January 28, 2020

Notice Regarding Development of Bonding Sheets Using Copper Nanoparticles for Power Device Applications

Taiyo Nippon Sanso Corporation ("TNSC") hereby announces that it has successfully developed bonding sheets using highly sophisticated and reliable copper nanoparticles for next-generation power devices such as silicon carbide (SiC) and gallium nitride (GaN).

1. Background

Power devices are semiconductor chips used in power conversion equipment such as inverters and converters for electric and hybrid vehicles. To make power devices highly efficient requires module miniaturization and raising the limit of their working temperature to increase the density of power output.

However, conventional mainstream silicon (Si) power devices have an operating temperature of 150°C, limiting the extent of module miniaturization due to heat resistance problems.

Device materials such as SiC and GaN are capable of operating at temperatures of 200°C or above, raising expectations of them becoming an alternative to Si power devices. Now, solder materials are often used as bonding materials for conventional Si power devices in electronic components, but these are lacking in heat resistivity and not suitable with SiC power devices projected for use in high-temperature environments, which boosted a need for bonding materials capable of high-temperature operations.

Metallic nanoparticles are attracting attention as a possible alternative for existing bonding materials used in power devices such as SiC, and they have raised expectations in particular from the standpoint of their ion migration* resistance and production cost. Generally, metallic nanoparticle welding materials are used as a paste but need to undergo a predrying process to eliminate solvents, requiring thermic pyrolysis to remove binders when sintering nanoparticles, with the risk of generating decomposed gas that can form voids or cracks in the bonding layer. There was an issue of maintaining powerful binding strength and ensuring reliability.

2. Overview of bonding sheets using copper nanoparticles

TNSC can use its oxygen combustion technology to fire particles under a reduction atmosphere with low-temperature firing at 150°C through a process using one of its technologies that dries copper particles covered in a suboxide layer with a particle size of about 100 nm and surface of several nm that enables them to be produced in large volumes.

TNSC has successfully developed bonding sheets capable of bonding without predrying under a nitrogen atmosphere (Fig. 1) or adding a reducing gas such as hydrogen, yet with high binding strength and outstanding reliability (Photo 1). It has done this by using copper nanoparticles synthesized to be binderless in a the production process, adding a small volume of reducing agent and optimizing the bonding layer structure.

A sample bonding SiC and a copper plate using this bonding material was confirmed to ensure high reliability at over 1,000 cycles in a heat cycle test without any interface peeling seen.

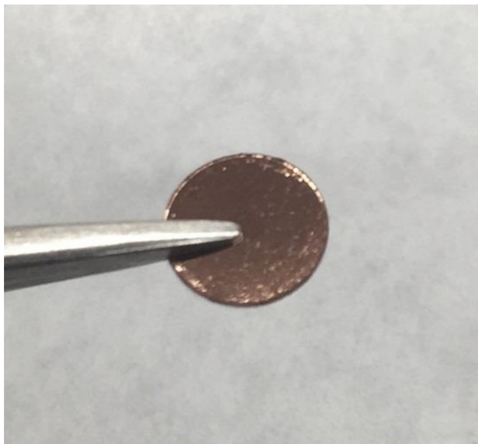

Photo 1: Copper nanoparticle bonding sheet

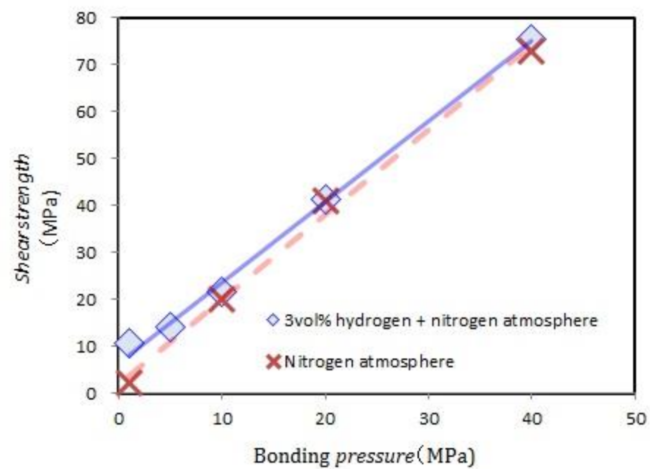

Fig. 1: Correlation between bonding pressure and shearing strength for a bond at 300°C for 5 minutes

3. Future plans

Going forward, TNSC will promote this bonding material for users and move ahead on user developments.

TNSC will give a verbal briefing of its findings at the 26th Symposium on Micro binding and Assembly Technology in Electronics (Mate 2020) (Venue A, Program No. 19) held at Pacifico Yokohama on Wednesday, January 29, 2020.

In addition, TNSC will also set up a booth (3W-N0O9) at the neo functional material 2020 exhibition held at Tokyo Big Sight from Wednesday, January 29 to Friday, January 31, 2020.

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* Ion migration: A state where metals between electrodes are ionized and cause short circuits when voltage is applied in humid environments