AREA Consortium

July 2014 Newsletter

advanced process lab
research • process support • analysis

Dear Members,

I would like to begin by saying that it was a pleasure working with all the members for the past two years as the AREA Consortium Manager. Thank you all for providing your industry experience, knowledge and friendship. Managing the consortium has been an incredible learning experience for me. Leaving this organization was not an easy decision and I am very excited that Jim Wilcox (formerly of IBM) has accepted the offer to be my replacement.

Secondly, I would like to take a moment to acknowledge the staff here at Universal. Michael, Pericles, Babak and Harry are the backbone of this organization and an incredibly dedicated and intelligent group of energetic people to work with. I will miss working with them on a daily basis.

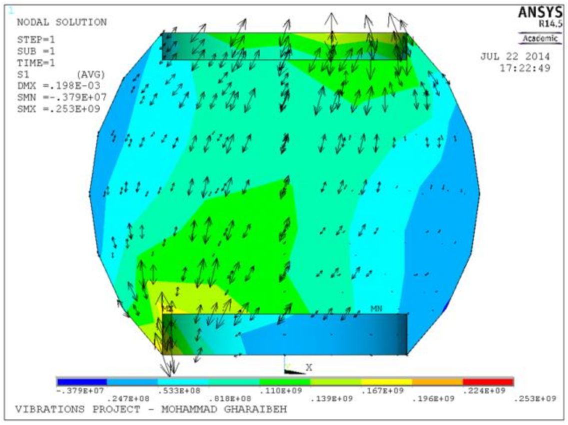
If any of you are hearing this for the first time I apologize. I tried my best to reach out to all of you regarding my exit.

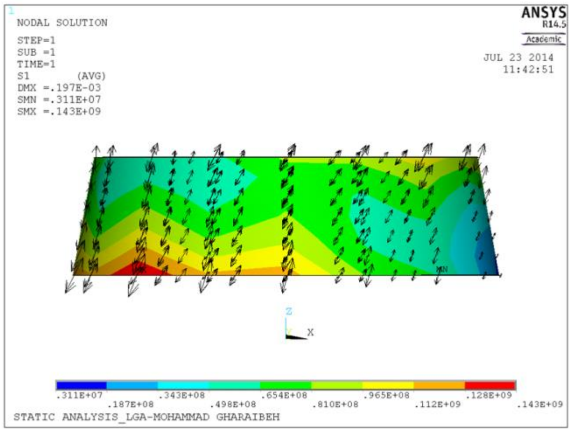
Thank you all again,

Martin Anselm
Former AREA Consortium Manager

REL3B: Vibration Reliability

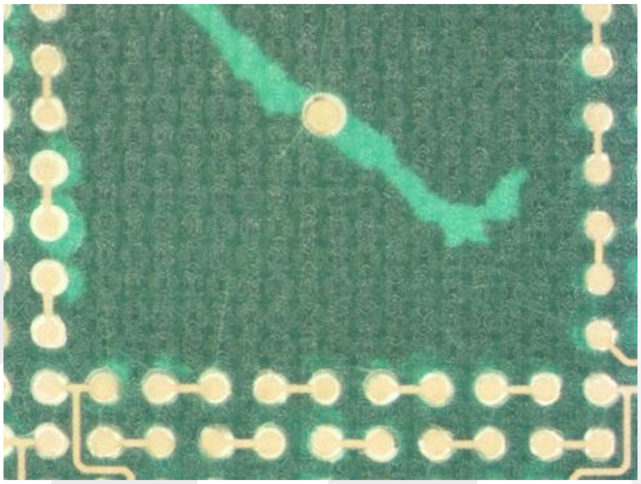
We are continuing harmonic vibration testing of test vehicles with land grid array (LGA) and ball grid array (BGA) daisy-chained components (17mm x 17mm package), each centrally mounted onto a square test board (76.2mm x 76.2mm). The test methods and preliminary results were presented at the June 2014 AREA Consortium Meeting (REL3A: LGA vs. BGA Vibration Performance – *Aaron Stewart*). These tests show the LGA interconnects are more reliable than the BGA interconnects for these assemblies. Finite element analysis (FEA) is underway to identify the critical stresses in the solder joints. Shown below are some FEA results showing the principal stresses for a BGA corner joint (left figure), and those for a LGA corner joint (right figure). Parameters were selected such that the center board deflections were identical for both cases. These results show the BGA joint has higher stress than the LGA joint, consistent with the vibration reliability test results. Future work will include extracting the dynamic parameters from the vibration data to allow stress estimations for every individual test board. These results will be used to create Stress versus Cycles-to-Failure curves (S-N).





MAT1A: Underfill Studies

Thermal cycling of assemblies underfilled with material A was suspended after about 3300 cycles, despite some parts still having few failures. The cycling of parts underfilled with material B has exceeded 2400 cycles with very few failures except for parts on two sites, which had lower reliability than their material A counterparts. Assemblies with material C have several failures already after 1063 cycles. Material D, the only reworkable material of the group, has many failures after only a couple hundred cycles. Failure analysis, mostly consisting of cross-sections and flat sections, is ongoing. The flow studies between glass slides using these four materials are essentially complete. Test Board 2014U and the components needed to populate it have been received. The underfill materials to be studied have not been decided yet.

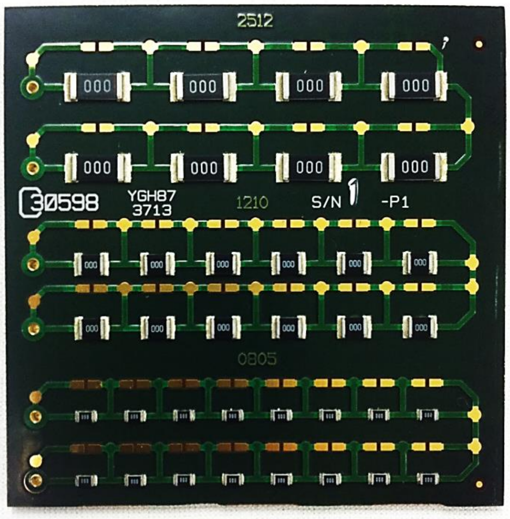


MAT4A: Characterization of Thermal Interface Materials

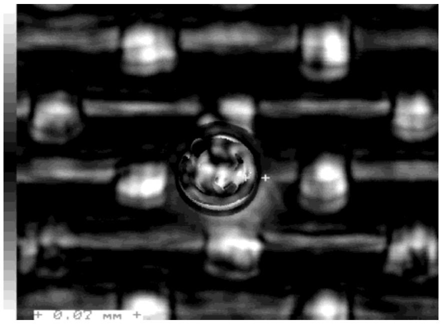
Work has begun on the “Effect of TIM Compression Loads on Component Reliability” project. At the June meeting we presented on the assembly process, fixture design, test plan, and initial modeling results. Since the meeting we’ve started the high temperature storage portion of the project. Fully assembled boards with heat sink fixtures are being stored at 125˚C for 1000hrs. Collapse of the first level (die bumps) and second level interconnects (BGA solder joints) is being monitored by cross sectioning samples at specific intervals during the test. Component pressure is being varied to reflect 30%, 50%, and 90% compression of a filled silicon elastomer thermal interface material. Thermal cycling of compressed components will begin shortly.

MAT6A: High Temperature Electronics Research

In June we presented on “Characterization of High Temperature Alloys” and discussed our current effort to develop a knowledge base on interconnects used for high temperature electronics. The test vehicle for this project is shown on the right. It consists of three chains of surface mount resistors: 0805, 1210, and 2512. Five solder alloys are being studied, the control Alloy 151 (92.5Pb-5Sn-2.5Ag), Alloy 164 (92.5Pb-5In-2.5Ag), BiAgXTM, Innolot, and Ag-filled epoxy. The microstructure was studied in the as-reflowed state and after high temperature storage at 200˚C for 1000hrs. Further, the chip shear strength was measured after reflow and after HTS at 200˚C. Thermal shock -50˚C to 200˚C is scheduled to begin in August. The electrical continuity will be monitored during thermal shock testing for failure detection. Failure analysis will be performed to determine the mode of failure.



MAT10A: Laminate and Glass Studies in Pad Cratering



Pad strength measurements on the new set of laminates have been concluded for all 5 pad diameters, using Hot Bump Pull at an angle. The parameters of the glass weave were verified experimentally and analysis of the effects of pad location relative to the weave has been completed. Pad fatigue life measurements, using the same technique, are almost complete. A similar location effect analysis will be performed when all the fatigue life data have been collected.

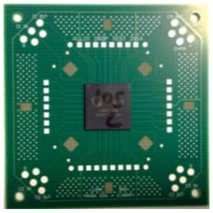
REL2A: Lead-Free Phenomenological Model Update

A model has been finalized for the damage and failure of SnAgCu solder joints in thermal cycling. A unique experiment employing a micromechanical tester with temperature control, allowing for the independent control of the individual parameters governing recrystallization, together with extensive EBSD analysis showed that the rate of damage is controlled by the build-up of a steady state dislocation structure during the low temperature dwell which helps stabilize further dislocations created at high temperature. The latter dominate the simultaneous coalescence and rotation of the dislocations to form subgrains and eventually high angle grains. It is proposed that the rate of damage per cycle should vary with the work done during the high temperature dwell. This is very different from current models assuming a dependence on the total inelastic work in the cycle, leading to very different predictions of life under various realistic conditions.

The ability to predict the temperature and strain enhanced precipitate coarsening and the resulting steady state creep properties vs. time and temperature has been developed in a separate effort now being completed. A major, albeit commonly overlooked, problem for current Finite Element Modeling of solder joints in thermal cycling is the inability to predict the primary creep dominating temperature ramps and early parts of dwells accurately, not to mention the effects of ongoing precipitate coarsening. However, an early result of the new experiment was to show that the high temperature work expected to determine the rate of recrystallization can be assessed based on steady state creep alone.

MAT7A: New Alloy Research

<u>Drop Test</u>: We have designed a new test board to study the drop reliability of lead free solder joints. Six different alloys (SAC 105, SAC 305, SAC-M SN99CN, SN100CN, and Innolot) will be evaluated. 400 boards were built in with LGA and BGA components mounted on two different surface finishes: Cu-OSP and Immersion Ag. Careful microstructural analysis will be performed before and after drop test.



Drop test board: 76 mm square board with a single 1.00 mm pitch part.

<u>Accelerated Thermal Cycling Test</u>: We are planning to perform a solder alloy study on the TB2013 test board. Similar parts used on TB2013 will be tested with selected new alloys on different surface finishes. The results will be compared to data we have previously obtained with SAC 305 alloy. If you have any specific alloys or surface finishes that you would like to be evaluated in ATC test, please contact Babak Arfaei.

MAT8A: Conformal Coating

The SnPb portion of our conformal coat reliability analysis has surpassed 2000 -40/125°C thermal cycles. The materials we are evaluating are Parylene C, Humiseal 1A33 and Arathane 5750. The Humiseal and Arathane legs include test cells with and without damming around the components.

As of this writing approximately 60% of the surface mount components in the test have failed and failure locations have been electrically mapped. Additionally, the non-coated baseline failures have been either cross-sectioned or subjected to dye penetration analysis in order to determine the 'expected' failure mode and location.

We have determined that the presence of the conformal coat can significantly affect the reliability test results of some devices as does the presence of the damming material. This includes a reduction or increase in time to failure and a shift in failure location. Most importantly, for the devices with significant failure accrual, Parylene C has shown to be the best performer resulting in improved lifetime over the baseline samples.

New AREA Consortium Manager: Jim Wilcox

One sign of a mature and stable organization is a demonstrated capability for smooth transitions as it adapts to inevitable changes in personnel and leadership. In August, the long-standing AREA consortium will welcome its fourth manager, Jim Wilcox.

Jim is formerly a Senior Technical Staff Member in the IBM Systems and Technology Group. A long career in various IBM technology organizations has afforded him a wide range of technology experience ranging from laminate fabrication development, to flipchip packaging assembly, to server board assembly manufacturing. He holds BS/MS degrees in Metallurgical Engineering from Michigan Technological University and the PhD degree in Materials Science from Cornell University. An IBM Master Inventor, he holds 35 US patents covering a range of electronic packaging technologies and process. Moreover, he has a long history of active engagement with industry and academia through various collaborative research consortia that address technology challenges faced by our industry.

You may contact him at jim.wilcox@uic.com or +1-607-779-5077 (after August 9th).

Professor Martin Anselm

We wish Martin the best of luck as he embarks on his new career in academia. His tenure with the AREA Consortium has been marked with notable improvements in operational efficiency and member company engagement. He leaves with our sincere gratitude.

Professor Anselm has agreed to be readily available to the Consortium team over the coming months to ensure a smooth leadership transition. He will also be attending our upcoming joint member meeting with the IPC PERM to be held the first week of November. Come join us at the meeting to wish him your congratulations in person.