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Interface Structure and Strength of $\text{Si}_3\text{N}_4/\text{Si}_3\text{N}_4$ Joints Brazed with Ni-Si-Ti Filler Metals

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Abstract

Si_3N_4 was brazed to Si_3N_4 using Ni-20Si-xTi Filler Metals in vacuum, where x changed from 0 to 15 at%. The wettability of the alloys against Si_3N_4 was evaluated by the sessile drop method. The contact angle of the alloys at 3.6 ks decreases effectively with increasing Ti content up to 10 at% from 130 degree for Ni-20Si to 22 degree for Ni-20Si-10Ti. The further addition of Ti content of 10 at% or more increases the contact angle to 48 degree for Ti content of 15at%. Ni-20Si-10Ti alloy exhibited the best wettability among the alloys against Si_3N_4 . The strength of $\text{Si}_3\text{N}_4/\text{Si}_3\text{N}_4$ joint brazed with the alloys showed the highest value of 243 MPa. The alloys which exhibit good wettability possess the highest bonding strength against Si_3N_4 .

KEY WORDS: (Ni filler metals) (Ni) (Si) (Ti) (Contact angle) (Wettability) (Brazing) (Bonding) (Ceramic joining)

1. Introduction

Si_3N_4 is one of the ceramics which attracts many interests in various industry fields, because it has good mechanical properties with high corrosion resistance. The joining of ceramics is necessary for expanding engineering applications, because of the poor machinability and brittleness of the ceramics. Brazing of ceramics is the easiest method among the joining processes. Ti in the alloys improves wettability against the ceramics as well as its joining ability. Urai et. al have reported that the addition of Sn to copper base alloys containing Ti improved the wettability against SiC [1], and Takase et. al also reported that the addition of Sn also improve the wettability of Ni-Ti alloys against Si_3N_4 [2]. The addition of Si definitely reduces the melting point of Ni [3], and could be applicable in the filler by controlling the melting points. This work investigates the wettability of Ni-20Si alloys containing Ti, and also the bonding strength of the alloys against Si_3N_4 .

2. Experimental Procedure

Pressureless sintered Si_3N_4 containing a few percent of alumina as a sintering aid was used. A series of Ni-20Si-xTi ($x=0, 5, 10, 15$) alloys were arc melted in argon gas, where the number designates the atomic percent of the element. Lap joints of Si_3N_4 of 6 mm diameter and 3 mm thickness to Si_3N_4 with 15 mm diameter and 3 mm thickness were made using the filler

metals at high temperatures in vacuum. The size of the filler metal was 6 mm diameter and 0.1 mm thickness. The wettability of the alloys was evaluated by the sessile drop method. The contact angle of a sessile drop of the alloy on Si_3N_4 in vacuum was measured using a camera. The strength of $\text{Si}_3\text{N}_4/\text{Si}_3\text{N}_4$ joint was evaluated by fracture shear testing [2].

3. Results and Discussion

Fig. 1 shows the Ti content dependence of contact angle at 1.8 ks and 3.6 ks for Ni-20Si-xTi alloys on Si_3N_4 at 1523 K. The contact angles at 1.8 ks and 3.6 ks shows the same tendencies against Ti content. The addition of Ti up to 10 at% effectively decreases the contact angle of the alloys at 3.9 ks holding time from 130 degree of Ni-20Si alloy to 22 degree for Ni-20Si-10Ti alloy. The further addition of Ti content of 10 at% or more increases the contact angle of the alloys. The alloys containing 10 at% Ti show the minimum contact angle, and the best wettability among the Ni-20Si-xTi alloys. The addition of 10 at% Ti content or more increases the contact angle and degrades the wettability of the Ni-20Si alloy.

The wettability of the Ni-20Si-xTi alloys is also confirmed by measuring the bonding strength of the alloys against Si_3N_4 . Fig. 2 represents the Ti content dependence of the $\text{Si}_3\text{N}_4/\text{Si}_3\text{N}_4$ joints. The addition of Ti up to 10 at% effectively increases the strength of the

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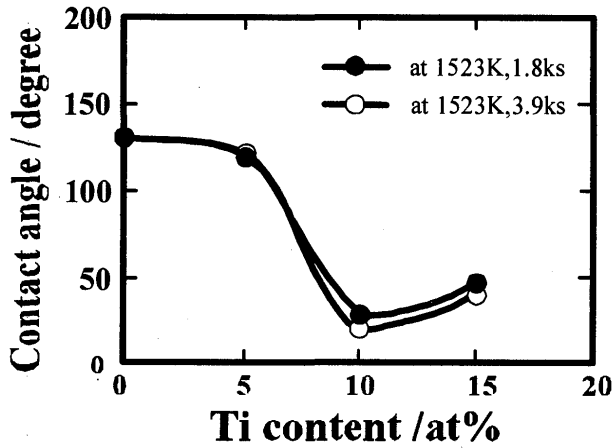


Fig. 1 Ti content dependence of contact angle for Ni-20Si-xTi alloys.

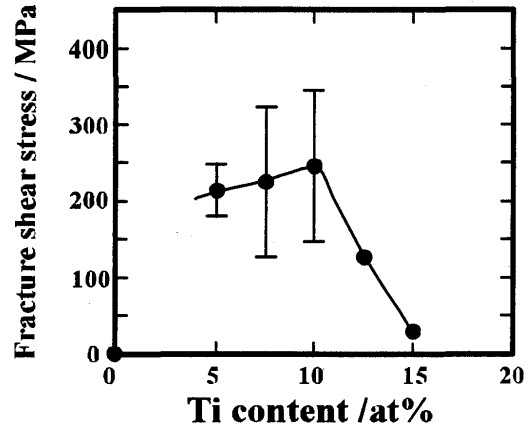


Fig. 2 Ti content dependence of strength of $\text{Si}_3\text{N}_4/\text{Si}_3\text{N}_4$ joints.

Ni-20Si alloys, and Ni-20Si-10Ti alloys shows a maximum of 243 MPa at a Ti content of 10at%. The further addition of Ti of 10 at% or more drastically decreases the strength of the Si_3N_4 joint only 29 MPa.

The alloys which exhibit the low contact angles and the good wettability against Si_3N_4 shows the high bonding strength against Si_3N_4 .

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