-melted under Ar atm about 168 alloy samples. The samples were given a final anneal at 500 °C for 3 days and quenched in liquid nitrogen. The phase equilibria were studied with x-ray powder diffraction. The isothermal section at 500 °C constructed by [2009Li] is shown in Fig. 1. The three ternary compounds are present, with  $\tau_2$  and  $\tau_3$  showing a range of homogeneity, see Table 1. Among the binary compounds, only Fe<sub>17</sub>Nd<sub>2</sub> shows a ternary solubility of 7.5 at.% Ga.

## Ternary Compounds

Three known ternary compounds in this system were confirmed by [2009Li]. Their nominal formulas are:

## References

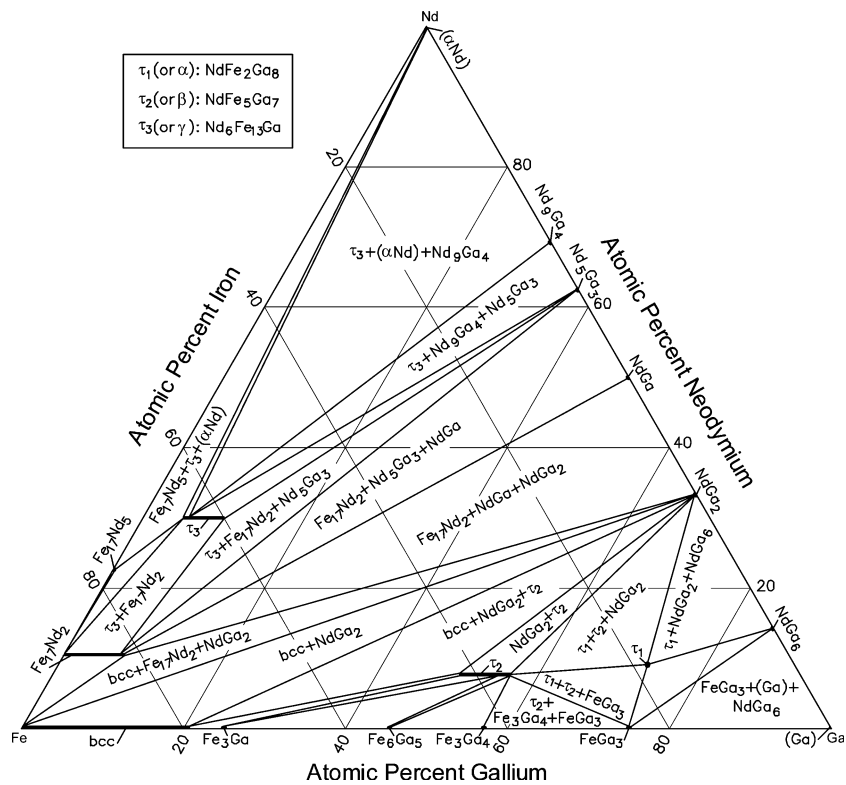
- 2004Oka: H. Okamoto, Fe-Ga (Iron-Gallium), *J. Phase Equilib. Diffus.*, 2004, **25**(1), p 100  
 2009Li: J.Q. Li, W.H. Zhang, Y.J. Yu, F.S. Liu, W.Q. Ao, and J.L. Yan, The Isothermal Section of the Nd-Fe-Ga Ternary System at 773 K, *J. Alloys Compd.*, 2009, **487**, p 116-120

**Table 1** Fe-Ga-Nd crystal structure and lattice parameter data [2009Li]

Phase	Composition, at.%	Pearson symbol	Space group	Prototype	Lattice parameter, nm
NdFe <sub>2</sub> Ga <sub>8</sub> ( $\alpha$ or $\tau_1$ )	18.2 Fe 72.7 Ga 9.1 Nd	<i>oP44</i>	<i>Pbam</i>	CaCo <sub>2</sub> Al <sub>8</sub>	$a = 1.43742$ $b = 1.24601$ $c = 0.40479$
NdFe <sub>5</sub> Ga <sub>7</sub> ( $\beta$ or $\tau_2$ )	42-35.8 Fe 50.3-56.5 Ga 7.7 Nd	<i>tI26</i>	<i>I4/mmm</i>	ThMn <sub>12</sub>	$a = 0.87358$ (a) $c = 0.50998$
Nd <sub>6</sub> Fe <sub>13</sub> Ga ( $\gamma$ or $\tau_3$ )	65-60 Fe 5-10 Ga 30 Nd	<i>tI80</i>	<i>I4/mcm</i>	La <sub>6</sub> Co <sub>11</sub> Ga <sub>3</sub>	$a = 0.80686$ (b) $c = 2.2937$

(a) At NdFe<sub>4.85</sub>Ga<sub>7.15</sub> and (b) at Nd<sub>6</sub>Fe<sub>13</sub>Ga

## Section II: Phase Diagram Evaluations



**Fig. 1** Fe-Ga-Nd isothermal section at 500 °C [2009Li]. Narrow two-phase regions are omitted