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Detecting Corrosion in Plastic Encapsulated Micro-Electronics Packages

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Plastic encapsulated microelectronics (PEMS represent approximately 95% of the worldwide market share for microcircuit sales.[1] The principal advantages of PEM devices include low cost, size, and weight. Acceptance of PEMs has come in spite of formidable reliability challenges over the last 20 years due to corrosion, cracking, and delamination problems. Technology improvements were made during this period focusing on the molding compounds, fillers, and processing parameters. The resultant changes have been revolutionary so that not only are low-cost PEMs commonplace, they also exhibit high reliability and performance.

In 1994, the "Perry Initiative" (Secretary of Defense William Perry,) mandated the use of commercial off-the-shelf (COTS) equipment for the Department of Defense (DoD) applications wherever possible. This action is forcing the utilization of PEM devices in long-life defense systems.[2]

In the past, most defense microelectronics components were packaged in ceramic, hermetic enclosures. PEMs are not hermetic because the plastic molding compounds are permeable to moisture. This lack of hermeticity creates an unknown liability, especially with respect to corrosion of the metallization features (in particular Al bondpads and traces). This potential liability must be addressed to ensure long-term reliability of these systems is maintained under conditions of long-term dormant storage. However, the corrosion process is difficult to monitor because it occurs under the encapsulating plastic and is therefore not visible.

We have developed techniques that allow us to study corrosion of Al bondpads and traces under relevant atmospheric corrosion conditions. The cornerstone of this capability is the ATC 2.6, a microelectronic test device designed at Sandia National Laboratories (Figure 1). This test chip contains a number of triple track structures and includes a set of bond pad resistance test structures.

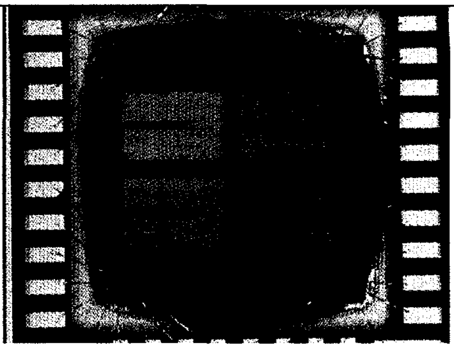

Figure 1. Image of the ATC 2.6 test structure used to study corrosion of Al metallization features in micro-electronic devices.

The extent of corrosion is monitored primarily through resistance measurements. Figure 2 shows the layout of the bondpad resistance structures in the two different measurement configurations that are used. The first is a 4-point measurement of the series-parallel combination of bondpad sheet resistance, Au ball bond resistance, and ball to pad interfacial resistance of the center pad. These 4-point measurements permit gradual degradation of the wirebond interface to be monitored. The second configuration shows how a 3-point measurement of the center bond wire/bond pad is performed. The 3-point measurement includes the additional series resistance of the bond wire itself. Because the resistance of the 1 mil Au wire is significant, these measurements primarily indicate when wirebond failure (detachment) has occurred. Both measurements can be made on the same pad during accelerated testing.

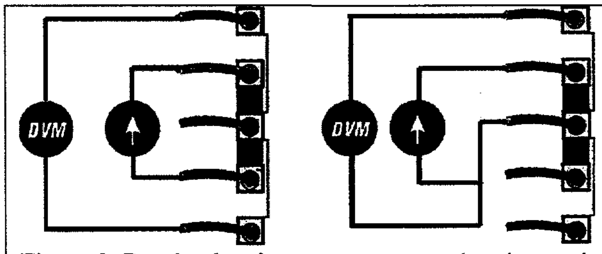

Figure 2. Bondpad resistance structures showing typical measurement connection for 4-point and 3-point options.

Corrosion tests were performed by exposing test chips to aggressive environments. The electrical response of the ATC indicated an increase in bondpad resistance

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with exposure time (Figure 3). Note that the change in resistance is not uniform from one bondpad to another. This illustrates the stochastic nature of the corrosion process. The change in resistance correlated with visual observation of corrosion of the bondpads on the unencapsulated test chips (Figure 4).

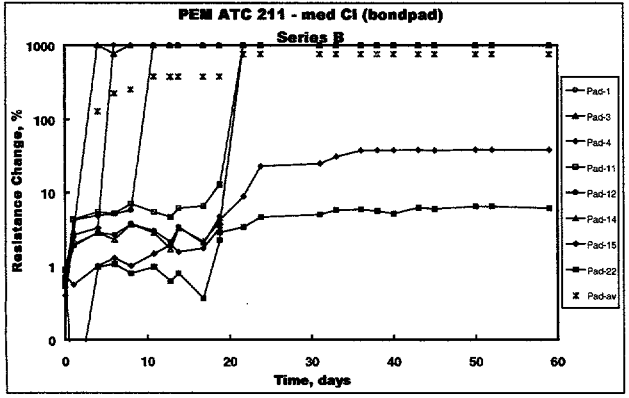

Figure 3. Resistance plots for ATC 2.6 structures exposed to accelerated atmospheric conditions.

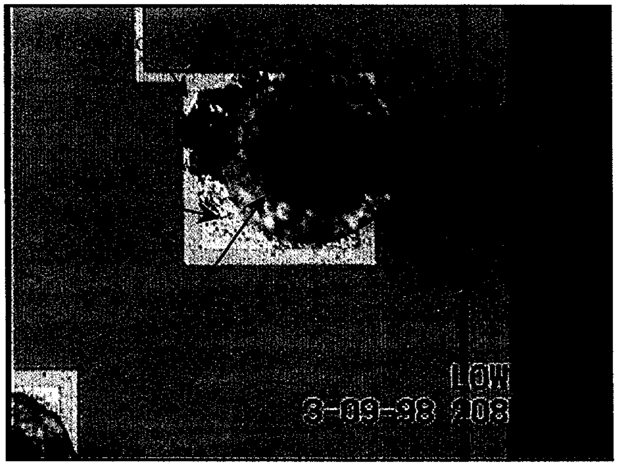

Figure 4. Optical image of gold wirebond on an Al bondpad. The ATC was exposed to elevated temperature & humidity for 50 days. Note the corrosion of the bondpad adjacent to the Au wirebond.

References:

1. Pecht, M. G., Nguyen, L. T. and Hakim, E. B., Plastic-Encapsulated Microelectronics, John Wiley & Sons, new York, 1995.
2. Wilson, J. R. "Is DoD COTS Initiative Moving Too Fast?," Military & Aerospace Electronics, August, 1996, p.6.