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Fe-Gd-Ge (Iron-Gadolinium-Germanium)

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Recently, [2009Zhu] determined an isothermal section for this system at 500 °C covering the entire composition range. It depicts four ternary compounds.

Binary Systems

The Fe-Gd phase diagram [1998Zha] depicts the following intermediate compounds: $\beta Fe_{17}Gd_2$ (Th_2Ni_{17}-type hexagonal), $\alpha Fe_{17}Gd_2$ (Th_2Zn_{17}-type rhombohedral), $Fe_{23}Gd_6$ ($D8_a$, $Mn_{23}Th_6$-type cubic), Fe_3Gd (Be_3Nb-type rhombohedral), and Fe_2Gd ($C15$, $MgCu_2$-type cubic). In the Fe-Ge phase diagram [Massalski2], the intermediate phases stable at 500 °C are: Fe_3Ge ($L1_2$, $AuCu_3$-type cubic), Fe_5Ge_3 ($B8_1$, NiAs-type hexagonal), Fe_6Ge_5 (Fe_6Ge_5-type monoclinic, space group $C2/m$), FeGe, and $FeGe_2$ ($C16$, $CuAl_2$-type tetragonal). The Gd-Ge phase diagram [Massalski2, 2009Zhu] depicts the following intermediate phases at 500 °C: Gd_5Ge_3 (hexagonal, $P6_3/mcm$), Gd_5Ge_4 (Ge_4Sm_5-type orthorhombic?), GdGe (B_f, CrB-type orthorhombic), Gd_2Ge_3 ($C32$, AlB_2-type hexagonal), and $GdGe_{2-x}$ ($\alpha GdSi_2$-type orthorhombic).

Ternary Compounds

[2009Zhu] identified four ternary compounds in this system at 500 °C: $GdFe_6Ge_6$ (τ_1) is hexagonal with Cu_7Tb as the prototype. $GdFe_2Ge_2$ (τ_2) has the Al_4Ba-type tetragonal structure. $Gd_{117}Fe_{52}Ge_{112}$ (τ_3) is cubic of the $Fe_5Ge_{11}Tb_{12}$-type. Gd_2FeGe_4 or $GdFe_xGe_2$ ($0.25 < x < 0.46$) (τ_4) is $CeNiSi_2$-type orthorhombic [1990Fra]. Table 1 lists the structural details of these compounds. The notations τ_1, τ_2, τ_3, and τ_4 used here correspond to A, B, C, and D, respectively, used by [2009Zhu].

Isothermal Section

With starting metals of 99.95% Gd, 99.99% Fe, and 99.999% Ge, [2009Zhu] arc-melted 183 alloys under Ar atm. The samples were given a final anneal at 500 °C for 15-60 d and quenched in liquid nitrogen. The phase equilibria were studied mainly with x-ray powder diffraction. The isothermal section at 500 °C constructed by [2009Zhu] is shown in Fig. 1. All the four ternary

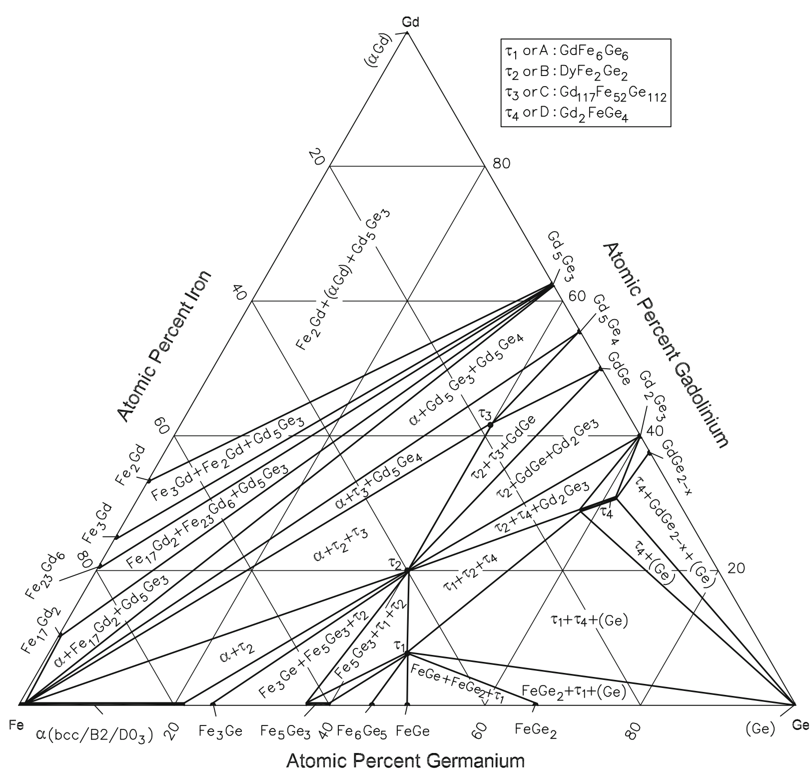

Fig. 1 Fe-Gd-Ge isothermal section at 500 °C [2009Zhu]. Narrow two-phase regions are omitted

Table 1 Fe-Gd-Ge crystal structure and lattice parameter data [2009Zhu]

Phase	Composition, at.%	Pearson symbol	Space group	Prototype	Lattice parameter, nm
$GdFe_6Ge_6$ (τ_1 or A)	7.7 Gd 46.15 Fe 46.15 Ge	*hP*8	*P*6/*mmm*	Cu_7Tb	*a* = 0.5118 *c* = 0.4056
$GdFe_2Ge_2$ (τ_2 or B)	20 Gd 40 Fe 40 Ge	*tI*10	*I*4/*mmm*	Al_4Ba	*a* = 0.3899 *c* = 1.048
$Gd_{117}Fe_{52}Ge_{112}$ (τ_3 or C)	41.6 Gd 18.5 Fe 39.9 Ge		$Fm\bar{3}m$	$Fe_5Ge_{11}Tb_{12}$	*a* = 2.8711
$GdFe_xGe_2$ (τ_4 or D)	30.8-28.9 Gd 7.7-13.3 Fe 61.5-57.8 Ge	*oC*16	*Cmcm*	$CeNiSi_2$	*a* = 0.4156 *b* = 1.608 *c* = 0.4046

compounds listed in Table 1 are present. None of the binary compounds show any solubility of the third component. To find whether the compound $GdFe_{8.4}Ge_{3.6}$ reported by [1996Wan] existed, [2009Zhu] prepared an alloy at this composition and found that it consisted of two phases (αFe) and $GdFe_2Ge_2$.

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