Proposed Standardizations of Lead Free Alloy Testing

Karl Seelig, AIM, Inc.

Although lead free assembly is now widely adopted the industry is still exploring a variety of options for lead free alloys. Attempts to standardize on a single alloy for either reflow or wave solder assembly have not been successful. Indeed, if anything, the proliferation of new lead free alloy types has increased.

For OEMs and EMS this poses a problem. All lead free alloys in general use, e.g. SAC 305, have a mix of desirable and not-so-desirable properties. It is the "not-so-desirable" properties, especially in contrast with the well known Tin-Lead systems, that make lead free assembly a process that poses unique difficulties and has a small process window. Solder suppliers, responding to these assembly problems, have proposed a large number of new materials that specifically address many of the vexing manufacturing properties of the first lead free alloys on the market. However, many of the first alloys introduced, e.g. SAC 305, are, if not completely characterized, better understood in terms of reliability properties than the new alloys being introduced. So while it is tempting for assemblers to look to the new alloys as solutions to the manufacturing issues of the "older" materials the lack of reliability characterization of these new materials introduces an element of uncertainty when compared to the current lead free materials in general use.

To address this problem the IPC Solder Products Value Council (IPC SPVC) in cooperation with several leading OEMs and EMS providers is developing a set of test protocols for evaluation of new lead free alloys on the basis of their physical properties, e.g. creep, and their performance in the assembly of a standardized test vehicle. This talk will focus on the physical testing aspect covering the genesis of this effort, input received from industry experts and the current status of the draft standard. The goal of this new test standard is to reduce the time and effort required to characterize an ally and thus help manufacturers improve their assembly processes without jeopardizing reliability.

Solder Alloy Test Methods: A Status Report

Back ground and progress

Karl Seelig Chairman of the SPVC/ V.P. of technology AIM

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New lead free alloy

- There are two schools of thought for new lead free alloy acceptance
- First is build test vehicle boards and run to failure
- Second is to develop strength of material testing relevant to electronic assembly
- Third is to merge these so future test data will be portable

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Initially both are needed Cons

- Test vehicle testing
  - Prone to assembly procedural failure
  - Flux compatibility with alloy and surface finishes
  - Surface finish, board and component quality
  - Very costly and may not mimic a broad enough product range

Pros of test vehicle testing

- Easier to relate to actual assembly use if similar to final product
- Actual solder joints are made
- Easier to understand

Strength of material testing cons

- Sample sizes of test vehicals are larger
- Relationship with solder connections is not fully understood
- Can not test all aspects of solder interactions

Strength of material testing pros

- Once related to circuit board assemblies testing is easier and less expensive
- Data can be portable for future alloy development
- Should reduce cost and time to market for new alloys

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SPVC has requested a new committee to study

- Directive to relate test methods and sample preparations relevant to circuit boards
- Eventually eliminating build to break methodology for most applications

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Outline

- Review of the December 2008 meeting
- Discussions at APEX 2009
- Input received
- Conference Call of July 22, 2009
- Review of the current draft
- Action Items Pending

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Summary of December 2008 Meeting

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Excerpts from Meeting Minutes

- The proliferation of lead free alloys is a test issue for OEMs and EMS: Does every alloy need to be tested completely?
- HP proposals for a standard test procedure were reviewed.
- Action item: Greg Munie to provide the test methods proposal.
- Group to reconvene at APEX 2009
- After APEX suggested test methods would be reviewed by members of the SPVC.
- IPC to create a committee using SPVC recommendations to create a standard on alloy material properties.

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Summary of APEX 2009 Meeting

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Excerpts from Meeting Minutes

- Status of the current draft of the alloy test method was reviewed.
- Additional comments from HP on a standard test procedure were reviewed.
- Flextronics presented a review of its lead free test vehicle.

Input Received on Draft Standard

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Jean Paul Clech: EPSI

- Temperature Effects:
  - Thermal cycling:
    - 0 to 100C
    - -40 and 125C
    - -55 and 125C.
  - Alloy characterization tests should cover the range of interest :
    - -55 to 125C.
- Creep characteristics (stress exponents and creep activation energies) are essential parameters

Chris Hunt: NPL

- Creep and relaxation are useful characteristics.
  - The stress strain loop
  - The hysteresis loop.
- Measurements need to be on joints of 1mm² cross-section and 200μm high:
  - Realistic of solder joints
  - Possible anisotropies of the materials and the effect of the interfacial intermetallics maybe significant.
- Vibration:
  - Preliminary data to date show that up to a factor of 10 can be observed in lifetime between SnPb and LF alloys.
  - LF alloys are much more sensitive to microstructure and ageing is critical.

Joe Smetana: Alcatel Lucent

- Reliability testing must be mandatory
- IPC 9701 TC1 should be shortened to 48 cycles per day or 36 cycles per day rather than 48.
- Thermal cycle temperature ranges:
  - -40 to +125C thermal cycle is extreme
  - 0-100C thermal cycle is mainstream for most products
- Test vehicles should include the key parameters
  - Ball size
  - Strain and type of stresses/strains on the particular solder joints
  - Board finish and component finish (The ideal situation is to test all variations)
  - Drop shock performance of an alloy based on vehicle design.

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Carol Handwerker: Purdue

- E-modulus is not an important parameter to measure
- Creep is critical
- DSC and simple wetting tests for manufacturing
- A test that mimics drop/shock/vibration is needed.

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Ganesh Subbarayan: Purdue

- Tensile and creep tests using a standard mechanical tester to identify constitutive behavior. If impact loading is important, the tests must also include those at higher strain rates conducted using Hopkinson bar or other test methods.
- Accelerated life tests including ATC, drop/shock tests.

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Paul Vianco: Sandia

- The typical ramp rate for DSC is 10C/min. There is very little difference in terms of the melting temperature versus the need for the slow ramp to do phase analysis.
- DSC testing must be performed in duplicate. The first run “conditions” the sample to pan; the second run is used for the actual data set.
- Two standards for DSC: In and Zn

Greg Henshall: HP

- The requirements provided in the draft are necessary but not sufficient for data to determine acceptance of new alloys
- More testing and specifics need to be present to provide an assessment of the long term reliability
- The type of testing required for qualification should depend on the solder form/application.
- Test the various solder forms in ways relevant to their end use.

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Greg Henshall: HP

- The current draft lacks sufficient assembly-level testing.
- Having data only on wetting behavior does not fully address concerns related to manufacturability. These tests do not provide data on the actual temperatures needed to process a PCA.
- The current proposal does not address the impact of alloy composition on copper dissolution
- Test methods need to be much more prescriptive, allowing much less variability in testing methodology.

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Greg Henshall: HP

- Interactions between a new alloy used in one part of the assembly with the current standard Pb-free alloys (e.g. SAC305) used in other parts of the assembly are not included in the proposal.
- The current proposal does not address concerns related to the impact of alloy composition on bend/flex response.
- The current proposal does not address vibration.
- We do not agree with the proposal to shorten the thermal cycle.

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Conference Call of July 22, 2009

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Excerpts from Meeting Minutes

- The draft was reviewed and major changes made:
  - Scope
  - Copper dissolution
  - All original “levels” of testing references were removed: the document becomes a stand alone test document.
  - Tensile and creep sample size: Auburn sample size procedure will be used
  - Speed and duration of testing changed
- A new committee, chaired by Greg Henshall of HP, will address the issues of manufacturability and reliability testing

Review of the Current Draft

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Overview: Sections 1, 2 and 3

- Sections 1 and 2: Boiler plate statement covering scope, purpose and other applicable standards (Scope will be changed per conference call action items.)
- Section 3: Specific test requirements changed per 7/22/09 meeting
  - 3.2.1 Composition: all elements to be reported via AES/ICP
  - 3.2.2 Wetting behavior: tested per user finish requirements
  - 3.6 Copper Dissolution per NIST 960-8 (or possible NPL proposal)

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Overview: Section 3

- 3.8.1CTE: measured through range of application (ASTM method E831-06 proposed as replacement for IPC-TM-650.2.4.24)
- 3.8.2 Tensile Testing
  - Sample size based on method developed at Auburn
  - Samples aged for 48 hours at 125° C
  - Strain rate of 0.01 minute^{-1}
  - Data collected for:
    - The 0.25 yield strength
    - The ultimate tensile strength
    - Strain at fracture/ductility
    - Temperature range of -50 to 150 ºC in increments of 25 ºC

Overview: Section 3

- 3.8.3 Creep
  - Temperature effects of 0 and 100 ° C
  - Sample size same as tensile testing
  - Sample aging same as tensile testing.
- 3.8.3.3 Dynamic Modulus per ASTM-1875-00 at ambient.
- All references to manufacturability and reliability removed (separate documents)

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Action Items Open

- Scope revision
- Test vehicle development (separate committee formed):
  - ATC
  - Shock/Vibration
  - Manufacturing
- Shock and Vibration test method (in development)
- Copper dissolution (in development)
- Standard sample and lot size
- Decision on CTE test procedure: ASTM or IPC?

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Discussion?

Karl Seelig Chairman of the SPVC/ V.P. of technology AIM

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