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Effect of Ti content on the wetting behavior of Sn0.3Ag0.7Cu/AlN system

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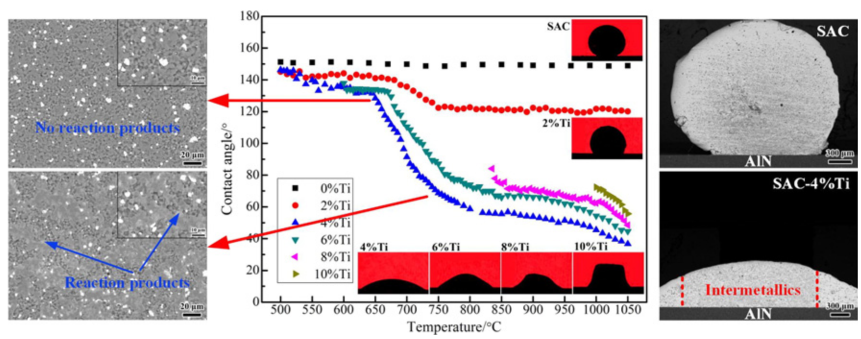
HIGHLIGHTS

- Effect of active Ti on the wettability of Sn0.3Ag0.7Cu/AlN system was investigated.
- Wetting process consisted of rapid-decrease stage and sluggish-decrease stage.
- Ti promoted the spreading of droplet by TiN formed by reaction between Ti and AlN.
- Solid Ti-Sn intermetallics and dissolved Ti inhibited the spreading of droplet.

GRAPHICAL ABSTRACT



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ABSTRACT

In this work, the effect of Ti content on the wettability of Sn0.3Ag0.7Cu/AlN system was investigated by sessile drop method at elevating and isothermal process. Added Ti resulted in a significant reduction of contact angle. The lowest contact angle was obtained with 4%Ti addition possessing sufficient Ti and proper fluidity. Interfacial reaction product TiN promoted the spreading of droplet on AlN. However, the formed solid Ti-Sn intermetallics and dissolved Ti inhibited the spreading of droplet resulting in a higher contact angle. In wetting process, the rapid-decrease stage and the sluggish-decrease stage were limited by the kinetics of reaction at triple line and the diffusion of Ti to the triple line respectively. The speed of the spreading stage varied from 0.04°/s to 0.36°/s resulting from different operative temperature. Eventually, the wetting process of Sn0.3Ag0.7Cu/AlN system was schematized.

1. Introduction

Due to its high thermal conductivity, dielectric properties, high mechanical strength, strong corrosion resistance and thermal and chemical stability, aluminum nitride (AlN) is a promising for or currently used in optical devices and high-powder and high-temperature electronic devices [1–3]. In most cases, in order to meet the fabrication demands of various structures, AlN is required to joint metals or ceramics, and firm ceramic-metal composite structures are in demand.

Brazing has been widely used in join ceramics because of its cost-effectiveness and convenience [4–6]. The wetting of ceramics by liquid alloys is critical metallurgical process in brazing ceramics to metals. Furthermore, the contact angle between brazing alloy and ceramic and the spreading time of molten alloys over ceramics surface are the main parameters that influence the quality of brazed joints.

It is well known that many pure metals and alloys performed poor wetting on the surface of ceramics [7–11]. To improve the wettability of alloys on ceramics, active elements such as Ti, Cr, Zr were added

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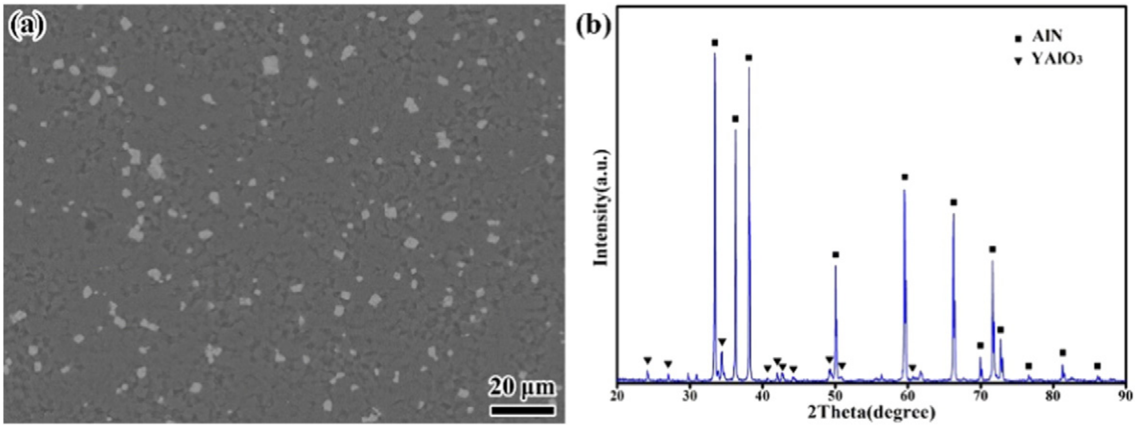

Fig. 1. Microanalysis of AlN substrate. (a) SEM image and (b) XRD pattern.

into brazing alloys, and many studies focused on the wetting of ceramics by active brazing alloys. The active element enriched at the interface and reacted with ceramic substrate forming a continuous metallic-like layer [12–14]. Contact angle varied with the classification and stoichiometric proportion of reaction layer [9,15,16]. Furthermore, Voytovych demonstrated a direct relation existed between interfacial chemistry and wetting for the CuAg-Ti/alumina system [17]. Researchers declared that the variation of interfacial chemistry attributed to the activity of active elements. The activity coefficient of Ti in Ag-Cu metals increased with a higher Ag concentration and decreased with the increment of Cu concentration [7,18,19]. Abed et al. [20] studied element In added into CuAgTi alloys resulted in enhanced wettability. The increase of the activity of Ti attributes to the solubility of titanium decreases and in additions segregate to the interface. Therefore, it is significant to investigate the effect of active elements on wettability of alloys/ceramics system.

In this work, active element Ti was selected into SnAgCu alloy. We investigated the wettability of SnAgCu-Ti alloy with various Ti content on AlN ceramic at elevating and isothermal processes. The contact angle of molten metals with different Ti content and the corresponding interfacial microstructures were analyzed. The results pave the way for the joining of AlN ceramic.

2. Experimental

Aluminum nitride (AlN) substrate, sintered by AlN powder and about 4 wt.% $YAlO_3$ as sintering aid, was supplied by the Fujian Huaqing Electronic Material Technology Co., Ltd. Fujian, China. The density, grain size and surface roughness of AlN sample were about 3.32 g/cm^3, 4 μm and 0.45 μm, respectively. The micro-characterization of AlN was shown in Fig. 1. It reveals that AlN substrate mainly consisted of two phases corresponding to AlN and $YAlO_3$. The dimensions of AlN substrates used for the wetting experiments were about 20 mm × 20 mm × 5 mm. The samples were grounded by 2.5 μm diamond paste and ultrasonic cleaned in ethanol for 15 min and dry by air blow before wetting experiment. The wetting powders SnAgCu-χ%Ti (wt.%) were prepared by Sn0.3Ag0.7Cu (SAC) powder (99.98 wt.%, ~37 μm), Ti powder (99.95 wt.%, ~40 μm) and 8 ml acetone by ball-milling with the ratio of ball-to powder of 15:1 in weight for 8 h. These powders were supplied by Zhejiang Metallurgical Research Institute, Hangzhou, China. Mixed powders were cold-press compacted into a cylinder in diameter of 3 mm under a pressure of 400 MPa. Then the obtained cylinder was grinded into a bulk of 50 mg in a dimension of about 2 mm × 2 mm × 2 mm by silicon paper with grit size 1000.

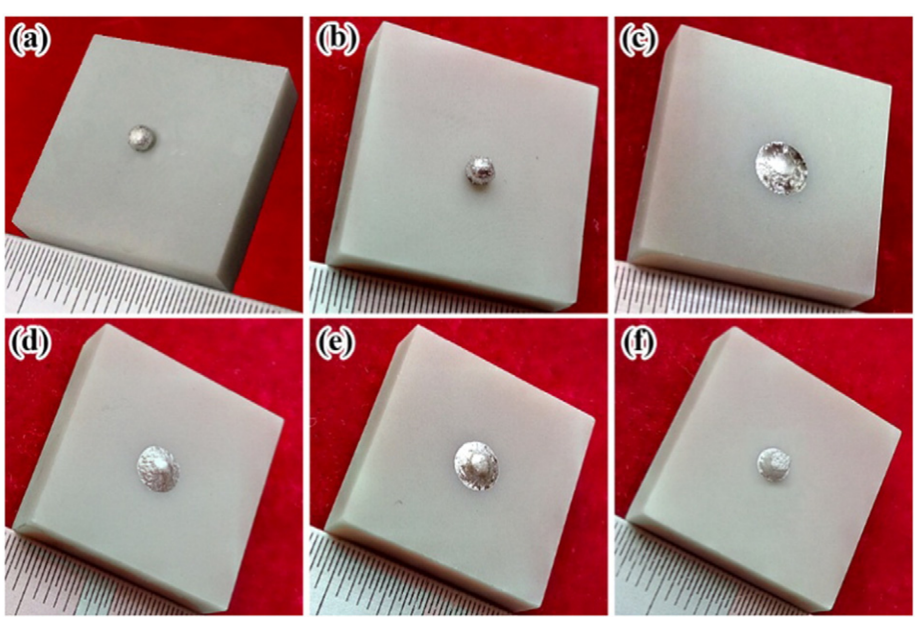

Fig. 2. Macro morphology of droplet after cooled from 1050 °C.