SOLDERLESS HIGH DENSITY INTERCONNECTS for BURN-IN APPLICATIONS

Fernando J. Guarin, Anastasios A. Katsetos
IBM General Technology Division, East Fishkill, New York, 12533

Abstract

The development and evaluation of a high contact density Burn-In socket for a pinless module with 1156 terminals, and an intended useful life of at least 1000 hours at 200 C will be described. Characterization and stress data for "wire button" contacts realized in various metallurgies along with results for elastomer contacts will be presented. Contact integrity and resistance were monitored while under temperature and current accelerated stress. A molybdenum wire button prototype socket was successfully constructed and stress tested.

I. Introduction

The trend toward smaller semiconductor device geometries has consistently increased the per chip density and performance of functions, resulting in a requirement for higher terminal count. Along with this requirement there has also been a dramatic reduction of the failure rates to which successful semiconductor manufacturers must conform in order to stay competitive in the market. Reliability engineers have for many years taken advantage of the thermal activation of a large number of failure mechanisms and have used Burn-In at higher temperatures, typically 125 C, to qualify new designs and to improve the reliability of the product in the field. Higher temperatures will allow for faster resolution of lower failure rates, as required by the higher integration levels. It should be noted that caution must be exercised when stressing at higher temperatures in order not to introduce new mechanisms, nor exceed the physical limitations of operating semiconductor devices at elevated temperatures.

This work describes some of the development and qualification effort for a high density footprint pinless burn-in socket for a ceramic substrate, with 1156 terminals consisting of an array of 34x34 pad contacts, 40 mils in diameter, with 50 mils center to center spacing. The application required high frequency response, and the ability to withstand Burn-In temperatures up to 200 C for extended periods of time while carrying currents in the hundreds of milliamps range while providing a high density of contacts and a small resistance over the temperature range.

II. Contact Technologies

Two major contacting technologies were evaluated - elastomeric and wire button contacts. The wire button contacts, are made of 1 mil wire, randomly wadded and gold plated, formed in a cylindrical shape with 20 mils diameter. Three wire alloy compositions were evaluated: CDA 174 beryllium copper, CDA 729 copper/nickel/tin, and molybdenum. The random shaping of the buttons produces many spring and cantilever contacts that run throughout the cylindrical shape, making redundant connections at the interface surfaces when compressed between them. Button resistance is a function of the compression force, although resistance values below 70 mOhms have been achieved with as little as 0.5 ounces per contact. A force of 2 ounces is recommended by the manufacturer. The buttons are captured on an insulating board with openings slightly smaller than the button diameter and forced into the holes under radial compression, remaining secured after assembly and yet being able to spring under pressure providing a mechanical wipe action when contact is made. The buttons protrude 0.008 inches above and below the insulating carrier board, therefore tight control of mechanical tolerances is required.

The elastomer connectors evaluated were formed in 22 X 22 mil square elements, each containing eight redundant metal layers supported inside an insulating rubber body which also seals out the metal traces from the surrounding environment. The metallurgy evaluated was gold plated nickel and copper. Contact is again established by compression of the elastomer elements to a typical deflection of 15 %.

III. Evaluation of Wire Button Materials

A polyamide-imide carrier board was inserted with 20 mil diameter buttons in the three metallurgies under evaluation (Be-Cu, Cu-Ni-Sn and Mo) placed with a center to center spacing of 50 mils. Four point measurements were performed using hardware configured as shown in Figure 1.

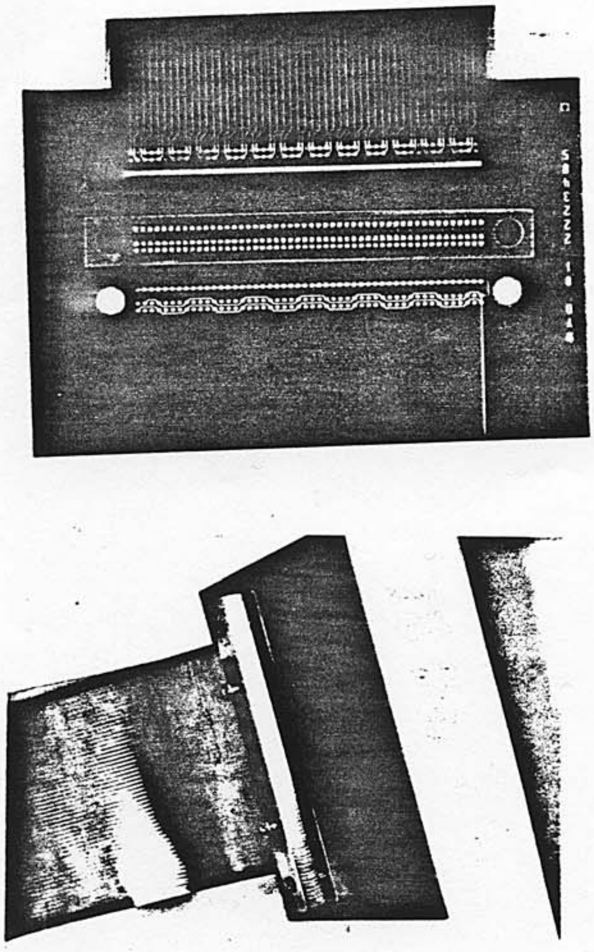

Fig. 1. Trace pattern and clamping mechanism for individual button measurements.

The buttons boards were clamped between the printed circuit board and a flexible cable employing the same clamping mechanism used by Almquist [1] in his characterization of button contacts for Liquid Nitrogen applications. All hardware was constructed using materials rated for operation at 200 C. The connecting pattern in this assembly was layed out in such a way that four wire measurements were easy to perform outside the oven. Notice that some of the buttons were actually utilized to complete the current forcing and the voltage sensing paths. With this arrangement, the individual resistance values for 24 of the buttons were measured for each of the metallurgies under evaluation, characterizing the variation of individual button resistance as a function of temperature. This data is presented, using box plots, in Figure 2 and it shows all metallurgies are below 70 milliOhms, for temperatures of up to 200 C with Be-Cu having the lowest mean and tighter distribution, followed by Molybdenum and then Cu-Ni-Sn.

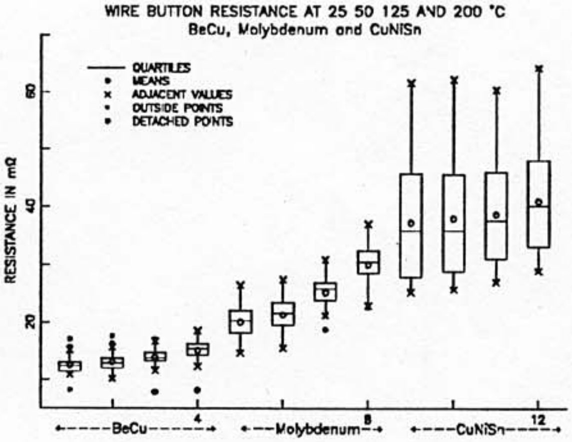

Fig. 2. Individual button resistance vs temperature

The variation of resistance with time at elevated temperatures was also characterized and is presented in Figure 3. While Be-Cu shows the lowest resistance and tightest distribution, data from the wire manufacturer shows that its remaining stress after a 1000 hour exposure to 200 C is 70%.

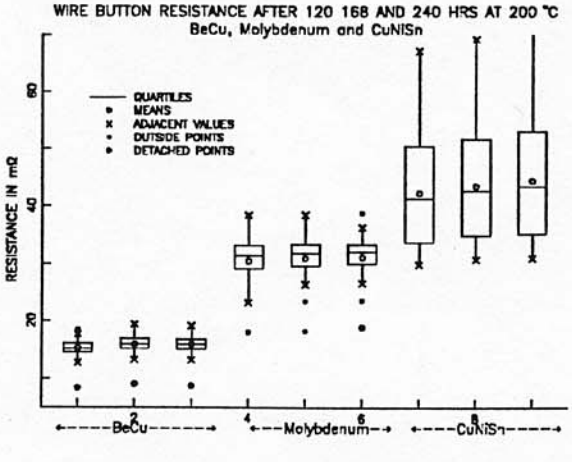

Fig. 3. Variation of individual button resistance after stress at 200 C.

IV. Wire Button Socket Evaluation

Prototype sockets with 1156 buttons with a diameter of 20 mils arranged in a 34 X 34 matrix spaced on 50 mils centers were built using Molybdenum wire buttons stuffed in a polyamide-imide carrier board. Molybdenum was chosen for its stress relaxation properties at elevated temperatures. The button board was clamped between a printed circuit board and a "dummy ceramic substrate" by a 0.375 inch bolster plate and a pressure plate with a one inch diameter circular opening over the center of the contact grid. A spring loaded clamping mechanism was devised using a spring-bolt pair on each of the corners. This arrangement is shown on Figure 4.

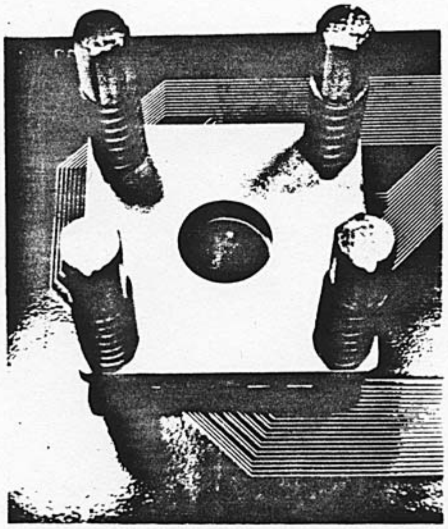

Fig. 4. Prototype socket and clamping mechanism.

The "dummy ceramic substrate" was only three millimeters in diameter so its deflection and stress were simulated using both "Roark" and Ansys quadrilateral thin shell models, to insure that all buttons would see the minimum required two ounces of force, especially those under the circular cutout, and that the maximum principal stress would be below the maximum allowable stress for the ceramic substrates.

The measurement set up included a precision current source, volt meter, scanner, and oven temperature controller. They were all computer controlled via the General Purpose Interface (GPIB) Bus. The printed circuit board and "dummy substrate" were configured so that each of the 1156 buttons was connected in series. Voltage measurement points were brought out for every row. Although no individual button resistance measurements were possible with this arrangement, any significant increases on individual buttons would be detectable. This scheme also permitted the forcing of current while under thermal stress. The results for one of the sockets evaluated in this manner is shown in Figure 5.

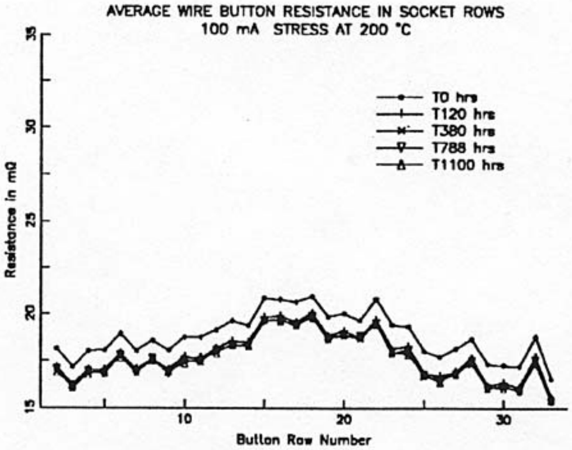

Fig. 5. Stress results for 1156 buttons in series, 100 mA @ 200 C.

The values for rows 1 and 34 are not shown because four point probe measurements were not performed due to the fact that the printed circuit boards did not have separate current and voltage lines for these two rows. The stress conditions were 100 mA and 200 C. No degradation was observed after 1100 hours of stress. It was also observed that the resistance value decreases from the time zero result. This "settling" effect was consistently observed in all of the stressed hardware. Another interesting observation is the fact that those rows towards the center show the effect of the circular cutout disturbance on the force exerted on the buttons located in this area manifesting itself by a slightly higher resistance value. Results for a second socket stressed at 500 mA and at 150 C for the first 113 hours, and an additional 282 hours at 200 C are shown in Figure 6.

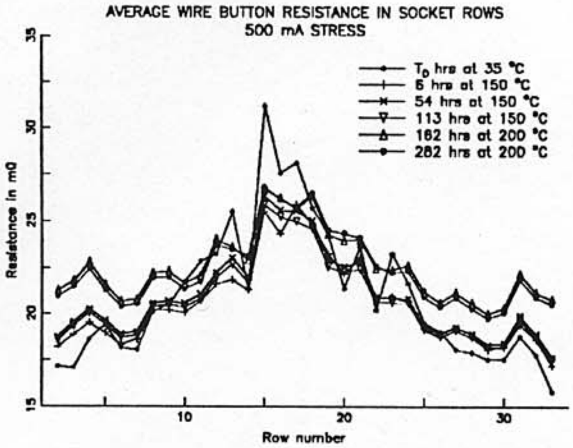

Fig. 6. Stress results for 1156 buttons in series, 500 mA @ 150C and 200 C.

V. Elastomer Socket Evaluation

Prototype sockets with 1156 elastomers in the same 34 x 34 matrix arrangement spaced 50 mils center to center were constructed using 0.022 X 0.022 inch square elastomer elements. The socket footprint was identical to that of the wire button sockets, so that the same printed circuit board and dummy substrates could be used for this portion of the evaluation. A cam mechanism made of a backing plate on the back side of the board and a bolted pressure plate with a one inch diameter circular cutout in the center provided the pressure necessary to establish contact. The same hardware and software described on the previous section were used and the results are shown on Figure 7.

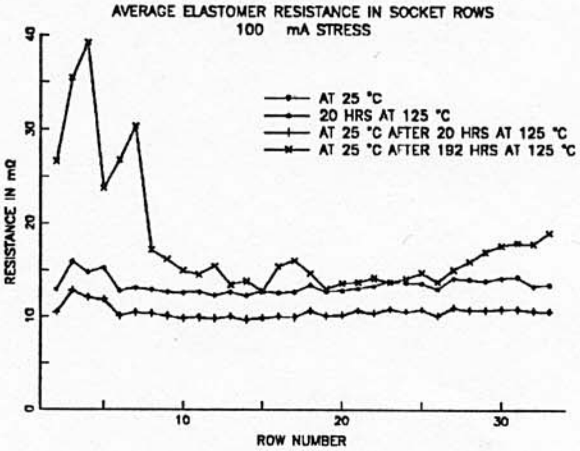

Fig. 7. Stress results for 1156 elastomers in series, 100 mA @ 125 C.

Once again rows 1 and 34 are not shown. The time zero results showed a tightly distributed average row resistance of slightly less than 10 milliOms. The socket contacts were stressed with a current of 100 mA for 192 hours at a temperature of 125 C. As it can be seen an increase in resistance was detected after only 192 hours. At this point analysis of elastomer elements showed they had permanently deformed under stress conditions, photographs for typical elements before and after stress are presented on Figures 8 and 9.

Fig. 8. Typical elastomer shape before high temperature stress.

Fig. 9.Typical elastomer shape after 125 C stress.

VI. Conclusions

The elastomeric interposers provided low resistance and good frequency response, within the required footprint demands, but were unable to meet requirements for temperatures above 125 C. The wire button approach provided a viable socket using molybdenum wire for over 1000 hours at temperatures up to 200 C. The stress results, adaptability for high density packing, and ease of solderless assembly/replacement, suggest the wire button as a suitable option for stress test or burn-in.

Acknowledgment

We wish to express our appreciation to John Bannister for his work on the development of the elastomer socket, to Howell Schwartz for his work on mechanical simulation, and to Frank Almquist for the fixturing used in our evaluation of various metallurgies. We would also like to express our appreciation to the reviewers for help in making necessary clarifications.

References

[1] F. Almquist "Button contacts for liquid nitrogen applications," Proc. IEEE 39th Electronics components conference, p89, 1989