Dear Members,

It's time for a shout-out to our various experimental measurement partners. Accurate measurement capability is critical for nearly all of our research activities and those in the instrument business often recognize the significance of our research and choose to contribute to our efforts. You'll note in this issue a typical example by Nordsen Dage, upgrading our micro-tester with enhanced control and analysis software. Other key measurement partners worthy of note are Finetech USA and Koh Young, both of which keep current model instruments in our laboratory that we routinely exercise to bring you the accurate and relevant experimental results you've come to expect. Soon Akrometrix will be joining their ranks (more on this in the coming months).

When necessary of course we'll fabricate our own custom instrumentation such the benchtop vacuum reflow oven discussed below. (Recall also the previously described APL TIM2 thermal resistance tester.) However, having professional partners in the equipment business is always preferred. We very much appreciate the ongoing contributions of these supplier partners. Be sure to consider their services when your own company has the need for such measurement capability.

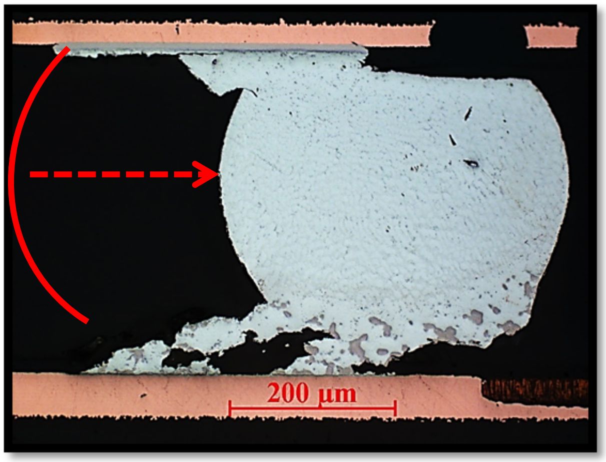
Sincerely,

Jim Wilcox

Consortium Manager

MAT7F. Low-Melt BiSn Mixed Solder Reliability Study

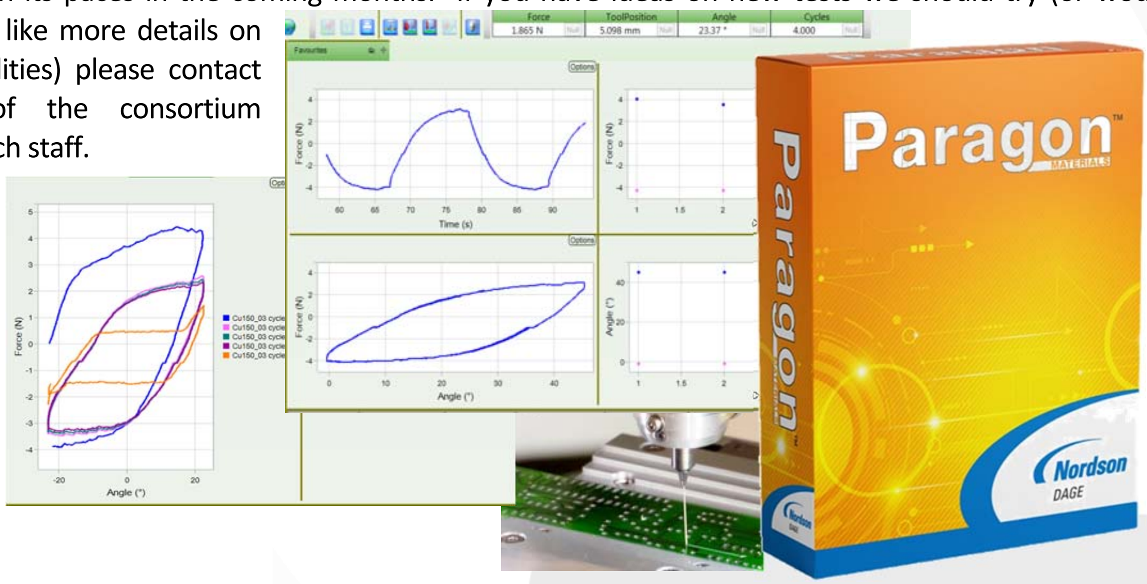
Reliability test boards assembled using low melting point BiSn eutectic solder pastes have been cycling in a -40 to 105°C thermal cycle for several months. This research studies the reflow mixing behavior of SAC305 solder in BiSn paste as well as the subsequent impact upon reliability for bottom terminated components. Post assembly analysis of these test boards showed encouraging results with all parts testing electrically good and solder joint voiding at acceptable levels. Microstructural analyses had shown there is limited solder mixing taking place in the low temperature reflow profiles used (peak reflow temperatures of 150, 175, or 200°C), similar to that used in the strain rate sensitivity sturdy reported at the March meeting. Preliminary thermal cycling results have shown a propensity for recrystallization within the BiSn paste region of the solder joint. The Bi-rich phase regions act to promote damage accumulation and recrystallization of the β-Sn grain.



Low melt attached SAC305 ball translated during ATC

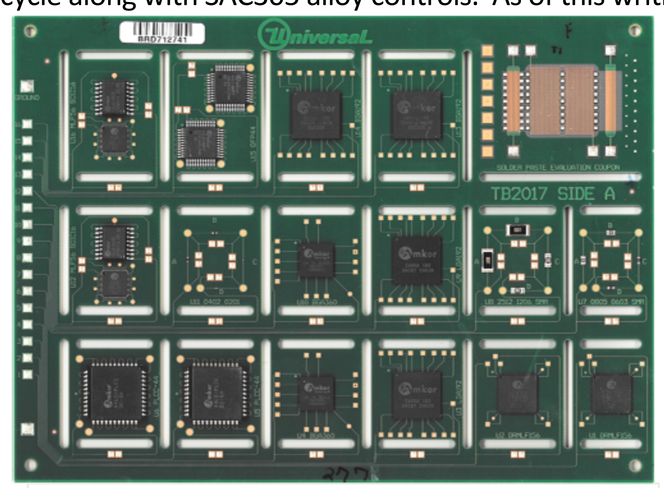
Additionally, an unusual phenomenon has been observed where select solder joints experience a significant lateral translation (200 - 400 microns) from their original design position. This strange behavior does not appear to be related to the typical thermal cycle induced recrystallization failure mechanism. In fact, these "shifted" interconnects are often still electrically sound and not the point of ATC failure. Additional experiments have been planned to attempt to identify the mechanism driving this intriguing behavior. As of this writing approximately 1200 thermal cycles have been completed.

The Dage 4000Plus microtester is one of the instrumental workhorses of our laboratory. In recent years it has it has provided a myriad of useful data on the mechanical behavior of various solder joints (at elevated and ambient temperature), laminate pad cratering comparisons, and solder joint fatigue response. Nordsen Dage has now generously upgraded APL testing capability through the installation of the latest Paragon™ Materials software on our 4000Plus unit. Their upgrade further includes the addition of several new test cartridges. We will be running this upgraded unit through its paces in the coming months. If you have ideas on new tests we should try (or would simply like more details on capabilities) please contact any of the consortium research staff.

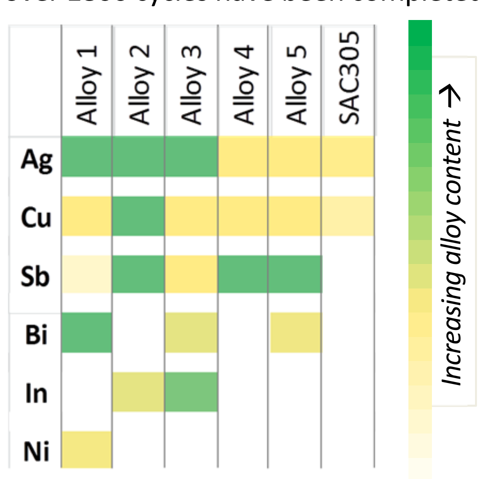


MAT6G. Pb-free Solder Alloys for Engine Control Applications

Five lead-free solder alloys are being evaluated for elevated temperature applications such as automotive engine control electronics. The alloys, supplied in both preform sphere and solder paste format, were used to assemble CSP, BGA, LGA, QFN, QFP, SOIC, PLCC, and SMR devices onto our TB2017 test board. BGA components were assembled using matching solder ball and paste alloys while the CSPs were assembled as a mixed alloy solder joints with SAC305 solder balls. Bottom terminated components of course have paste only connections. To emulate extreme application conditions, the assembled test vehicles are being subjected to a -40 to 150˚C accelerated thermal cycle along with SAC305 alloy controls. As of this writing, over 1800 cycles have been completed.

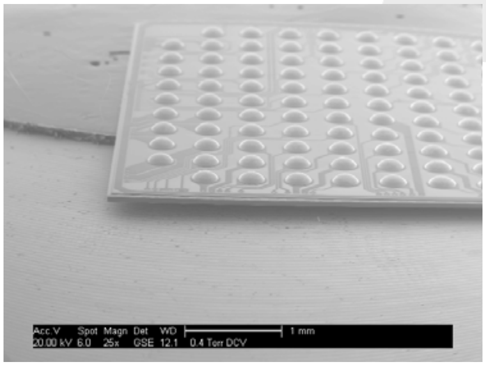


Assembled TB2017 for automotive solder alloy evaluation

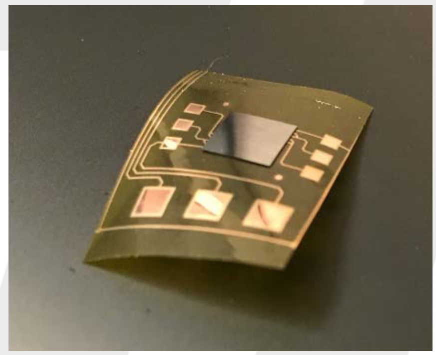


APD2B. Thin Die Flipchip Assembly

Fifty micron thick, wafer level CSPs have been obtained for flexible substrate joining studies. The silicon die have 100µm tall SAC405 bumps on a 500µm pitch (image below, left). They are being used to evaluate ultra-thin die handling and test material compatibility of bonding methods for flexible electronic applications. Using the APL Finetech Pico-ma die bonder with a nozzle designed specifically for working with thin die, we have been able to handle and join these thin die with no significant issues. Joining processes to bond the SAC405 solder bumps, using either low melt BiSnAg paste or conductive adhesives have been confirmed to work acceptably with thin die. One such thin die CSP with low melt soldered SAC bumps to copper circuitized polyimide flex is shown below right.



SEM image of ultra-thin WLCSP

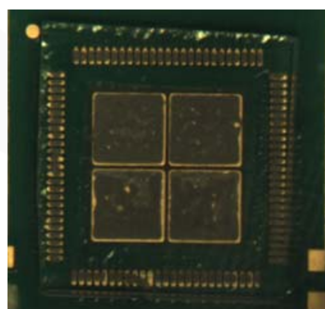


Ultra-thin WLCSP bonded to polyimide flex

Vacuum Reflow with a View

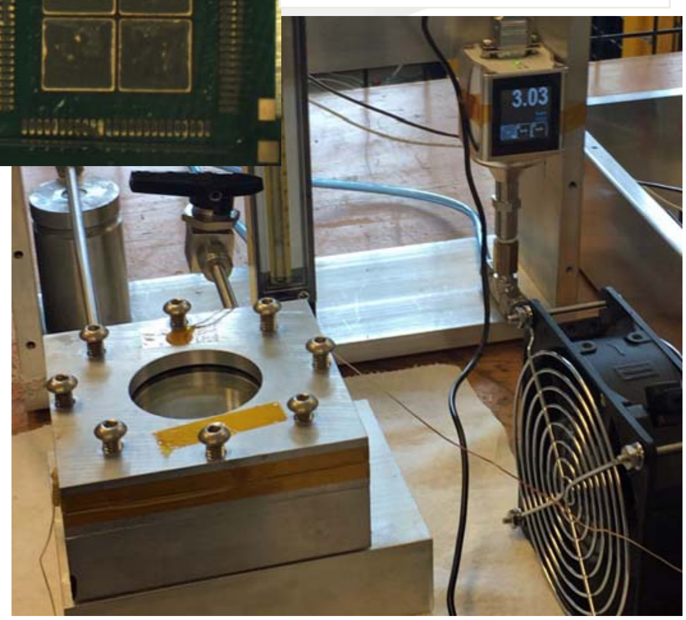
A mini reflow furnace has been designed and fabricated to run controlled and viewable reflow experiments with vacuum. The process chamber is 50 mm square x 12 mm high and has a 50 mm diameter glass viewport. An auto-tune PID (proportional – integral – gain) temperature controller is used to set the ramp rate and peak temperature. Vacuum is activated manually and can be controlled with a needle valve as low as 2 torr. Nitrogen gas flow is controlled with a rotameter up to 100 mL/min. The glass viewport allows visual or microscopic viewing as well as video recording to observe directly void expression and escape in solder paste during reflow. Experiments are planned to determine process windows for vacuum level, vacuum time on, dwell and off vs temperature.

Inset image shows a quartz substrate placed on a QFN solder paste footprint in preparation for a viewable solder paste reflow event.



Left: Glass slide placed over QFN solder paste footprint.

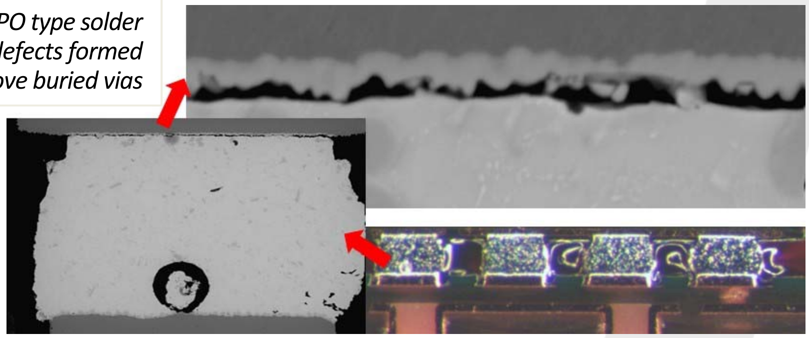
Below: Vacuum reflow apparatus for viewing void development



REL9A. Mixed VIPPO (Via-in Pad Plated Over) Array BGA Soldering Defects

Reflow experiments have begun using the thick version of the primary VIPPO empirical test board containing footprints for two large BGAs and multiple copies of two memory devices. These sites contain several different VIPPO location patterns and different types of non-VIPPO pads in order to identify effects of these design parameters on the incidence of VIPPO-induced solder defects. After the second reflow, all assemblies were still electrically continuous but dye-and-pry revealed many VIPPO-type failures (*i.e.*, solder-component pad interfacial separation with the solder side of the failure relatively smooth). To date, these failures were observed exclusively in joints on VIPPO-pads next to non-VIPPO pads. The electrical continuity was due to small regions of the interface that remained connected or to large intermetallic particles that remained embedded in the solder even after it had separated from the rest of the pad.

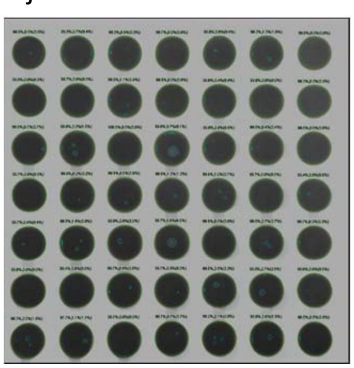
VIPPO type solder defects formed above buried vias



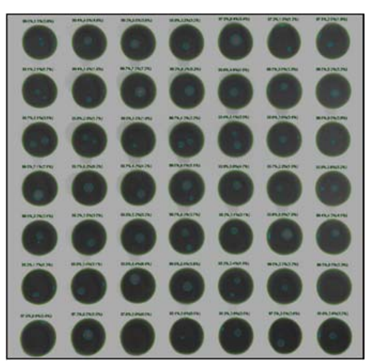
A similar investigation using alternate test parts is looking both at design and at process parameters. This investigation involves boards with long buried vias under some of the pads instead of VIPPOs. The design parameter studied was via location relative to the soldered pads. Process parameters included different reflow profiles and ambient atmosphere during first and second reflow. While parts built with the reference variable set had many VIPPO-type defects, certain combinations of alternative designs and process variables greatly reduced their severity, sometimes even completely eliminated it.

APD8A. In-line Vacuum Reflow: Solder Joint Voiding Elimination

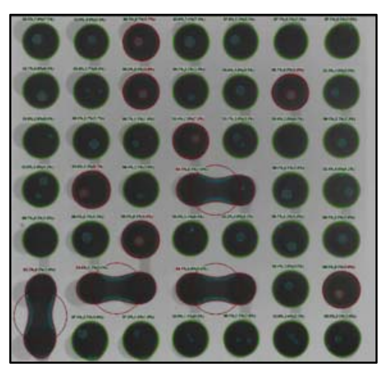
Our vacuum reflow trials have revealed that fine pitch CSP yields may be affected by vacuum level. When using 0.4mm pitch wafer level CSPs processed with solder paste, it was observed that solder joint void size increased as atmospheric pressure decreased; perhaps not unexpected given the pressure differential in the void relative to the surrounding vacuum environment. With extreme pressure differentials, some CSP solder voids could grow so large that solder joints would bridge to neighboring joints. Such vacuum induced bridging was observed in samples processed at 120 Torr or less with the number of defects increasing as reflow pressure decreased. Void origin was traced to the solder paste. CSP samples assembled using flux only did not produce solder bridges when subjected to vacuum reflow.



(a) Convection reflow, no vacuum



(b) 40 Torr vacuum / 20 second hold



(c) 1 Torr vacuum / 20 second hold.