AREA Consortium

April 2015 Newsletter

advanced process lab
research • process support • analysis

Dear Members,

Thank you for the excellent attendance and participation at our March consortium meeting. Nearly all of our membership was represented, but for those of you who couldn't attend, the meeting content is posted under the 2015 Meetings link in our website: www.uic-apl.com [*members only*]. The agenda title link will download the presentation charts, but also, the On Demand link immediately following that title link will play the verbal commentary that goes with the charts. Conveniently, you can navigate directly to specific charts of interest. If you only need to hear one chart, simply click on the slide title listed in the contents list displayed on the left during the recording playback. Try it.

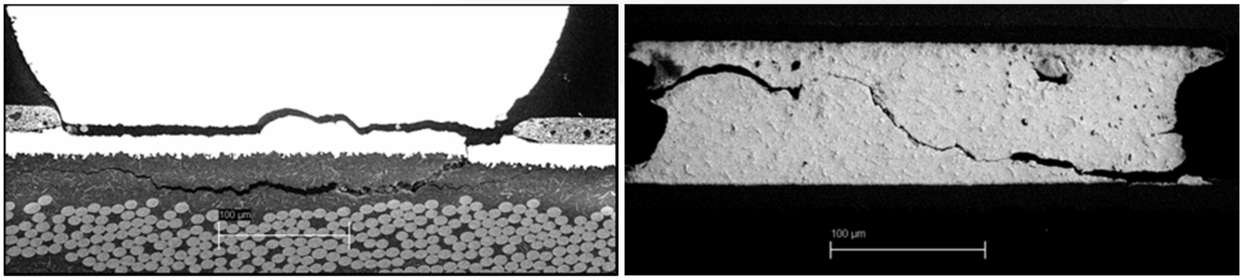
For our mid-year project updates this year, we'll be trying something a little different. Over the summer months we'll be offering a series of web based project reviews that will be broadly grouped by topic. We will still be recording the content for your post-event review, so don't be too concerned about your vacation conflicts. The content will still be available. Watch for scheduling notices in the coming months. Consider this an operational experiment. (Feedback welcome.) Our October meeting will return to the traditional face to face meeting covering the full spectrum of Consortium research projects.

Sincerely,

Jim Wilcox
Consortium Manager

MAT7D. Drop Shock Reliability with Various Pb-free Solder Alloys

Drop shock testing of alternate alloy BGA and LGA solder joints has completed. Six different Pb-free alloys assembled on ImAg and Cu-OSP surface finishes were tested on the recently proposed, revised JEDEC drop test board. Approximately 400 boards were dropped to interconnect failure. Microstructural analysis of BGA joints is complete and work is underway to finish the corresponding analysis of LGA solder joints. The final report will be available soon.



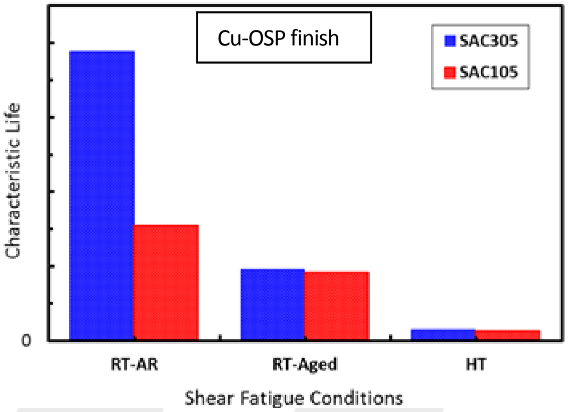
SEM images of SAC105 BGA and LGA joints subjected to 900G level drops. Different failure modes were observed.

MAT8B. Conformal Coating Materials

The 2015 conformal coating project is progressing. We have commitments from our membership to provide coating of several target materials but still have a few on our wish list yet to be sourced. We plan to assemble the TB2015 test boards within the next few weeks and ship them out for coating. The bulk of the coated assemblies will be reliability tested in a -40 to 125C thermal cycle. Some boards will use an alternate thermal cycle (*e.g.,* -20 to 80C) to explore the impact of coating on fatigue acceleration factors. An additional side project has been added to this effort that will evaluate the corrosion resistance imparted by various coating materials to standard SMT resistors (*i.e.,* without anti-sulfur finish).

MAT7B. Isothermal Mechanical Behavior of Solder Alloys

Shear fatigue testing of 20 mil solder ball attachments is being used to characterize the mechanical robustness and microstructural stability of various alternate solder alloys, including some of specific member interest containing Bi or Sb alloying elements. Fatigue loading is isothermal, either at 125C or ambient temperature. The effect of PCB surface finish (Cu vs ENIG with various Au thicknesses) on alloy performance is being investigated. The effect of other parameters such as reflow condition (time above liquidus, cooling rate, etc.), thermal aging and shear load levels are also being studied. The effect of those parameters on solder bump microstructure along with correlations to shear fatigue life are being carefully monitored. Aging is seen in the attached figure to minimize the effect of Ag content.

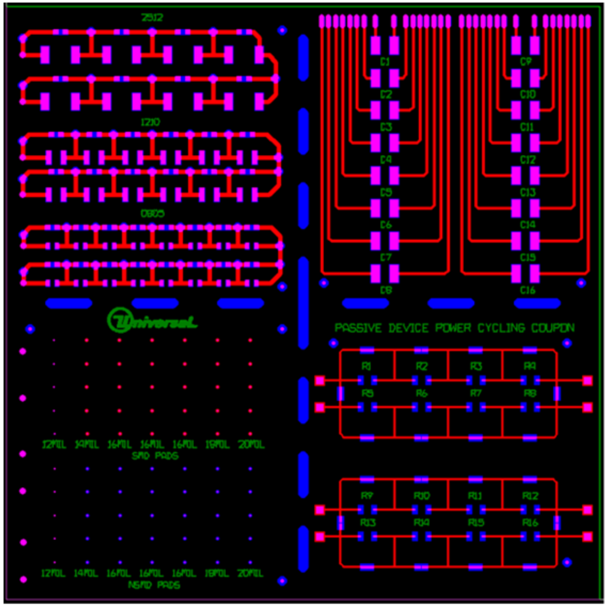


Characterstic shear fatigue lives of 20 mil SAC105 and SAC305 samples after reflow (AR) tested at room temerature (RT), aged at 125C (RT-Aged) and tested after reflow at high temperature (HT).

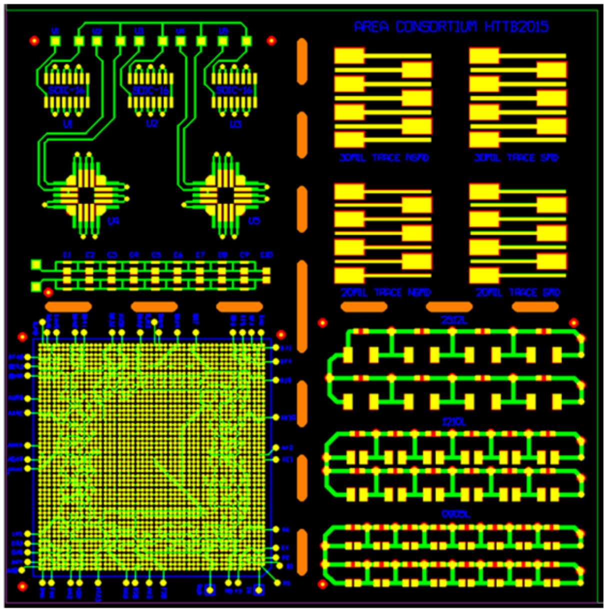
High Temperature Electronics Research

The design of the 2015 High Temperature Test Board (HTTB2015) is complete. This four layer test board will be fabricated with a polyimide laminate material to enable higher temperature reflow and elevated temperature operation. It will be sourced with an ENIG surface finish. A CAD image of the surface features is shown below. The various coupons will support the following projects:

MAT6E. Effect of Passive Device Surface Finish on Thermomechanical Reliability in High Temperature Applications
MAT6F. Evaluation of Pb-free Alloys for Engine Control Applications
MAT6G. Intermetallic Growth Kinetics on Electrolytic Ni in High Temperature Environments
REL15A. Power Cycle Reliability



HTTB2015: Front side



Back side (flipped L →R)

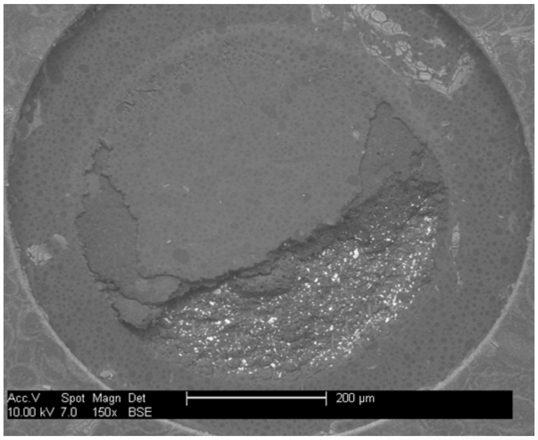
Pad Cratering Studies

MAT2C. High T_g PCB Laminate Materials

Two nominally identical boards from the multiple reflow set of each of the 20 different laminates have been tested for pad cratering resistance. Pad separation loads have been tabulated and plotted. Detailed examination of the pad failure surfaces is ongoing. Strength distributions and characteristic failure modes have been found to vary widely among the various laminate materials. Measurement of the corresponding non-reflowed samples has begun.

MAT2D. Effect of Cu Roughness on Pad Strength

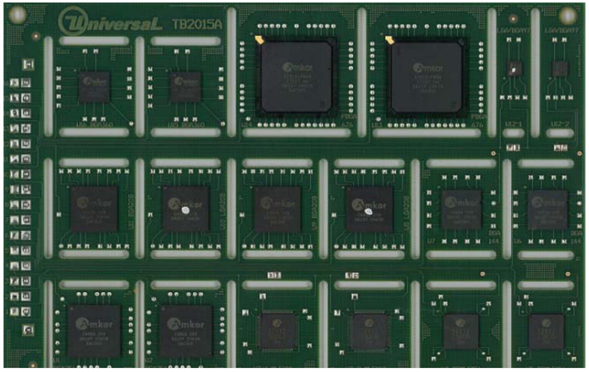
Due to skin-effects, high frequency circuit boards can suffer significant attenuation losses from the roughness of the copper foil treatment used to bond the conductive traces. To minimize these losses, high performance PCBs are often made using lower profile (smoother) Cu foil treatments. Previous comparative characterizations of laminate pad cratering response have all been done without regard to copper foil roughness of the pad in question. This project explores the impact of Cu roughness on measured pad cratering resistance.



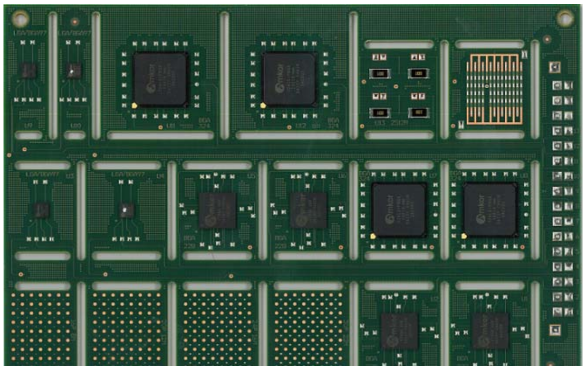
Two laminate materials, each fabricated with Cu foils of five different levels of surface roughness, are being evaluated using the angled Hot Bump Pull technique. The samples with either the smoothest or the roughest Cu have been tested first. The smoothest Cu samples with one laminate failed consistently with a mixed failure mode (partial pad peel and partial pad cratering). To address the reduced copper adhesion encountered with low profile treatments, foil suppliers often treat such foils with additional adhesion promoters. Sorting out the roughness effect is complicated by the presence of such an adhesion promoter on the smoothest Cu samples. The second leg of the experiment, testing of the next smoothest Cu which is available both with and without adhesion promoter, has begun.

Test Board 2015

The first batch of the new TB2015 board design was recently assembled. These initial Pb-free assemblies will establish the quality of the assembly process and also serve as the accelerated thermal cycle reliability testing baseline for both the Conformal Coating and Paste Printing Variability studies. They are scheduled to begin thermal cycle testing (-40 to 125C) soon. The assembled images below show the BGA, CSP, LGA, and QFN devices to be tested. In general, these will built as either front side only or back side only assemblies, not double sided.

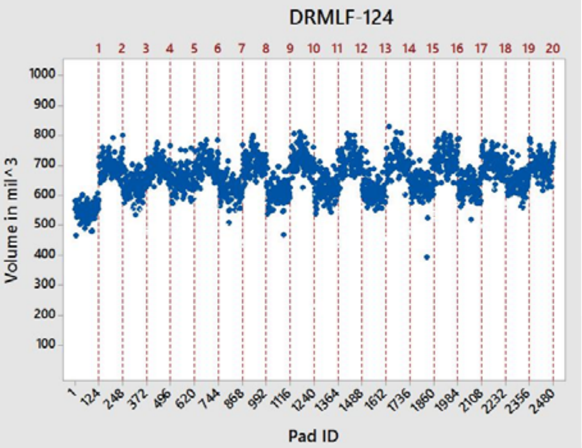


TB2015: Assembled - Front side



Assembled - Back side (flipped L→R)

REL6A. Paste Print Variability



Nominal paste volume variability on a dual row MLF footprint for successive forward and reverse screening passes.

The paste printing variability project explores the reliability consequences of episodic low volume solder paste deposits that are inherent to large scale manufacturing. The plot of paste deposit volumes from repetitive screening operations reveals several naturally occurring low volume outliers. Such outlier deposit volumes are being intentionally designed to occur at discrete, high risk, locations of various package footprints. Assembly and thermal cycle then determines the reliability consequences.

We ran a small assembly evaluation using LGA and QFN devices with paste deposit outliers designed from 10 to 60% of the nominal deposit volume. By tracking each paste deposit we determined that those in excess of ~35% of nominal always produced a functional solder joint. Next, we'll be running a larger sample size to verify the results and produce outlier assemblies for accelerated thermal cycle tests which will determine if such undersized deposits have a negative impact on component interconnect reliability.

MAT1B. Reworkable Component Underfills

Sixty test boards have been assembled, enough to test three reworkable underfill materials plus a reference non-underfilled set in Accelerated Thermal Cycle. Additional boards were also built for dispense setup trials and follow-on rework experiments. Material E has been used to underfill the first fifteen boards for ATC test plus two for rework studies. Thermal cycling of these and the non-underfilled reference set have begun. Flow studies with material F are complete and the dispense parameters have been chosen; underfilling of the F boards will commence shortly with material G to follow. The plan has now been expanded to include SnPb solder assemblies.

MAT6B. Sintered Silver Die Attach Materials

The microstructural evolution of sintered Ag die attachments in extended high temperature storage is being studied along with the consequent reliability in high temperature thermal shock. Representative images of the sintered Ag microstructure through high temperature storage are shown below. A dense silver layer forms at the Direct Bond Copper (DBC) surface leaving a reduced density structure near the die. Shear strength measurements on various aged attachment structures were presented at the March meeting. Next, we will be examining the effect of die bond line thickness on microstructural evolution and thermal shock reliability.