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The Ti-Si-C System (Titanium-Silicon-Carbon)

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In the present article different isothermals of Ti-Si-C system at temperatures ranging from 1250 to 2877 °C, previously reported by [1966Bru], [1989Tou], [1991Wak], and [1993Sei], were assessed and redrawn on the basis of the recently reported binary alloy phase diagram of Ti-Si, Ti-C, and Si-C.

1. Ti-C System

The assessed phase diagram of Ti-C system shown in Fig. 1 is taken from [1998Oka]. Other recent work done on this system has been published by [1993Oht], [1995Alb], [1996Sei1], and [1996Jon]. The system consists of two terminal solids α-Ti and β-Ti, a refractory monocarbide TiC. Other phases present are liquid and graphite (C). Two eutectic reaction and one peritectoid reaction appear in this system at 1646, 2776, and 920 °C, respectively. Crystal structure data shown Table 1 are taken from [Massalski1].

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2. Ti-Si System

The equilibrium phase diagram of Ti-Si binary system shown in Fig. 2 is taken from [1996Sei2]. An important contribution is from [1989Vah]. The Ti-Si system is characterized by three eutectic and two peritectic reactions. The different intermediate phases present in this system are Ti_3Si, Ti_5Si_3, Ti_5Si_4, Ti_6Si_5, TiSi, and $TiSi_2$. Crystal structure data shown in Table 2 are taken from [Massalski1].

3. Si-C System

Very few experimental data are available on Si-C binary system. The assessed phase diagram in Fig. 3 is taken from [1992Luk]. This system includes one peritectic reaction and

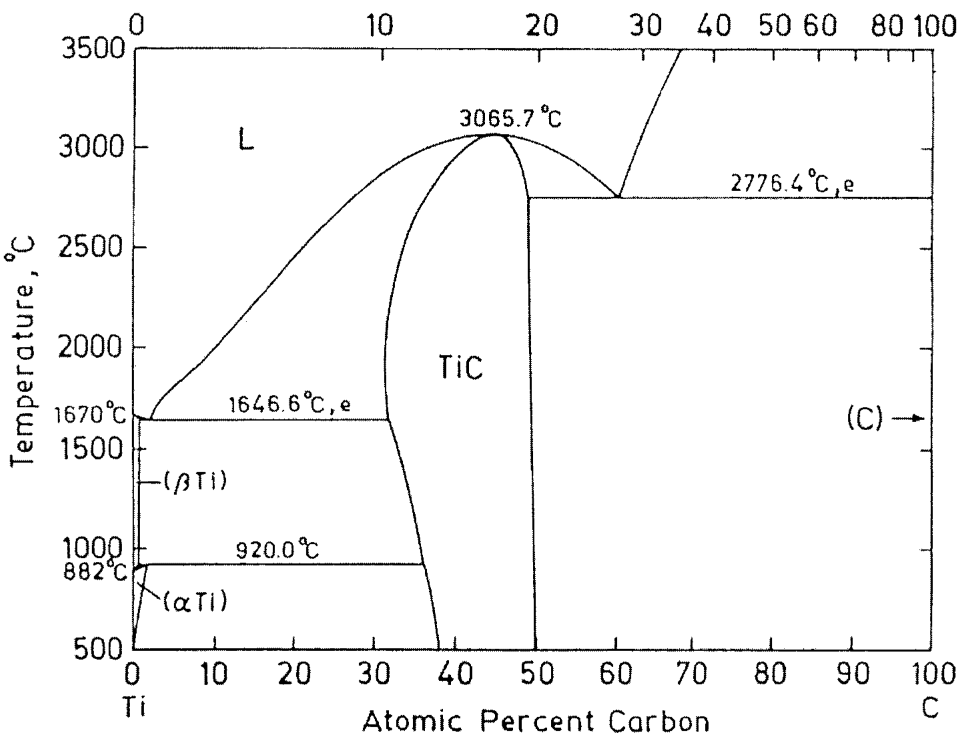

Fig. 1 Ti-C phase diagram

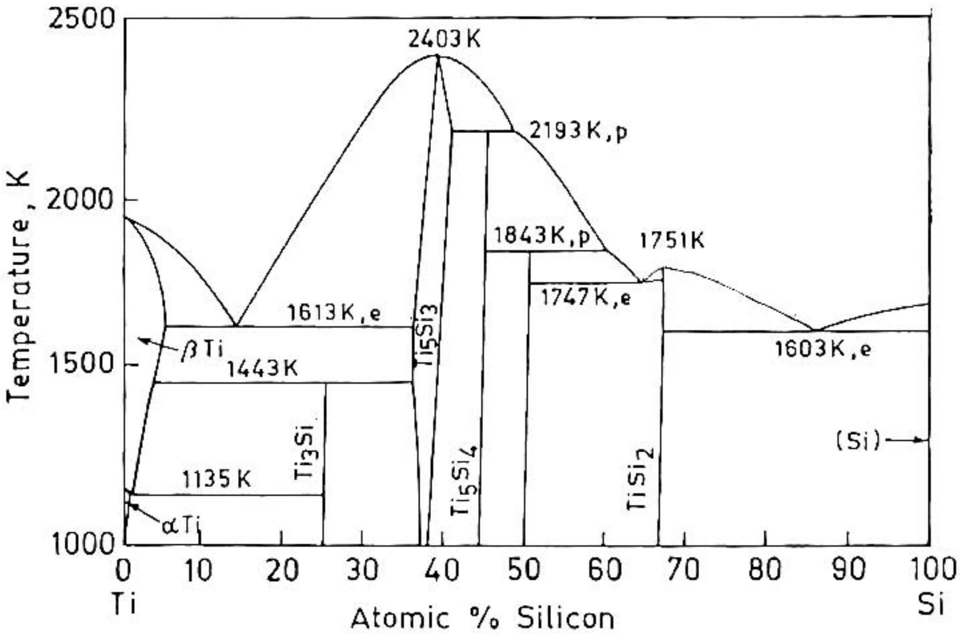

Fig. 2 Ti-Si phase diagram

Table 1 Ti-C crystal structure data

Phase	Composition, at.% C	Pearson symbol	Space group	Strukturbericht designation	Prototype
(β-Ti)	0 to 0.6	*cI*2	$Im\bar{3}m$	*A*2	W
(α-Ti)	0 to 1.6	*hP*2	$P6_3/mmc$	*A*2	Mg
γ-TiC	~32 to 48.8	*cF*8	$Fm\bar{3}m$	*B*1	NaCl
Ti_2C	~32 to 36	*cF*48	$Fm\bar{3}m$	*B*1	NaCl

Table 2 Ti-Si crystal structure data

Phase	Composition, at.% Si	Pearson symbol	Space group	Strukturbericht designation	Prototype
(α-Ti)	0 to 0.5	*hP*2	$P6_3/mmc$	*A*3	Mg
(β-Ti)	0 to 3.5	*cI*2	$Im\bar{3}m$	*A*2	W
Ti_3Si	25	*tP*32	$P4_2/n$	…	Ti_3P
Ti_5Si_3	35.5 to 39.5	*hP*16	$P6_3/mcm$	$D8_8$	Mn_5Si_3
Ti_5Si_4	44.4	*tP*36	$P4_12_12$	…	Zr_5Si_4
Ti_6Si_5	45.5	(a)	…	…	…
TiSi	50	*oP*8	*Pmm*2	…	TiSi
		*oP*8	*Pnma*	*B*27	FeB
		*oP*8	*Pnma*	*B*27	FeB
$TiSi_2$	66.7	*oF*24	*Fddd*	*C*54	$TiSi_2$
(Si)	100	*cF*8	$Fd\bar{3}m$	*A*4	C(diamond)

(a) Tetragonal, related to σ ($D8_8$)

one eutectic reaction at 2545 and 1404 °C, respectively. Crystal structure data shown in Table 3 are taken from [Massalski1].

4. Ti-Si-C System

Phase stability in the Ti-Si-C ternary system was investigated by [1992Sam]. They have constructed an isothermal

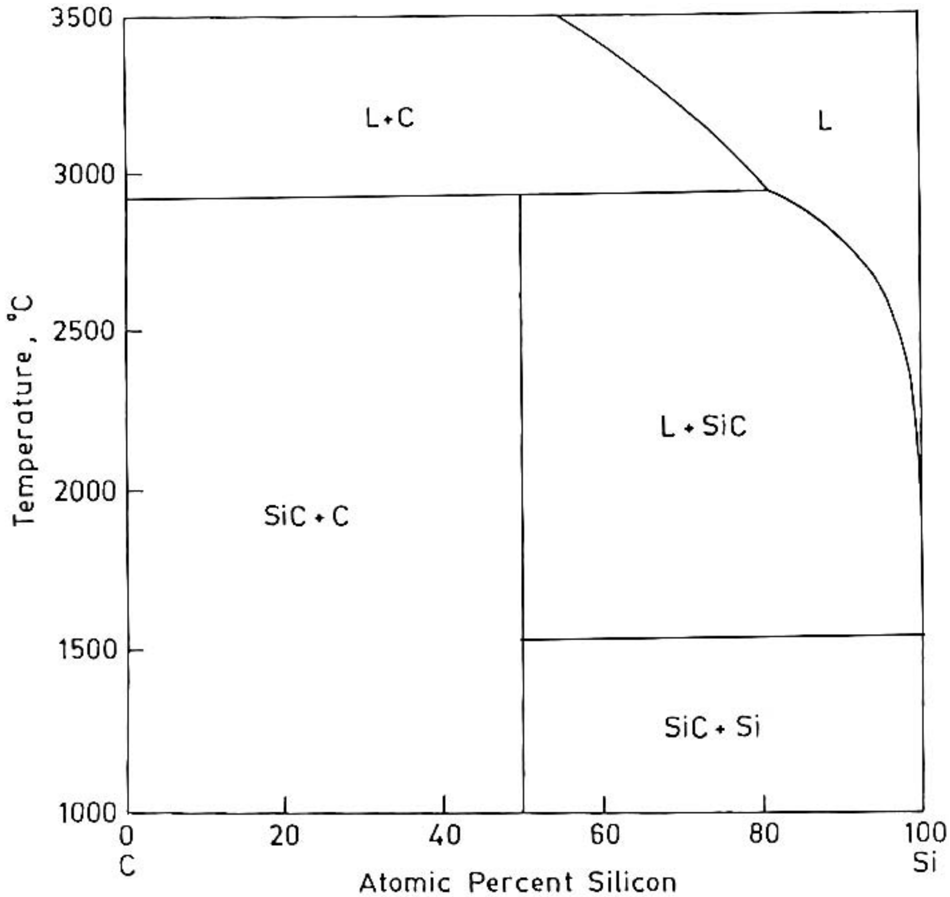

Fig. 3 Si-C phase diagram

Table 3 Si-C crystal structure data

Phase	Composition at.% Si	Pearson symbol	Space group	Strukturbericht designation	Prototype
(Si)	0	*cF*8	$F\bar{4}3m$	*A*4	C(diamond)
SiC or β-SiC	50	*cF*8	$F\bar{4}3m$	*B*3	ZnS
C or graphite	100	*hP*4	$P6_3/mmc$	*A*9	C(graphite)
α-SiC(a)	50	(b)	…	…	…
Amorphous (c)	39 to 61	…	…	…	…
High Pressure					
SiC II	…	tI_4	$I4_1/amd$	*A*5	β-Sn

(a) Other SiC poly-types have been reported. (b) Hexagonal. (c) SiC is a line compound even amorphous. 39 to 61 at.% of SiC could be a mixture of SiC and Si or SiC and C.

section at 1200 °C and 240 MPa pressure. A previous study was done on this system by [1966Bru]. The isothermal section at the above temperature and pressure constructed by [1992Sam] shows the existence of $Ti_3Si(c)$ phase that was not present in the study of [1966Bru]. [1975Ava] investigated the possibility of isolating a single phase using the method of crystallization from the gas phase in this system in the temperature range of 1100-1700 °C. Interaction between titanium and SiC was studied by [1990Cho] by electron microprobe, scanning electron microscopy (SEM), and transmission electron microscopy (TEM) techniques. [1989Tou] reviewed the Gibbs free energies of formation of the solid compounds in the Ti-Si-C system and calculated an isothermal section at 1227 °C. Extensive work on this system was done by [1993Sei]. On the basis of the work done by [1966Bru], [1989Tou], [1991Wak], and [1993Sei] together with recently assessed binaries, the ternary Ti-Si-C alloy phase diagram has been assessed and from this has been drawn the isothermal sections from 1250 to 2877 °C that are shown in Fig. 4-7.

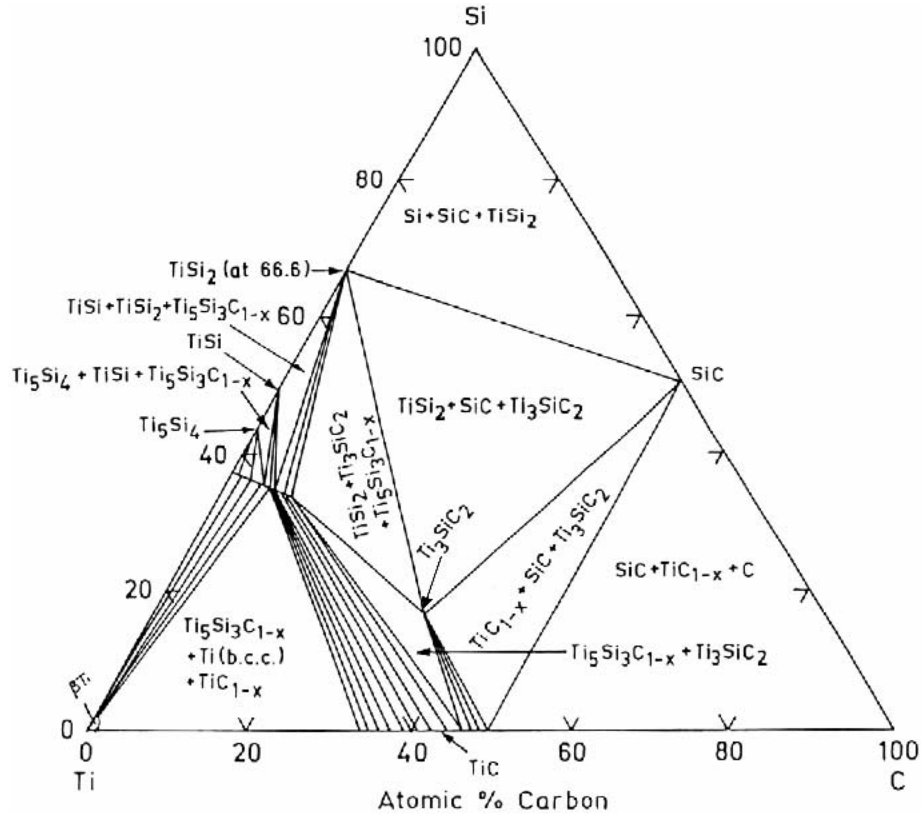

Fig. 4 Isothermal sections of Ti-Si-C system at 1250 °C

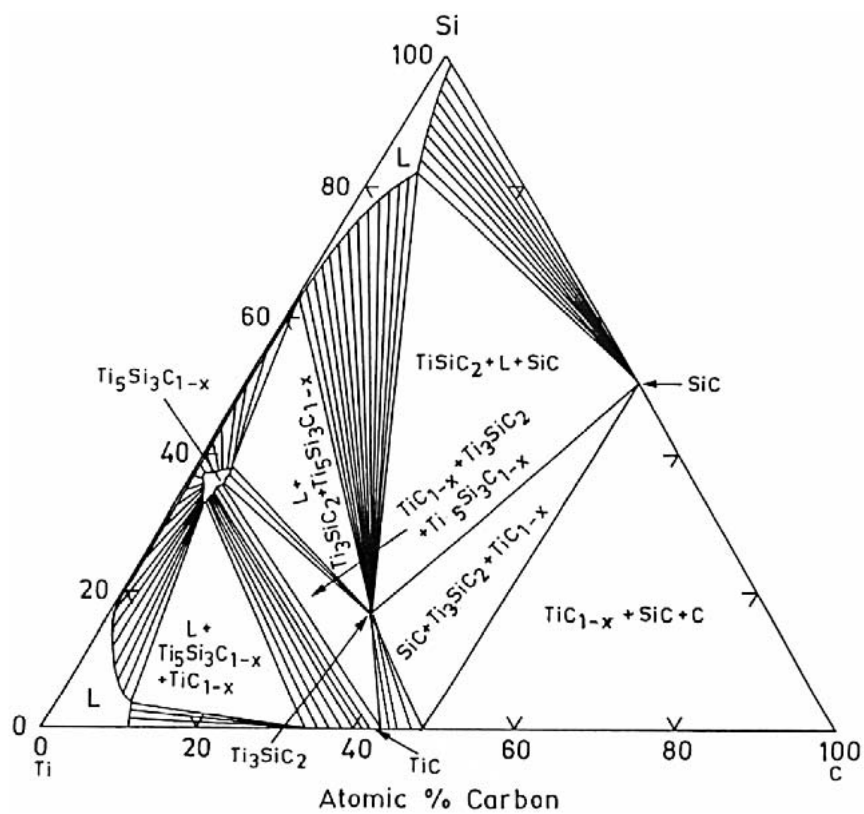

Fig. 5 Isothermal sections of Ti-Si-C system at 2222 °C

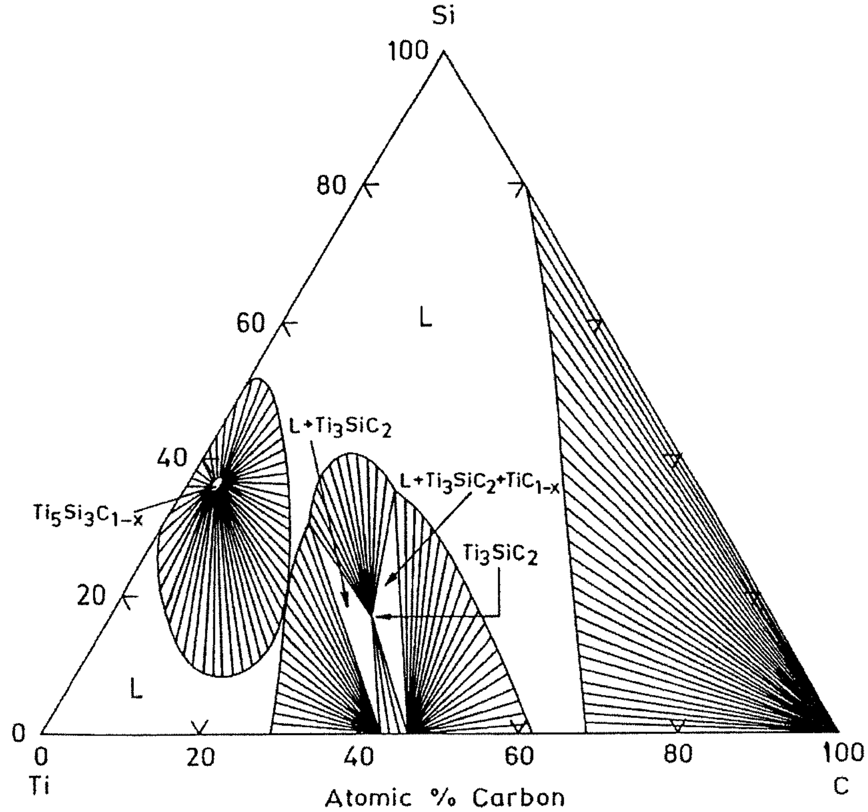

Fig. 6 Isothermal sections of Ti-Si-C system at 2827 °C

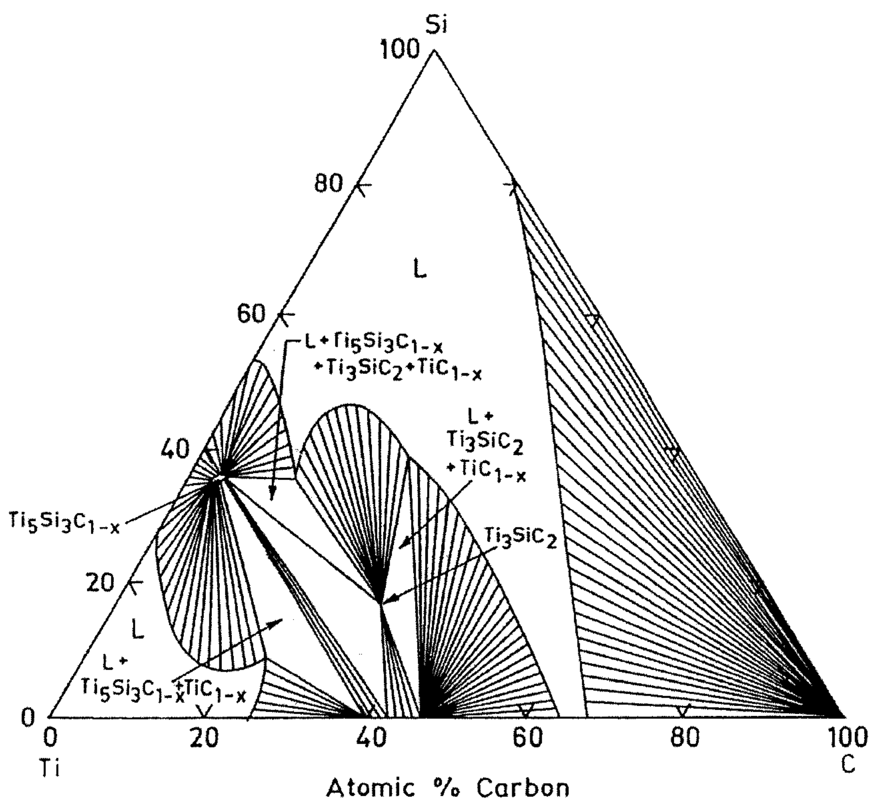

Fig. 7 Isothermal sections of Ti-Si-C system at 2877 °C

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