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Short Communication

Interfacial microstructure and mechanical properties of joining electroless nickel plated quartz fibers reinforced silica composite to Invar

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ABSTRACT

Vacuum brazing of electroless nickel plated quartz fibers reinforced silica composite (QFSC) to Invar alloy using Ag–Cu eutectic alloy at various temperatures (1073–1163 K) and times (5–35 min) has been investigated. The scanning electron microscopy, energy dispersive spectroscopy and X-ray diffraction examination of the joints showed that the junction between QFSC and Invar produced reaction products like $Cu_{3.8}Ni$, Cu (s, s), Ni (s, s) and Ag (s, s), with the structure of Invar/$Cu_{3.8}Ni$ + Ni (s, s)/Ni (s, s) + $Cu_{3.8}Ni$ + Ag (s, s) + Cu (s, s)/Cu (s, s) + $Cu_{3.8}Ni$ + Ni (s, s) + QFSC. The shear strength of joint was effected by the changes of relative amount of Cu–Ni eutectic structure ($Cu_{3.8}Ni$ + Ni (s, s)) and thickness of nickel plating film at different parameters. The shear strength of joint increased when there were proper amount of Cu–Ni eutectic structure and nickel plating film for reinforcement, and decreased while them were consumed excessively in interaction. The maximum shear strength of joint is 29 MPa, which was brazed at 1103 K for 15 min.

1. Introduction

As a potential structure material, quartz fibers reinforced silica composites (QFSCs) has become a promising candidate material in the space shuttle and other re-entry type aerospace vehicles due to its unique combinations of various properties, such as low density, low thermal conductivity, acceptable levels of mechanical properties, excellent thermal as well as electrical insulating properties and low dielectric constant and low loss tangents [1]. However, the reliable bonding between QFSCs and other materials is the crucial factor for its industrial applications. Although the fabrication and characteristics of fibers reinforced ceramic matrix composites are comprehensively studied in recent years [2–4], joining of QFSCs to metal is no reported. In addition, the research about the bonding of quartz glass to alloy is also rarely reported [5]. Many bonding methods, however, for other fibers reinforced composites can be referenced, such as adhesion bonding [6,7], mechanical joining [8] and active brazing [9,10]. Besides, metallization usually be utilized for improving joining property of ceramic [11,12]. And the brazing with metallization can avoid the use of costly Ti-based active filler alloy. Electroless plating [13] is a simple technique for metallization on ceramic substrates, has been applied on surfaces of various ceramics such as Al_2O_3, SiC, AlN and Si_3N_4 [14–16]. Moreover, electroless plating exhibits excellent coating property at the surface of composites as interlocking between plating film and the anchor sites of composites [17,18].

In this study, brazing of QFSCs to Invar alloy was investigated using Ag–Cu eutectic alloy. The specimens of QFSCs were pre-metallized by nickel coating. And the aim of this work is to research the relationship between brazing parameters and interfacial characters.

2. Experimental procedure

The original QFSCs (Fig. 1a) were synthesized by quartz fibers braided at two dimensions, via process of quartz fiber clothes tiering upon tiering in silica sol and agglomeration. The composite has different strengths in different directions (the shear strength in the vertical direction with fibers reached 160 MPa, but in the parallel direction was only 10.6 MPa). In the present study, the surface parallel to the orientation of the fibers was used for brazing. Commercial Invar alloy (Fe36Ni) was used as substrates in the experiment (Fig. 1b), with chemical composition listed in Table 1. The samples of original QFSCs and Invar were sliced into dimensions of 10 mm × 10 mm × 6 mm, respectively. QFSCs were metallized by nickel coating via electroless plating technique to be specimens for joining, with the thickness of plating film about 10 μm (see Fig. 1c and d).

Commercial Ag–Cu eutectic foil was used as braze alloy in the thickness of 200 μm. All these specimens were ultrasonically cleaned in acetone for 15 min, and dried in air. Specimens for brazing were mounted in a die with braze alloy between, and were

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