Dear Members,

We've been seeing much more interest among our OEM member community in the assembly and reliability of higher power devices such as wideband power amplifiers in various package types. Of particular concern is the role of solder paste voids in large area solder connections which pose a reliability risk by impeding the extraction of heat from local device hot spots. In 2Q2018, we'll be evaluating the effectiveness of vacuum solder reflow in minimizing or eliminating process induced solder voiding for a variety of package sizes and types. An in-line vacuum reflow oven will be installed in the Advanced Process Lab through the second quarter. We have allocated time later in the quarter for confidential trials on member company product. If you have some troublesome components prone to voiding, consider allocating some appropriate hardware for a reflow trial here in the APL.

Please block your travel calendars for March 28th and 29th. We'll be hosting the next consortium research review meeting at Binghamton University. Further following the high power theme, we're including on the meeting agenda some invited content on general power packaging challenges. We hope you can join us.

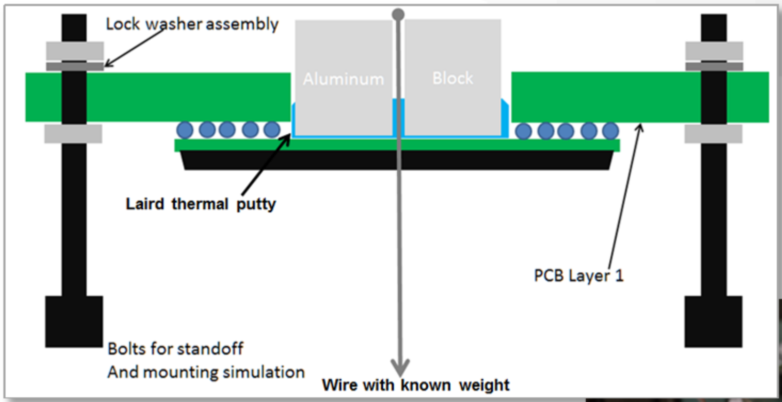
Sincerely,

Jim Wilcox

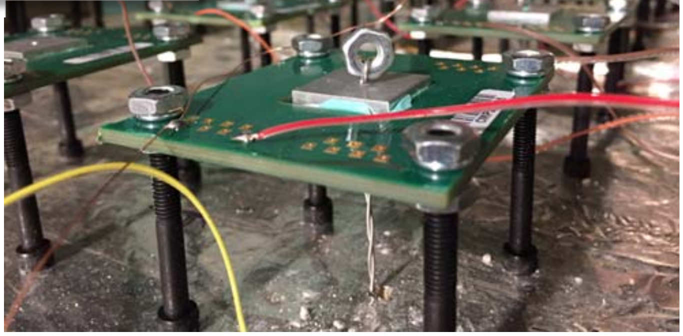
Consortium Manager

REL11B. Effect of Superimposed Tension on BGA ATC Reliability

Applications are being proposed that require thermal solutions to be applied through an open window in the circuit boards. Heat sink loads applied to a thermal interface material will necessarily put the package attachment solder joints in tension. The reliability consequences of such a superimposed load have been measured experimentally. A 40mm, 892 I/O, perimeter array PBGA component was subjected to environmental thermal cycling while supporting a 0.0, 0.5, 1.0 or 3.0 kg mass. These loads subject the solder joints to tensile loads similar to those expected in an actual product. After 2000 thermal cycles, testing was suspended with 43 of the 48 samples having BGA failures. Data analyses indicate that the supported loads have little, if any, impact on SAC305 BGA solder joint reliability.



Schematic of apparatus to load a perimeter BGA package through a central hole in the circuit board.

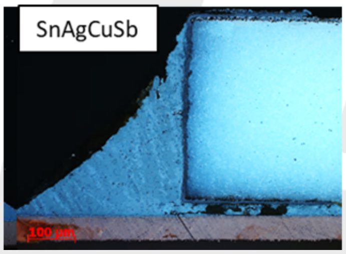


Array of test boards weighted and instrumented for thermal cycle test. Weights are suspended outside of the heated chamber to reduce thermal inertia of the system.

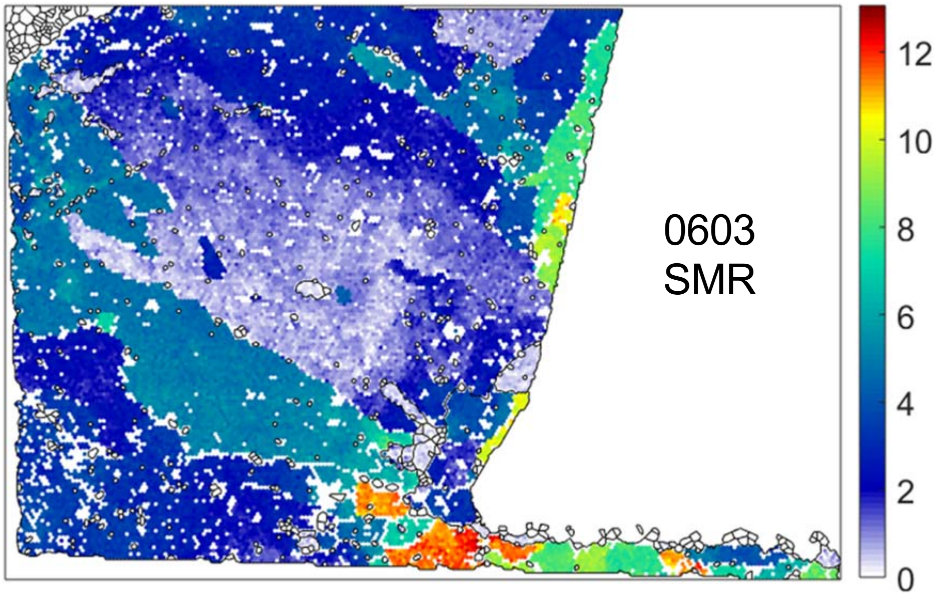
MAT6G. Pb-free Solder Alloys for Engine Control Applications

Our investigation into the reliability and microstructural behaviors of solders developed for extended operation at elevated temperatures such as automotive engine control applications uses a two phase experimental approach. Phase one investigates the microstructural behavior of several candidate solder alloys during various harsh environment thermal cycle and thermal shock exposures. The solder alloys under study, all SnAgCu based, are alloyed with different combinations of Sb, In, and/or Bi. Pastes of these alloys were used to solder 0603 surface mount resistors for harsh environment stress testing. Samples were removed from cycling at regular intervals to measure the joint shear strength using a Dage 4000+ Bondtester. Some of these initial shear strength measurements have been reported previously. All micro-alloyed solders tested to date show a clear improvement over the SAC305 solder control. Shear strengths at room temperature and high temperature (125°C) are initially greater and retain superior strength throughout cycling.

Representative samples from these various stress test intervals were set aside for SEM/EBSD analysis. Optical microscopy and electron backscatter diffraction (EBSD) has demonstrated that the presence of the micro-alloy elements is successful to varying degrees in delaying the onset of global recrystallization. Such recrystallization events are known precursors to thermal fatigue damage. An analysis of the high angle grain boundaries in the alloys after 200 cycles (-40/125°C, 10 min dwells) showed their development to be slowed in all four of the micro-alloyed solders. An example analysis for a SnAgCuSb alloy at 200 cycles is shown in the image below.



Accumulated solder fatigue damage after 1800 cycles.

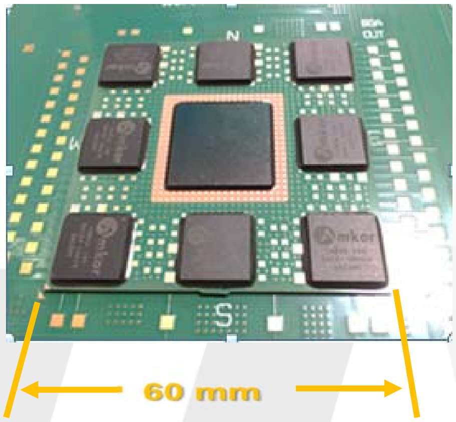


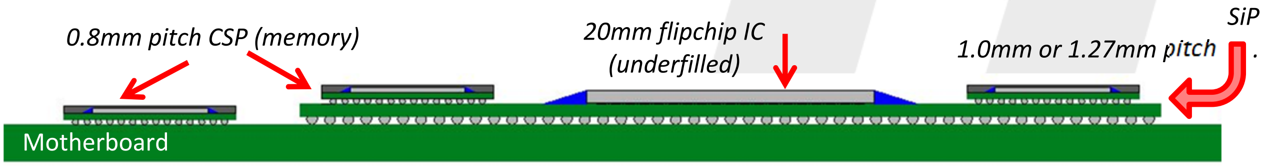
Kernal Average Misorientation (KAM) map of a SnAgCuSb alloy after 200 cycles of -40/125°C (10 min dwells) showing the misorientation for each location with respect to the mean. Recrystallization is clearly visible in the solder beneath the 0603 resistor and in the immediate surrounding area.

The second phase of this study consists of assembling a variety of package types onto a test board using the same solder alloy paste materials. Packages tested include MLF56, QFP44, BGA192, LGA192, BGA360, PLCC-44, and DRMLF156 as well as surface mount resistors in 0805, 0603, 2512, 1206, 0402, and 0201 formats. These assemblies will be electrically monitored during a -40/125°C thermal cycle, scheduled to begin shortly.

REL17A. System in Package Interconnect Reliability: SAC305

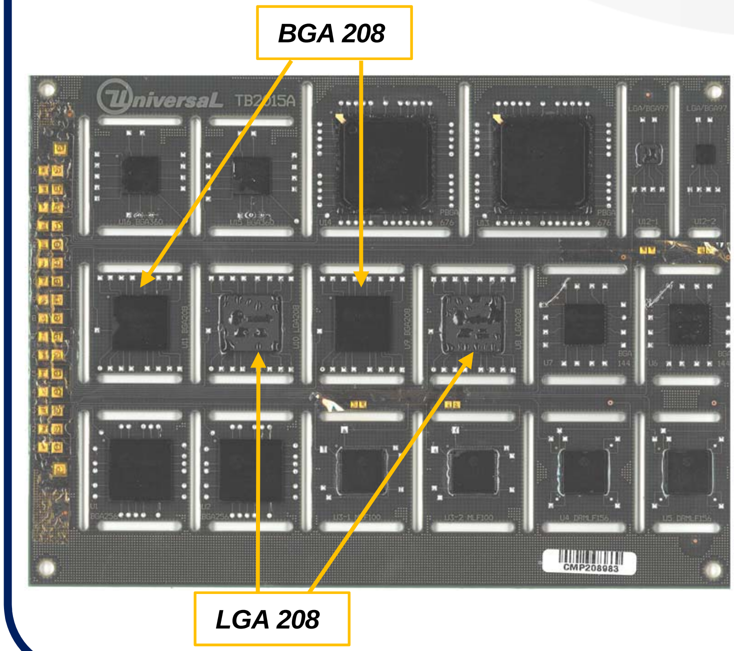
Thermal cycle reliability testing of ten large body (60mm) System in Package structures having four different CSP memory configurations is nearly complete. With approximately 95% of the samples having failed in a -40 to 125°C thermal cycle comparisons among the various designs are possible. Four SiP memory layouts were tested: no SiP memory, 4 edge, 4 corner or all 8 position memory. Additional experimental variables include 1.0mm vs. 1.27mm pitch SiP (3364 vs. 2025 I/O), SnPb eutectic vs. SAC305 BGA connections and underfilled memory packages.





MAT8B. Conformal Coatings: New Materials and Methods

Environmental thermal cycle testing of five different conformal coatings applied to board assemblies containing BGA, CSP, LGA and QFN package types is in progress. The goal of this experiment is not to evaluate the coatings for their environmental protection performance but rather to evaluate their effects on solder joint reliability in various packages. Coating materials being evaluated include a UV curable epoxy (EMCAST 1902), a two part epoxy (Humiseal 2A53), a single component synthetic rubber (Humiseal 1B59LU), a plasma nanocoating (Semblant MobileShield 1.1) and a fluorinated coating (3M Novec 2708). Uncoated board assemblies have been included in the thermal cycle chamber as a reference comparison. Over 600 thermal cycles have been completed to date with many failures already detected.



*A populated TB2015 test board coated with **EMCAST 1902** conformal coating ready for thermal cycle test.*
(Color adjusted to enhance contrast.)

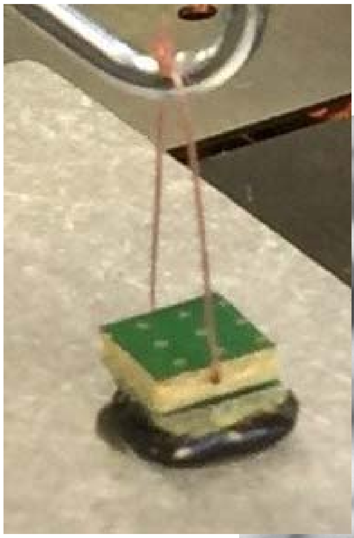
Note the difference in wetting characteristics of coating on the backside of otherwise identical Chip Array BGA 208 and LGA 208 components. Presumably, the wash operation associated with ball attach has substantially improved the adherence of the coating to the component.

REL9A. Mixed VIPPO Array BGA Soldering Defects

The designs for the VIPPO empirical test boards are complete and the sourcing of the first thick board design is underway. In the meantime, the single joint mechanistic experiments are continuing, with further refinements of the technique. The objective of this series of experiments is to identify under what conditions (load, temperature and temperature gradient) the characteristic mixed VIPPO solder joint interfacial separation will occur. For these experiments test samples emulating a single BGA to board joint are made by soldering together two small pieces of laminate using a single SAC305 solder sphere. The ‘component’ side of the joint has an SMD ENIG finished pad, while the pad of the ‘board’ side is NSMD with a Cu/OSP finish. Precise alignment and soldering of the two parts is accomplished using the APL Finetech multi-purpose die bonder.

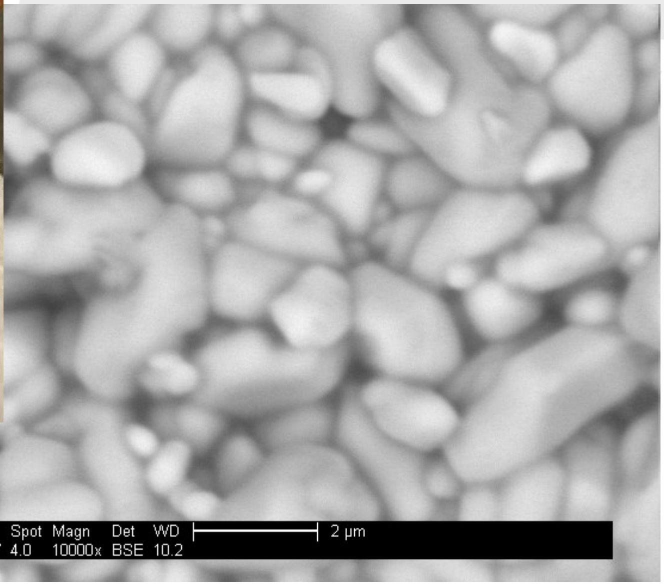
One side of the soldered sample is attached to a fixed surface with an adhesive. A wire is inserted in a very fine hole previously drilled through the other side and closed to form a loop. This loop is pulled with a known upward force while the whole assembly is being heated until the joint fails. Heating using either the DMA or the Finetech hot stage establishes a temperature gradient with the joints uniformly failing at the hotter side. Alternatively, heating inside a box oven provides a near isothermal environment. Separations can occur on either side of such isothermal joints.

Careful SEM observation of the joint failure surfaces, including EDX analysis, has shown that the failure is always between the bulk solder and a pad intermetallic layer (with little to no solder remaining on the IMC), very similar to the failure mode encountered in second reflow induced mixed VIPPO pad solder defects.



Left: single BGA joint sample configured for test

Below: Component pad intermetallic separation surface



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Additions to the AREA report archive …

[Large Body BGA with Thermal Lid: Assembly and Reliability Analysis]
by Michael Meilunas

[Reliability Testing and Performance Review of Thermal Interface Materials]
by Divya Choudhary and Michael Gaynes