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

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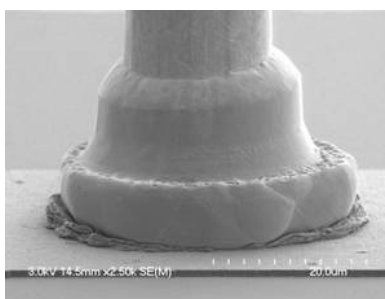
Background

- Gold (Au) wire bonding is one of today's most common and well understood first level interconnects. However copper (Cu) bond wires are increasingly being used for a wide variety of components. In addition to consumer applications, high-reliability electronic systems also face the trend of conversion to Cu wires. For such applications, reliability and performance need to be assessed and understood.
- Recently published work has shown that Cu wire bonding requires more rigorous bonding process control and stricter packaging material selection. Despite the positive impact of these improvements, reliability needs to be collectively assessed by the industry in a quantitative manner. Furthermore, for component qualification purposes, standard reliability test methods and durations for Au wire device may not be sufficient for Cu. Extended reliability evaluation may be needed to evaluate today's commonly used BOMs (bill of materials) for Cu wire bonded devices.

Source: Images courtesy of K&S



Wire Bonded Package



Chip Ball Bond



Leadframe Stitch Bond

Purpose of Project

- Understand key issues and concerns regarding reliability of Cu wire bonding for semiconductors.
- Assess reliability performance of components with Cu bond wires and compare to components with Au bond wires.

- Identify key packaging material properties that impact reliability performance, and provide guidelines on packaging material selection.
- By using a test-to-failure methodology, assess the effectiveness of standard reliability test methods on addressing reliability risks of Cu wire bonded devices.

Scope of Work

- This project will identify and assess the key contributing factors to the reliability performance of semiconductor packages using Cu bond wires.
- Key aspects of the packaging designs will be considered, including wire/pad materials and properties of packaging materials (e.g., molding compound).
- Only fine-pitch components will be included. Both leadframe based and substrate based components will be investigated. Components with Au bond wires will be included as a benchmark.
- The output of the project will be a set of reliability testing results for the components using the various packaging material combinations. Standard JEDEC test methods will be used for reliability evaluation. Test durations beyond current component qualification requirements or test method changes that may be more appropriate for Cu wire bonding will also be considered.
- This will be a 2-phased project. The first phase will focus on collecting information from the industry regarding the key processing and reliability issues pertaining to Cu wire bonding. The second phase of the project will perform necessary experimental work in the areas as defined by Phase 1. The whole project is expected to complete in approximately 12 months from the time of project launch.
- The detailed experiment design for Phase 2 will be based on Phase 1 results. The SOW update for Phase 2 will be reviewed and finalized by the project team and approved by the iNEMI Technical Committee.

Business Impact

The usage of copper wire has been growing in the industry as the price of gold has increased in recent years. However, the main concerns that would prevent the companies using copper wire technology in the future are in-service reliability, process yield, and unproven historical performance. (*Source: SEMI survey report, January 2010.*)

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

- Reduce the need and efforts for individual member companies to run evaluation on the reliability performance of Cu-wire devices by performing these tasks collectively and sharing data openly.
- 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.
- A result summary should be available to all iNEMI members in reports from this project.

Previous Related Work

- Existing literature publications and data will be reviewed and summarized as part of this project.

Expected Participants

iNEMI's member companies will encourage 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

Project Formation Participants

Name	Company
Bernd Appelt	ASE
Peng Su	Cisco
Martin Bayes	Dow Chemical
Dave Mendez	Flextronics
Johnny Yeung	Heraeus
Itsuo Watanabe	Hitachi Chemical
Russ Lewis	HP
Tao Wu	Intel
Jeffrey Lee	IST
Bob Chylak	K&S
Horst Clauberg	K&S
Yoshihiro Morimoto	Nitto Denko
Steve Greathouse	Plexus
Muneaki Kure	Shinko
Francis Classe	Spansion
JaeHak Yee	STATS ChipPAC
Ippei Kato	Sumitomo Bakelite
Naoko Chiba Ghoneim	Sumitomo Bakelite
TP Low	Sumitomo Metal Mining

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

The project will use a matrix to identify contributing companies to the required resources and tasks. The resources needed for Phase 2 will be further defined when Phase 1 is completed, and the matrix below will be completed. Phase 1 of the project is being carried out by the project formation team and the resources will not be discussed in this matrix.

Tasks	Resource type	Task leader	Contributing firm	Key contact
Phase 2				
1. Review DOE matrix	man hour			
Test vehicle design	design			
2. Design/Procure Materials				
Wafers	material			
Substrates	material			
Leadframes	material			
Molding compounds	material			
Test boards	material			
3. Assembly				
BGA	manufacturing			
SOP	manufacturing			
QFN	manufacturing			
Etc.	manufacturing			
4. Reliability Tests				
AATC	test			
HTS	test			
THB or HAST (Biased)	test			
Etc.	test			
5. Failure Analysis				
CSAM	test			
X-ray	test			
Cross-section	test			
6. Summary				
	man hour			

Schedule with Milestones

This is a tentative schedule. Timing for completion of Phase 2 may vary depending on equipment and material availability at team members.

Tasks	Months																	
	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17
Phase 1																		
1. Industry Survey	x	x																
Create questionnaire	x																	
Prepare recipient list	x																	
Data collection		x																
Review key findings		x																
2. Existing data review		x	x															
3. DOE Plan for Phase 2		x	x															
Phase 2																		
1. Finalize DOE				x														
2. Procure Materials				x	x													
3. Package Assembly						x	x											
4. Reliability Tests								x	x	x	x							
5. Failure Analysis									x	x	x	x						
6. Summary										x	x	x	x					

Detailed Project Planning

Phase 1

Task 1 – Industry Survey

- Resource: All team members are expected to contribute and review the list of questions, contribute to the survey recipients list, distribute the survey to their partners in the supply chain, and review results.

Create questionnaire: The questionnaire has been created as part of the project formation process and is ready to be distributed to iNEMI member companies and additional key industry members.

Data collection and analysis: Survey results will be analyzed and discussed during regularly scheduled project calls, with possible invitations extended to individuals outside the project team to assist in clarifying specific issues. Revision of the experimental matrix will be made based on the outcome.

Task 2 – Existing Data Review

- Resource: All team members are expected to contribute to the literature search. A task matrix will be defined so that members may focus on specific areas of interest.
- Major publications related to copper wire bonding applications and technical challenges will be collected and reviewed. The information gathered will include industry data & academic studies on design, materials, process improvement, reliability testing, and failure analysis techniques and methodologies.
- Information collected will be shared within the project team.

Task 3 – Outline Phase 2

- Resource: Evaluation and experimental matrix for Phase 2 of the project will be proposed by the project leader and will be reviewed and approved by all project team members before proceeding.
- Key items of the definition will include test vehicles, materials, processes, and reliability tests.
 - Identify contributing members for key tasks & determine schedule
 - Material suppliers
 - Assembly locations
 - Reliability tests
 - Failure analysis
 - Material variations
 - Cu wires: diameter, hardness, composition (purity and alloying), surface coated/not coated
 - Include Au wire as benchmark
 - Bonding pad design (thickness, material, size, pitch, dielectric and metal layers under pad)
 - Substrate pad finish, leadframe finish (Cu vs pre-plated)
 - Molding compound (supplier and chemistry variations)
 - Reliability test methods and duration
 - MSL3
 - Thermal cycling
 - HTS
 - HAST (biased)
 - THB (biased)

- Resource & task matrix to identify available resource (contribution/donation by project members) and gaps (material/service to purchase or expect support) will also be defined.
- Update the SOW for Phase 2 and submit to Technical Committee for approval.

Phase 2 (to be updated based on Phase 1 result)

Task 1 – Finalize DOE design

- Resources: All team members.
- Review the proposals and committed resources, and finalize the experimental designs.

Task 2 – Design/Procure Materials

- Wafers
 - Identify supplier(s)
 - Determine schedule
- Wires
 - Identify supplier(s)
 - Determine schedule
- Substrates
 - Identify supplier(s)
 - Determine schedule
- Leadframes
 - Identify supplier(s)
 - Determine schedule
- Molding compounds
 - Identify supplier(s)
 - Determine schedule
- Test boards
 - Identify supplier(s)
 - Determine schedule

Task 3 – Package Assembly

- BGA assembly
 - Locations
 - Detailed process DOE
- QFN / QFP/Etc.
 - Locations
 - Detailed process DOE

Task 4 – Reliability Tests

- AATC
 - Location
 - Schedule
- HTS
 - Location
 - Schedule

- HAST
 - Location
 - Schedule
- THB
 - Location
 - Schedule

Task 5 – 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.

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).
- 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.