New Active Brazing Filler Metal Pushes Down Material Cost

Tanaka Kikinzoku Kogyo K.K. started offering the newly developed TKC-651 active brazing filler metal in April 2012. Active brazing filler metals are brazing filler metals that can bond various materials, including metals and diamond, as well as ceramics, such as alumina (Al_2O_3) and silicon nitride (Si_3N_4), by brazing. Conventionally, the metalizing method has been adopted for the bonding of ceramics and metals. However, this method has drawbacks, such as the complex process involved and high cost. Active brazing filler metals, which can directly braze ceramics and metals, are expected to significantly reduce the bonding process.

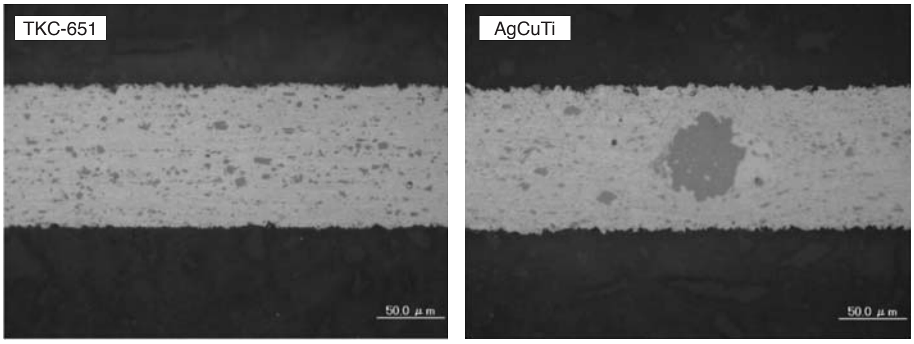

Photo 2: Sectional structures of the rolled TKC-651 and AgCuTi alloy

Table 1: Chemical compositions and other properties of TKC-651

Product	Alloy Composition				Melting Point	Density	Form	Dimension
	Ag	Cu	Ti	Sn				
AgCuTi	71 (±1.0)	27.5	1.5 (±0.5)	–	Approx. 790°C	10.0 g/cm³	Foil	Width 110mm or less Thickness 0.1mm or more
AgCuTiSn (TKC-651)	65 (±1.0)	28 (±1.0)	2 (±0.5)	5	Approx. 770°C	9.6 g/cm³	Foil, Wire	Width 110mm or less Thickness 0.05mm or more Diameter 0.2mm or more

So far, the company has marketed active brazing filler metals. However, the company has encountered difficulty in the supply of foils with thickness of 100µm or less. Moreover, the supply of wires themselves was restricted. On the other hand, TKC-651 can be supplied in a foil with thickness of 50µm and in a wire with a diameter of 200µm. In addition, because silver (Ag) content has been controlled to around 6 percent, the material cost can be reduced, making it an exceptionally high-quality active brazing filler metal (Photo. 1). In general, brazing filler metals for sealing are formed by pressing a foil so that they match the shapes of the joining section. This process causes drafts to generate, requiring a larger area of foil than that of products. This actually leads to poor yield, which is passed onto product costs. As it has become possible to supply the brazing filler metal in wire, the yield of the brazing filler metal can be significantly improved by processing the wire into the shape of the joining section. Hence, low-cost sealing can be achieved.

Photo 1: TKC-651 active brazing filler metal

Tin is Added to Alloy

AgCuTi alloys, in which titanium (Ti) as an active metal is added to AgCu alloy, are widely known as active brazing filler metals. In general, AgCuTi alloys are produced by melting and casting. Rolling is applied to an ingot after it is cast until it is processed to a specified shape. However, coarse CuTi intermetallic compounds of 100µm or larger are deposited while AgCuTi alloys are cast, thus significantly deteriorating workability. Hence, it has been difficult to process them into minute shapes, which accommodate brazing of electronic components that have become lighter, thinner, and shorter. In addition, it was impossible to produce thin foils, which led to higher material costs, and the degree of freedom in product shapes becomes limited.

Furthermore, the local reduction of the amount of Ti stemming from the deposition and falling out of coarse CuTi intermetallic compound on the surface of the foil, reduces the reliability of brazing.

Hence, Tanaka Kikinzoku Kogyo has evaluated the addition of the fourth metal element and optimized the material composition to make it possible to reduce the thickness of foils and to offer wires. As a result, the company has found that metal organization can be significantly improved by the addition of tin (Sn) to AgCuTi alloy. The addition of Sn causes microscopic SnTi compounds of approximately 20μm or smaller to disperse in the AgCu alloy matrix. This property prevents coarse CuTi compounds from depositing (Photo 2, Table 1).

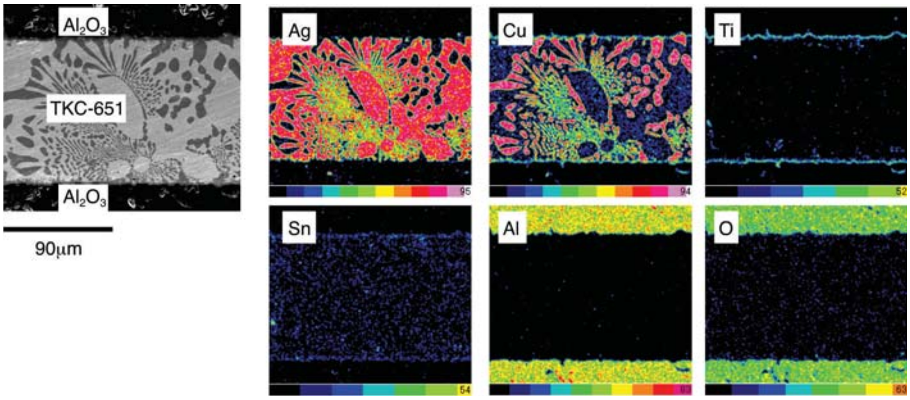

Photo 4: EDS analyses of the cross-section of the bonded interface of Al_2O_3 brazed by TKC-651

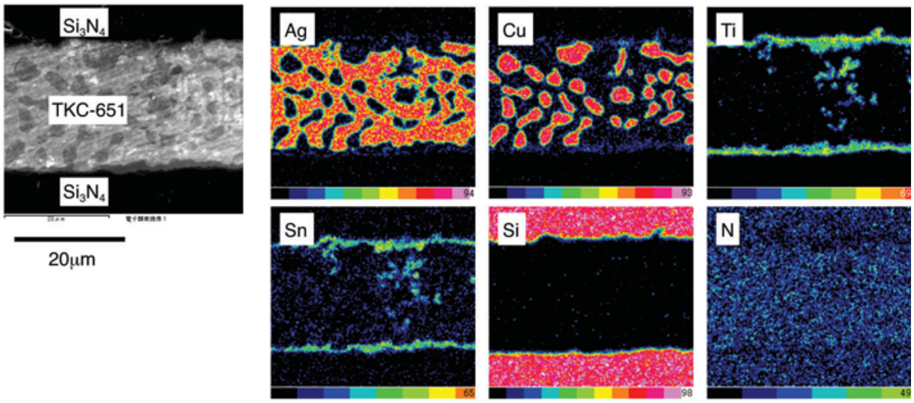

Photo 5: EDS analyses of the cross-section of the bonded interface of Si_3N_4 brazed by TKC-651

Reliably Strong

In an experiment on the brazing characteristics of ceramics that use TKC-651, Tanaka Kikinzoku Kogyo bonded Al_2O_3 to Al_2O_3 and Si_3N_4 to Si_3N_4, respectively, by brazing in a vacuum, and inspected the state of the bonded interfaces and measured the rapture strength by the four-point bending test (Photo 3). Photo 4 shows the cross-section of the bonded interface of Al_2O_3 analyzed by energy dispersive X-ray spectrometer (EDS), while Photo 5 shows that of Si_3N_4. Like the bonding behavior of the conventional active brazing filler metal of AgCuTi alloy, a Ti layer is formed at the bonded interface between the brazing material and alumina or silicon nitride, and it has been confirmed that the brazing material is bonded to the ceramics by the operation of Ti compound in the AgCuTiSn alloy. As for joint strength, when the force of 310MPa was applied to the Al_2O_3 bonded to each other, a fracture developed in the Al_2O_3 material, not in the part joined by brazing. Hence, it was confirmed that the joint strength was stronger than the strength of the Al_2O_3 base material. Likewise, in the four-point bending test of Si_3N_4, a fracture developed in the part joined by brazing, at which time, the force of 340MPa was applied. Hence, it was confirmed that the joined part was bonded with higher breaking strength than that of Al_2O_3 base material. These results show that the active brazing filler metal of AgCuTiSn alloy can bond ceramics.

Photo 3: Test pieces for bonding by brazing (Left: Al_2O_3, right: Si_3N_4)

In the brazing of an active brazing filler metal, it is necessary to ensure that the active brazing filler metal does not react with oxygen or nitrogen in the atmosphere before it is joined. Tanaka Kikinzoku Kogyo recommends that a vacuum of 2×10^{-2} Pa or less or noble gas atmosphere, such as that of argon, is used, and brazing is conducted in an environment, wherein the dew point is -55ºC or lower, in order to prevent the effects of water, and that heating temperature of 790 to 850ºC is used for 1 to 5 minutes.

Tanaka Kikinzoku Kogyo will actively carry forward the development of new materials that use precious metals. ❑

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