advanced process lab
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AREA Consortium

Dear Members,

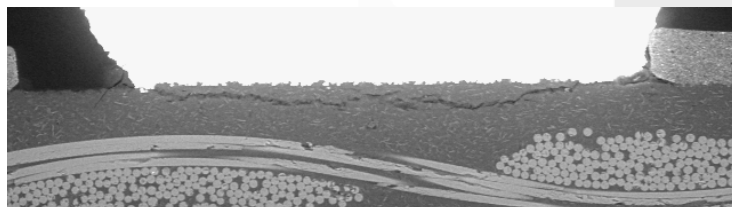
The fall member meeting this year is being held in conjunction with IPC PERM Council meeting. The **P**b-free **E**lectronics **R**isk **M**anagement (PERM) Council is an organization of mission critical electronics manufacturers whose product set is currently outside the scope of the RoHS directive. They are tasked with identifying risks of regulatory driven material changes in their products and promoting research to address them. Given the historically strong interest of PERM members in the metallurgy and reliability of various Pb-free alloy interconnects, we anticipate considerable overlap in the technical interests of our two organizations and that some useful synergy may arise from a shared meeting.

PERM meeting #22 will be hosted by Universal Instruments at their Conklin, NY facility on November 4, 2014. The meeting will be open to all AREA members to attend. The AREA member meeting will be held the following day (November 5th and 6th) on the Binghamton University campus with its usual format. If your travel schedule allows, please consider arriving a day early and attend the PERM meeting as well.

Jim Wilcox,
Consortium Manager

MAT1A: Underfill Studies

ATC testing of underfilled assemblies on TB2013 continues. Parts underfilled with material B have exceeded 3400 cycles but cycling continues because most parts have no failures or just one. Material C, after 2065 cycles, has more failures than B, and material D (the only reworkable of the group) at 1378 cycles has the most failures of all. The failures are not evenly distributed, with some parts having more failures with one underfill material and other parts with another. Failure analysis is in progress with samples from all materials. In addition to solder cracks, damage to the laminate was often seen, occasionally leading to almost complete pad cratering.



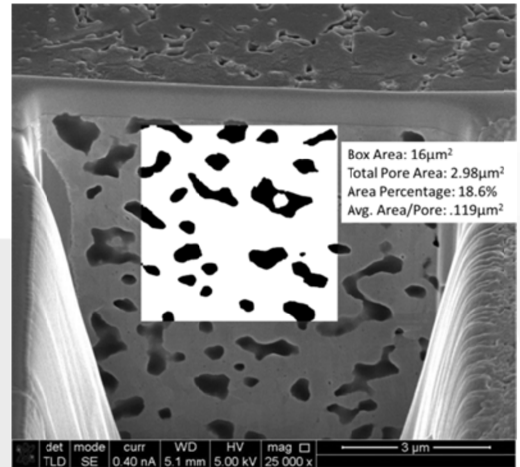
The first project with TB2104U is underway. Boards were assembled without underfill, with a conventional underfill and with strips of underfilm. ATC testing of the three different groups is ongoing, with no failures yet. Drop testing of another set has started.

MAT10A: Laminate and Glass Studies in Pad Cratering

The pad fatigue life measurements mentioned in the July newsletter have been completed. Analysis of the results to identify any effects of pad location relative to the underlying weave is ongoing.

An older project was revisited to address a question that had been left unanswered. That project had compared HBP performance of pads on two different laminates and a hybrid of the two. The question was whether the laminates, and especially the hybrid, could withstand multiple Pb-free reflows. The boards used for that previous test were designed especially for pad testing, so new boards were made with the same layered construction but with chained plated through holes and other features appropriate for multiple reflow survivability testing. ATC and CAF testing of as received and 6X reflowed boards are underway.

MAT6B: Die Attach



We are currently evaluating an experimental Ag-sintered interconnect material for die attach applications. Ag-sintered materials are being considered as a Pb-free alternative to traditional high-Pb alloys such as Pb-Sn-Ag for power and high temperature electronics. Initial work will focus on the effect of process variables on porosity, shear strength and high temperature shear strength. An SEM image of a Ag-sintered joint prepared by FIB (Focused Ion Beam) is shown below. The microstructure and strength will be evaluated on two different surface finishes: Au and Ag. 92.5Pb-5Sn-2.5Ag will be used as a control in this study. Initial results will be presented at the November AREA Consortium meeting.

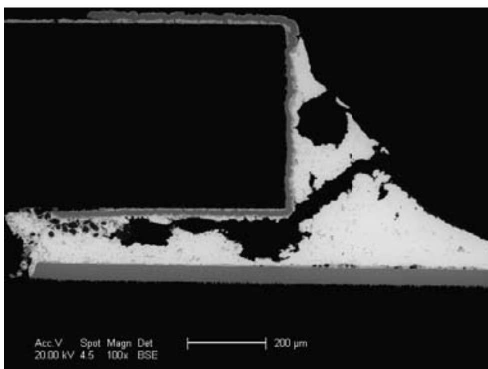
MAT8A: Conformal Coating

The SnPb samples from our conformal coat reliability analysis have now surpassed 3000 -40/125°C thermal cycles. The materials being evaluated are Parylene C, Humiseal 1A33 and Arathane 5750. The Humiseal and Arathane legs include test cells with and without damming around the components. Non-coated baseline samples are also included.

80% of the surface mount components in the test have now failed and we have completed failure analysis on many device types and conformal coat combinations. Overall, Parylene C is the best performer producing assemblies which were typically more reliable than the baseline samples. The results for the Humiseal and Arathane materials are far more complicated with some material/part combinations showing improved lifetime while others resulted in reduced lifetime. Possible explanations for such results will be discussed when the project is presented at the November AREA meeting.

MAT6A: High Temperature Electronics Research

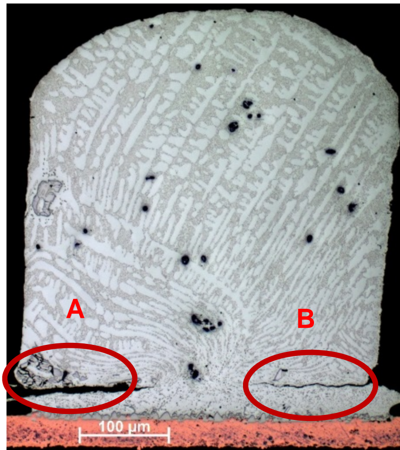
Work continues on project MAT6C “Characterization of High Temperature Alloys”. Six alloys are being studied: three Pb-based alloys, Alloy 151 (92.5Pb-5Sn-2.5Ag), Alloy 164 (92.5Pb-5In-2.5Ag), and the superplastic alloy (85Pb-10Sb-5Sn), and three Pb-free alloys, BiAgX™, Innolot, and Ag-filled Epoxy.



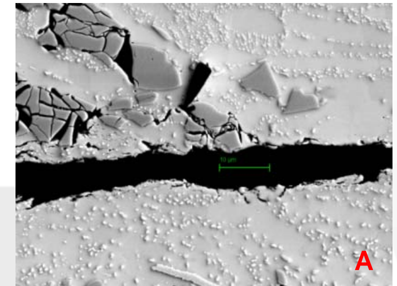
In June we presented on the microstructure and chip shear strength before and after high temperature storage at 200˚C for 1000hrs. In August we began harsh temperature cycling from -50˚C to 200˚C with five minute dwells and a ramp rate of 85˚C/min. Electrical continuity is being monitored through event detection. As samples fail they are being removed and cross sectioned for failure analysis. The image shows solder joint fatigue in Alloy 164, 2512 resistor joint, after 458 thermal cycles.

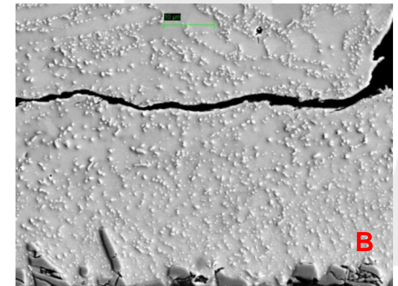
MAT7A: New Alloy Research

Shear Fatigue



Room temperature shear fatigue testing continues on various solder alloys (more than ten different compositions). In addition to Cu surface finish, ENIG surface finish is also being evaluated. Fatigue lifetime and failure mechanism as a function of solder alloy and surface finish are being investigated. A careful microstructural analysis on failed and partially cycled samples is in progress to correlate the effect of thermal history and precipitate size and distribution to crack initiation and propagation. The result will help us to understand the cause for early and late failures in fatigue tests.





REL11A Effect of TIM Compression Loads on Component Reliability

The high temperature storage portion of project REL11A "Effect of TIM Compression Loads on Component Reliability" has been completed. Fully assembled boards with heat sink fixtures were stored at 125˚C for 1000 hours at three different compression loads reflecting 30%, 50%, and 90% gap pad compression. Collapse of the first level (die bumps) and second level interconnects (SAC 305 BGA solder joints) were monitored by cross sectioning samples at specific intervals during the test. Results showed little collapse even under the harshest conditions (720 psi for 1000 hours at 125˚C). Solder joint height variation from component to component was greater than the magnitude of solder joint collapse. In the next phase of this project we will look at the effect of compression loads on solder joint reliability in thermal cycling -40/125˚C.

Fine Pitch Cu Pillar Interconnects

2.5D & 3D semiconductor packaging technologies are of growing interest in the electronics industry. They have become a reality in some market sectors and are the topic of major research efforts in others. A new project has been initiated in AREA to explore the assembly, metallurgy, and reliability of ultra-fine copper pillar solder joints required for this technology. Through collaboration with IBM, Corning and Binghamton University, fine pitch copper pillar soldered interconnects to glass interposer substrates will be assembled and evaluated in APL lab. If you would like to be involved please contact Babak Arfaei <babak.arfaei@uic.com>.

2014 SMTA International Conference

The AREA Consortium showcased a sampling of its research portfolio at the recent 2014 SMTA International conference in Chicago. Four papers were presented by our Consortium staff: one as a standalone talk and three in a single dedicated session of the Pb-free Symposium.

- **A.R.E.A. - Component Warpage: Issues with Measurement and Standardization**
  Martin Anselm, Ph.D., Universal Instruments Corporation

  The various modes of temperature induced component distortion that contribute to BGA Head-in-Pillow defects were described. Inadequacies of the current industry specification infrastructure were pointed out. Several case studies were included.

- **A.R.E.A. - Low Loss Laminate Material Pad Cratering Resistance**
  Michael Meilunas and Martin Anselm, Ph.D., Universal Instruments Corporation

  Presented by Jim Wilcox

  Data from three different laminate materials, from standard loss to low loss, are used to illustrate our efforts to capture the initiation of pad cratering defects. Copper surface traces connected to outer row BGA pads are aligned with the maximum principal stress in a four point bend test. Electrically monitored fracture of these traces in bending was anticipated to indicate the onset of laminate cracking. However not all laminate materials exhibited cracking after trace failure.

- **A.R.E.A. - Effect of PCB Surface Finish on Sn Grain Morphology and Thermal Fatigue Performance of SnPb and Lead Free Solder Joints**
  Babak Arfaei, Ph.D., Francis Mutuku and Martin Anselm, Ph.D., Universal Instruments Corporation

  The presence of various surface finishes alters the solidification behavior of Sn bases solders and hence the Sn grain structure and thermal fatigue performance. The fatigue performances of six different surface finishes are ranked according their -40/125C thermal cycle lifetime in both BGA and LGA packages.

- **A.R.E.A. - Component Level Testing of Thermal Interface Materials**
  Harry Schoeller, Ph.D. and Martin Anselm, Ph.D., Universal Instruments Corporation

  The thermal resistances of thirteen different thermal interface materials (gap pads) were measured at 10% and 30% compression and compared with supplier provided data. The microstructure of each gap pad material was studied in conjunction with the thermal resistance measurements to assist in explaining differences in performance.

In each paper, partial results were presented to illustrate some key conclusions of our studies. The complete research results are included in the final project reports for member-only access through our web site document repository.

At the technical conference award breakfast, our very own Babak Arfaei was formally recognized for his previous best paper contribution to the 2013 SMTA International Conference Proceedings. Congratulations again, Babak, for a job well done.