JPEDAV (2009) 30:82–83
DOI: 10.1007/s11669-008-9435-4
1547-7037 ©ASM International

Al-Si-Ti (Aluminum-Silicon-Titanium)

V. Raghavan

The update of this ternary system by [2005Rag] presented a reaction sequence, a liquidus projection, a partial isothermal section at 1250 °C from the experimental results of [2004Bul], and six computed isothermal sections for Ti-rich alloys between 1200 and 700 °C from the thermodynamic description of [2002Aze]. Liquidus and solidus projections, a reaction sequence, and several isothermal sections were also presented in an updated review by [2006Per]. Recently, [2008Liu] reported new results on the liquidus projection and isothermal sections at 1000 and 900 °C.

Binary Systems

The Al-Si system is of the simple eutectic type, with the eutectic temperature at 577 °C and 12.2 at.% Si. Recently, [2006Sch] carried out a new assessment of the Al-Ti system and presented a revised phase diagram. The intermediate phases in the system are: Ti_3Al ($D0_{19}$, Ni_3Sn-type hexagonal, denoted as α_2), TiAl ($L1_0$, AuCu-type tetragonal, denoted γ), $TiAl_2$ ($HfGa_2$-type tetragonal), $TiAl_3$ (HT) ($D0_{22}$-type tetragonal), and $TiAl_3$ (LT) (tetragonal, space group $I4/mmm$). The Si-Ti phase diagram [Massalski2, 2008Liu] depicts the following compounds: Ti_3Si (Ti_3P-type tetragonal), Ti_5Si_3 ($D8_8$, Mn_5Si_3-type hexagonal), Ti_5Si_4 (Zr_5Si_4-type tetragonal), TiSi (*B*27, FeB-type orthorhombic above ~800 °C), and $TiSi_2$ (*C*54, $TiSi_2$-type orthorhombic).

Ternary Phase Equilibria

[2003Gup] studied diffusion couples of pure Ti and an Al-Si eutectic alloy and identified the binary compounds and the ternary phases τ_1 and τ_2 of this system. With starting metals of 99.99% Al, 99.99% Si, and 99.98% Ti, [2008Liu] arc-melted more than 30 alloys under Ar atm. The alloys were annealed between 1000 and 550 °C for 2-3 weeks and quenched in water. The phase equilibria were studied with x-ray powder diffraction, energy dispersive x-ray analysis on a scanning electron microscope and differential thermal analysis (DTA) at a heating and cooling rate of 5 °C/min. The crystal structures, lattice parameters, and compositions of the identified phases were listed.

The isothermal sections constructed by [2008Liu] at 1000 and 900 °C are shown in Fig. 1 and 2. At 1000 °C (Fig. 1), the ternary phase τ_2 ($ZrSi_2$-type orthorhombic) is present. It forms incongruently at 1338 °C and has a composition range from $Al_{21}Si_{46}Ti_{33}$ to $Al_8Si_{59}Ti_{33}$ [2008Liu], with the lattice parameters of a = 0.35833 nm, b = 1.3552 nm, and c = 0.35793 nm at $Al_8Si_{59.6}Ti_{32.4}$. At 900 °C (Fig. 2), the ternary phase τ_1($Zr_3Al_4Si_5$-type tetragonal; space group $I4_1/amd$) is additionally present at the composition $Al_8Si_{58.6}Ti_{33.4}$ with a = 0.35788 and c = 2.7132 nm. It melts incongruently between 953 and 1000 °C. The liquidus surface constructed by [2008Liu] from DTA data is shown in Fig. 3. The ternary phases τ_2 and τ_1 form through ternary peritectic reactions P_1 and P_2,

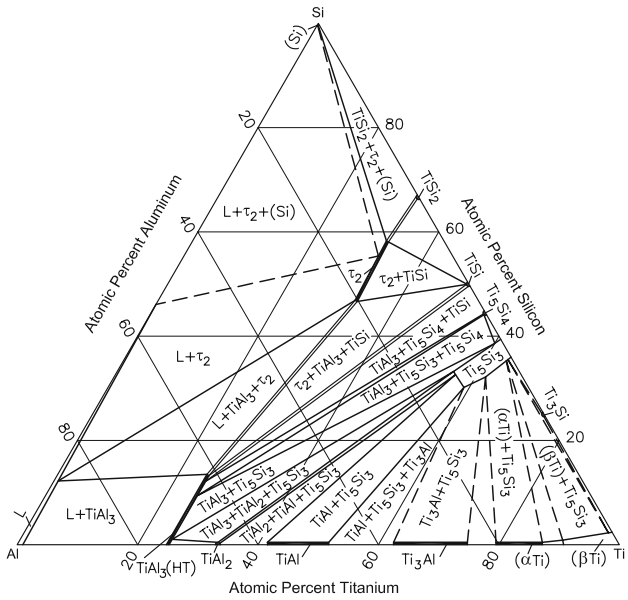

Fig. 1 Al-Si-Ti isothermal section at 1000 °C [2008Liu]

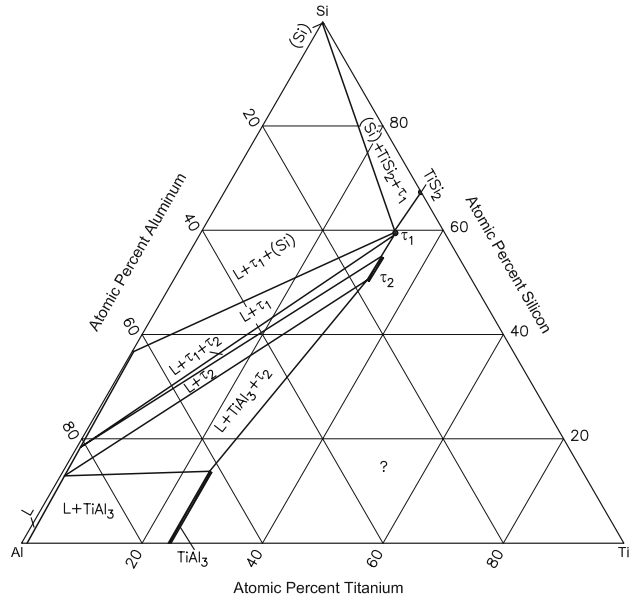

Fig. 2 Al-Si-Ti partial isothermal section at 900 °C [2008Liu]

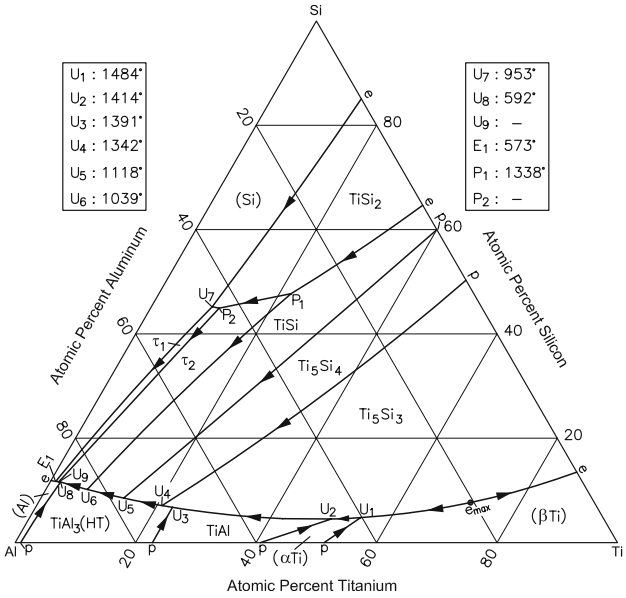

Fig. 3 Al-Si-Ti liquidus projection [2008Liu]

respectively. The incongruent formation of τ_1 through reaction P_2, however, could not be detected from DTA experiments. The solidification starts near the Ti end at a eutectic maximum e_{max}: $L \leftrightarrow (\beta Ti) + Ti_5Si_3$ at 1540 °C and proceeds toward the Al corner through a series of transition reactions U_1 to U_9. The final solidification is through the ternary eutectic reaction E: $L \leftrightarrow (Al) + (Si) + \tau_1$ at 573 °C. A reaction sequence for the solidification range was given by [2008Liu].

References

2002Aze: C.R.F. Azevedo and H.M. Flower, Experimental and Calculated Ti-rich Corner of the Al-Si-Ti Ternary Phase Diagram, *CALPHAD*, 2002, **26**, p 353-373

2003Gup: S.P. Gupta, Intermetallic Compounds in Diffusion Couples of Ti with an Al-Si Eutectic Alloy, *Mater. Characterizat.*, 2003, **49**(4), p 321-330

2004Bul: M. Bulanova, L. Tretyachenko, M. Golovkova, and K. Meleshevich, Phase Equilibria in the αTi-Al-Si Region of the Ti-Si-Al System, *J. Phase Equilb. Diffus.*, 2004, **25**(3), p 209-229

2005Rag: V. Raghavan, Al-Si-Ti (Aluminum-Silicon-Titanium), *J. Phase Equilb. Diffus.*, 2006, **26**(6), p 624-628

2006Per: P. Perrot, Aluminum-Silicon-Palladium, Chapter in *Landolt-Bernstein New Series IV*, 11A4, 2006, p 1-15

2006Sch: J.C. Schuster and M. Palm, Reassessment of the Binary Aluminum-Titanium Phase Diagram, *J. Phase Equilb. Diffus.*, 2006, **27**(3), p 255-277

2008Liu: S. Liu, F. Weitzer, J.C. Schuster, N. Krendelsberger, and Y. Du, On the Reaction Scheme and Liquidus Surface in the Ternary System Al-Si-Ti, *Int. J. Mater. Res.*, 2008, **99**(7), p 705-711