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From: Code 562

Date: September 10, 1998

Subject: Evaluation of the Die Attachment, Ablestik 84-1, for its reliability for TDRS

Introduction

The evaluation was initiated when significant resistance changes were observed after the die was attached during the fabrication of the hybrids for TDRS program. The silver filled conductive Ablestik 84-1 is a common die attachment and has a good electrical conductivity. In order to investigate the characteristics of the epoxy, the following experiments were performed to understand its effect on the increased resistance:

- Measurement of the resistance after aging
- Inspection of the silver settlement of the cured epoxy
- Finite Element Analysis (FEA) of thermal stress due to mismatch of coefficient of thermal expansion.

The resistance of the epoxy was measured after various stages. The epoxy was cured at 160 °C for 2 hours. The initial measurement was made after the cure. Then the epoxy is baked at 100°C for 24 hours up to 5 times to simulate the aging process. This study is to investigate the resistance increases as epoxy ages. The investigation of the silver settlement is to observe if the silver grains settle at the bottom of the epoxy blob during the cure. The settlement of the silver grains can cause inconsistency in resistance measurement. Finally, the FEA was performed to determine the thermal stress of the expansion/contraction of the epoxy due to temperature cycling.

Approach

<u>Case 1. Measurement of the resistance</u>

Six circuit boards were prepared; each board contains four sites. Each site has same wiring connection and the silver conductive 84-1 epoxy bridged between two wiring connections shown in Figure 1a. The wire is soldered with eutectic Pb63. The current and the voltage across the two wires were measured by using 4-point ohmmeter (Kelvin Method). The Kelvin method (Figure 1b) was used to eliminate the potential inaccuracy caused by the effect of the resistance along the wires that may be much larger than the resistance of the epoxy.

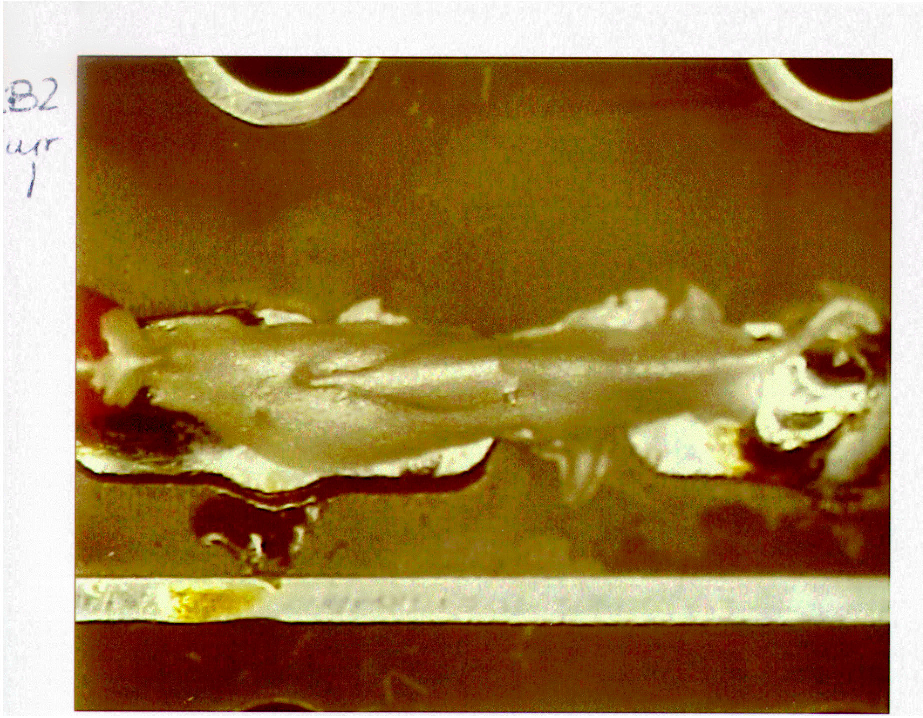


Figure 1a. Epoxy bridge over two wires

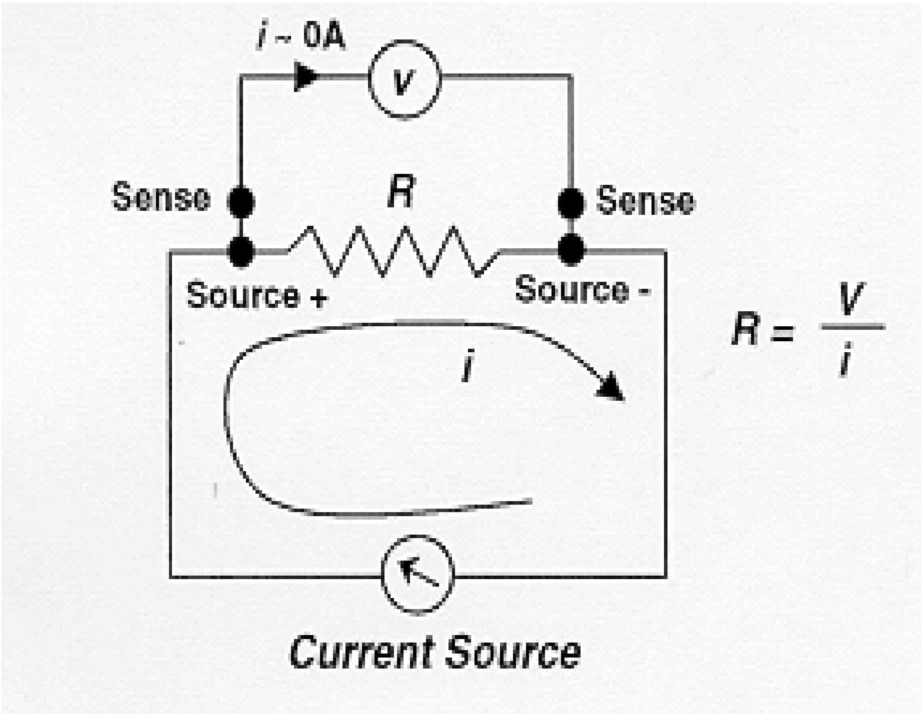


Figure 1b. Kelvin method circuit diagram

Board 1: Baked at 160 °C for 6 hours and 24 hours. Measurement was made after each baking period.

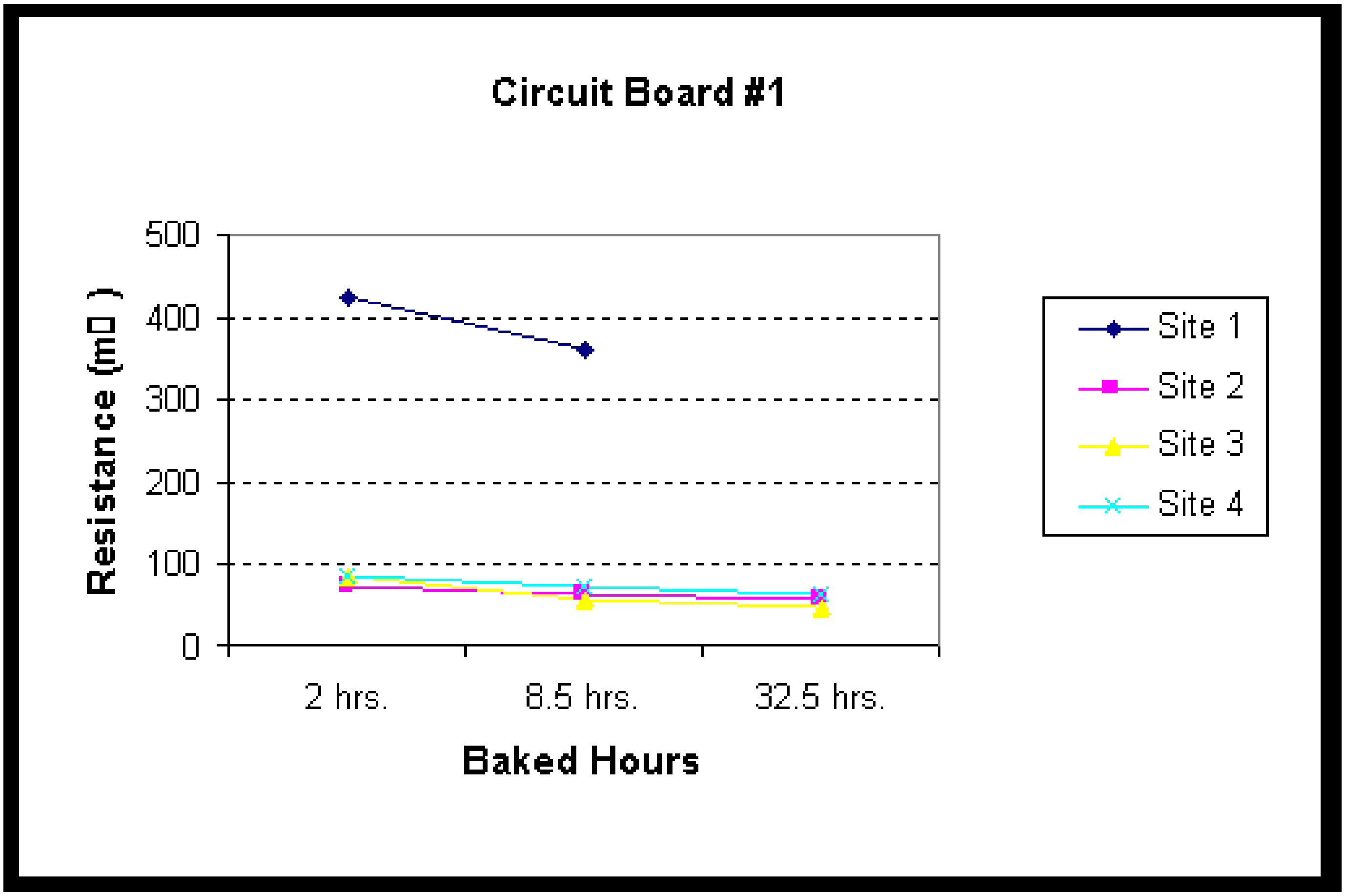
Board 2: Baked at 100 °C for 24 hours at a time, 5 times. Measurement was made after each baking period.

Board 3: Baked at 100 °C for 24 hours at a time, 2 times. Measurement was made after each baking period.

Board 4, 5, & 6: Baked at 100 °C for 24 hours at a time, 4 times. Measurement was made after each baking period.

(Note: Some of the data are not included due to incorrect measurement. Also some of the data read higher than others because the amount of epoxy varies sample to sample.)

As shown in Figure 2, the measurement at various stages remained consistent. The results show that the resistance of the epoxy is fairly stable.



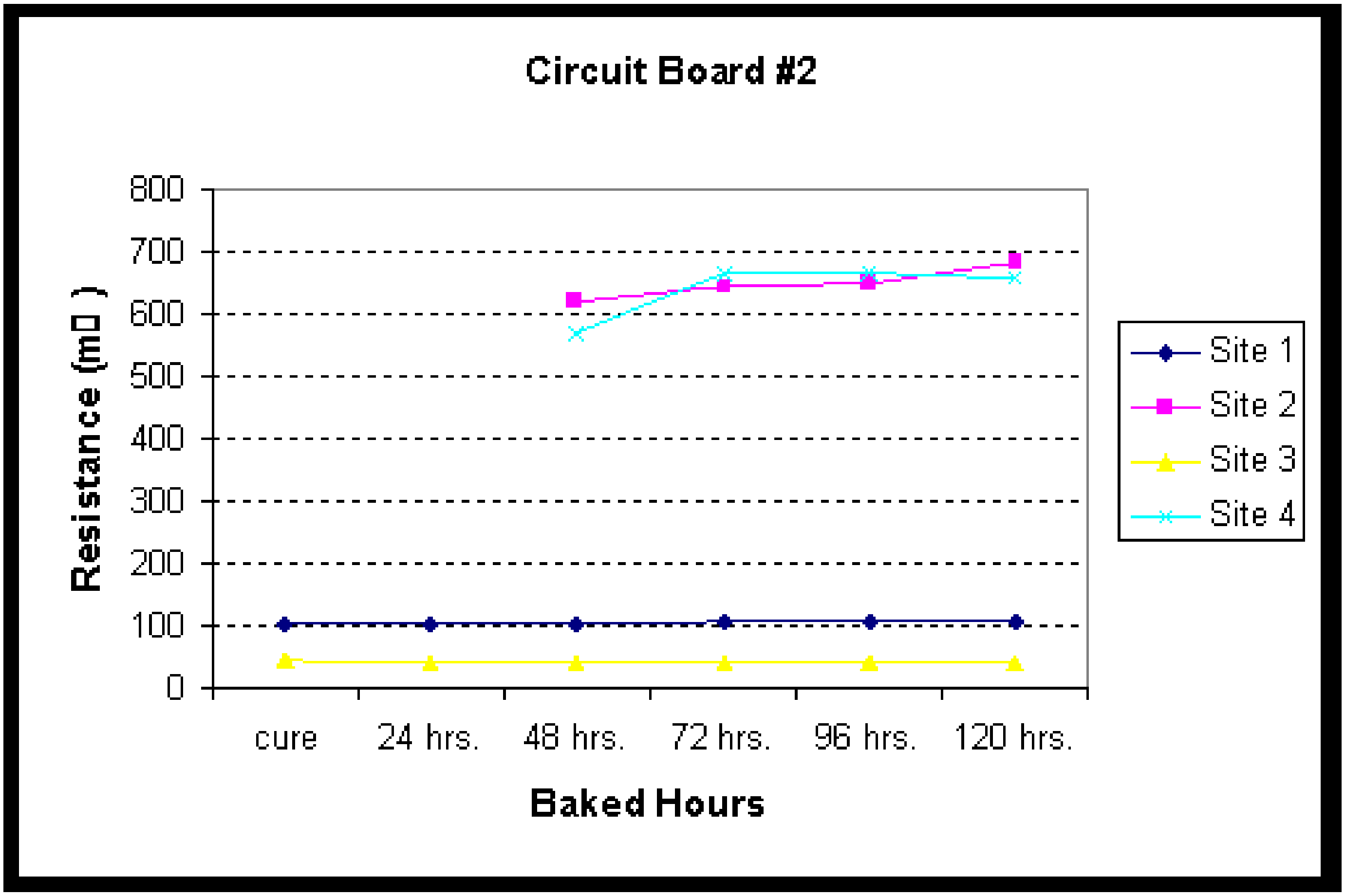
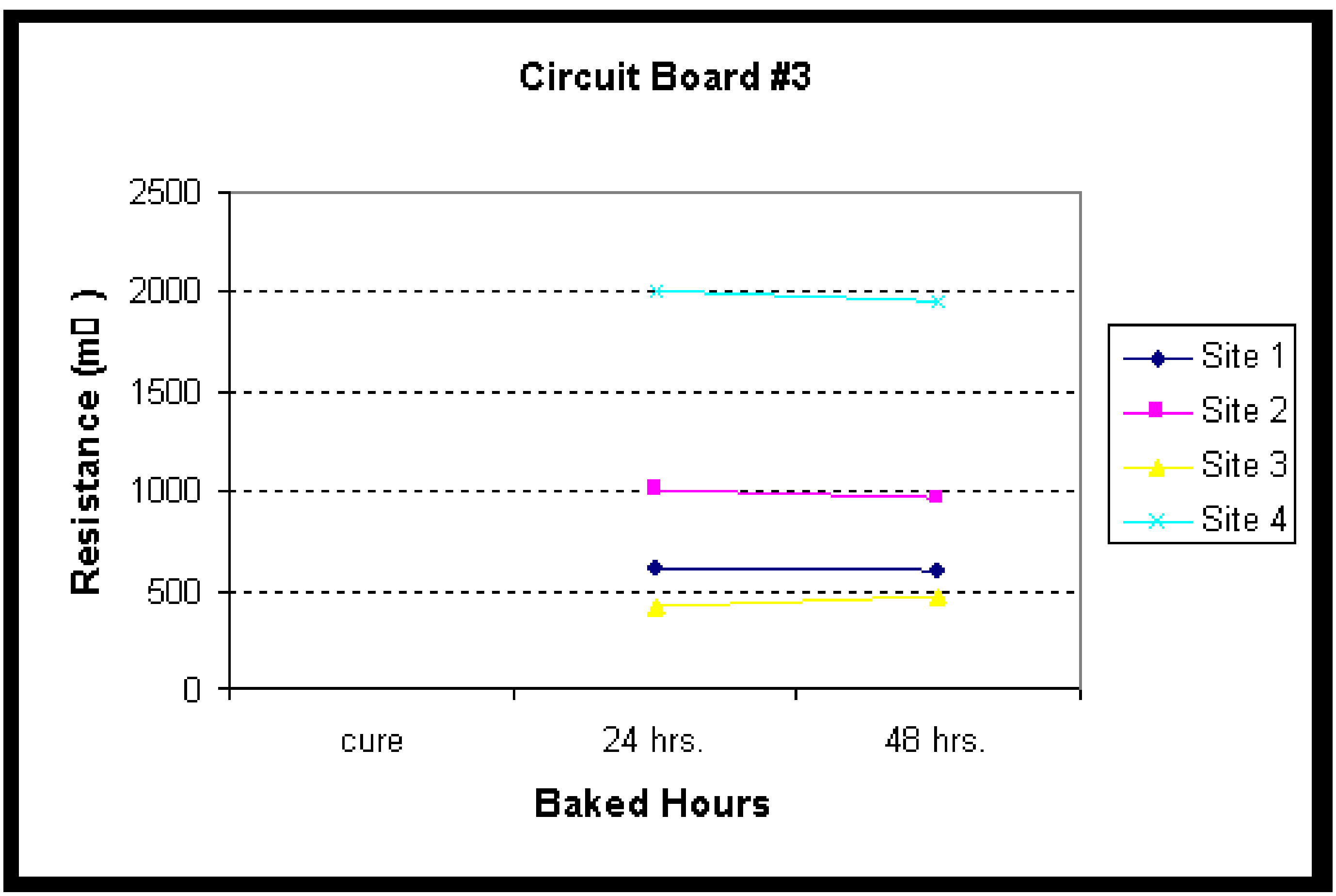


Figure 2. Result of the resistance measurement at each board



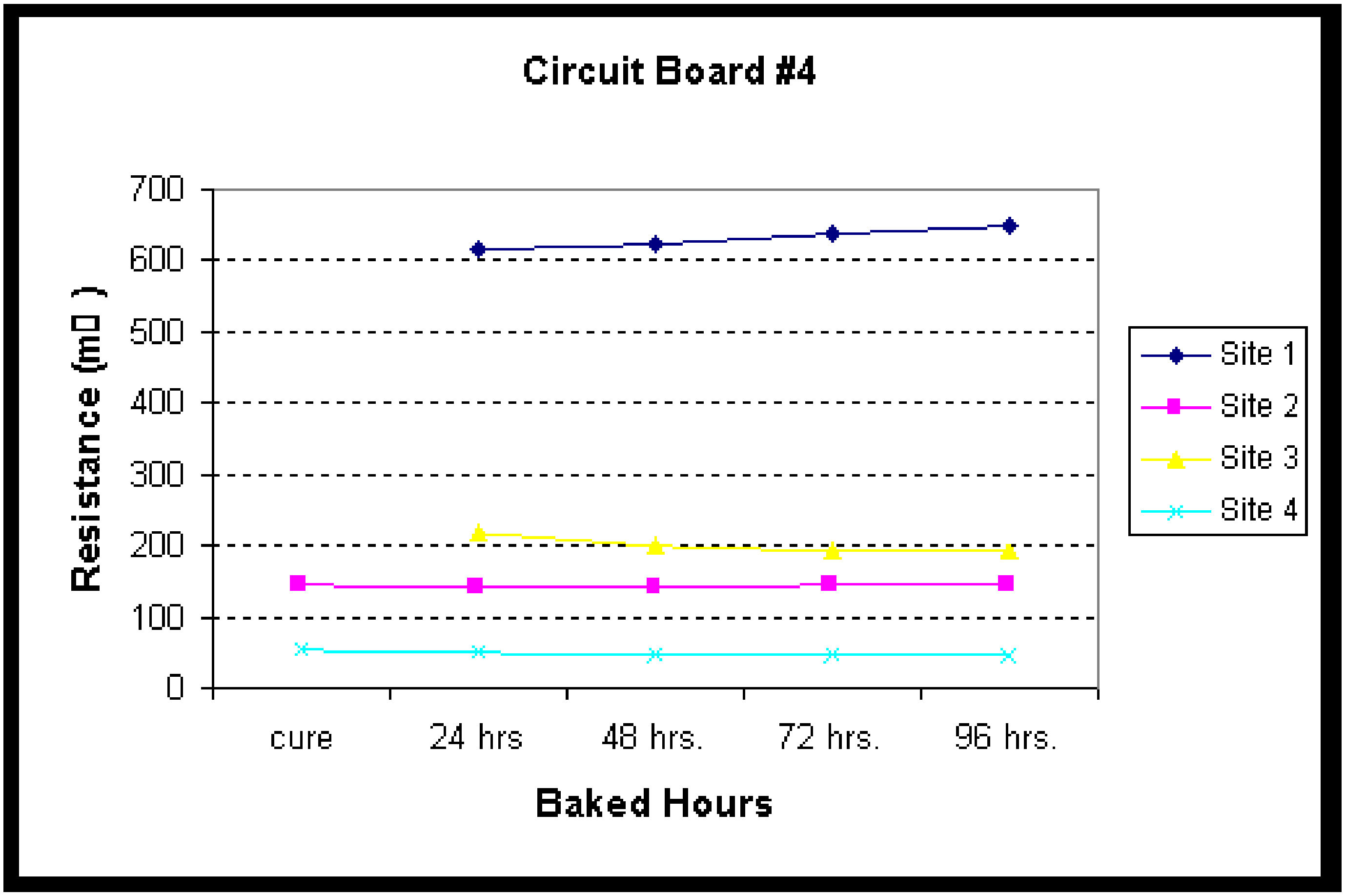
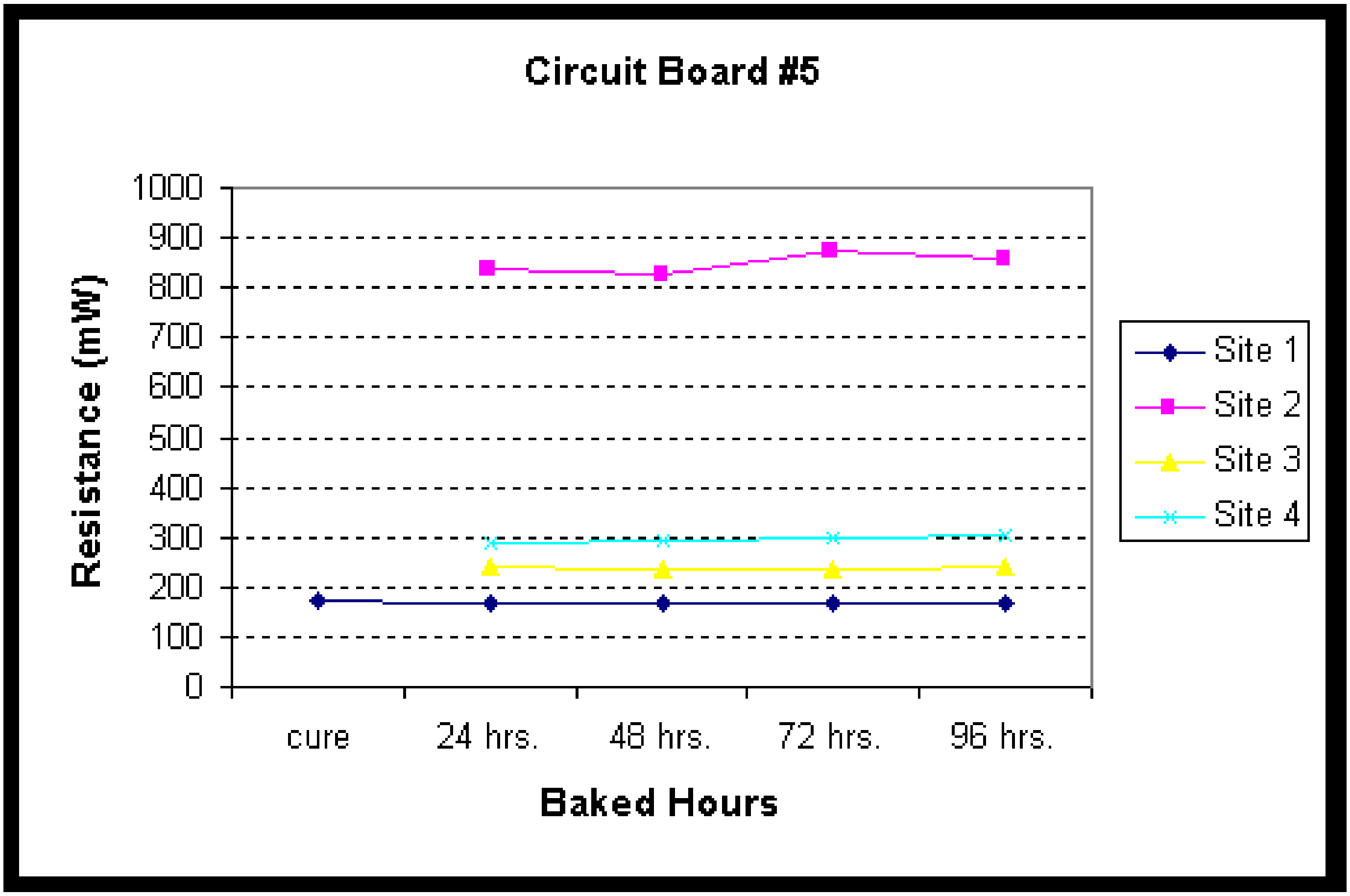


Figure 2. Result of the resistance measurement at each board (continued)



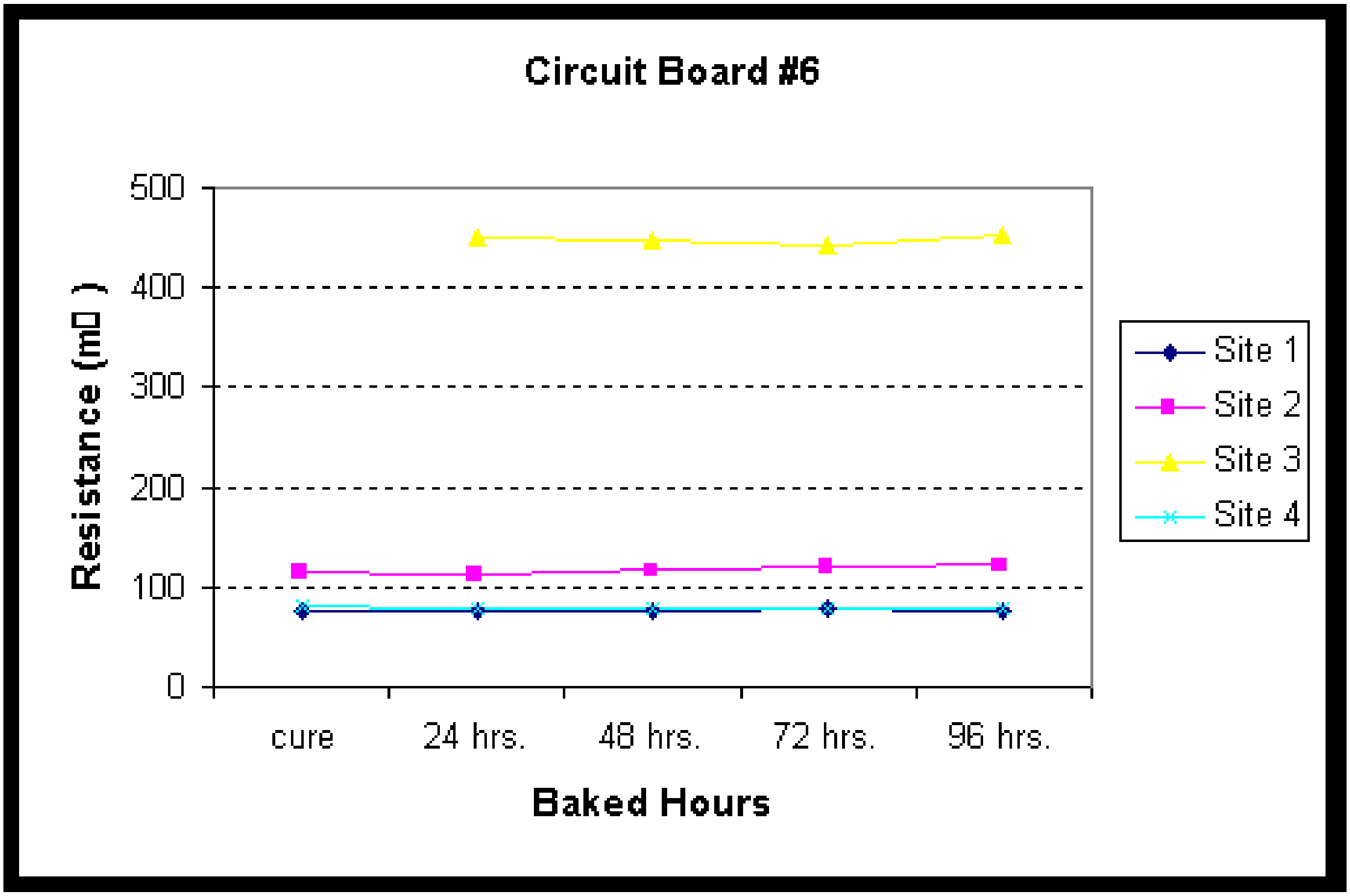


Figure 2. Result of the resistance measurement at each board (continued)

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Case 2: Silver settlement investigation

The purpose of this experiment was to understand the effect of the settlement of the silver grains. The blob of epoxy was deposited in a glass test plate, and sat for one week for the silver grain to settle. Then the epoxy was cured at 160°C for 2 hours. The cured epoxy was cross-sectioned and visually inspected under Scanning Electronic Microscope (SEM) for the distribution of the silver grains within the epoxy resin. As shown in Figure 3, the silver grains are spread consistently across the area. This indicates that the inconsistency of the resistance measurement is not due to uneven silver grain distribution.

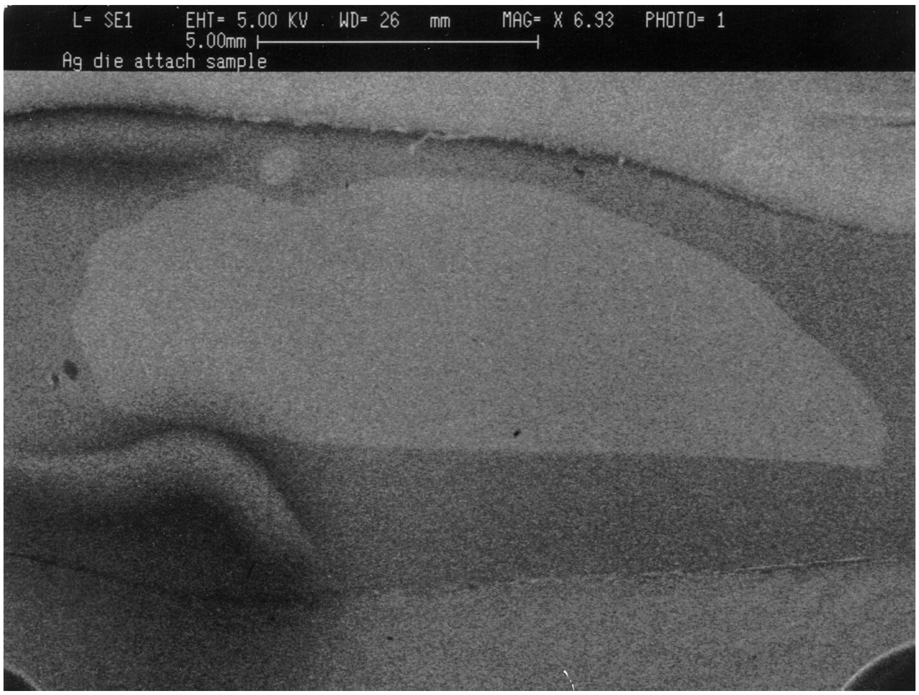

Figure 3. Cross-section of the silver filled epoxy

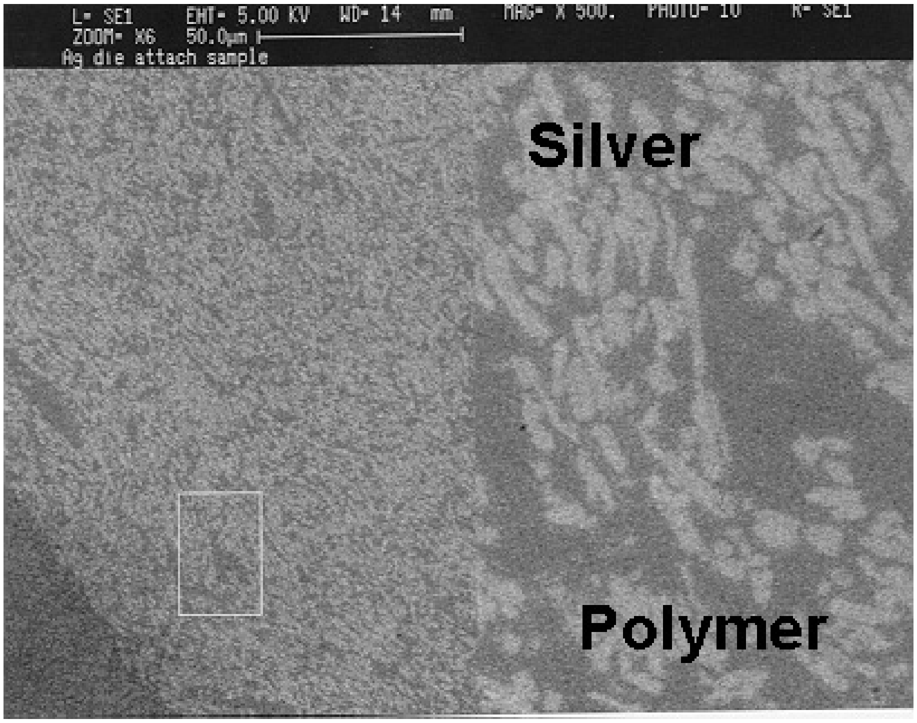

Figure 3A

Figure 3B

Figure 3C

Case 3. FEA of thermal stress due to mismatch of coefficient thermal expansion

The objective of this analysis is to investigate the ability of Ablestik 84-1 die attachment epoxy to withstand the thermomechanical stress induced by thermal cycling. Ablestik 84-1 is a silver filled conductive epoxy which is bonded between the silicon die and the alumina substrate.

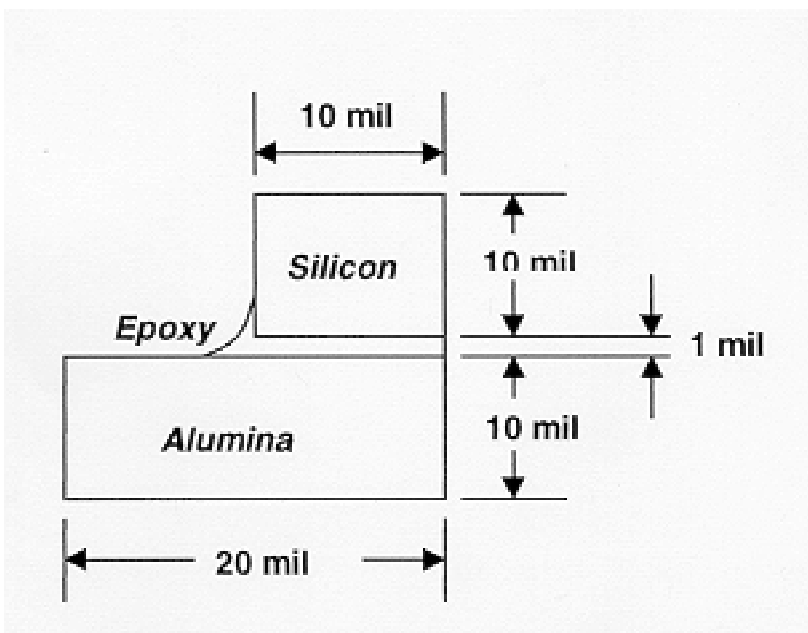

Figure 4. Cross-sectional view of the back contact resistors

The Finite Element Model shown in figure 4 was generated using MSC/PATRAN (version 7.0). The three-dimensional solid model (C3D8) contains 9365 HEX. elements and 10950 nodes. The material properties are listed in Table I. Young's modulus and the Coefficient of Thermal Expansion (CTE) of Ablestik 84-1 were provided by the manufacturer. Such parameters for epoxy are often temperature dependent. ABAQUS was used for nonlinear elastic analysis. ABAQUS is a software tool that has the capability of solving linear and nonlinear problems; linear being proportional increases between the stress and the strain, and nonlinear being the stress increase is not proportional to the strain. Elastic is defined as the return to the original shape from the deformation after the load is removed. The nonlinear elastic behavior of Polymer Epoxy can be found in any literature search.

Ablestik 84-1 has a glass transition temperature of 103 ° C and is cured at 150 ° C for one hour. The die adhesion model was analyzed for one temperature cycle from 150 ° C to -55 ° C.

Table I

Material Properties

Material	**Young's Modulus** **Gpa (10^6 psi)**	**Poisson's Ratio**	**CTE** **10^{-6} m/m °C** **(10^{-6} in/in °F)**
Silicon	150 (21.7)	0.30	4.1 (7.38)
Epoxy	3 (0.43) 6.3 (9.14) @ 45 °C 1.50 (2.30) @ 65 °C 0.32 (0.458) @ 78 °C 0.1 (0.145) @ 100 °C 0.063 (0.0914) @ 150 °C	0.40	60 (108) 55 (99) @ <Tg 150 (270) @ >Tg
Alumina	260 (37.7)	0.23	6.9 (12.42)

As the temperature goes down to -55 ° C, the die attachment shrinks much more than the die and the substrate. The die and the substrate are almost rigid compared to the die attachment. The die attachment material is placed under tremendous tension between the two rigid bodies due to the shrinkage. The results show the die attachment has a maximum stress at 10 ksi at the corner of the attachment and the die interface. The stress is much larger than the ultimate strength. The published strength is about 3 ksi. The strain is more than 30%. Based on this material model, the die attachment will not survive the temperature cycle without cracking. However, this material model may be inadequate for Ablestik 84-1, because most polymer materials behave viscoelastically under large loading. Creep analysis may be required to obtain accurate results. The creep constitutive model of this particular epoxy is not well established. Therefore, further analysis may require more literature searches or experimental creep studies.

Conclusion

Based on above experiments, it is concluded that the characteristics of the epoxy do not contribute to increases of the resistance. The silver filled Ablestik 84-1is determined to be adequate for its use as a die attachment in this TDRS application.

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