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Ce-Fe-Si (Cerium-Iron-Silicon)

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The previous results on the phase equilibria of this system were reviewed by [1992Rag] and pertain mainly to a composite isothermal section reported by [1970Bod] at 800 °C for the composition range of 0-33.3 at.% Ce and at 400 °C for the 33.3-100 at.% Ce range. Recently, [2007Ber] determined an isothermal section for this system at 900 °C, which depicts six ternary compounds.

Binary Systems

The Ce-Fe phase diagram [Massaslki2] depicts two stoichiometric compounds: one dimorphic, $\beta Fe_{17}Ce_2$ (Th_2Zn_{17}-type rhombohedral), and $\alpha Fe_{17}Ce_2$ (Th_2Ni_{17}-type hexagonal), and the other Fe_2Ce ($C15$, $MgCu_2$-type cubic). The Ce-Si phase diagram [2002Bul] depicts the following intermediate phases: Ce_5Si_3 ($D8_m$, W_5Si_3-type tetragonal), Ce_3Si_2 ($D5_a$, U_3Si_2-type tetragonal), Ce_5Si_4 (Zr_5Si_4-type tetragonal), CeSi ($B27$, FeB-type orthorhombic), Ce_3Si_5 ($GdSi_2$-type orthorhombic), and $CeSi_2$ (C_c, $ThSi_2$-type tetragonal). Among these, $CeSi_2$ has a homogeneity range from 64 to 66.7 at.% Si. In the Fe-Si system [Massalski2], the Fe-based face-centered cubic phase γ is enclosed by a loop. The intermediate phases are: α_2 ($B2$, CsCl-type cubic), α_1 ($D0_3$, BiF_3-type cubic), Fe_2Si (stable between 1212 and 1040 °C; hexagonal), Fe_5Si_3 ($D8_8$, Mn_5Si_3-type hexagonal), FeSi ($B20$-type cubic), $\beta FeSi_2$ (tetragonal), and $\alpha FeSi_2$ (orthorhombic).

Ternary Compounds

Table 1 lists the six ternary compounds identified by [2007Ber] at 900 °C. The compounds labeled τ_1, τ_2, and τ_3 by [1992Rag] were reported earlier by [1970Bod] and correspond to C, D, and B respectively in the notation used by [2007Ber]. The compound Ce_2FeSi_3 (denoted τ_4 by [1992Rag] and A by [2007Ber]) was reported by [1970Bod], but not found by [2007Ber]. It has the same AlB_2-type of structure as τ_4 (E) found by [2007Ber] at the composition $Ce_5Fe_2Si_8$. The compounds τ_5 and τ_6 correspond to F and G in the notation of [2007Ber]. They both lie along the isoconcentration line of 7.1 at.% Ce and have a homogeneity range, see Table 1.

Isothermal Section

A total of 40 alloy samples were arc-melted by [2007Ber] starting from metals of unspecified purity. The alloys were annealed at 900 °C for 10 days and quenched to room temperature. The phase equilibria were studied by x-ray powder diffraction, scanning electron microscopy and energy dispersive X-ray spectroscopy. The isothermal section at 900 °C constructed by [2007Ber] is redrawn in Fig. 1 to agree with the accepted binary data. The six ternary compounds listed in Table 1 are present. The binary compounds Fe_2Ce and $Fe_{17}Ce_2$ dissolve 5 and 15.8 at.% Si, respectively. The compounds Ce_3Si_5 and $CeSi_2$ dissolve 4.7 and 3.3 at.% Fe. The other binary compounds showed negligible solubility for the third component [2007Ber].

Table 1 Ce-Fe-Si crystal structure and lattice parameter data [2007Ber]

Phase	Composition, at.%	Pearson symbol	Space group	Prototype	Lattice parameter, nm
CeFeSi (τ_1 or C)	33.3 Ce 33.3 Fe 33.3 Si	*tP*6	*P*4/*nmm*	Cu_2Sb	*a* = 0.4084 *c* = 0.6783
$CeFe_2Si_2$ (τ_2 or D)	20 Ce 40 Fe 40 Si	*tI*10	*I*4/*mmm*	Al_4Ba	*a* = 0. 4005 *c* = 0.9838
$CeFeSi_2$ (τ_3 or B)	25 Ce 25 Fe 50 Si	*oC*16	*Cmcm*	$CeNiSi_2$	*a* = 0.4088 *b* = 1.6821 *c* = 0.4016
$Ce_5Fe_2Si_8$ (τ_4 or E)	33.3 Ce 13.3 Fe 53.3 Si	*hP*3	*P*6/*mmm*	AlB_2	*a* = 0.4079 *c* = 0.4251
$CeFe_{10.6\text{-}10.4}Si_{2.4\text{-}2.6}$ (τ_5 or F)	7.1 Ce 75.7-74.3 Fe 17.1-18.6 Si	*cF*112	$Fm\bar{3}c$	$NaZn_{13}$	*a* = 1.1384(a)
$CeFe_{9.5\text{-}8}Si_{3.5\text{-}5}$ (τ_6 or G)	7.1 Ce 67.9-57.1 Fe 25-35.7 Si	*tI*56	*I*4/*mcm*	$Ce_2Ni_{17}Si_9$	*a* = 0.7896(a) *c* = 1.1692

(a) Lattice parameters are for $CeFe_{10.6}Si_{2.4}$ and $CeFe_8Si_5$, respectively

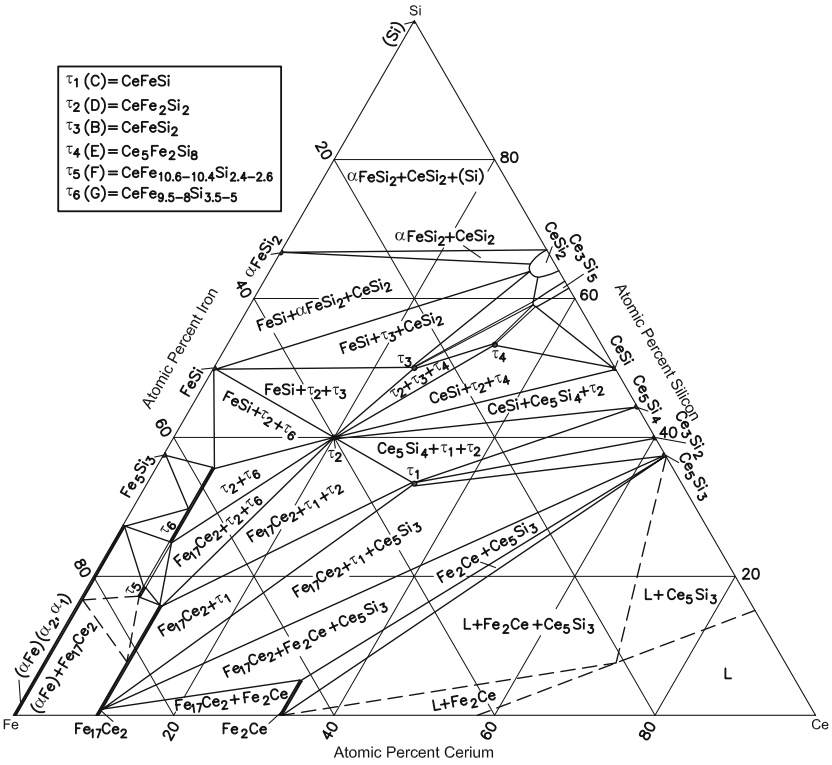

Fig. 1 Ce-Fe-Si isothemal section at 900 °C [2007Ber]. Narrow two-phase regions are omitted

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