

iNEMI Statement of Work

Joint Board Assembly & Substrates TIG Project

Evaluation of Pb-Free Component & Board Finish Reliability

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Table of Contents

Table of Contents	1
Purpose.....	2
Background and Motivation.....	2
Scope of Work	2
Prospective Participants	3
Schedule and Resources Required from Participants.....	3
Key Milestones	4
Phase 2 – Detailed Information.....	5
Project Monitoring Plans	10
Outcome of the Project.....	10
Specifications and Standards.....	10

Purpose:

Evaluate the effects of alternative surface finishes for circuit boards and package substrates on Pb-free solder joint reliability during mechanical and thermal stress testing.

Background and Motivation:

The transition to the use of Pb-free solder alloys introduces new concerns regarding solder joint reliability. The implementation of alternative surface finishes for circuit boards and package substrates/leadframes compounds these reliability concerns. Although multiple studies are investigating the impact of Pb-free solder on board-level temperature cycling lifetime, few efforts have dealt with the impact of alternative surface finishes on Pb-free solder joint reliability.

Scope of Work:

Comparative reliability testing will be conducted on Pb-free components assembled on test boards. Test board assemblies will be configured to evaluate multiple component surface finishes and 2 circuit board surface finishes. The reliability testing will be conducted with mechanical testing- with and without aging. Mechanical testing will consist of 4-point monotonic bend testing (IPC/JEDEC-9702) and drop testing.

The component surface finishes to be evaluated are listed below:

1. Electrolytic Ni/Au
2. Electroless Ni/Au (ENIG)
3. SnAgCu solder over Cu
4. Matte Sn over Cu
5. Matte Sn over Ni/Cu
6. Au/Pd/Ni
7. SnBi over Cu

The 2 printed wiring board (PWB) surface finishes will be evaluated as follows:

1. Electrolytic NiAu
2. Organic Solderability Preservative (OSP)

The plan-of-record SnAgCu composition for the solder paste and component solder will be the NEMI Sn3.9Ag0.7Cu alloy; however, the final selected alloy may change, depending upon results of on-going evaluations of alternative compositions, e.g., Sn3.0Ag0.5Cu.

Prospective Participants

Company Name	Agreed to Participate?	Agreed to provide financial support?	Contact Person	Contact Info
Agilent	Yes	Yes (\$6k max)	Julie Silk	julie_silk@agilent.com 707-577-4296
Alcatel-Lucent	Yes	Yes (\$6k max)	Richard Coyle	rcovle1@alcatel-lucent.com 908-582-8062
Cisco	Yes	Yes (\$6k max)	Gnyaneshwar Ramakrishna	gnyramakr@cisco.com 408-853-6140
Cookson	Yes	No	Jim Kenny	jkenny@cooksonelectronics.com 503-880-6069
Dage	Yes	No	Bob Sykes	b.sykes@dage-group.com 44-1206-877501
HP	Yes	No, but will provide in-kind support	Elizabeth Benedetto	elizabeth.benedetto@hp.com 281-518-1141
Huawei	Yes	Yes (\$6k max)	Ye Yuming	yeyuming@huawei.com + (86)-755-89651222
Intel	Yes	Yes (\$6k max)	Houssam Jomaa	houssam.jomaa@intel.com 480-552-3741
Plexus	Yes	Yes (\$6k max)	Bill Barthel	bill.barthel@plexus.com 920-996-8681
Multek	Yes	No, will provide in kind support	Mark Mai	mark.mai@hk.multek.com
Sanmina-SCI	Yes	No	Robert Kinyanjui	robert.kinyanjui@sanmina-sci.com 256-882-4046
Flextronics	Yes	Yes (\$6k max)	Sundar Sethuraman	Sundar.Sethuraman@flextronics.com 408-576-7661
iNEMI			Bob Pfahl	bpfahl@inemi.org
			Jim Arnold	jim@rissastudios.com

Schedule and Resources Required from Participants:

Task Number	Task Description	Estimated Sample Qty	Estimated Start Date	Estimated Completion Date	Task Duration
PHASE 1 (COMPLETED)					
Completed	Gather Components	75-150 of each pkg type	1/2005	Completed 12/2005	
Completed	Component Construction Analysis	-	8/2005	Completed 12/2005	

Task Number	Task Description	Estimated Sample Qty	Estimated Start Date	Estimated Completion Date	Task Duration
Completed	PWB Design – panels 6060 A/B, 6072 A/B & 6073 A/B	-	1/2005	Completed 4/2006	
PHASE 2					
Task 1	PWB Fabrication	230 boards	X (original plan 6/2008)	X+3 months	3 months
Task 2	PWB Construction Analysis	-	X+3 months	X+5 months	2 months
Task 3	PWB Fixtures, Setup & Assembly	-	X	X+5 months	5 months
Task 4	Monotonic Bend Test – fixtures, setup & test		X+5 months	X+8 months	3 months
Task 5	Mechanical Shock Test		X+5 months	X+9 months	4 months
Task 6	Failure Analysis		X+5 months	X+12 months	7 months
Task 7	Data Completion			X+12 months	
Task 8	Project Report			X+13 months	1 month
Total Duration from Test Board PO Issuance					13 months

Key Milestones

- Task 1
 - Acquire 230 test panels (X/2008)
- Task 2
 - Complete PWB construction analysis (X + 5 months)
- Task 3
 - Design of PWB test fixtures (X + 1 month)
 - Complete assembly of test panels (X + 5 months)
- Task 4
 - Complete monotonic bend test (X + 9 months)
- Task 5
 - Complete mechanical shock testing (X + 9 months)
- Task 6
 - Complete failure analysis (X + 12 months)
- Task 7 (dates tied to those of Task 6)
 - Identify venues to publish summary of results (X + 12 months)
 - Complete compilation of test results (X + 12 months)
- Task 8 (dates tied to those of Task 6)
 - Complete summary of test results for iNEMI membership (X + 13 months)
 - Complete final report for project participants (X + 13 months)

Phase 2 – Detailed Information

Task 1 – PWB Fabrication

Resources

1. Design of the test PWBs was completed during Phase 1 and will be used in the construction of the 230 test boards needed for Phase 2
2. Huawei Technology has agreed to lead the acquisition of the 230 PWB panels needed for this phase of the project
3. Select participating companies have agreed to provide a maximum of US \$6,000 each to acquire the PWBs.

Materials and Processes

4. Huawei has obtained quote from their supply chain and will lead the effort to acquire the PWBs.
5. PWB material selection (230 boards) is under discussion by the Team, with the current default material being Isola (Polyclad) 370 HR. Current quotation from Huawei is for 230 boards.

Assembly #	PCB#	Quantity Required	Test Vehicle Description
6072A	6072A	30(OSP) + 30 (Elytic Ni/Au)	Bend test Vehicle (93-mil thick PCB)
6073A-2	6073A	40 (OSP) + 40 (Elytic Ni/Au)	Drop test vehicle for IBM 42.5mm FCBGA device (62-mil thick PCB)
6060A-2	6060A	40 (OSP) + 40 (Elytic Ni/Au)	Drop test vehicle for ASE 42.5mm FCBGA device (62-mil thick PCB)

6. Huawei quotation:

Assembly #	Purpose	PCB #	Finish	Total # Boards needed	Engineering Charge (Yuan)	Board Cost (Yuan)	Sum Total (Yuan)	Cost/Board (\$), assuming exchange rate of 7.1 Yuan/Dollar	Adjusted Sum Total
6060A-2	Drop test for ASE 42.5mm FCBGA (62-mil thick board)	6060A	OSP	40	8500	31520	40020	\$70	\$5,600.00
6060A-2		6060A	E-lytic Ni/Au	40					
6072A	Bend Test (93-mil thick PCB)	6072A	OSP	30	8500	81560	90060	\$317	\$19,020.00
6072A		6072A	E-lytic Ni/Au	30					
6073A-2	Drop test for IBM 42.5mm FCBGA (62-mil thick PCB)	6073A	OSP	40	8500	15760	24260	\$85	\$6,800.00
6073A-2		6073A	E-lytic Ni/Au	40					
								Based on March Exchange Rate	\$31,420.00

7. Note that original plan included drop (shock) boards for Intel components, (6073-B), however it is no longer included in the plan (Intel components are no longer available).
8. Current total cost for boards is \$31,420 based on latest Huawei quotation. If the final, total cost (currently \$31,420) is less than the sum total of commitments from the participants making a financial contribution, the amount required per participating company will be reduced accordingly. The maximum cost per company will not exceed US \$6000 for this project.
9. The planned surface finish supplier for OSP deposition on the boards is Shenzhen Shennan Circuits Co., LTD, Point of contact is:
Sha Lei
Tel: +86-755-8406-2590
Email: shalei@shennan.com.cn
10. The Planned Surface finish supplier for electrolytic Ni/Au plating on the boards is Multek Electronics Limited. Point of contact is:
Mark Mai
Tel: + 86.756.553.9888
Email: mark.mai@hk.multek.com

Note that in discussions with Multek, the preference is for Multek to plate Electrolytic Nickel Gold and complete the board manufacturing process including solder mask deposition and inspection.

11. Above quotation assumes 100% of boards have OSP; Since Electrolytic Ni/Au plating will be an in-kind contribution from Multek, whereby Multek will assist in this project as a subsidiary of Flextronics who is

already an iNEMI member. Final cost details for board construction and logistics of boards transfer to Multek still needs to be worked out between Huawei, SYE, and Multek.

12. Cookson has agreed to continue participation in the project, despite a change to from immersion Ag to electrolytic Ni/Au on the test boards. Cookson has indicated that they can support electrolytic Ni/Au Plating. Huawei must resolve the logistics of using Cookson's electrolytic NiAu with their PCB fabricator.

Testing Procedures

13. Initial incoming inspection of PWBs will be performed by Huawei. Cookson can characterize the electrolytic Ni/Au surface finish.
14. Team agreed to focus on selection of robust laminate material and to skip IST testing

Task 2 – PWB Construction Analysis

Resources

- High temperature laminate materials (“Pb free” PCB materials) have evolved considerably since the original project plan was developed. The team agreed to reduce the scope of the PWB construction analysis to include only a board inspection at Huawei; this inspection will compare the boards to a set of minimum acceptance criteria, as proposed by Huawei and the team. The acceptance criteria IPC-610D will be used
- **A list of committed resources from Huawei for this task is to be added to address overall manufacturing requirements**
- No additional funding is expected for this part of the project.

Materials and Processes

- Huawei will use IPC-610D as their minimum board acceptance criteria.

Testing Procedures

- Desire is to use standard practices for board inspection, and any commonly used software (where needed) to reduce costs and widen applicability of results.

Task 3 – PWB Fixtures, Setup & Assembly

Resources

- Components for assembly of the test structure were obtained during Phase 1 and currently being stored at Flextronics, Milpitas.

Current component list from Phase 1

						Current Component Inventory					
Component Type	ID	Manufacturer	I/O Count	Pitch (mm)	Body Size (mm x mm)	Electrolytic NiAu	ENIG	SAC/Cu	Sn/Cu	Sn/Ni/Cu	Au/Pd/Ni/Cu
FC-BGA	1	ASE	1936	1	45x45	203	295	294			
FC-BGA	2	IBM	1680	1	42.5x42.5		298	121			
FC-BGA	3	Intel	479	1.27	35x35		0				0
BGA	4	Amkor	676	1	27x27	430					
CSP	5	Amkor	64	0.8	8x8	462					
CSP	6	Amkor	84	0.5	7x7	462					
MLCC	7	Agere	56	0.4	7x7				481	485	
QFP	8	Agere	176	0.4	20x20				97	98	
TQFP	9	Texas Instruments	176	0.4	20x20						88
2512 resistor	10	Practical							4000		
0606 resistor	11	Practical							10000		
0201 resistor	12	Practical							10000		
SMT header	13	Sherwood	12	2.54		2000					
FC-BGA	14	ASE	1681	1	42.5x42.5		153	120	60		

- Flextronics will do the surface mount assembly of the test boards. **A detailed list of the resources needed by Flextronics to complete assembly will be added.**
- No additional funding is expected for this part of the project.

Materials and Processes

- The Pb-free solder paste will be the preferred material used by Flextronics and is likely to be SAC 305.
- The Pb-free soldering profile will be developed by Flextronics and will conform to typical Pb free processing guidelines.
- No specific suppliers or technologies required at this time.
- No custom components are deemed necessary at this time.

Testing Procedures

- The anticipated number of parts to be tested is 230.
- IPC 9701 0-100C will be used as baseline ATC.
- Baseline samples may be evaluated; **details TBD by Team**

Task 4 – Monotonic Bend Test – Fixtures, Setup & Test

Resources

- Original plan was for Sun (no longer participating in the project) to complete this task. Keith Newman from Sun indicated that we can still use Sun's equipment for this test. Cisco has agreed to share bend test fixtures with Flextronics, and Flextronics will coordinate testing with Sun. **Resource requirements to support this testing are TBD.**
- No additional funding required for components, assembly, design, and testing.

Materials and Processes

- The 6072A bend test vehicle board (30 with OSP, 30 with electrolytic NiAu) will be used for this assessment. The currently planned components which will undergo bend testing are detailed in the table below.

Bill of Materials for iNEMI 6072A Assembly

Item	Part Description	Component Plating Finish	Quantity/Board	Reference Designator	Board w/ SOP @ 0 hrs	Boards w/SOP @24 hr 150C	Boards w/SOP @48 hr 150C	Board w/ NiAu @ 0 hrs	Boards w/ NiAu @24 hr 150C	Boards w/NiAu @48 hr 150C
14A	ASE 42.5mm FCBGA 1681 I/O	Im-Sn	1	U1 12	6 boards	12 boards	12 boards	6 boards	12 boards	12 boards
14B	ASE 42.5mm FCBGA 1681 I/O	ENIG	1	U1 22						
14C	ASE 42.5mm FCBGA 1681 I/O	DSOP	1	U1 32						
2A	IBM 42.5mm FCBGA 1680 I/O	ENIG	1	U2 22						
2B	IBM 42.5mm FCBGA 1680 I/O	OSP	1	U2 32						
3C	Intel-35mm FCBGA 479 I/O	ENIG	0	U3-22						
3D	Intel-35mm FCBGA 479 I/O	NiPdAu	0	U3-62						
3X	Intel-35mm FCBGA 479 I/O	-	0	U3-X2						
4A	Amkor 27mm PBGA 676 I/O	Elytic Ni/Au	1	U4 12						
5A	Amkor 8mm CSP 64 I/O	Elytic Ni/Au	1	U5 12						
6A	Amkor 7mm CSP 84 I/O	Elytic Ni/Au	1	U6 12						
7A	Agere 7mm MLCC 56 I/O	Matte Sn	1	U7 42						
7B	Agere 7mm MLCC 56 I/O	Matte Sn/Ni	1	U7 52						
13A	Sherwood 12-Pin SMT Header	Ni/Au	22	J3-J6, J11-J14, J16, J20-J24, J29-J37						
16A	Adam Tech 12-Pin SMT Header	Ni/Au	No Load	J10, J15, J23, J28						
17A	Adam Tech 18-Pin SMT Header	Ni/Au	No Load	J7-J9, J17-J19, J25-J27						
18A	Vishay Uniaxial Strain Gauge	-	No Load	TP45-TP70						

Testing Procedures

- Current plan is a total of 30 of each component would be mounted on boards w/ OSP (total of 30 boards with OPS), and another 30 of each would be mounted on boards w/ electrolytic Ni/Au (total of 30 boards with Ni/Au). Of the 30 OSP boards, 12 assemblies will be put through thermal aging at 150 C for 24 hours, another 12 assemblies will be put through thermal aging at 150C for 48 hours prior to bend test, while 6 boards will not undergo any aging prior to bend test. Likewise for electrolytic NiAu boards, 12 assemblies will be put through thermal aging at 150 C for 24 hours, another 12 assemblies will be put through thermal aging at 150C for 48 hours prior to bend test, while 6 boards will not undergo any aging prior to bend test..
- IPC/JEDEC-9702 publication, “Monotonic Bend Characterization of Board-Level Interconnects.” Four point bend test will be used for this assessment, as per agreement from team. Test speed (slow vs. fast bend) is TBD by the team.

Task 5 – Mechanical Shock Test

Resources

- Intel to support shock testing at Folsom site.
- Detailed list of committed resources from Intel will be defined later.
- No additional funding is expected for this part of the project.

Materials and Processes

- Two separate shock test vehicle board designs will be used for this assessment. The 6073A-2 design (62 mil thick PCB; 40 with OSP, 40 with E-lytic Ni/Au) will be used with IBM 42.5 mm FCBGA devices. The 6060A-2 design (62 mil thick PCB; 40 with OSP, 40 with E-lytic Ni/Au) will be used with ASE 42.5 mm FCBGA devices. The currently planned components which will undergo bend testing are detailed in the table below.

Bill of Materials for iNEMI 6073A-2 Assembly

Item	Part Description	Component Finish	Quantity/Board	Reference Designator	Board w/ SOP @ 0 hrs	Boards w/SOP @24 hr 150C	Boards w/SOP @48 hr 150C	Board w/ NiAu @ 0 hrs	Boards w/ NiAu @24 hr 150C	Boards w/NiAu @48 hr 150C
2A	IBM 42.5mm FCBGA 1680 I/O	ENIG	1	UIY3	2	4	4	2	4	4
2B	IBM 42.5mm FCBGA 1680 I/O	OSP			2	4	4	2	4	4
13A	Sherwood 12-Pin SMT Header	Ni/Au	4	J41-J44	-	-	-	-	-	-

Bill of Materials for iNEMI 6060A-2 Assembly

Item	Part Description	Component Finish	Quantity/Board	Reference Designator	Board w/ SOP @ 0 hrs	Boards w/SOP @24 hr 150C	Boards w/SOP @48 hr 150C	Board w/ NiAu @ 0 hrs	Boards w/ NiAu @24 hr 150C	Boards w/NiAu @48 hr 150C
14A	ASE 42.5mm FCBGA 1681 I/O	Im-Sn	1	U1Y3	1	2	3	1	2	3
14B	ASE 42.5mm FCBGA 1681 I/O	ENIG			1	2	3	1	2	3
14C	ASE 42.5mm FCBGA 1681 I/O	OSP			1	2	3	1	2	3
13A	Sherwood 12-Pin SMT Header	Ni/Au	4	J41-J44	-	-	-	-	-	-

- Intel’s internal shock test best known method will be used, due to lack of industry standardization on this test.

Testing Procedures - This needs to be re-visited and reassessed by the Team.

- Intel suggests ~40 units per shock test board design (5 units on OSP boards w/out aging, 7 units on OSP boards with 150C, 24 hrs aging and 8 units w/OSP boards with 150C 48 hrs aging- similarly for Ni/Au boards)

Task 6 – Failure Analysis

Resources

- It is expected that the FA participants will define and provide the necessary resources for these tasks. This needs to be re-visited and reassessed by the Team
- No additional funding is expected for this part of the project.

Materials and Processes/ Testing Procedures

- Standard optical metallography and SEM will be performed as needed. Materials will be donated by member companies performing the analyses. The amount of FA will be determined by the member companies performing the work in conjunction with the Team.

Task 7 – Data Completion

Resources

- Project team members are expected to review and assess some portion of the existing knowledge base on new Pb-free alloys. They are expected to summarize their findings in a manner consistent with the project schedule. Members will work with the team to put together and communicate an overall picture of the results and to publish this information.
- No additional funding is expected in the compilation of the data collected during Phase 2.
- No equipment will be required.

Task 8 – Project Report

Resources

- iNEMI members will be provided with a summary of the results and thus will receive this information well before the general public.
- No additional funding is expected for providing iNEMI members with a summary of the work performed in Phase 2.
- No equipment will be required.
- Project participants are expected to help in the writing and review of the summary.
- List of committed resources from participating companies will be completed after Project Team has been finalized.

Project Monitoring Plans

- Monthly teleconferences (restarted January 2008)
- Re-establish commitments from participants, including assembly, testing, and FA/characterization commitments
- Establish iNEMI website for this project to facilitate file sharing among members
- Request progress reports as tasks are completed
- Dates of technical reviews (2 per year) and progress reports and what they will contain
- Practice risk analysis by anticipating problems and having alternate solutions ready
- Use opportunity analysis to identify new areas or topics that might be addressed in additional projects. This will prevent the scope of the current project from expanding and keep the project focused on original goals
- Regularly review project requirements with project participants and suppliers

Outcome of the Project

- Deliverables listed for each task as stated above
- Clear definition of which project results will be shared, with whom, and by what means will be determined once the Team has been re-formed and the contributions of each member have been finalized. Project participants will decide what results will be shared external to the project team; however a minimum requirements is that a summary of the results will be provide to the complete iNEMI membership.

Specifications and Standards:

IPC/JEDEC-9702 publication, “Monotonic Bend Characterization of Board-Level Interconnects.”

IPC-9701 standard, “Performance Test Methods and Qualification Requirements for Surface Mount Solder Attachments.”

NOTE: All changes to SOW must be approved by the TC (version control)