Interface Structure and Strength of Si₃N₄/Si₃N₄ Joints Brazed with Ni-Si-Ti Filler Metals

TAKASE Hideki* and NAKA Masaaki**

Abstract

Si₃N₄ was brazed to Si₃N₄ using Ni-20Si-xTi Filler Metals in vacuum, where x changed from 0 to 15 at%. The wettabiltiy of the alloys against Si₃N₄ 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 15 at%. Ni-20Si-10Ti alloy exhibited the best wettabiltiy among the alloys against Si₃N₄. The strength of Si₃N₄/Si₃N₄ joint brazed with the alloys showed the highest value of 243 MPa. The alloys which exhibit good wettabiltiy possess the highest bonding strength against Si₃N₄.

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

1. Introduction

Si₃N₄ is one of the ceramics which attracts many interests in various industry fields, because it has good mechanical properties with high corosion 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 wettabiltiy 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 Si₃N₄ [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 wettabiltiy of Ni-20Si alloys containing Ti, and also the bonding strength of the alloys against Si₃N₄.

2. Experimental Procedure

Pressureless sintered Si₃N₄ 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 Si₃N₄ of 6 mm diameter and 3 mm thickness to Si₃N₄ 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 Si₃N₄ in vacuum was measured using a camera. The strength of Si₃N₄/Si₃N₄ 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 Si₃N₄ 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 Si₃N₄. Fig. 2 represents the Ti content dependence of the Si₃N₄/Si₃N₄ joints. The addition of Ti up to 10 at% effectively increases the strength of the
Ni-20Si alloys, and Ni-20Si-10Ti alloys shows a maximum of 243 MPa at a Ti content of 10 at%. The further addition of Ti of 10 at% or more drastically decreases the strength of the Si₃N₄ joint only 29 MPa.

The alloys which exhibit the low contact angles and the good wettability against Si₃N₄ shows the high bonding strength against Si₃N₄.

References