AREA Consortium

April 2013 Newsletter

Dear Members;

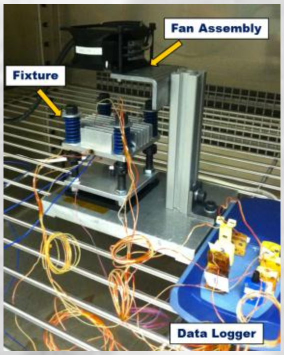
The AREA Consortium is diligently preparing for the June meeting with significant accomplishments in our research. Momentum from last year's planning efforts are starting to pay off with more topics to discuss than there is time allotted. In addition, we are planning a few guest speakers as we normally do in June. Several reports have been published on the website under the 2013 reports link (http://www.uic-apl.com/reports/2013-reports) so make sure you visit often.

It has been over a year since I have taken the role of AREA Consortium Manager and I am continuously learning the needs of our members. However, I feel there are still opportunities for greater involvement and interaction between our companies. As we prepare ourselves for summer vacations and family get-togethers don't forget that I will be reaching out to you all at the end of August and September to understand your research interests. Topics of broadband printing have been discussed as well as PCB stacked via design. We will need to lock down some of the variables for these research topics for us to be able to include them in next year's research. Included in this newsletter are only a few of the topics that have been keeping us busy.

Martin Anselm, Manager AREA Consortium

MAT4A: TIM

Characterization of gap pads as a function of compression continues. Thermal storage of five select gap pads at 30% compression will begin in a few days. Each gap pad has been characterized using SEM and EDS to determine filler composition and morphology.

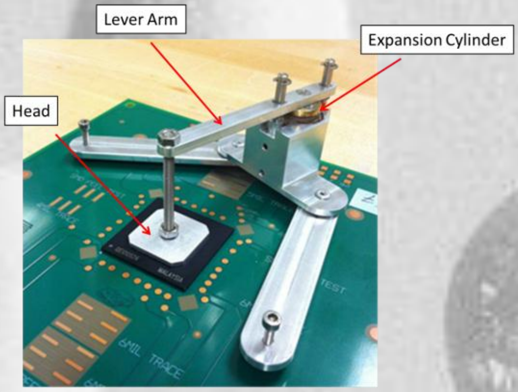


MAT1A: Underfill Studies

A letter soliciting suggestions for underfills to study has been sent to the members and several responses have been received. The first material (the Loctite Eccobond E1216M) has already been ordered.

APD4A: Rework for High Thermal Mass Devices

Work has begun on the vapor phase rework project. The objective of this project is to compare vapor phase de-soldering to a conventional de-soldering process for large BGAs. Processes will be compared in terms of process variables such as time and temperature, and in terms of drop/shock reliability after the rework process and reassembly. We've developed rework profiles for both the Pb-free and SnPb assemblies on the vapor phase machine. The ReSy rework fixture pictured left will be used to de-solder the components. Re-ball and assembly should be completed within the next two weeks.

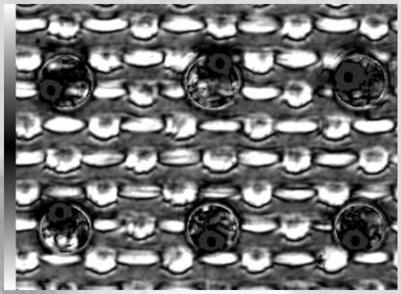


MAT6B: Lead-Free Die Attach

Work continues on the Pb-free die attach project. New test coupons have been built using a new die metallurgy Ti/Ni/Au. Indium's Bi-Ag-Xx will be compared to 92.5Pb-5Sn-2.5Ag. Die shear tests will be performed after reflow and after 2000 cycles of -55/150°C liquid shock. We are also characterizing new Bi-based alloys developed by Binghamton University.

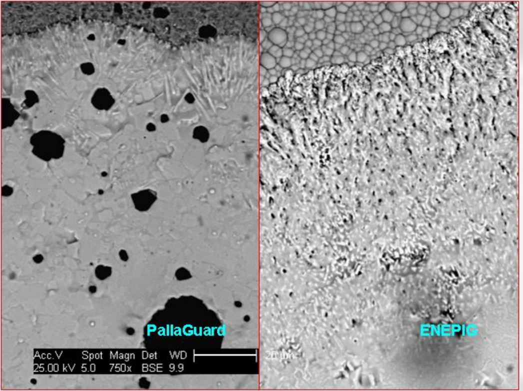
REL9A: Pad Cratering

Fatigue pull tests at 30° continued on the 370HR boards, with more points added to the data set. In addition, several smaller parallel projects were initiated. One involved fatigue tests at 0° for comparison with the angled pulls. Another (finished) compared fatigue lives for two different pull speeds. Finally, the APL's acoustic microscope has been used to generate high magnification images showing cratered pads and the underlying glass bundles and mathematical analysis is ongoing in an effort to correlate strength results with pad location. The picture shows one such scan with 6 pads of 2 sizes.



MAT3A: Pad Finish Studies

TB2013 panels from all 6 pad finishes were examined in detail inside the SEM for surface texture and (by means of EDX) for variations in layer thicknesses, especially as a function of pad/feature size. Our recent build included printed paste deposits on large square pads to study the wetting of the surfaces and the spread of the solder after reflow. While the wetting behavior on different finishes is not connected with the robustness of the resulting solder joints, large variations on the spread area on pads of the same finish could indicate potential soldering issues. Some of these deposits were studied in more detail in the SEM with special attention paid to the wetting front and the intermetallic particles that were visible there. The picture shows side-by-side view of the flow fronts for the direct Pd on Cu (PallaGuard) and the ENEPIG finishes (the black spots are flux residues).



REL4A: Creep Corrosion

Flower of Sulfur tests on all 6 pad finishes of the Test Board 2013 commenced immediately after the first build. The tests used coupons with a comb pattern; a large number of passives were mounted on the other side. Both sides will be examined for creep corrosion (as well as other types of corrosion). Three groups of samples are currently inside the FoS chambers (cleaned samples, samples with Cl$^-$ contamination, and samples with flux residue contamination). The first group will be out on May 2nd.

REL2A: Lead-Free Solder Fatigue Phenomenological Models

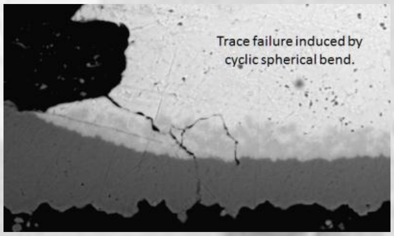
Work on lead free solder fatigue falls into two categories, isothermal and thermal cycling, as the mechanisms controlling the damage rates are completely different.

Isothermal Cycling: The failure of typical SnAgCu solder joints in vibration or cyclic bending occurs by the growth of transgranular cracks, which scales reasonably well with the work done on the joints. The assumption of a fixed amount of work to failure provides for a conservative extrapolation of accelerated test results to the much lower cycling amplitudes characteristic of long term life in service. Work is being initiated to learn how to account for relatively small effects of energy going to other mechanisms and thus further improve on accuracy.

Otherwise, isothermal cycling research is focused on the effects of varying amplitudes in cycling. Life under realistic isothermal cycling conditions in service is systematically overestimated by predictions based on the assumption of Miner's Rule and other current damage accumulation rules. A preliminary approach to dealing with that for combinations of a few amplitudes has been outlined and demonstrated. Recent work has focused on effects of strain rate, extrapolations to much lower amplitudes not accessible in any meaningful way in accelerated testing, and the relative severity of effects on different alloys. Extrapolations to low amplitudes are what our research is all about, and these must necessarily be based on modeling. The calculation of stress-strain hysteresis loops and the associated work relies on constitutive relations to describe creep rates, and calculations are usually based on the assumption of steady state creep. However, dedicated experiments now suggest that primary creep must play a significant role in each cycle, even if the amplitude remains constant. Recent results also show different lead free solder alloys to have different sensitivities to variations in amplitude.

Thermal Cycling: Accelerated thermal cycling experiments continue with different maximum and minimum temperatures and dwell times at both, further supporting our new model. A major effort does, however, remain as far as extracting the individual materials parameters used in the model. FEM shows the sensitivity of extracted parameters to the accuracy of the constitutive relations, etc., and the available computing resources. A new set of experiments on pre-aged assemblies, which would simplify such extraction, is proposed. A completely different approach is also being developed, which will allow the much more direct and accurate determination of the parameters.

REL1A: Impact of Partial Pad Cratering on PCB Reliability



We have begun analyzing the effects of cyclic loading using the spherical bend test method. We've already learned that the cyclic spherical bend method produces electrical failures not only at the corner most solder joints, but at other joint locations as well. This appears to be due to the fact that the spherical bend method applies a point load to drive displacement fatigue, while other mechanical tests (drop, vibration, 4-point bend) tend to better distribute loading across the entire test vehicle.

We have been working on two large experiments on the reliability of lead free solder joints in accelerated thermal cycling tests. Both projects; the effect of pre-aging and the effect of different alloys on thermal cycling performance of solder joints will help us answer some of the important issues regarding the failure mechanism of LF solder joints.

MAT2B: Effect of Aging on Reliability of Packages in Thermal Cycling Test

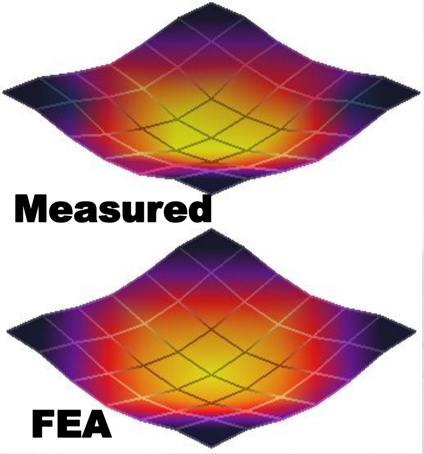
We had very good discussions with our members in Alcatel-Lucent and IBM, who were also involved in HDPUG and iNEMI projects, in order to effectively design our DOE. We have planned to look at the effect of pre-aging on low silver (SAC 105) and commonly used SAC alloy (SAC 305) of various sizes (10 and 16 mil) in ATC test. The performance of aged samples (five weeks @ 125C) and as reflowed ones will be evaluated. The effect of strain level on fatigue performance will be analyzed as well.

MAT7A: New Lead-Free Solder Alloy Evaluations & Microstructure

We are continuing our study to evaluate various low/no Ag solder alloys. We worked closely with our members, particularly Nihon Superior and Indium Co., who provided us with various solder alloys at different ball sizes. Our goal is to better understand the properties of different solder alloys on various pad finishes (available on our TB2013 board). Our careful microstructure analysis will answer some fundamental aspects of the failure in ATC tests. In the short term, in June, we plan on presenting the mechanical properties of these alloys after reflow and also as a function of size and aging.

REL3A: Vibration Testing Method and FE Analysis for Circuit Board Solder Joint Reliability

We are continuing to refine our finite element analysis (FEA) procedures for analyzing the stresses within circuit assemblies due to shock and vibration. Experimental modal analysis is used to dial in the parameters of the model to the physical packages. We have fully worked through the process for one circuit assembly configuration and are applying these methods to assemblies with different geometries. The finite element models allow estimates of the stress within assembly interconnections which are not obtainable through measurements.



Vibration reliability experiments on assemblies with daisy chained components also continue using the resonance tracking test method, which drives the test assembly at resonance and adjusts the excitation frequency to follow changes in the resonant frequency of the system. Tests are also being done on a number of parts with fixed frequency excitation. We will use these results to compare the two vibration test methods.