High-Reliability Bonding Wire for Automotive IC's

1. Overview

The development of electronics technologies in the pursuit of safety and comfort of automobiles have accelerated the application of electronics to automobiles. As a result of such developments, the role of ICs used therein has become increasingly important. Such automotive ICs are usually required to operate safely with high reliability over a long period, even under harsh working conditions, such as the high temperatures and high humidity conditions enveloping an engine, which is peculiar to automobiles. Improved automotive ICs are expected to achieve higher reliability of gold bonding wires for sending and receiving electrical signals therein.

NSC and its subsidiary, Nippon Micrometal, have been developing and producing gold bonding wires, and as well as high-reliability gold bonding wires that can be applied to the improvement of high-temperature reliability of automotive ICs.

2. Improvement of Automotive ICs for Higher Reliability

These fine gold wires (on the order of 15 to 40 μm in diameter) can be used for the electric connection between aluminum electrodes and the internal terminals of the IC. Gold wires are required to meet rigid quality control specifications for failure rates in ppm at the IC assembly processes, and must be serviceable at high reliability. Actual occurrences of the poor performance, such as high electric resistance and low bonding strength at the gold wire and aluminum electrode connections, have been reported for certain special uses in extended exposure to high temperatures. For automotive ICs used in high-temperature environments, highly pure gold wires (>99.99% purity), the most commonly used today, do not always ensure sufficient reliability with regard to bonded connections. An attempt was made to look into the cause of this poor performance in high-temperature environments. It was discovered that the design of the wire components to control diffusion behavior in bonded interface was effective in improving bond reliability. Through the design of wire components and the optimizing of production conditions, highly reliable bonding wires have been developed in the form of the so-called Series G.

3. High-Reliability Bonding Wires

The Series-G high-reliability bonding wires are being commercialized to meet various customer needs for assembling, operating and other conditions. The main features of G1 wires, which are already in use, are as follows.

(1) The deterioration of bonding strength, electric resistance and other properties in high-temperature environment are minimal.

(2) The failure rate at 150°C for 2,000 hours, evaluation criteria for reliability of the automotive ICs, is low (**Fig. 1**). This low rate has been achieved by controlling corrosion of Au-Al intermetallic compounds and void formation that are the causes of bond failure (**Fig. 2**).

(3) The bondability, looping shape and other properties are maintained as good as those of highly pure, commercially used gold wires. The G1 wire easily replaces that product.

(4) The G1 wire improves reliability compared to specification changes to molding resin and package structure.

(5) The G1 wire is also applicable to conventional semiconductors by designing the wire components to reduce the increase in specific resistivity.

(6) The G1 wire is also applicable to state-of-the-art uses such as high-density packaging and stacked dies.

(7) The G1 wire can be modified to have greater bonding capacity with emphasis on applicability to thick-film electrodes of power ICs.

G1 wires are mass-produced for automotive ICs and are favorably accepted for their high-temperature reliability.

In preparation for ever more strict requirements for reliability at

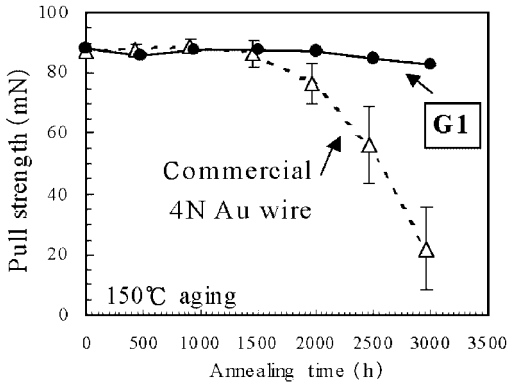

Fig. 1 Bond strength of gold wire bonds after aging

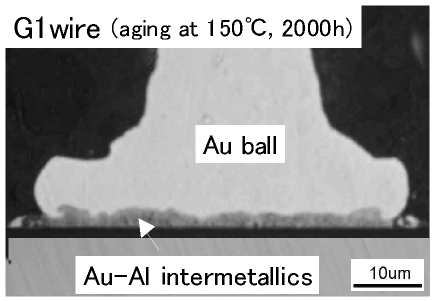

Fig. 2 Gross sections of high reliability wire G1 after aging

higher temperatures, developments are proceeding for G5 wires that have higher resistance to heat (**Fig. 3**). The G5 wire is one of the high-concentration gold alloy wires (2N, with purity ~ 99%) taking the lead in commercialization. They are expected to exhibit sufficient reliability even at the very high temperature of 175℃.

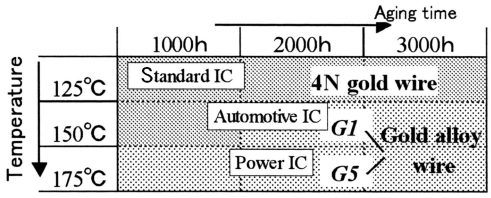

Fig. 3 High temperature evaluation and suitable bonding wires

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