



inEMI

International Electronics Manufacturing Initiative

Pb-Free BGAs in SnPb Assembly Process Project

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Jabil*

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Advancing manufacturing technology

Project Scope

- 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.

Objectives

- **Phase 1**

- To assess the process parameters for assembling Pb-free SnAgCu BGAs under the temperature constraints of a conventional tin-lead (SnPb) assembly process.

- **Phase 2**

- 1) Characterize homogeneity of lead-free BGAs in a SnPb process with the following considerations:
 - 1) Package size/ball volume
 - 2) Reflow Temperature
 - 3) Time Above Liquidus
 - 4) Solder paste volume
- 2) Examine the thermal and mechanical reliability of lead-free BGAs in SnPb process

- **Phase 3**

- To develop a “generic” process guideline and risk assessment for assembling Pb-free BGAs in a SnPb assembly process.

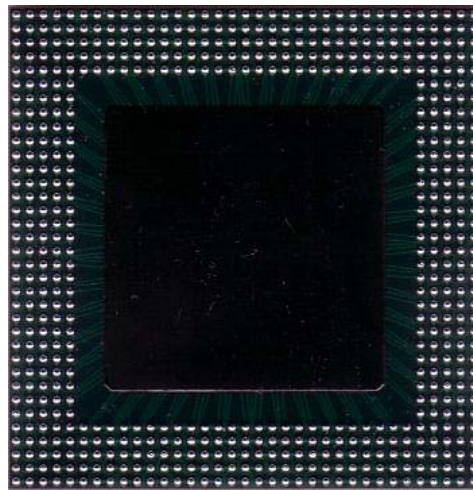
Components Consideration

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

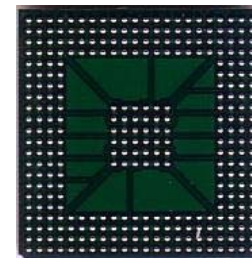
Pb-free BGA ball alloy: SAC405

Note:

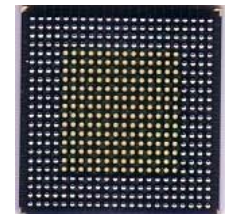
- SnPb components of each type were used for baseline run.



1.27mm
SBGA600



1.0mm
PBGA324



0.8mm
CABGA

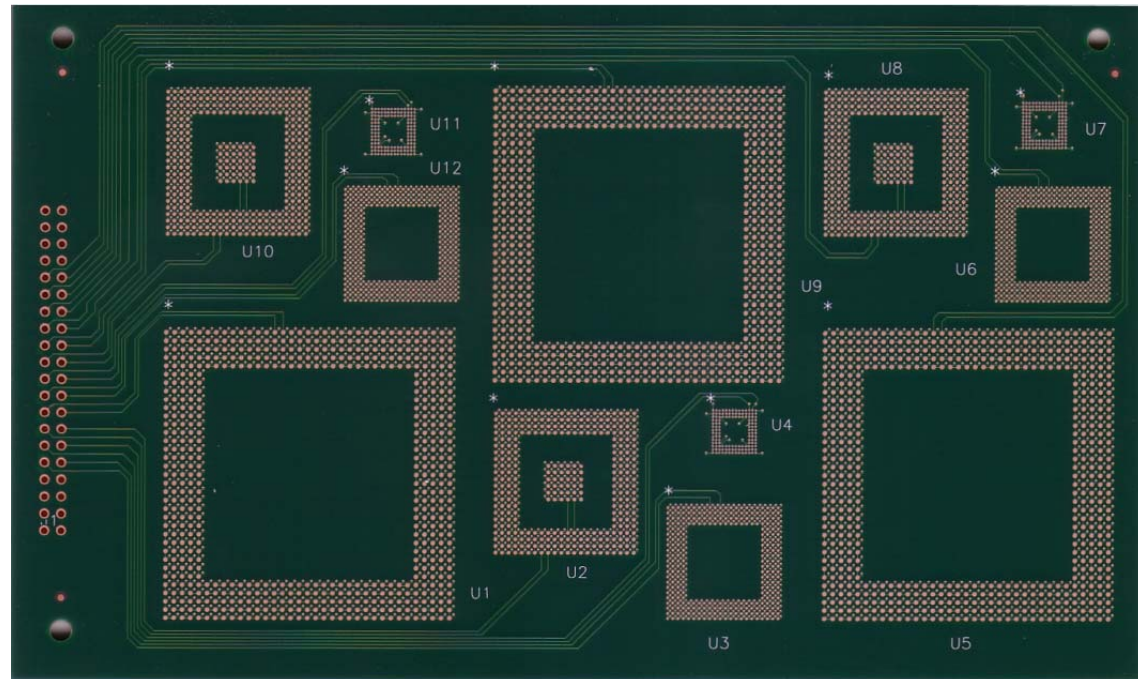


0.5mm
CTBGA132



PCB Laminate

- **PCB Dimensions:**
 - 6.800” x 4.075” x 0.093”
- **Finish**
 - Electroless Nickel Immersion Gold (ENiG)
 - Copper OSP
- **Number of Layers**
 - 18 Internal board Layers
 - 12 Ground [1 oz.] Layers,
 - 6 Signal Layers
- **Tg = 170°C**
- **Td = 340°C**



Bare Test Board

Assembly Consideration

- **Assembly Setup**

- Two thermocouples were placed at the center and corner joints of each component type on a sample test board
- Five profiles were generated
 - Peak Temp: 210C, 215, and 235C
 - Time Above Liquidus (TAL): 60, 90, 120sec

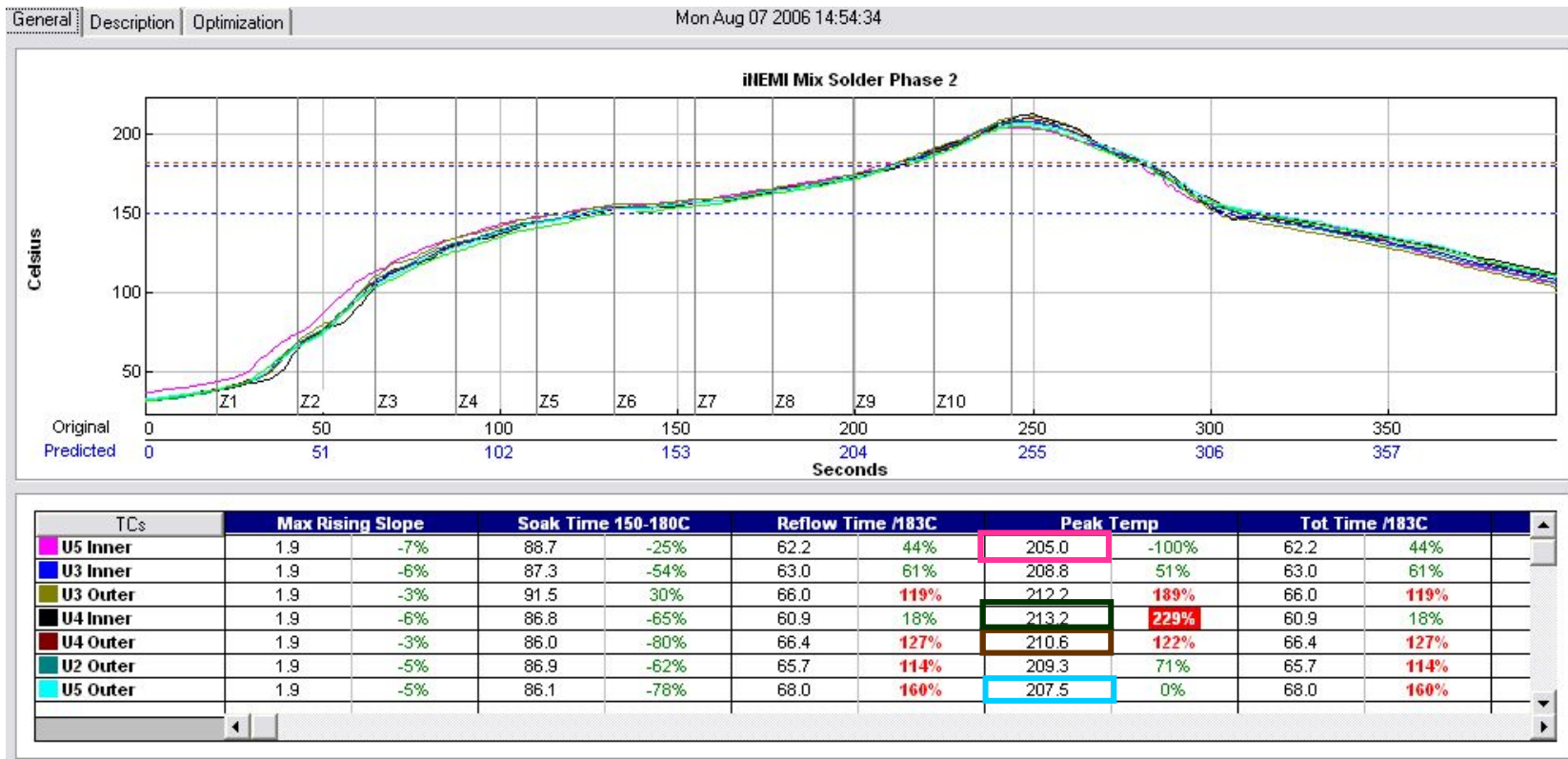
- **Stencil**

- 6 mil foil thick
- Two aperture openings (1:1 and 10% Reduction)
 - For the 0.5mm pitch component, the same aperture opening was used for better paste release (used a 12 mil² opening).

Summary of Assembly Matrix

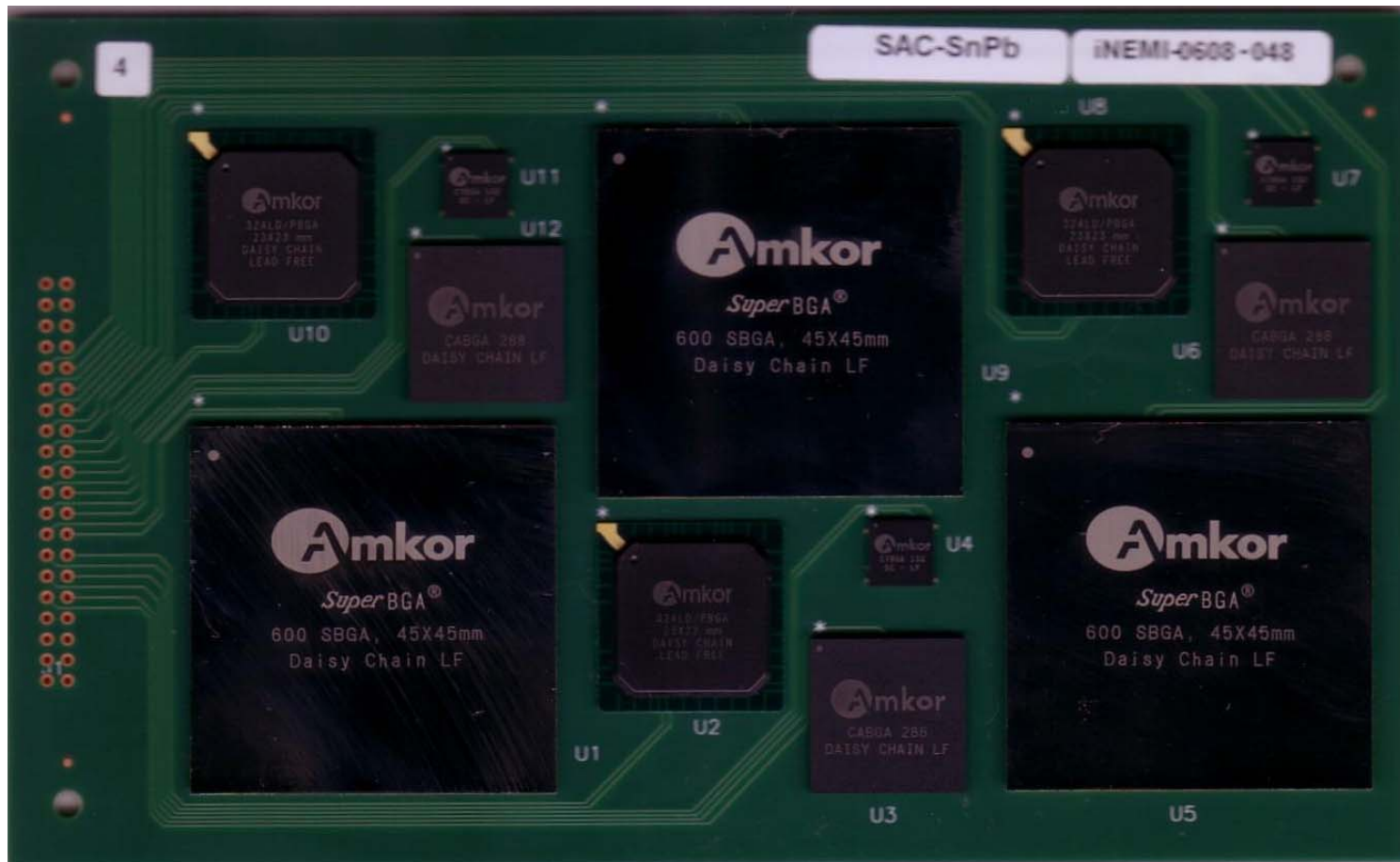
Assembly Process Flow	BGA Ball/ Solder Paste Alloy	Tpeak (°C)	TAL (sec)	Paste Volume (Stencil Opening/Pad ratio)	# of Boards for Initial Test (Dye & Pry and metallography)		# of Boards for Reliability Test				Total # of Boards Built	
							ATC Test (-40 to 125°C)		Mechanical Test (Drop test)			
					ENIG	OSP	ENIG	OSP	ENIG	OSP	ENIG	OSP
1	SnPb/SnPb	210	60	10% Reduction	0	2	3	6	0	5	3	13
2	SAC/SnPb	210	60	10% Reduction	0	2	0	6	0	5	0	13
5				1:1	0	2	3	6	0	5	3	13
3			90	10% Reduction	0	2	0	6	0	5	0	13
6				1:1	0	2	0	6	0	5	0	13
4			120	10% Reduction	1	2	3	6	0	5	4	13
7			SAC/SAC	235	60	10% Reduction	0	2	0	6	0	5
8	SAC/SnPb	215	60	1:1	0	1	0	3	0	3	0	7
# of boards built					1	15	9	45	0	38	10	98

Representative Reflow Profile



Reflow Profile Conditions: Target Peak Temp. = 210°C; TAL = 60sec

Assembled Test Board



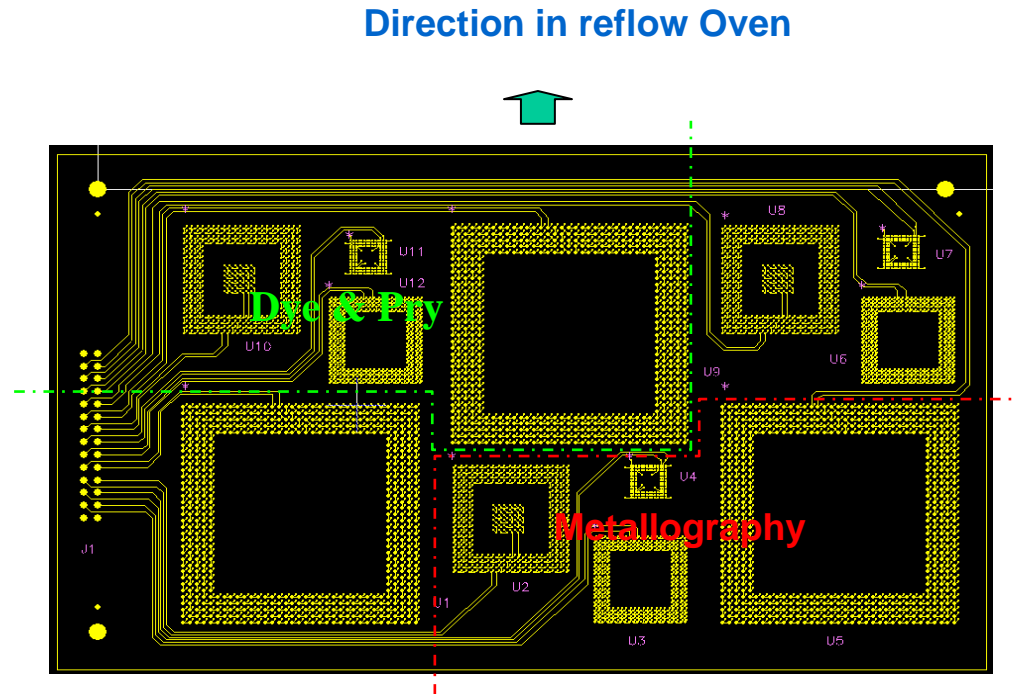
Reflow Profile Conditions = Target Peak Temp. = 210°C; TAL = 60sec

Initial PCBA Analysis

- **Analysis of as-reflowed BGA solder joints integrity through dye & pry and metallography**

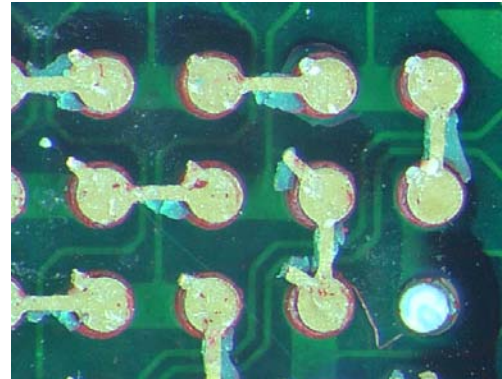
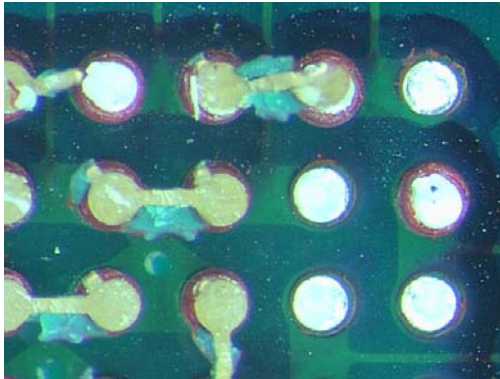
–One board from each of the conditions was subjected to dye & pry followed by metallographic analysis:

- Determine the solder joint structure
- Examine the degree of mixing between SnPb and Sn-Ag-Cu solder alloys
- Characterize the solder joint height/diameter

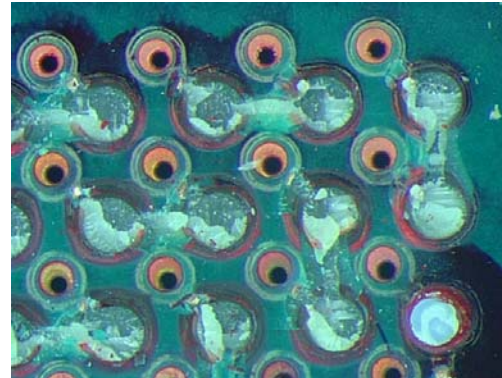
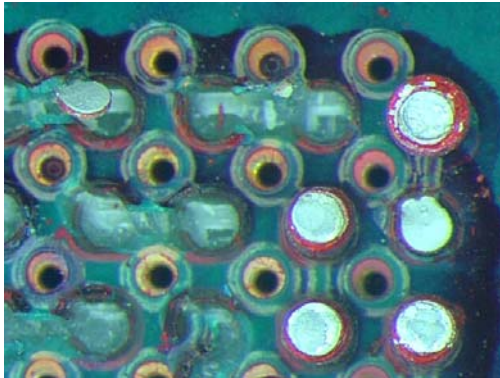


Representative Dye & Pry Results

Package Side



PCB Side



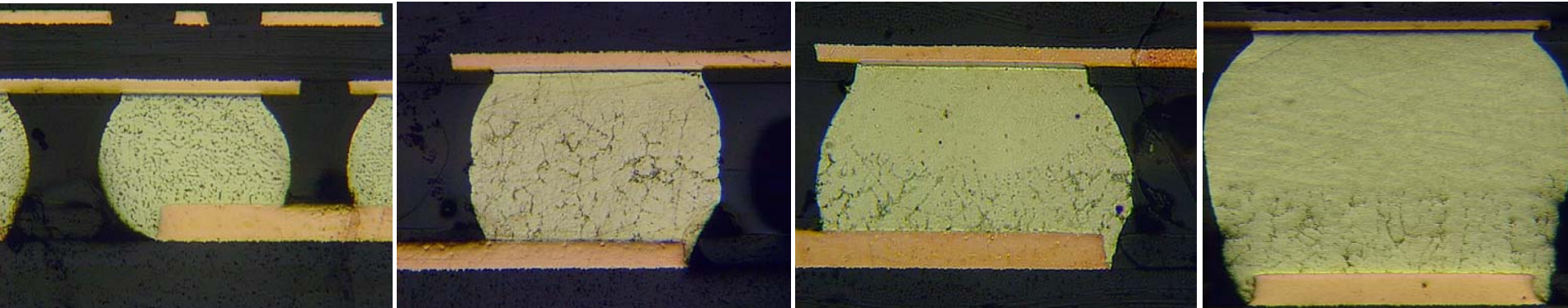
0.8mm
CABGA288

1.0mm
PBGA324

- No dye intrusion was observed  no signs of open joints

Effect of Package Size on the Solder Joint Microstructural Homogeneity @ $T_{peak} = 210C$ & $TAL = 60$ secs

Increasing Package Size 



0.5mm
CTBGA132

0.8mm
CABGA288

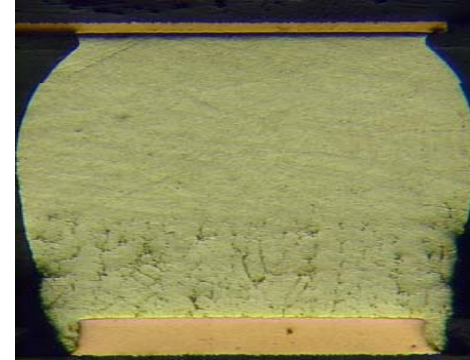
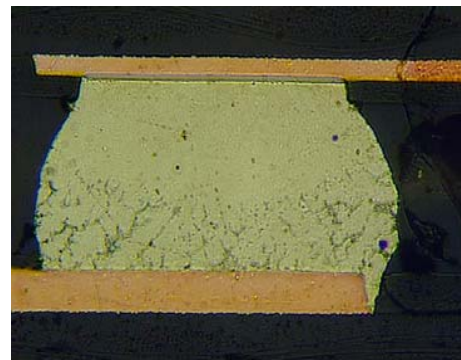
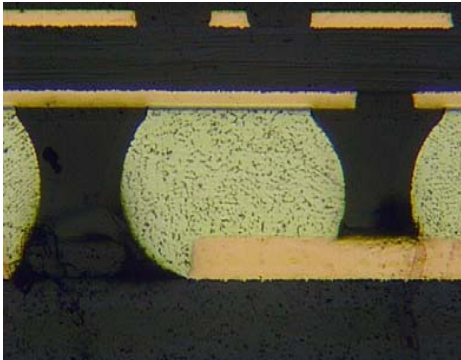
1.0mm
PBGA324

1.27mm
SBGA600

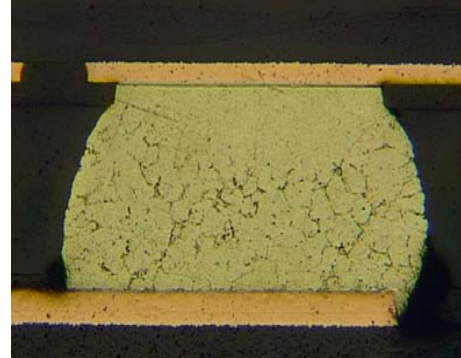
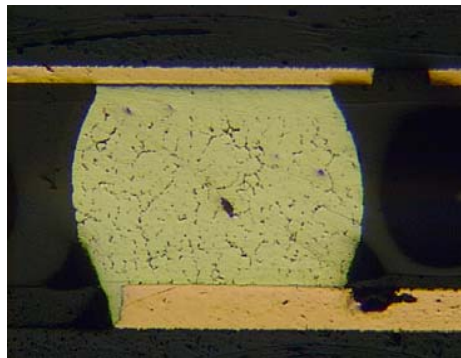
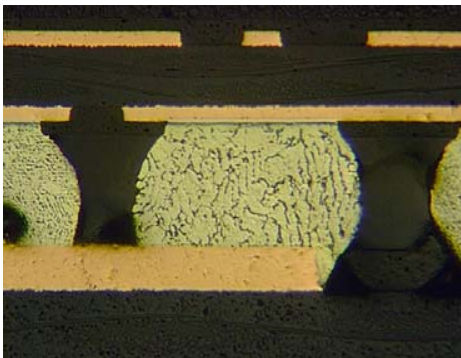
- The degree of mixing decreases with increasing package (or solder ball volume) size.

Effect of Time Above Liquidus (TAL) @ Tpeak = 210C

TAL: 60sec



TAL: 120sec



0.5mm
CTBGA132

0.8mm
CABGA288

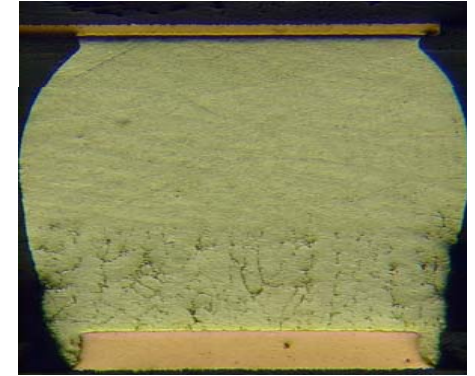
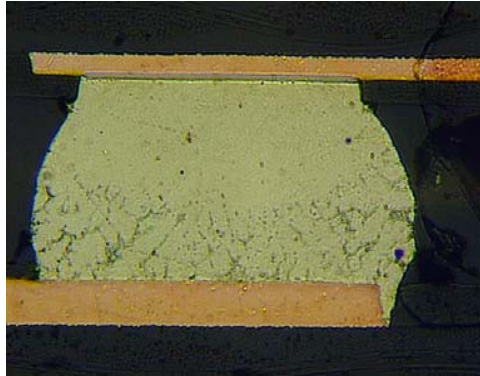
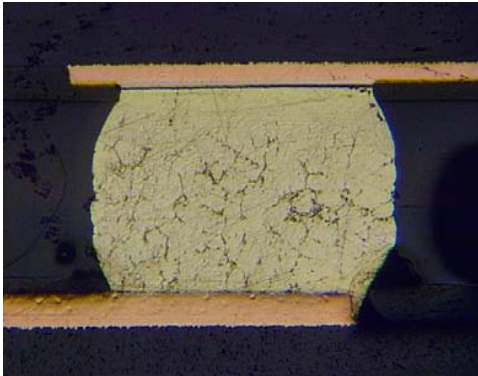
1.0mm
PBGA324

1.27mm
SBGA600

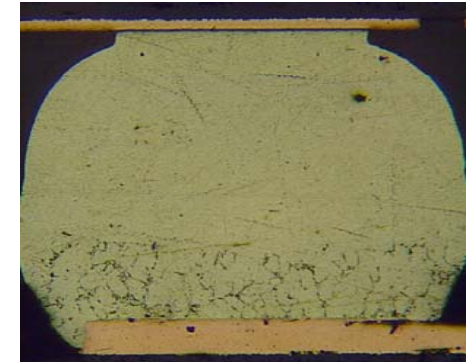
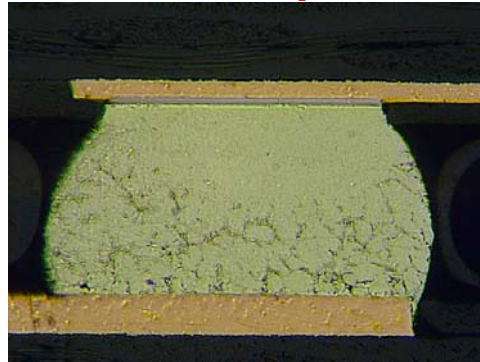
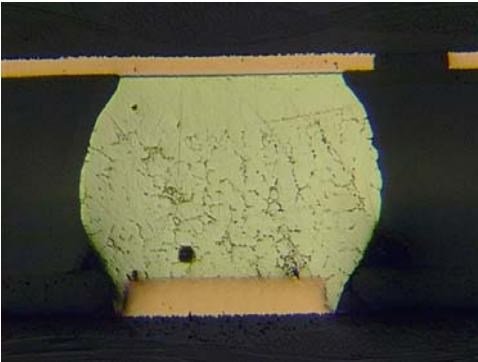
- Doubling the time above liquidus leads to significant increase in the degree of mixing.

Effect of Paste Volume @ 210C/60sec on Degree of Mixing

10% Paste Reduction



1:1 Paste Aperture



0.8mm
CABGA288

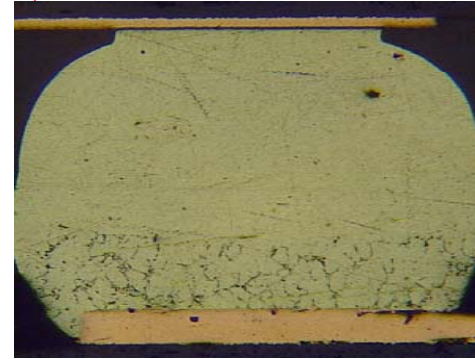
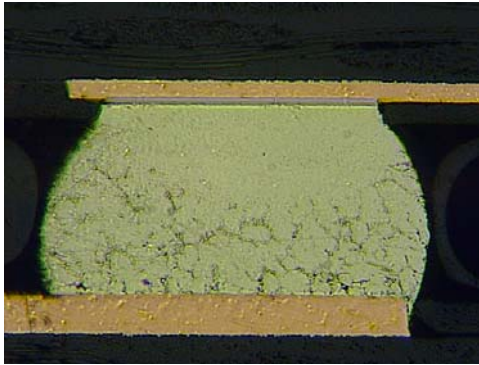
1.0mm
PBGA324

1.27mm
SBGA600

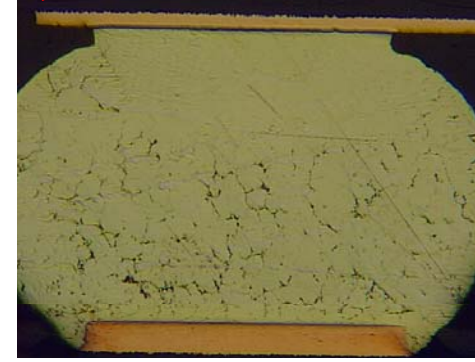
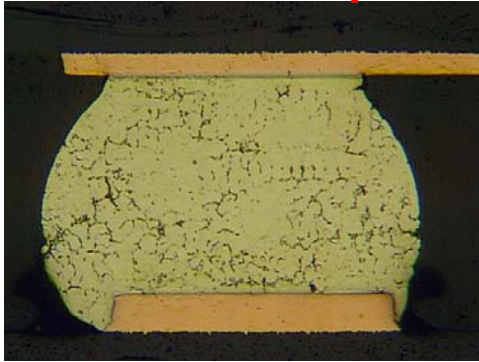
- Little or no discernable difference is observed in the degree of mixing for the largest package (SBGA600).

Effect of Peak Temperature on Degree of Mixing

T_{peak} = 210C, TAL = 60sec



T_{peak} = 215C, TAL = 60sec



**1.0mm
PBGA324**

**1.27mm
SBGA600**

- Increasing the peak temperature by 5°C with TAL = 60 sec, leads to an increased degree of mixing for both PBGA324 and SBGA600.

Summary of Observations

- **The larger the package/ball volume, the lower the degree of mixing observed.**
 - **CTBGA132 (0.5mm Pitch) showed a 100% mixing at 210°C and 60sec time above liquidus**
- **Doubling the time above liquidus (from 60sec to 120sec), increased the degree of mixing (~30% increase in mixing was observed).**
- **For the small packages (reduced SAC solder ball volume), increased paste volume corresponds to increased degree of mixing.**
 - **However, for the largest (SBGA600) package no significant change in mixing was observed.**
- **Increasing the peak temperature from 210°C to 215°C led to a significant increase in the degree of mixing (almost doubled) the extent of mixing.**


Project Status


- **Phase 1: Completed and report presented at APEX 2006**
- **Phase 2:**
 - **ATC: -40 to 125°C (currently @ ~ 2000 cycles) testing**
 - **Failure analysis is in progress**
 - **Mechanical test (Drop Test) is in progress**
- **Phase 3:**
 - **“A Mixed Soldering Guidelines Document” will be released as part of the final project report**

Phase 2 Project Time-line

Activities/Ownership

- Reliability Test:
(Thermal test)
Project Members
- Sourcing of Components:
Project Members
- Laminates:
Tyco Electronics
- Assembly Service:
Jabil Circuit Inc.
- Mechanical testing
(Drop test):
Henkel Technologies
- Failure Analysis
(75 X-sections)
Optical & Electron
Microscopy work)
Celestica

 Activity cleared to go

 Yet to confirm start date

	1.5 Months	1 Month	2 Months	4 Months	2 Months	2 Month
Comp. & PCB Procurement	Assembly	Preliminary Analysis	Reliability Testing	Failure Analysis	Final Report Write-up	
BGA Components High T _l and T _g PCB Laminate	Single Sided SMT Assembly	Optical Analysis X-ray Analysis Dye and Pry Cross-Section Analysis	ATC:-40<-+125°C for 3000 Cycles Mechanical test: Drop Test	Dye and Pry Cross-Section Analysis Metallographic Analysis	Word Doc Presentation	

Closed

In-Progress

August 15, 2006

Nov 1, 2007



Project Participants



SANMINA-SCI

