Dear Members,

Long term reliability testing is humming along steadily here in the lab. All thermal cycle chambers are running at capacity (along with several thermal shock chambers). And, after a little planned test part consolidation, we will be starting up a 0-100°C ATC chamber to run alongside our ever popular -40/125°C thermal cycle.

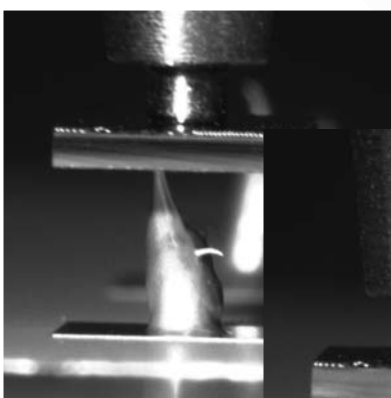
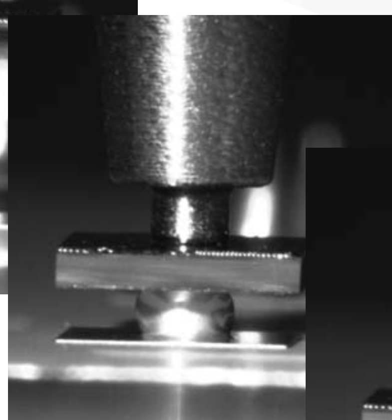
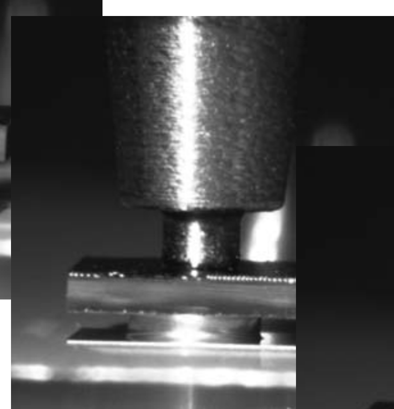
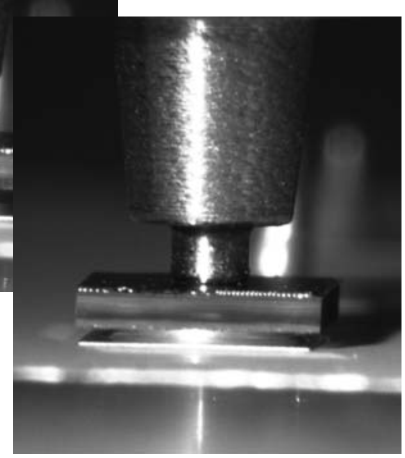
In the academic world, the spring semester will be ending soon. Several of our resident graduate student research assistants are finishing up their thesis research and will be graduating at the end of the month. They are prepped and ready for the industrial job market. So, if you have need for a skilled entry level engineer with experience based knowledge of electronic assembly and demonstrated laboratory and analysis skills, we have several good candidates for you to choose from.

Sincerely,

Jim Wilcox
Consortium Manager

MAT6B. Sintered Silver Die Attach

The second phase of the sintered silver project, focusing on process development and the effect of process parameters on thermomechanical reliability of sintered joints is now underway. Initially, silver paste was printed with a stencil printer and an automated placement machine, set at the lowest possible force, was used for die placement but controlling the bond line thickness proved challenging. While an automated assembly process still remains the goal, a Metcal Scorpion rework/placement machine is now being used to place die semi-manually without applying any force to the paste. Dispensing directly from a syringe is also being used as an alternative method of depositing the paste on the substrate. Substrates and silicon die with different surface metallizations were joined using sintering profiles in either the BTU Pyramax reflow oven or a simple box oven. Microstructure of the resulting sintered silver joints is being examined through cross-section. Bond strength is being measured through die shear testing. The metallization of the die and the board pad finish have been found to play a major role in the shear strength of the assemblies.

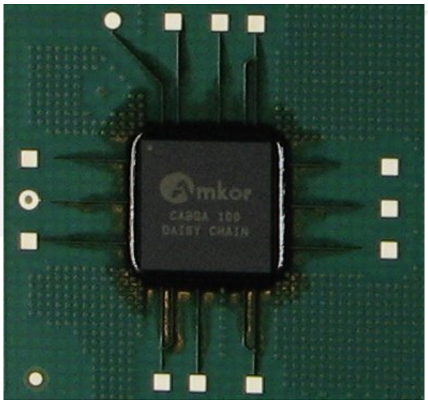
Time sequence of semi-manual die placement into a syringe dispensed silver paste deposit. Displacement control of the placement head (i.e., minimal placement load) is required to control excessive squeeze-out of the low viscosity paste material.

Manufacturing Process Stressing of Solder Pastes: A Statistical Evaluation

An important consideration for the selection of manufacturing solder paste formulations is the consistency of print performance over a broad range of environmental exposure. The process window for satisfactory printing would ideally be maintained after extended times in storage or time opened on the manufacturing assembly line. An extensive study of paste printing process performance after non-optimum handling and exposures has recently been completed.

The focus of this investigation is to understand how various solder pastes perform in harsh paste printing conditions. It compares the print performance of several solder paste materials, including one novel formulation intended to be tolerant of non-ideal storage and use conditions. These materials were exposed to extreme manufacturing environments to understand their capacity to withstand the realities of modern assembly processes operations, recognizing that many of the pastes are being used outside the supplier's specified use conditions. Stencil aperture designs representing various product types with fine pitch components such as 0.3 mm CSP and 01005/0201 passives were used in the print evaluation. Harsh manufacturing processes were simulated by aging the pastes at ambient and elevated temperatures followed by printing after defined time intervals as well as simulating extended continuous printing. SPI paste volume measurements were used to quantify the print performance. Detailed statistical analyses identified the relationship between the exposure history of the solder paste and the paste volume printed on PCB pads of given component types.

MAT1B. Reworkable Component Underfills



The TB2015U test boards have been returned after a well-characterized post-assembly cleaning at the Kyzen R&D laboratory. Component underfilling is in progress with all three underfill materials having been dispensed. Two soldermask materials are included. On one mask type, all underfills were seen to wick away from the component along the mask covered traces and other features for a distance of several millimeters. This 'back-wetting' occurred in both cleaned and non-cleaned boards, extending yet further from the component during underfill cure. This phenomenon was not observed on the second mask material. No explanation could be found for this pathological wetting behavior and underfilling is continuing.

Thermal cycling of the prior TB2014U test boards with various underfilled components continues. The earliest group (underfills E and F plus non-underfilled controls) was removed from the chamber after more than 5500 cycles. The second group (underfills G and H) is still cycling and has now exceeded 3400 cycles. Failed parts have been cross-sectioned to identify failure modes.

Component removal and site cleaning processes for underfilled parts with reworkable underfills have been refined and optimized. The extent of damage imparted to the PCB pads due to thermal cycling and/or rework is being investigated through hot bump pull pad strength tests. Pad strength measurements have been performed on samples at all stages of the process (*i.e.*, as-received boards, underfilled and non-underfilled samples with components removed before and after thermal cycling).

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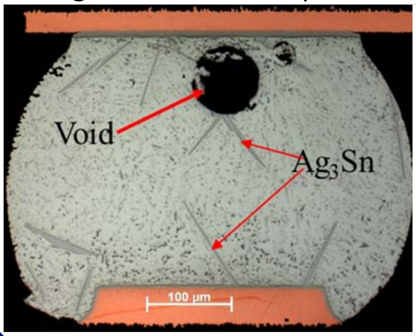
MAT7E. Alternate Solder Alloy Effects on Thermal Cycle Reliability

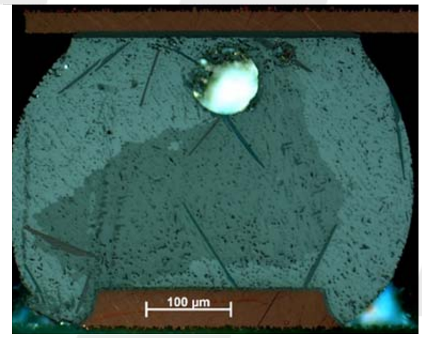
The alternate solder alloy study is a broad based parametric study of the properties and reliability performance of various Pb-free solder alloys relative to more conventional alloys such as SAC305. Microstructural characterization of all alloys in the as-reflowed state is nearing completion. The effort includes detailed and careful characterization of the Sn grain and second phase particle morphologies.

The experiment includes several instances of mixing solder pastes of different alloys than the BGA solder balls. Failures have been recorded for all the mixed alloy cases on both board surface finishes (Cu-OSP and ENIG) and with both ATC profiles (0/100°C and -40/125°C). Failure analysis is in progress. We have reached 1536 cycles of the most severe cycle (-40/125°C). For most of the solders alloys (unmixed cases), a substantial number of failures have been recorded for eight of the 18 component types included on the TB2015 board.



*LEFT: Bright field optical micrograph of an **Innolot** alloy BGA solder joint on Cu-OSP surface finish (board side) and electrolytic nickel-gold (component side).*

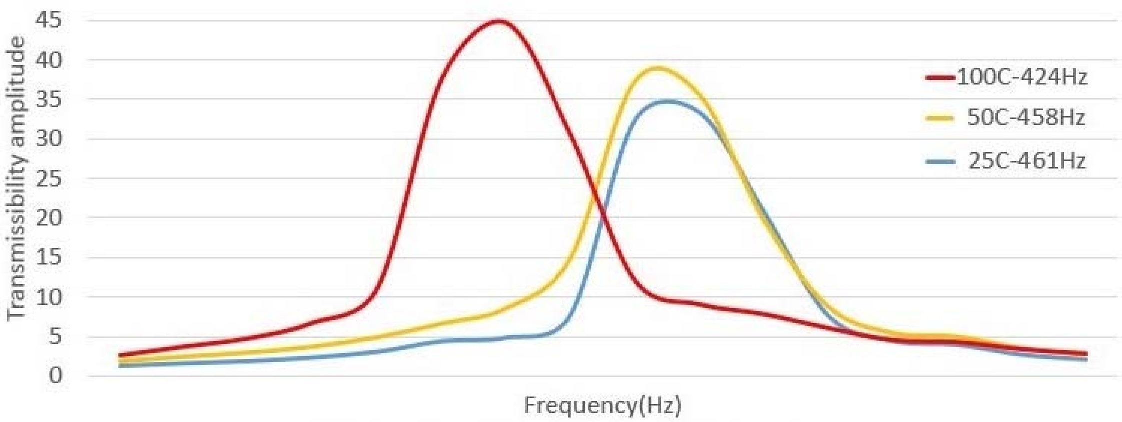
RIGHT: Cross-polarized optical image of the same joint revealing a multigrain Sn grain morphology.



REL3C. Elevated Temperature Vibration Testing

Development of APL vibration test capability continues. A small environmental chamber has been mounted above the shaker table to enable elevated temperature vibration testing. Frequency sweeps of the single component vibration test board are shown below for three different test temperatures. Transmissibility increases with increasing temperature while the resonant vibration frequency of the test board decreases.

Fixed frequency vibration testing has been used to produce solder fatigue failures of SAC305 BGA connections at a variety of temperatures. An acceleration of 3.0 g, produces failures relatively quickly at elevated temperatures. Peak accelerations for higher temperature vibration have therefore been reduced to produce reasonable laboratory fatigue acceleration levels. At 120°C, 1.0 g fixed frequency vibration at resonance produces solder joint failures at test times on the order of 30 minutes.



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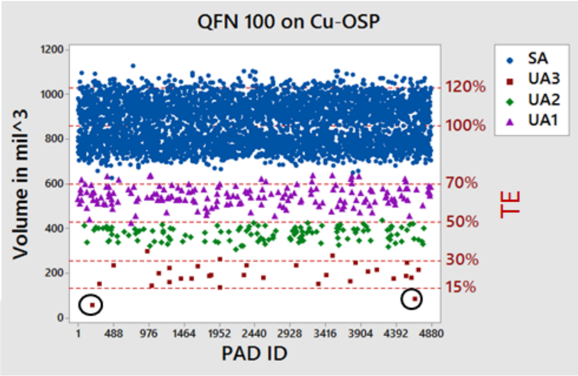
REL6A. Solder Paste Print Variability

The solder paste print variability project continues with additional bottom terminated component assemblies (LGA, QFN and CSP) now in accelerated thermal cycle testing. Rather than targeting high risk pad locations as previously done (right, for QFN 100), this time we are looking at the effects of undersized deposits on assembly yield and reliability when the small deposit is located randomly among the solder joint array. From an assembly perspective, we were able to achieve 100% yield when outlier deposit sizes as small as 27% of the nominal stencil volume were introduced into the process for LGA and QFN components.



Print volumes obtained with various Undersized Apertures (UA) relative to those with the Standard Aperture (SA) for QFN100. Circled points produced assembly defects.

MAT8B. Conformal Coating Materials

TB2015 assemblies coated with HumiSeal UV40 are still cycling in a -20 to 80C air-to-air thermal shock environment. This mild test condition was chosen as representative of a realistic operational temperature range for the UV40 material which has a relatively low glass transition temperature of 45°C. Now through 2500 thermal shock cycles, it appears as if we can expect a significant reduction in lifetime for LGA, QFN, BGA and CSP devices when coated with UV40 versus non-coated control samples.

MAT8C. Conformal Coated Resistor Corrosion

As reported at the March consortium meeting, all conformal coated resistor boards have been removed from the Flowers of Sulfur test chambers. The various conformal coating materials included in this study provided a range of protection levels against the Ag_2S corrosion known to accumulate on the terminations of thick film resistors lacking an Anti-Sulfur treatment.

Test nets on boards with very thin (~0.1 µm) plasma applied coatings all failed very early but not due to the anticipated silver sulfide corrosion at the resistor terminations. Instead, a copper creep corrosion reaction was causing failures at all exposed copper traces (see below). This phenomenon was not observed on boards with any of the other coating materials. Other coatings exhibited only the expected Ag_2S corrosion growing on the resistor terminations to varying degrees.

A solder bead test point between 0603 and 0402 SMD resistors on a thin plasma coated board; a black creep corrosion product is visible growing on all exposed copper traces and surfaces.