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iNEMI Statement of Work (SOW) Packaging TIG iNEMI Copper Wire Bonding Reliability Project Phase 2

Version # 2.7

Date: August 8, 2011

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Co-Chair:

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Background

- This project is a continuation of the first phase of the iNEMI Copper Wire Bonding Reliability Project.
- During the first phase, member companies outlined and conducted a survey on the industry-wide conversion status as well as key reliability concerns for Cu wire bonding. The results of the survey have been summarized and published to all iNEMI member companies.
- Based on the findings from this survey and published literature, it is determined that reliability performance of Cu wire bonding needs to be further evaluated with experimental work so that the effects of key factors such as packaging material selection on reliability performance can be better understood.

Purpose of Project

- Design an experimental matrix that includes realistic packaging material variations for both leadframe and substrate-based packages.
- Perform a series of acceleration tests on components with these material variations and collect lifetime data.
- Perform failure analysis and identify test methods and material properties that impact lifetime during such tests.
- By using a test-to-failure methodology, assess the effectiveness of standard reliability test methods and durations on addressing reliability risks of Cu wire bonded devices.

Scope of Work

- Identify materials sources and design an assembly variation matrix.
- Select a series acceleration tests and focus on temperature-humidity test methods. Use multiple temperature-humidity level combinations and attempt to derive a lifetime model based on the results from these tests.

- Based on acceleration tests and failure analysis data, the effects of packaging material properties can be understood. Effective acceleration test methods and durations can also be determined.

Business Impact

Experimental evaluation and technical data will provide member companies with first-hand insight into the key factors that affect Cu wire bonding reliability.

This project will provide the following benefits to participating companies and the industry in general:

- Using Cu wire as a replacement for Au wire may bring material cost savings to the industry, but will require sufficient understanding/management of reliability issues.
- Generate lifetime data from a series of acceleration tests and perform failure analysis on components from select test methods.
- Share technical data among member companies and provide understanding of failure mechanism and process for Cu wire bonded components.
- Establish potential common requirements on key materials properties for packaging materials so that all component suppliers and users have identical qualification requirements.
- Determine the suitability of using current standard JEDEC test methods and durations for the reliability performance for Cu wire devices. Recommend new testing requirements if the current common practice is found to be inadequate.

Expected Outcome

- Test results will be provided for all reliability tests, including electrical pass/fail data and all other failure analysis data.
- An assessment of the reliability of Cu bond wire (as defined by this project) will be provided, and recommendations will be made for best practices in packaging materials selection and component qualification that will meet the predefined lifetime reliability requirements for copper wire bonding to be approved for usage in long life products.
- A result summary should be available to all iNEMI members in reports from this project.

Previous Related Work

- Existing literature publications were reviewed and summarized as part of project phase 1.

Expected Participants

The following companies participated in the first phase of this project: Agilent, Atotech, ASE, Celestica, Cisco, Dow, HP, Plexus, Heraeus, IBM, IST, Lenovo, STATS ChipPAC, NMC, and Amkor.

iNEMI encourages the participation of individuals from different disciplines and divisions within their organizations to contribute on the range of tasks outlined in the project plan. The group should include representatives of:

- OEMs
- ODMs/EMS
- IC vendors
- Assembly houses
- Equipment suppliers
- Material suppliers (wire material, molding compound)
- Substrate suppliers

DoE matrix

The detailed DoE is managed in an Excel sheet. Here summarizes the major variables to be studied.

Main matrix:

- 2 package types: BGA, Leadframe
- 3 bond wires: Au, Cu, Pd-coated Cu; 1 diameter
- 1 substrate
- 2 EMCs for Cu
- 1 Process variation: optimize bonding conditions for given wire, substrate, etc.
- 7 Acceleration Tests: 5 conditions for Biased-HAST (130C/85RH, 110C/85RH, 85C/85RH, 130C/55RH, 110C/55RH), 1 condition for HTS (175C), 1 condition for AATC (-55-125C, 2 cycles /hr), and MSL3 260C
- 50 components / cell

Sub-matrix for surface finish:

- Plan to have a surface finish sub-matrix on BGA substrate. Will not investigate finish options on leadframe or wafer in this phase. Electrolytic NiAu used in the main matrix would be the baseline. The sub-matrix for finishes will be:
- 2 finishes (ENEP, ENEPiG)
- 2 Cu wires (Cu, Pd-coated Cu)
- 2 Suppliers
- 50 components / cells

Resources Required from Participants

The Copper Wire Bonding Reliability Project asks each participating company to commit to the following (details refer to the associated Project Statement):

- Agree to commit appropriate resources to meet project timeline and target dates.
- Agree to provide materials, components, test vehicles, design capability, component fabrication, assembly, test capability, failure analysis capability as negotiated and agreed, with other members of the projects, to fulfill the Statement of Work.
- Collaborate on input to the final report. Document results and publish findings to iNEMI members and/or the public.
- Provide recommendations for changes to industry standards as necessary. Promote the adoption of any recommended standards, tools, or processes that are developed by this project internally within the participating company and its supply chain partners.

Project Participant Commitment Matrix

As an output of phase 1, a number of companies has been identified who are willing to support the materials and the execution of tasks. Detailed arrangement will be confirmed when the project phase 2 sign-up is finished.

Tasks	Resource type	Resource availability	Task leader	Contributing firm	Remark
Phase 2					
1. Review DOE matrix	man hour	Planned			
Test vehicle design	design	Planned			
2. BGA Assembly		Planned			
Wafers	material	Planned			
Wires	material	Planned			
Substrates	material	Planned			
Leadframes	material	Planned			
Molding compounds	material	Planned			
Test boards	material	Planned			
Surface finish	material	Planned			
3. QFP Assembly	manufacturing	Planned			
Wafers	material	Planned			
Wires	material	Planned			
Leadframes	material	Planned			
Molding compounds	material	Planned			

Tasks	Resource type	Resource availability	Task leader	Contributing firm	Remark
Test boards	material	Planned			
Surface finish	material	Planned			
4. Reliability Tests		Planned			
AATC	test	Planned			
HTS	test	Planned			
HAST (Biased)	test	Planned			
MSL3	test	Planned			
5. Failure Analysis		Planned			
CSAM	test	Planned			
X-ray	test	Planned			
Cross-section	test	Planned			
6. Summary	man hour	Planned			

Schedule with Milestones

Phase 2	Months											
Tasks	1	2	3	4	5	6	7	8	9	10	11	12
0. Continuous literature review												
1. Finalize resource & DoE												
2. Materials sourcing												
3. Assembly components												
4. HAST boards design & manufacturing												
5. Reliability Test												
5.1. MSL3												
5.2. HAST												
5.3. AATC												
5.4. HTS												
6. Failure analysis												
7. Summary report												

Phase 2 Detailed Project Planning

Task 0 – Continuous Literature Review

- Resources: Team members to establish a sub-group
- After the sign-up of project phase 2, review the commitments from the participating team members and establish a sub-team to review and assess any new information on that becomes available during the project’s execution. This task will require a minimum of 2 companies to sign-up as part of the Project Statement commitment, otherwise Task 0 will be dropped from the project.

Task 1 – Finalize DOE design

- Resources: All team members.
- After the sign-up of project phase 2, review the committed resources and schedule, finalize the experimental designs and assign task owners.

Task 2 – Materials sourcing

- Possible suppliers & materials have been identified as an output of phase 1. Procure the materials including wafers, wires, substrates, leadframes, molding compounds.

Task 3 – Assembly components

- Assemble the components (BGA, QFN) at identified assembly houses, using optimized process parameters.

Task 4 – HAST boards design & manufacturing

Task 5 – Reliability Tests

- MSL3 260C
- AATC at (-55-125C) - 2 cycles /hr
- HTS at 175C
- HAST: 5 conditions for Biased-HAST (130C/85RH, 110C/85RH, 85C/85RH, 130C/55RH, 110C/55RH), with extended test duration.

Task 6 – Failure Analysis

- Exact analysis types will be determined based on the outcome of reliability tests.
- Analysis methods needed may include cross-section, FIB, de-capping (acid and/or laser) and others.

Task 7 – Summary report

- Summary report will be provided to iNEMI members.

Project Monitoring Plans

- Ensure open lines of communication among participants
 - Bi-weekly conference calls
 - Meeting minutes provided through e-mail
 - Follow-up with individuals on an as-needed basis
 - Workshops and face-to-face meetings as appropriate
- Technical reviews (2) will be provided to update the Technical Committee.
- Progress reports will be provided upon request for presentation at regularly scheduled iNEMI meetings (e.g., at member council meetings).
- Track and document approximate man-months per quarter per team member (this will require the active members of the team to provide estimates).
- Track and document approximate number of people on the project per quarter (this can be tracked through iNEMI's WebEx account).
- Define appropriate metric to quantitatively evaluate the project business impact.
- Project phase/summary report will be provided to iNEMI members and the report will be published on the iNEMI website.

General and Administrative Guidelines

General and Administrative Guidelines for this project and all other iNEMI Projects are documented at http://thor.inemi.org/webdownload/join/gen_guidelines.pdf.