Gold Ball Wire Bonding with Heated Tool for Automotive Microelectronics

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Abstract

Microelectronics used in automotive applications have grown considerably in the last few years with more high tech electronics controlling more functions in automobiles. In an effort to have more precise control and to reduce vehicle weight manufacturers are integrating more functions into smaller packages. Many of these packages are embedded in molded plastic. This causes challenges when it comes to wire bonding these devices. They often cannot be heated to traditional Gold Ball Thermosonic wire bonding temperatures of 120 - 150C. However, using a heated capillary to bond the parts which remain at room temperature simplifies the process considerably. Alternatives such as pre-heating the parts in an oven and complex hot gas handler systems are not required. With a resistive wire coil heater surrounding a standard (or long capillary for deep access) sufficient heat can be provided to the wire bond site for a strong and reliable interconnect. The bonding surface can be any material used in gold ball bonding: aluminum bond pads on die, plated contacts, ceramic substrates or plated copper traces on PCBs. This paper will show that this heated tool process has been successfully utilized with 1mil Au wire and many of the standard die and substrate materials with little impact on process parameters.

Key words: Wire Bond, Reliability, Hybrid, Military, Biomedical, Optoelectronic, Optical, Automotive

Introduction

Gold ball wire bonding is still the predominate method for interconnects in microelectronics. Industries are further utilizing novel packaging designs to shrink both final product size and weight. This is affecting the downstream processes in more dramatic ways than we have seen before. Now more plastic packages are being utilized with embedded microelectronic circuits. More sensors and controls are being added to cars every year, more intelligence is being embedded into these sensors to offload the car's Electron Control Unit (ECU). These odd form-factor thermally isolated devices still require reliable wire bonding to complete the interconnections. Rather than relying on complex handler systems with pre-heated parts and hot gas bond fixtures a heated capillary can produce a robust gold ball wire bonding process. This allows the circuit designer the most flexibility to meet his desired goal with less consideration necessary to thermal issues related to the wire bonding process.

Motivation for study

Demonstrate the Robust Process of Wires Bonded at Room Temperature

- Verify wire pull and ball shear strengths meet expected values for similar wires attached using standard heated workstage.

More applications have appeared in recent years requiring wire bonding parts that are already packaged in plastic housings that distort when subjected to the 120-150°C temperature typically required to perform reliable gold ball wire bonding. These applications may be processed utilizing a heated tool process to successfully bond wires that meet all quantitative wire bond quality measures applicable. Figure 1 and 2 provide an example plastic packaged sensor.

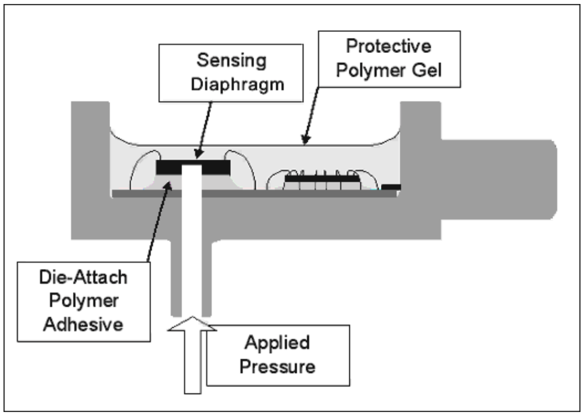


Figure 1 Shows a cross section drawing of a typical automotive pressure sensor.

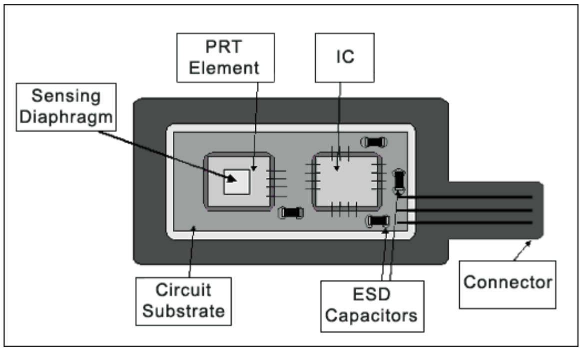


Figure 2 Typical layout for pressure sensor.

Figure 3 shows a wire bond capillary with a coil heater encircling it. This provides the heat necessary to form a reliable thermosonic gold ball wire bond. The coil is heated to 150-250°C.

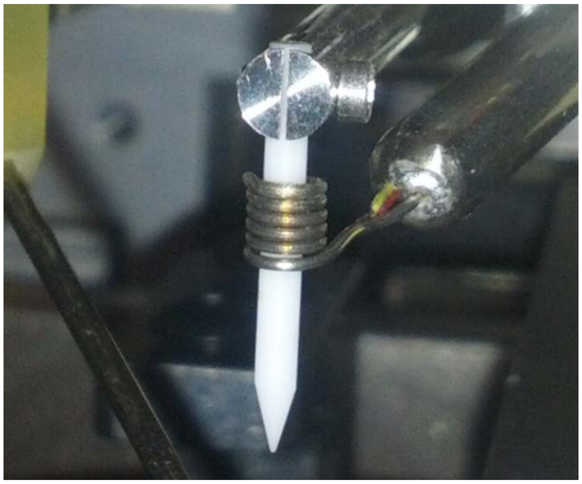


Figure 3 Tool Heater Coil Surrounds and Heats Wire Bond Capillary.

The wire passing through the heated capillary is bonded to the device using typical wire bond parameters (force, time and ultrasonic power) with a few milliseconds of delay after touchdown to allow the heat to transfer to the underlying material.

Figure 4 Parts in plastic housing bonded using heated tool.

This process works with die mounted on ceramic substrates as well as gold plated contacts embedded in the plastic.

Note the plastic packages typically require deep access reach of the capillary. The package in figure 4 requires over 300 mil of clearance.

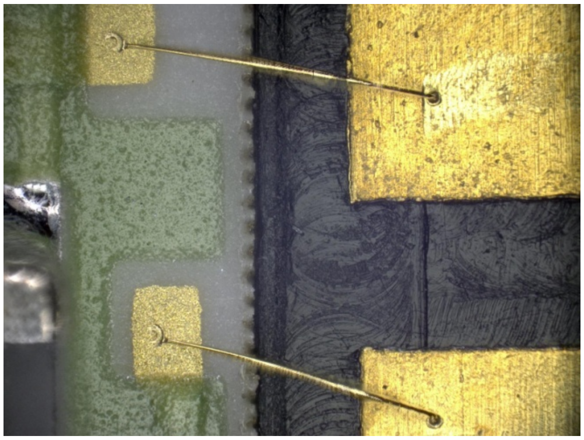


Figure 5 Wires bonded from leads embedded in plastic to thickfilm on ceramic substrate.

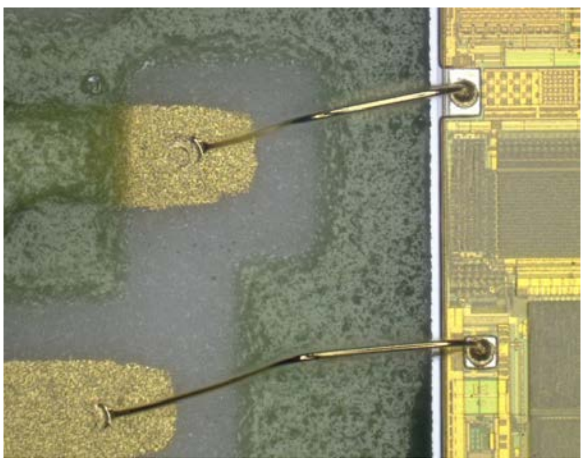
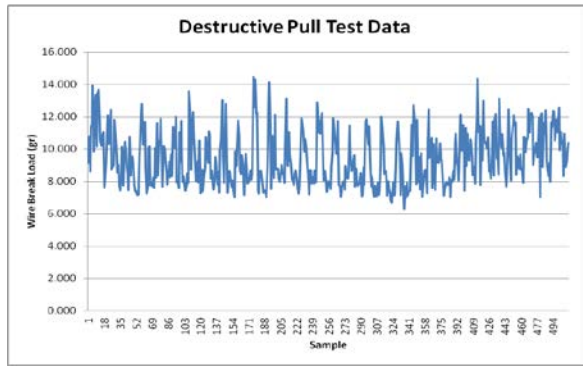


Figure 6 The above wires were bonded using the Heated Tool process.

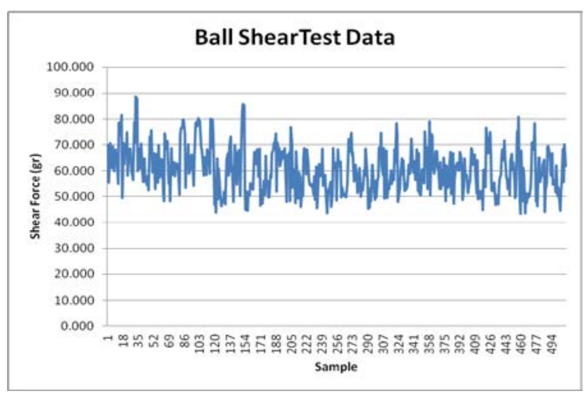
The pull strength data from 510 wires shows these wires exceed the Mil Std-883 specification for 1 mil Au wire. The somewhat large range is due to a mixture of long low loop wires and tall shorter length wires.



Statistics	
S	1.685
Minimum	6.312
Maximum	14.462
Mean	9.429
Range	8.150

Table 1 Summary of Wire Pull test data from 510 wires.

The ball shear test data from 510 wires shows these wires exceed the EIA/JEDEC Standard EIA/JESD22-B116 specification for 85 micron MBD with an average of about 6.8 grams per mil^2. Some variation is due to shearing the ball placed on different metalizations (gold plated contacts and aluminum bond pads on silicon die).



Statistics	
S	8.821
Minimum	43.475
Maximum	88.666
Mean	60.414
Range	45.190

Table 2 Summary of Ball Shear test data from 510 wires.

Another use for this process is applications where the chip is thermally sensitive (such as thermal sensors – microbolometers) that could be damaged or change their characteristics if subjected to normal wire bonding temperatures.

Conclusion

This study demonstrates that the Heated Tool Gold Ball Wire Bonding process provides a robust interconnect process without subjecting the parts to high temperatures typically required for such processes.

Biography

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David has over 30 years experience with wire bonding from the equipment manufacturing side and is currently a Senior Applications Engineer for Palomar Technologies.

References

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Method 2017.7 Section 3.1.5.3

EIA/JEDEC Standard EIA/JESD22-B116

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