Dear Members,

In November, Universal Instruments hosted meeting #22 of the IPC PERM Council allowing us to integrate some relevant PERM content with our fall consortium meeting agenda. PERM Council members representing various mission critical product sectors (including some consortium member companies) also participated in our usual technical project reviews. Our PERM guests expressed considerable interest in our consortium research topics and offered informative commentary on some key projects. The infusion of such new industry perspectives is always welcome. We look forward to their continued involvement and potential membership of those guest companies.

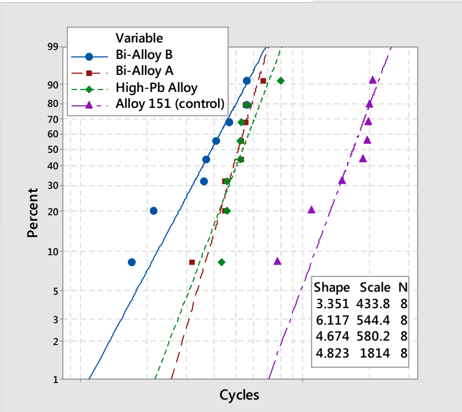
Using the technical interests solicited from our membership, we have defined a comprehensive research plan for the coming year. Project summaries are compiled in the 2015 plan document posted on our web site. Several of the new projects described are well underway, with test hardware defined and ordered. Other new projects, such as conformal coating and compliant pin interconnect, are still actively soliciting member company participation and technical input to formulate detailed plans.

Sincerely,

Jim Wilcox
Consortium Manager

MAT6C: Characterization of High Temperature Alloys

The thermo-mechanical reliability of several high temperature interconnects in harsh environment thermal shock was reported in November. A -50/200˚C cycle with 5 minute dwells and a ramp rate of 85˚C/min was used. Six alloys are included in this study, three Pb-based: Alloy 151 (92.5Pb-5Sn-2.5Ag), Alloy 164 (92.5Pb-5In-2.5Ag), 85Pb-10Sb-5Sn, and three Pb-free: BiAgX™, Innolot, and Ag-filled Epoxy. Results indicate that the Pb-based alloys generally outperform the Pb-free options.



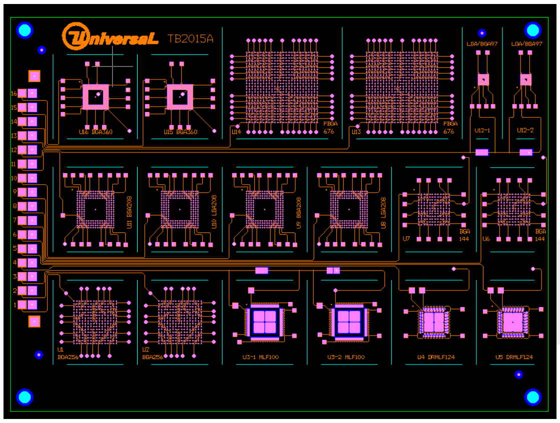
A Weibull distribution plot of the thermal shock failure rates for four alloys is shown. The 85Pb-10Sb-5Sn alloy is not included; only two joints have failed. The superior high temperature thermal fatigue resistance of this particular Pb-based alloy was attributed to a duplex microstructure which inhibits grain coarsening at elevated temperatures and accommodates grain boundary sliding at high homologous temperatures without microvoid nucleation, both being fundamental attributes of the superplastic behavior reported for this alloy at temperatures above 200˚C.

All Innolot and Ag-filled epoxy samples failed thermal shock relatively early (<200 cycles). The failures were attributed to interfacial reactions at high temperatures. For Innolot joints, interdiffusion voids formed at the solder-component side IMC interface during high temperature exposure. Growth and coalescence of these interdiffusion voids led to early failures. For Ag-filled epoxy joints, Sn from the component termination diffused into the joint, forming Ag_3Sn at the interface, weakening the interfacial bond.

AREA Consortium

MAT7F: Effect of Solder Composition and Surface Finish on ATC Reliability

The 2015 research plan for our ongoing alternate Pb-free alloy evaluation program will include extensive ATC reliability testing. Seven different solder alloys, including eutectic SnPb and SAC305 control alloys and some new alloys such as INNOLOT and 'Violet' (a lower melting alloy) as well as a mixed solder alloy (SAC 305 sphere + SnPb paste) will be evaluated in -40/125 and 0/100C thermal cycling tests. Two different board surface finishes, Cu-OSP and ENIG, will be used. A new consortium test board (TB2015) has been designed and various components chosen for this project, based on member feedback. Test hardware has been ordered and board assembly will begin by end of February.



New TB2015 design used in alloy study

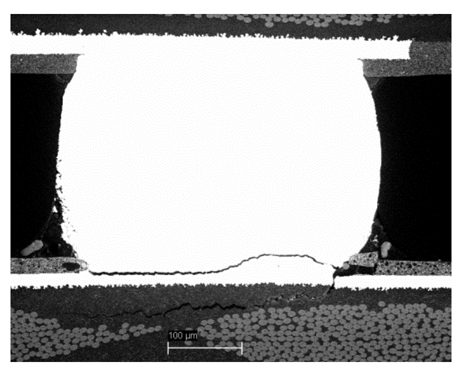
REL2A: Phenomenological Lead-Free Fatigue Model

Major progress has been made regarding how to conduct accelerated vibration tests of soldered electronic assemblies and how to interpret results. Notably, accelerated vibration test results may be completely obscured by effects of damage induced in the printed circuit board; something not expected to be a factor in service. Vibration testing should therefore be limited to levels that do not cause a resonance shift. Isothermal shear cycling with varying load amplitudes is seen to change the dominant solder deformation mechanism. This leads to different constituent relations than those measured in conventional creep experiments. It also explains the break-down of common damage accumulation rules (including fatigue models and the well-known Miner's rule) observed in the case of varying amplitudes. Most recently this break-down, which was first observed in shear fatigue testing, has now also been documented for vibration to many millions of cycles.

A quantitative thermal cycling model has been proposed and is being further validated. Notably, it indicates that accelerated testing must be limited to levels where $N_{63} > 500$ cycles. We have further shown that damage in a thermal cycle can indeed be assessed based on the work done during the steady-state part of the high temperature dwell.

MAT7D: Drop Shock Reliability of Various Lead-Free Alloys

The drop shock reliability of several different lead-free solder alloys is being evaluated. In addition to SAC305 and SAC105, low Ag and no Ag alloys with microalloying elements (such as SN100C and SACMn) are also being studied. The new proposed JEDEC drop test board is used for this study. BGA and LGA components were assembled on both Cu-OSP and immersion Ag surface finishes. The board was carefully designed in order to achieve solder failure during the test. Careful microstructural analysis is in progress to explore correlations between the as-reflowed microstructure and observed drop shock reliability of the various solder alloy interconnects.



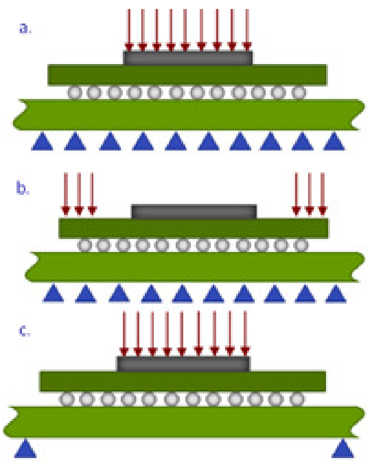
IMC and bulk solder failure during drop

REL11A Effect of TIM Compression Loads on Component Reliability

Bare die flipchip packages being stored at 125˚C under typical compression loads required for Thermal Interface Materials were removed at regular intervals to quantify the resultant creep deformation in the supporting BGA joints. Compressive creep in the SAC305 BGA solder joints was found to be negligible even at the longest time (1000hrs) and highest compression (5MPa) condition.

Config.	TIM Comp. [%]	Pre-Aging Time, [hr]
(a)	0, 30, 50, 90	-
(b)	0, 30, 50, 90	-
(c)	50	-
(a)	50	0, 100, 250, 500, 1000

Thermal shock test plan



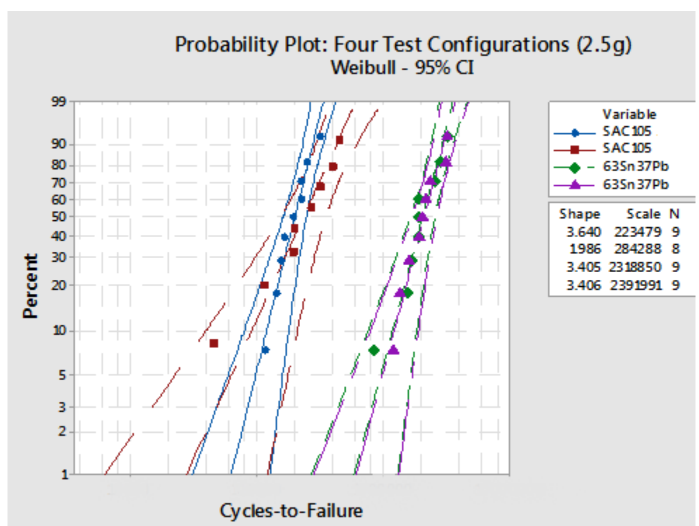
Tested configurations

Detailed results were presented in the November meeting.

In the second phase of this study, the effect of superimposed compression loads on BGA reliability will be measured using -40/125˚C thermal shock. The test plan is shown above. Superimposed compressions vary from 0.15MPa for 30% TIM compression to 5MPa for 90% TIM compression. In addition to the magnitude of the superimposed pressure, the various different support configurations shown are being evaluated. No failures have occurred through 1000 cycles of thermal shock.

REL3A. Vibration Testing Methodologies

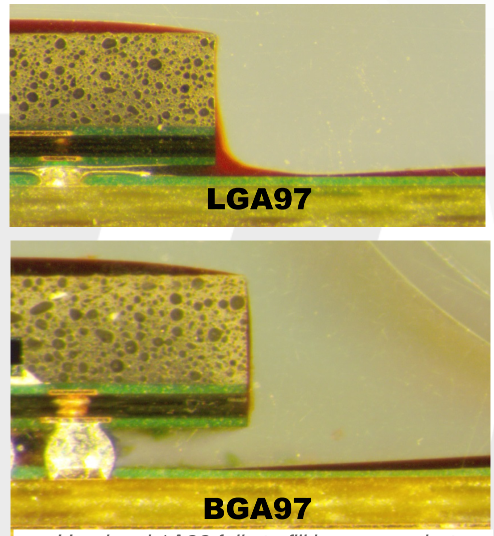
Vibration reliability of four different package configurations was measured using the method of sinusoidal dwell with resonance tracking. The package configurations tested were 256 I/O BGA and LGA formats attached using either SAC105 and 63Sn37Pb solder. Sine resonance dwells were imposed at the first resonant frequency (≈560 Hz) at a 2.5G input vibration level. Resistance monitoring event detection was used with a failure criterion of 1000 Ω. The resulting failure mode was identified as solder fatigue. The results for each of the four assembly configurations are presented in the Weibull failure rate distribution plots shown. 63Sn37Pb solder out-performed the SAC105 solder. Reliability differences between the BGA and LGA formats could not be distinguished with this limited sample size (nine each).



MAT8A: Conformal Coating

The SnPb solder phase of our conformal coat reliability analysis with -40/125°C thermal cycles is effectively complete. The materials evaluated were Parylene C, Humiseal 1A33 and Arathane 5750. The Humiseal and Arathane legs also included test cells with and without damming around the components. Uncoated SnPb control samples are also tested.

Characteristic of generally available package formats, the assembled TB2014 solder joint gap heights were measured to be either high (>130µm, *e.g.*, BGA) or low (<75µm, *e.g.*, LGA, MLF, *etc*.). Parylene uniformly coated all solder joints independent of gap height and consistently improved thermal cycle fatigue life. The Arathane results were notably dependent on the solder joint gap height. It produced significant reduction in fatigue life for small gap packages but had negligible effect on large gap packages. All Humiseal components with a dam experienced a substantial degradation in reliability. Humiseal coating without a dam demonstrated a more complicated dependency on package type, in some instances improving, some instances degrading and others having minimal effect on the fatigue life.



Humiseal 1A33 fails to fill large gaps but forms encapsulating fillet with low gap