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Dy-Fe-Ge (Dysprosium-Iron-Germanium)

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

Binary Systems

The Dy-Fe phase diagram [Massalski2] shows the following intermetallic compounds: $Fe_{17}Dy_2$ ($Ni_{17}Th_2$-type hexagonal), $Fe_{23}Dy_6$ ($D8_a$, $Mn_{23}Th_6$-type cubic), Fe_3Dy (Be_3Nb-type rhombohedral), and Fe_2Dy ($C15$, $MgCu_2$-type cubic). The Dy-Ge phase diagram [Massalski2, 2009Zhu] depicts the following intermediate phases: Dy_5Ge_3 ($D8_8$, Mn_5Si_3-type hexagonal), Dy_5Ge_4 (Ge_4Sm_5-type orthorhombic), DyGe (B_f, CrB-type orthorhombic), Dy_2Ge_3 ($C32$, AlB_2-type hexagonal), Dy_3Ge_5 (Ge_5Y_3-type orthorhombic), $DyGe_2$ (Ge_2Tb-type orthorhombic), and $DyGe_3$ ($DyGe_3$-type orthorhombic). In the Fe-Ge phase diagram [Massalski2], the intermediate phases found 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).

Ternary Compounds

[2009Zhu] identified five ternary compounds at 500 °C. $DyFe_4Ge_2$ (τ_1) has the $ZrFe_4Si_2$-type tetragonal structure. $DyFe_6Ge_6$ (τ_2) is orthorhombic, with Fe_6Sn_6Tb as the prototype. $DyFe_2Ge_2$ (τ_3) has the Al_4Ba-type tetragonal structure. $Dy_{117}Fe_{52}Ge_{112}$ (τ_4) is cubic of the $Fe_5Ge_{11}Tb_{12}$-type. $DyFe_xGe_2$ (τ_5) is $CeNiSi_2$-type orthorhombic. It has a homogeneity range of x = 0.25-0.46, corresponding to 7.7-13.3 at.% Fe. Table 1 lists the structural details of these compounds. The notation τ_1, τ_2, etc., used here correspond to 1, 2, etc., used by [2009Zhu].

Isothermal Section

With starting metals of 99.9% Dy, 99.9% Fe, and 99.99% Ge, [2009Zhu] arc-melted 187 alloys under Ar atm. The alloys were given a final anneal at 500 °C for 720 h and quenched in liquid nitrogen. The phase equilibria were studied with x-ray powder diffraction, optical microscopy, and differential thermal analysis at a heating rate of 10 °C per min. The isothermal section at 500 °C constructed by [2009Zhu] is shown in Fig. 1. All the five ternary compounds listed in Table 1 are present. As seen in Fig. 1, only the Dy-Fe binary compounds show some solubility for the third component. To find whether a compound analogous to $GdFe_{8.4}Ge_{3.6}$ reported by [1996Wan] exists in this system, [2009Zhu] prepared an alloy with the composition $DyFe_{8.4}Ge_{3.6}$ and found that it consisted of two phases (α Fe) and $DyFe_2Ge_2$.

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

Phase	Composition, at.%	Pearson symbol	Space group	Prototype	Lattice parameter, nm
$DyFe_4Ge_2$ (τ_1)	14.3 Dy 57.1 Fe 28.6 Ge	*tP*14	$P4_2/mnm$	$ZrFe_4Si_2$	a = 0.7318 c = 0.3865
$DyFe_6Ge_6$ (τ_2)	7.7 Dy 46.15 Fe 46.15 Ge		*Cmcm*	Fe_6Sn_6Tb	a = 0.8118 b = 1.768 c = 0.5116
$DyFe_2Ge_2$ (τ_3)	20 Dy 40 Fe 40 Ge	*tI*10	$I4/mmm$	Al_4Ba	a = 0.3957 c = 1.0446
$Dy_{117}Fe_{52}Ge_{112}$ (τ_4)	41.6 Dy 18.5 Fe 39.9 Ge		$Fm\bar{3}m$	$Fe_5Ge_{11}Tb_{12}$	a = 2.8518
$DyFe_xGe_2$ or $Dy_5Fe_2Ge_{10}$ (τ_5)	30.8-28.9 Dy 7.7-13.3 Fe 61.5-57.8 Ge	*oC*16	*Cmcm*	$CeNiSi_2$	a = 0.4121 b = 1.581 c = 0.4011

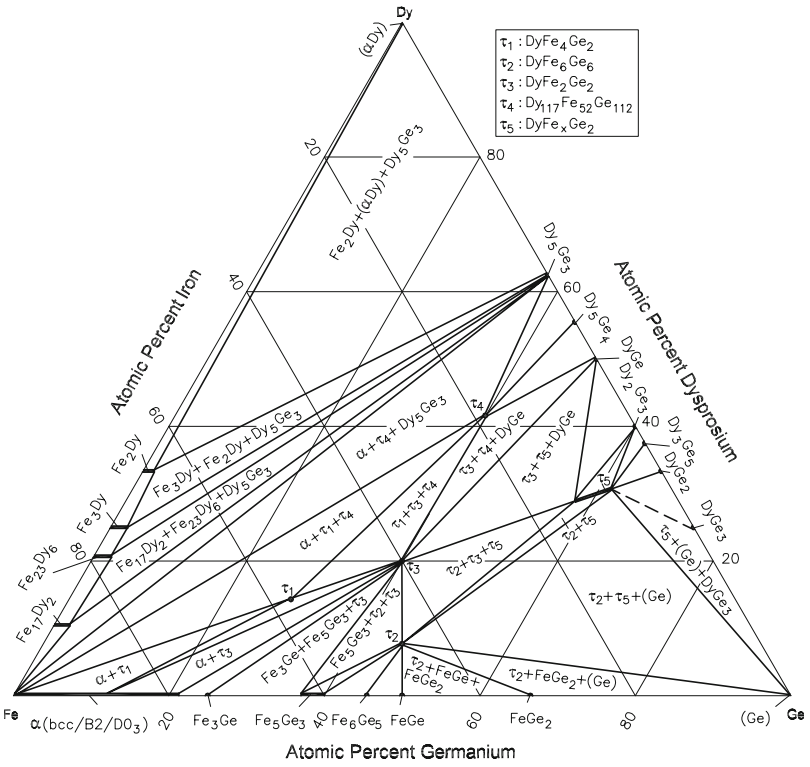

Fig. 1 Dy-Fe-Ge isothermal section at 500 °C [2009Zhu]. Narrow two-phase regions are omitted

References

1996Wan: K.Y. Wang, J. Hu, Y.Z. Wang, B.P. Hu, and Z.X. Wang, Formation of Novel Ternary Iron-Rich Rare Earth Compounds R-Fe-Ge (R = Sm, Gd), *J. Alloys Compd.*, 1996, **233**, p L1-L2

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