iNEMI

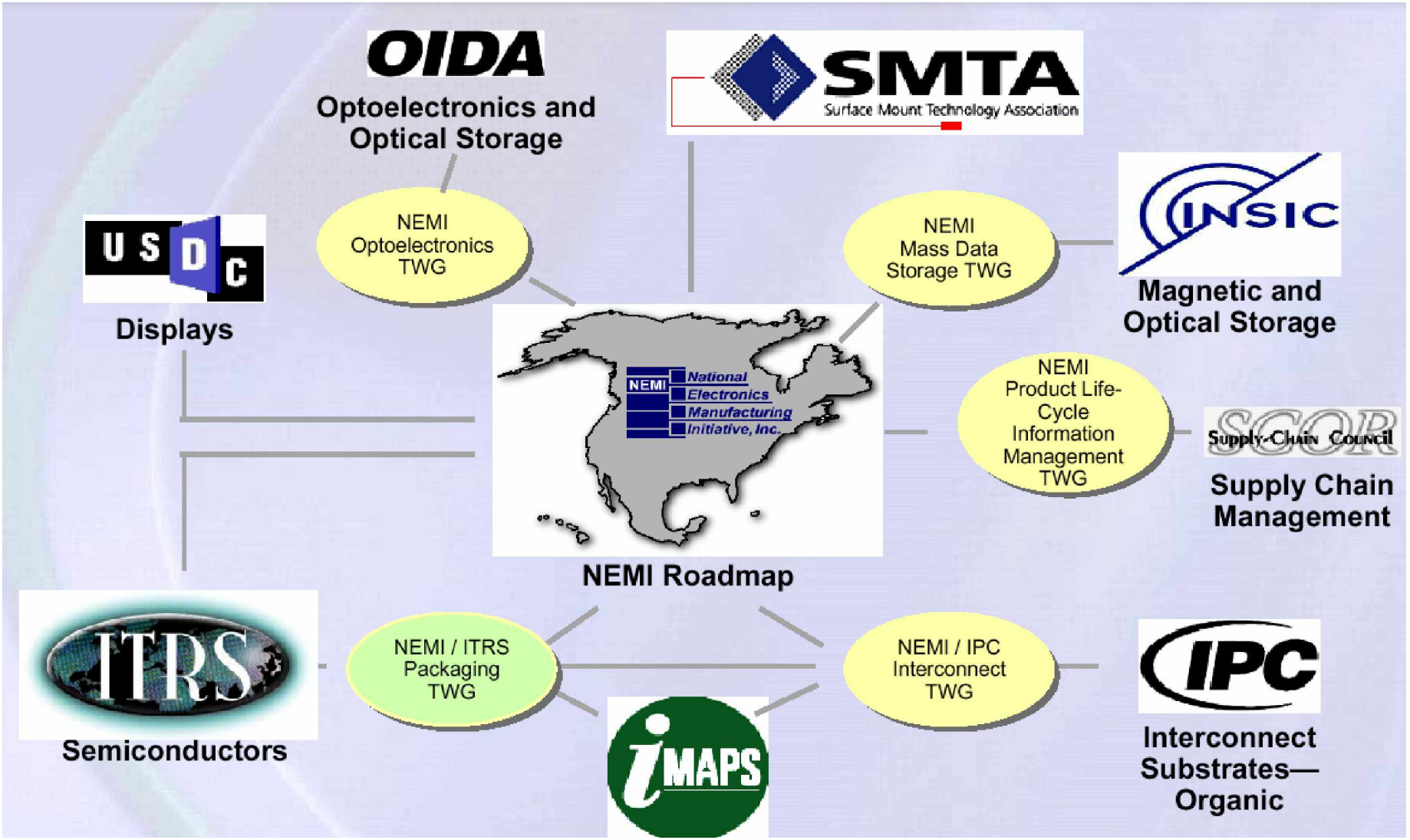
International Electronics Manufacturing Initiative

Active Projects and Research Review

Denis Barbini, Ph.D., Vitronics Soltec

Productronica
Munich, Germany
November 17, 2005

Overview


OIDA
Optoelectronics and Optical Storage
SMTA
Surface Mount Technology Association
NEMI Optoelectronics TWG
NEMI Mass Data Storage TWG
INSIC
Magnetic and Optical Storage
USDC
Displays
NEMI National Electronics Manufacturing Initiative, Inc.
NEMI Roadmap
NEMI Product Life-Cycle Information Management TWG
SCOR
Supply-Chain Council
Supply Chain Management
ITRS
Semiconductors
NEMI / ITRS Packaging TWG
iMAPS
NEMI / IPC Interconnect TWG
IPC
Interconnect Substrates—Organic

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International Electronics Manufacturing Initiative

Pb-Free BGAs in SnPb Process Study

Chair: Robert Kinyanjui, Sanmina-SCI

Co-Chair: Quyen Chu, Jabil Circuit

Pb-Free BGAs in SnPb Process Study

Project Participants: **Agilent Technologies, Alcatel Corporation, Celestica, Inc, Cisco Systems, Inc, Cookson Electronics, Henkel Technologies, IBM Corporation, Jabil Circuit, Inc. Lucent Technologies, Sanmina-SCI Corporation, NIST, Plexus Corporation, Solectron**

Project Justification

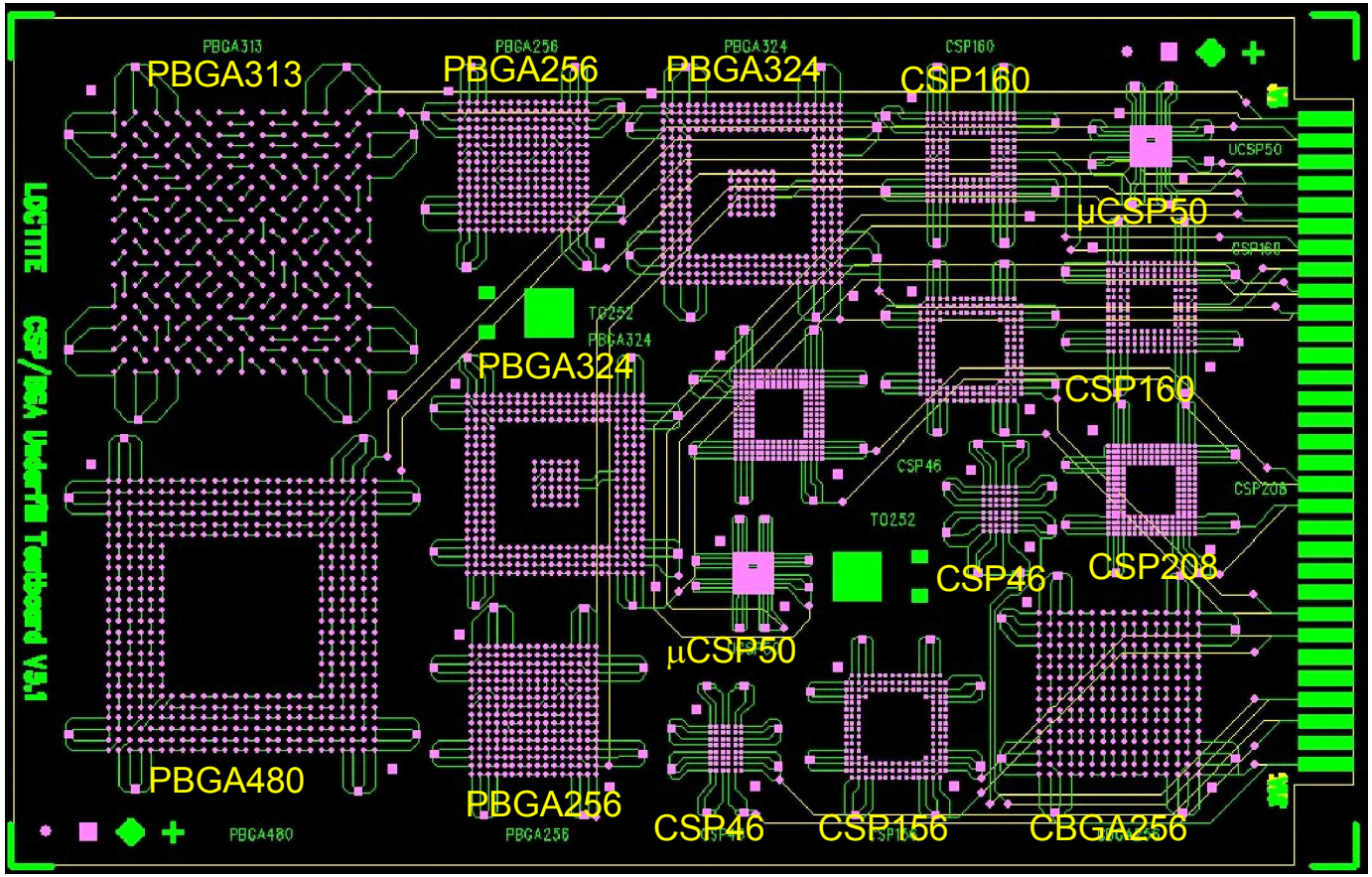
- ✓ For companies choosing to take the RoHS exemption and continue to manufacture SnPb products beyond July 1, 2006, there will be a growing issue with the lack of availability of SnPb components. Many companies may be compelled to use Pb-free BGAs in a SnPb process, for which the process and reliability have not yet been characterized.

Project Objectives

- ✓ To assess the process parameters for assembling Pb-free SnAgCu BGAs under the temperature constraints of a conventional tin-lead (SnPb) assembly process.
- ✓ To understand the reliability of mixed-alloy (SnAgCu in SnPb) solder joints.
- ✓ To develop a “generic” process guideline and risk assessment for assembling Pb-free BGAs in a SnPb assembly process.
- ✓ **Project Target completion date:-November 2006**

Phase 1 Test Vehicle

Phase 1: Characterization of peak temperature and time above Liquidus (TAL) for mixed (SnAgCu in SnPb) solder Joints



✓PBGA 313 and PBGA324 were selected for examination

Phase 2 Components Consideration

Phase 2: Reliability studies of mixed (SnAgCu in SnPb) solder joints

Component Part Numbers	I/O	Pitch (mm)	Size (mm)	Ball Alignment	Quantity per Board	Total Parts
A-SBGA600-1.27mm-45mm	600	1.27	45	Perimeter	3	400
A-PBGA324-1.0mm-23mm	324	1.00	23	Perimeter	3	400
A-CABGA288 0.8mm-19mm	288	0.8	19	Perimeter	3	400
A-CTBGA132-0.5mm-8mm	132	0.5	8	Perimeter	3	400

Note:

- **80 SnPb components of each type will be used for baseline runs.**
- **A range of different component sizes (in pitch) has been selected for study**

Reliability Studies: Accelerated Thermal Cycling Tests (0 to 100C and -40 to 125C), Bend Tests and Microstructural studies through optical and electron microscopy.

iNEMI

International Electronics Manufacturing Initiative

Evaluation of Substrate Surface Finishes for Pb-free Assembly Project

Acting Chair: *Keith Newman, Sun Microsystems*

Co-chair: *Charan Gurumurthy, Intel*

iNEMI Substrate Surface Finishes for Pb-Free Assembly

Objective:

The transition to the use of Pb-free solder alloys introduces new solder joint reliability concerns. The implementation of alternative surface finishes for circuit boards and package substrates compounds these concerns.

Abstract:

This iNEMI project is evaluating the effects of alternative surface finishes for circuit boards and package substrates on Pb-free solder joint reliability. They are conducting comparative four-point bend testing, drop testing and board-level thermal cycling of Pb-free components assembled on test boards.

The test packages include BGA, CSP and QFP devices, manufactured in a variety of Pb-free surface finishes. OSP and immersion Ag surface finishes are being evaluated for the circuit boards. Sn3Ag0.5Cu solder paste has been selected for the component attachment.

Project completion is targeted for late 2006.

Lead-free Surface Finish Project

Project Participants

- Agere, ASE, Cisco, Cookson, Dage, Foxconn, Henkel, HP, IBM, Intel, Lucent, Merix, Plexus, Solectron, Sun, Vitronics-Soltec

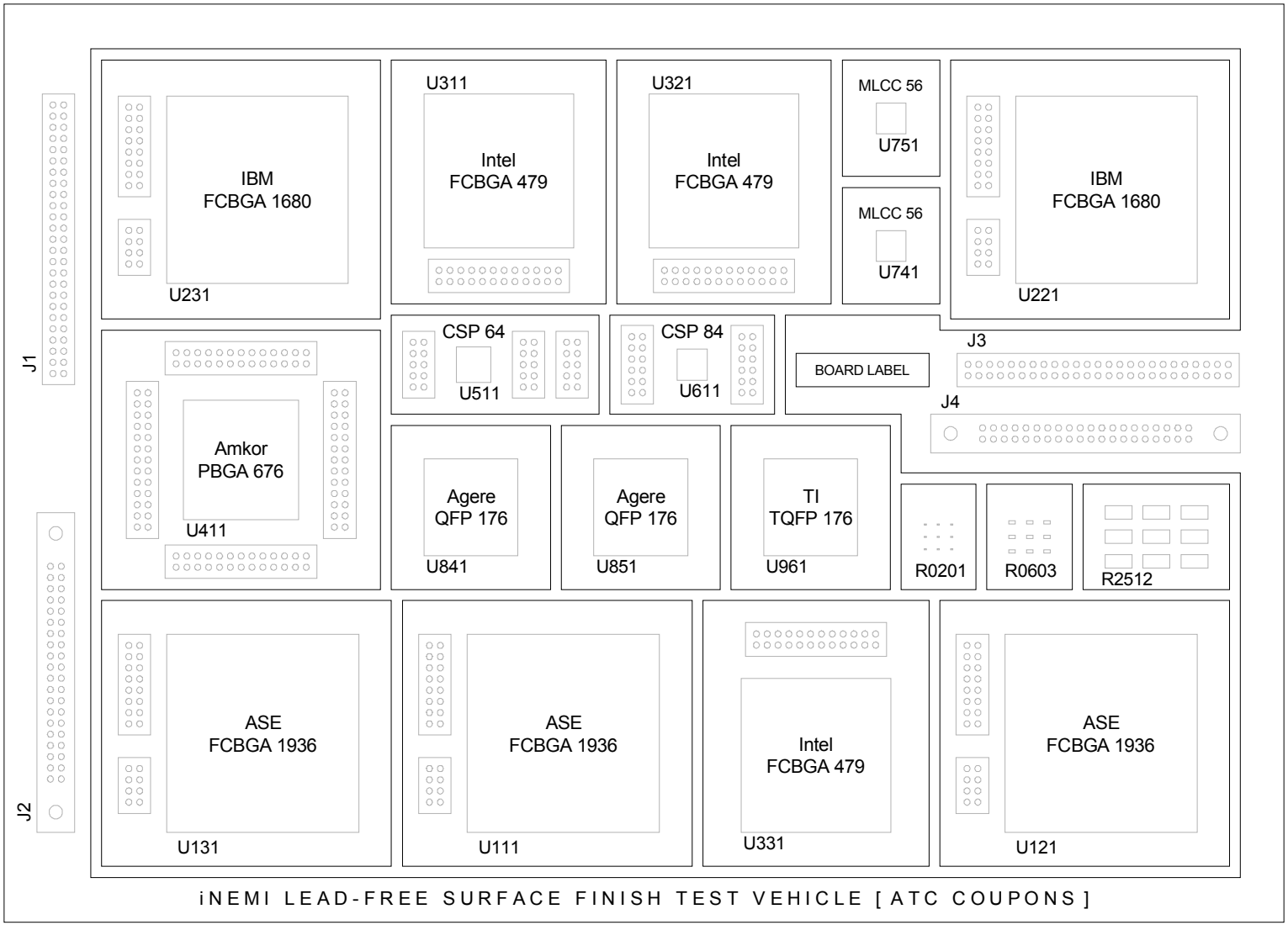
Lead-free Surface Finishes

- PWB Surface Finishes
  - OSP and Immersion Ag
- BGA Substrate Surface Finishes
  - Electrolytic Ni/Au, ENIG, Cu OSP, Solder on Pad, Ni/Pd/Au and Immersion Sn
- Lead-frame Surface Finishes
  - Matte Sn, Matte Sn/Ni and Ni/Pd/Au

Test Details

- Solder Ball Pull/Shear Tests
- Accelerated Thermal Cycling Tests
- Interconnect Stress Tests
- Monotonic Bend Tests
- Drop/Shock Tests
- Failure Analysis

Lead-free Surface Finish ATC Test Vehicle



iNEMI

International Electronics Manufacturing Initiative

Lead Free Wave Soldering Initiative

Chair: *Denis Barbini, Ph.D., Vitronics Soltec*

Co-chair: *Paul Wang Ph.D., Microsoft Corp.*

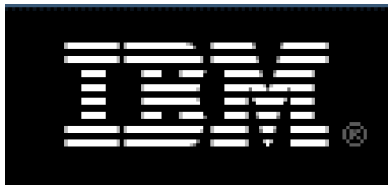
Project Justification

- The focus of the first two NEMI lead free assembly projects focussed on assembly, reliability, and rework of lead free joints. All participants in these two groups identified thru-hole assembly as a gap in the respective project scopes. This project aims to fill in this gap by addressing the lead free wave soldering issue on two levels: process and board level.

Project Objectives

- Phase I will aim to understand and characterize process-related challenges and material impact based on a low cost, representative test vehicle. The purpose of characterizing the lead free wave process in Phase I is to optimize process parameters for Phase II where solder joint performance will be evaluated based on a specific, optimized lead free wave soldering process.
- Phase II encompasses the development of the GTLO test vehicle which is characterized by a complex network of components assembled upon varying board construction complexity. The purpose of the GTLO assembly will be to characterize joint performance.

Member Companies



Phase I

- **Cookson Test Vehicle design “Skate”.**

Board Specification

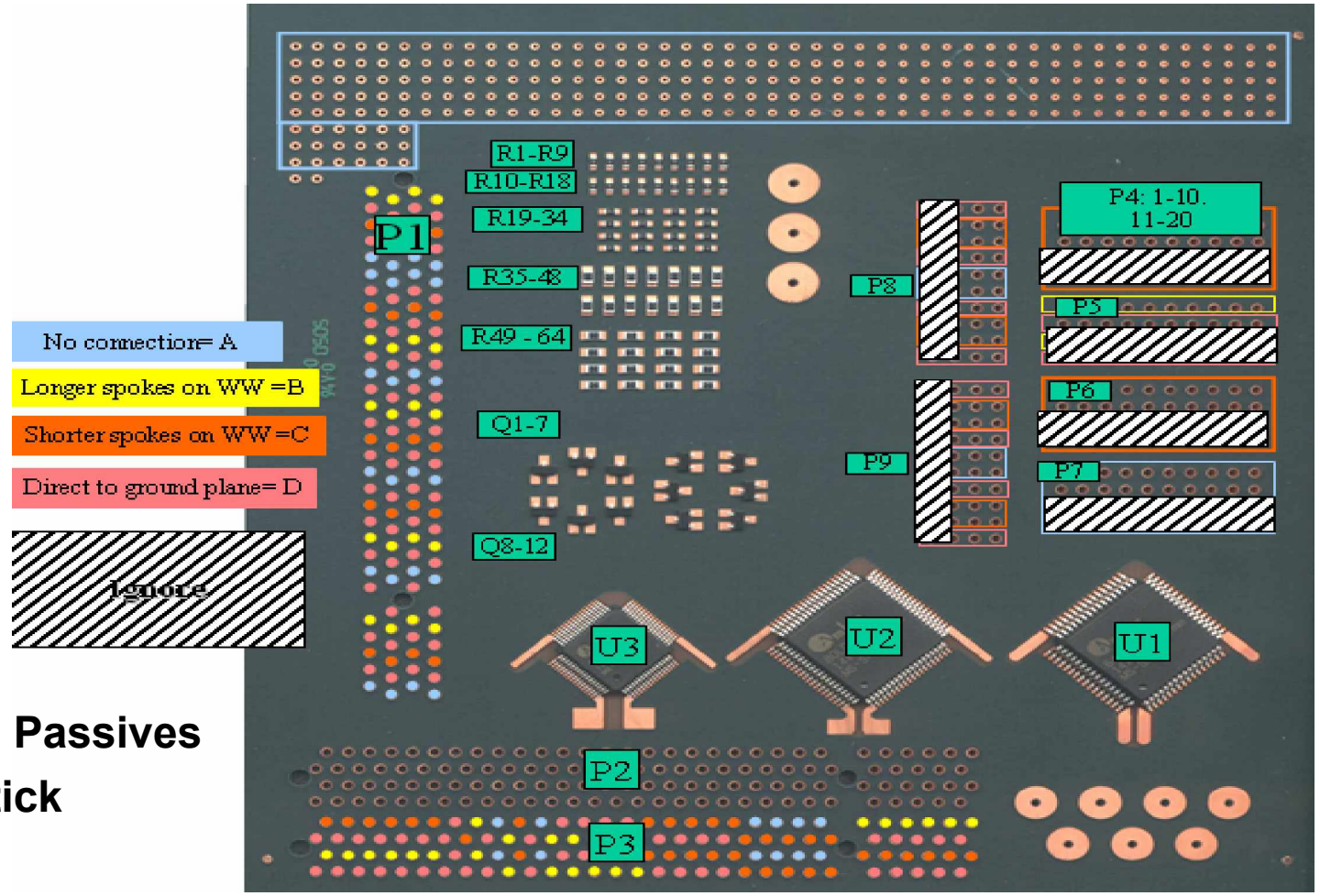
- 64 mil
- 93 mil
- 135 mil
- CuOSP
- HASL

Alloys

- SAC 305
- SACx
- Sn100C
- SnPb

Components

- QFP’s, SOT, Passives
- PCI, Berg Stick

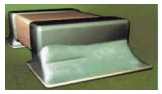
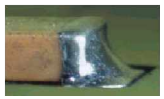
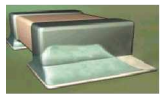
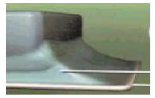
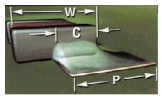
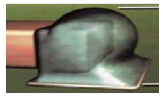


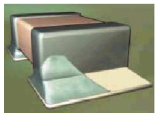
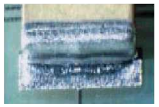
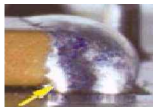
Process Optimization for Lead Free

- Designed an experiment to investigate the impact of various materials and process parameters on joint formation with specific focus on thru-hole penetration.
- Experiment was executed in March 2005 at Vitronics Soltec.

Std Order	Atmosphere	Belt speed	Preheat Temp	Flux Quantity	Flux Type	Chip Wave	Solder Temp	PCB Thickness
1	N2	3	100	1 low	VOC Free	on	255	0.062
2	N2	3	110	2 med	Alcohol	off	265	0.094
3	N2	2	130	3 high	WS	on	275	0.135
4	N2	3.5	90	1 low	Alcohol	off	275	0.135
5	N2	4.5	110	2 med	WS	on	255	0.062
6	N2	4.5	130	3 high	VOC Free	on	265	0.094
7	N2	5	100	2 med	VOC Free	on	265	0.135
8	N2	6	110	3 high	Alcohol	on	275	0.062
9	N2	6	130	1 low	WS	off	255	0.094
10	Air	3	90	3 high	WS	off	265	0.062
11	Air	3	115	1 low	VOC Free	on	275	0.094
12	Air	2	130	2 med	Alcohol	on	255	0.135
13	Air	4.5	90	2 med	WS	on	275	0.094
14	Air	3.5	115	3 high	VOC Free	off	255	0.135
15	Air	4.5	130	1 low	Alcohol	on	265	0.062
16	Air	6	90	3 high	Alcohol	on	255	0.094
17	Air	5	110	1 low	WS	on	265	0.135
18	Air	6	130	2 med	VOC Free	off	275	0.062

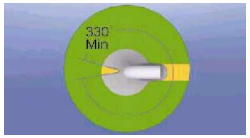
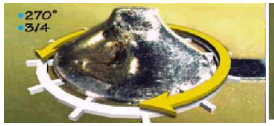
Inspection Criteria for SMD's

Score	End Joint Width, min	Fillet Height, min	Fillet Height, max
0 = Perfect	As wide as lesser of terminal/land width	Fillet height = solder thickness +75% terminal height. Wetted.	Fillet height = solder thickness +75% terminal height. Wetted.
			 0.5 Ref. sample ->
1 = Good	75 - 100% of terminal/land width	Solder thickness + 25-50% term. height. Wetted.	solder height +100% of terminal height.
			 1.5 Ref. sample ->
2 = Fair	50% of terminal/land width	solder thickness + 25% terminal height. Wetted.	fillet overhangs land or top of terminal but not on comp body
			 2.5 Limit sample ->

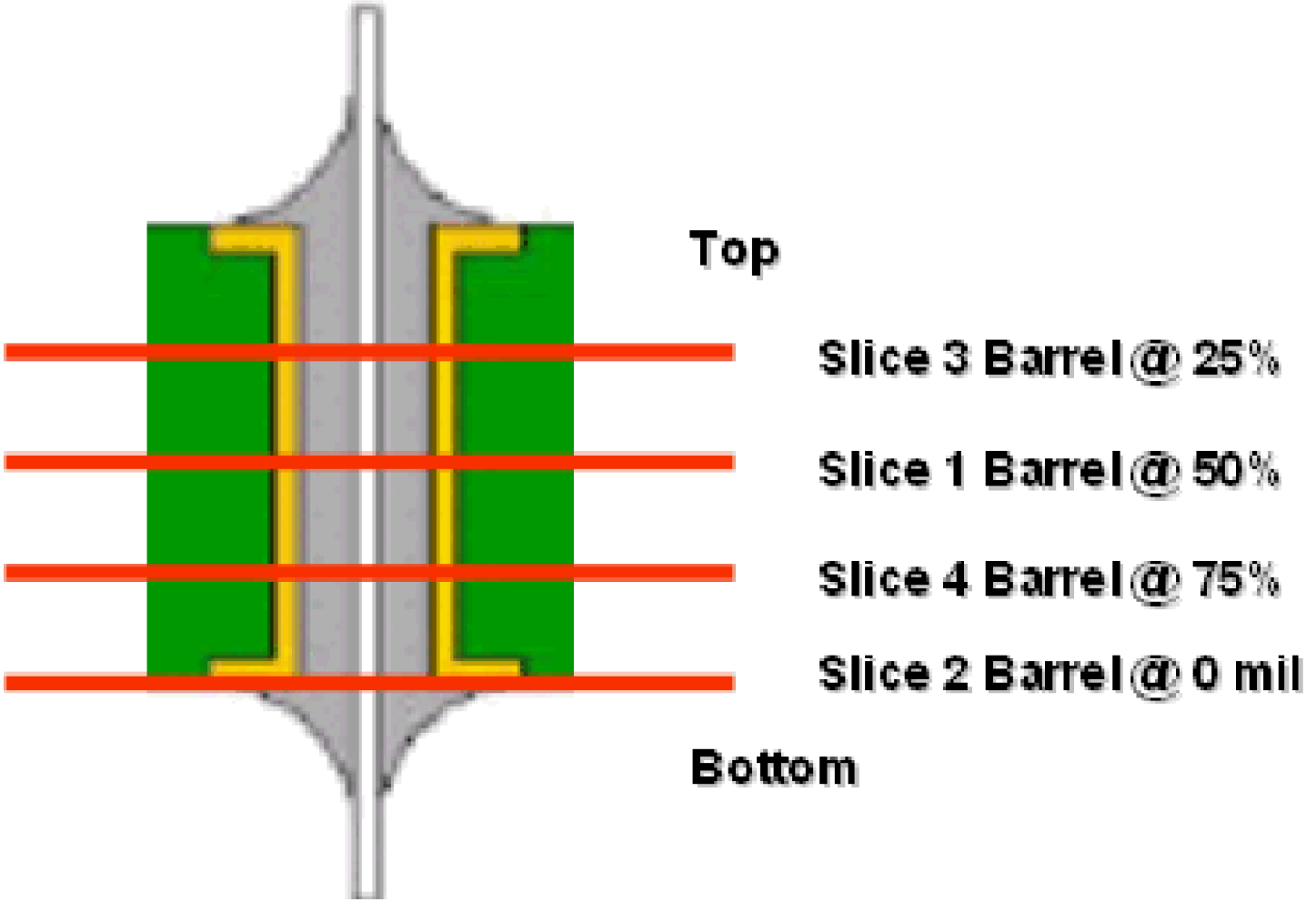
3 = NG marginal	25-50% of terminal/land width	solder thick +slightly <25% terminal height. Poorly wetted.	fillet barely extends onto component body.
			 3.5 Ref sample ->
4 = Bad	<25% of terminal/land width	solder thick + far <25% of term ht.	fillet clearly extends on component body
			4.5 Ref sample ->
5 = Horrible	no connecting joint	no connecting fillet	fillet far extends on and above component body

- **Criteria per IPC-A610-C chapter 6 Solder Acceptibility Requirements (MFG Eng Solder Best Practices website).**

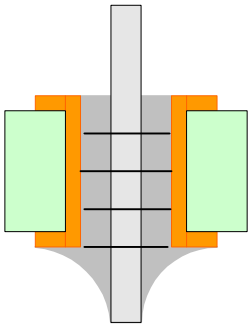
Inspection Criteria for Thru-Hole

Score	Fillet shape	Circumferential Wetting	Land cover %	Solder Balls in 2cm area
0 = Perfect	Concave, <90*cont.angle, wetted	360 * circum.	100% cover	none
				
1 = Good	Concave, 45 - 75* wetted	330 - 360* cricum.	90-100% cover	diam < .005" / 1-3 per area
				
2 = Fair	barely concave, 75 - 90*	270 - 330* circum.	75-90% cover	diam .005<d< .010" / 3-6 per area
				

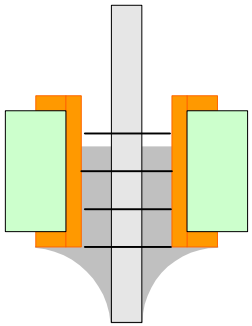
Thru-Hole Penetration Criteria



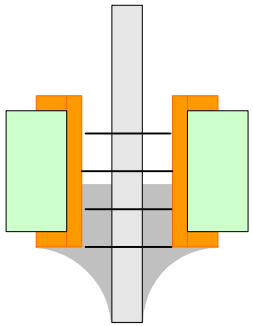
Thru-Hole Penetration Analysis



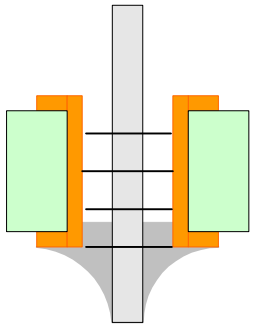
No defect



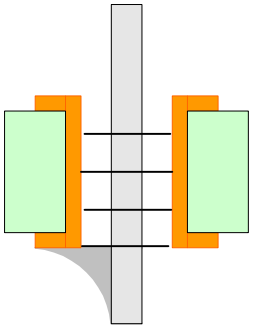
Defect
S3-25%



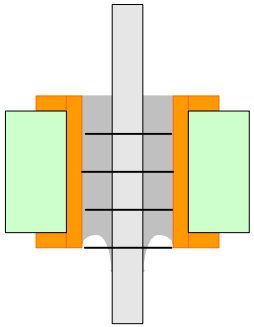
Defect
S3-25%
S1-50%



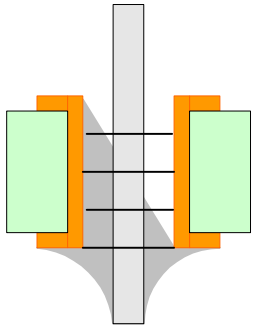
Defect
S3-25%
S1-50%
S4-75%



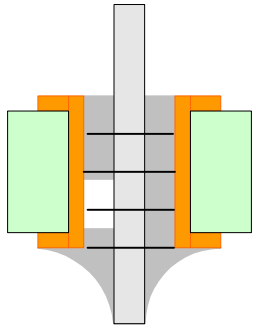
Defect
All Slices



Defect
S2-0%

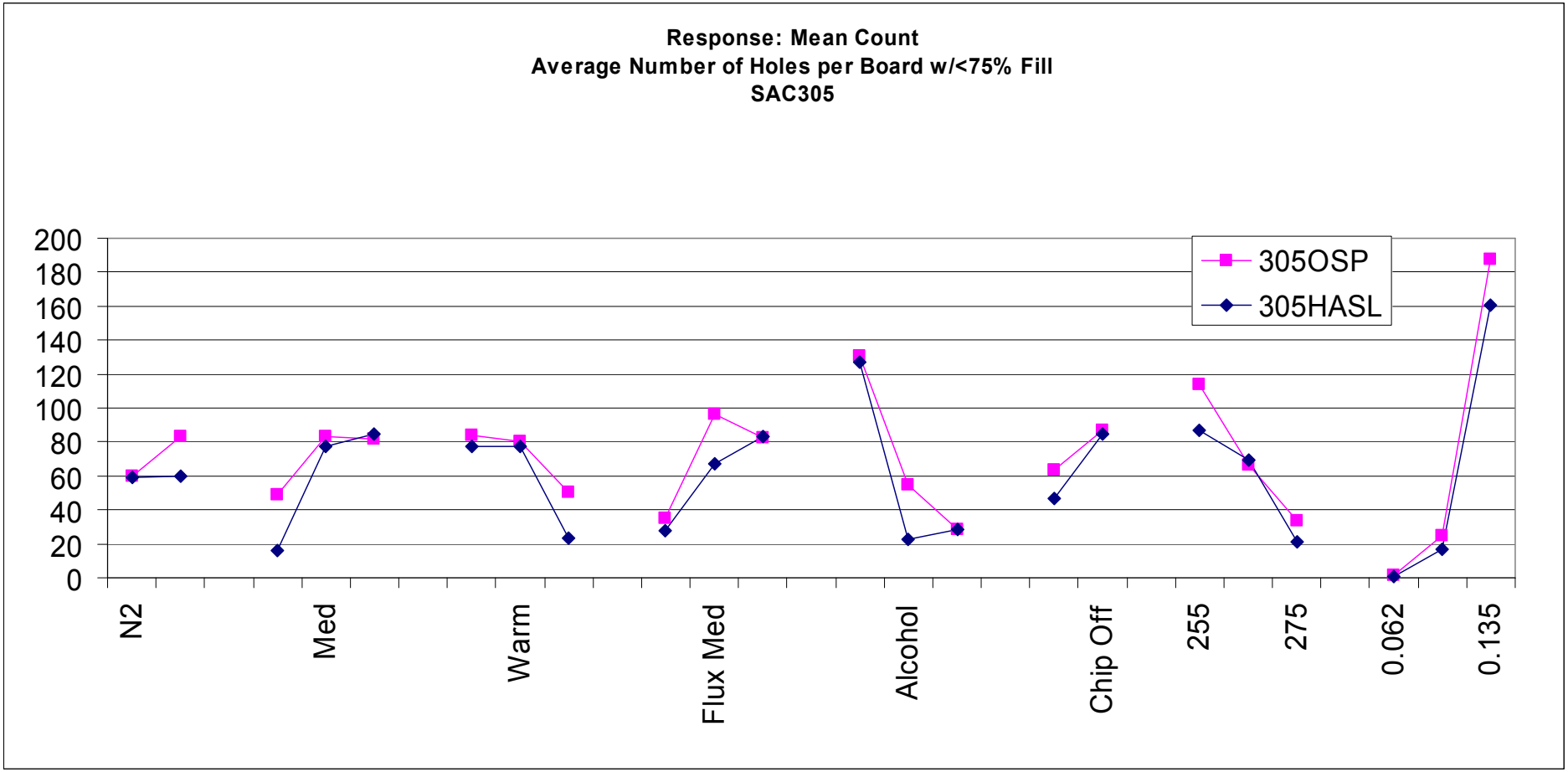


Defect
S3-25%
S1-50%
S4-75%



Defect
S4-75%
Void

Preliminary Results



Conclusions

- Phase I complete yielding an optimized process for lead free soldering using three different lead free alloys.
- Phase II in progress.
- Collaboration with the lead free rework project
- Next Project Release will be at APEX 2006.