Comparison of Copper Erosion at Plated Through-Hole Knees in Motherboards Using SAC305 and an SnCuNiGe Alternative Alloy for Wave Soldering and Mini-pot Rework

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Abstract
Copper erosion from plated through holes (PTH) barrels in printed circuit boards (PCB) during both wave soldering and mini-pot rework can increase the risk of PTH reliability failures during field use. Alternative Alloys are being touted as one solution to reducing copper erosion. This study will compare the copper erosion resulting from use of one alternative alloy in wave soldering and mini-pot rework with the currently used SAC305 solder alloy. The PTH knee thickness will be measured on as-received boards, after wave soldering and after one 45 second cycle of mini-pot rework, and compared with the minimum PTH thickness necessary to meet product reliability requirements. The board test vehicle for this study has a thickness of 93 mils (2.362 mm) and its design is similar to a mid-size server board. The SnCuNiGe alternative alloy was chosen from the results of the previous investigation that compared 5 different alloys for the magnitude and variation in copper erosion from PTH knees when subjected to a mini-pot rework cycle, without prior wave soldering [1]. While the mean value of the copper erosion data sets from all 5 alloys did not show any technically significant difference, a particular alloy exhibited significantly lower variation in copper erosion data at the PTH knees. A comparison of this alloy with the SAC305 alloy for PTH knee copper erosion under actual wave solder and mini-pot rework process conditions was required.

Introduction
Copper dissolution and erosion at the PTH knee can be a serious reliability issue if there is not enough copper left after wave solder and mini-pot rework. This issue is exacerbated for thick boards with many copper planes, such as server boards. Previous studies [2-4] have shown when the copper at the PTH knee goes below 0.5 mils (12.7 µm) cracks will form after temperature cycling and possibly result in electrical opens at the solder joint.

There are many parameters that can play a role in reducing the copper thickness at the PTH knee during wave soldering and mini-pot rework. The main parameters are pot temperature, solder contact time and solder flow rate. Some other effects on final copper thickness after processing are the copper plating processes, initial copper thickness and the solder flow type (laminar or turbulent). In the mini-pot rework process the solder flow out of the nozzle is not uniform across its length. The middle area has a higher flow than the ends and this directly impacts the copper left at the PTH knees [5-7].

There are various methods for minimizing the impact of copper erosion on board processing through the wave solder and when required, the mini-pot rework station. One method is using alternate alloys that reduce the copper erosion rate during board processing. From a previous mini-pot rework experiment using four alternate alloys on bare boards, one alloy had a low variation at the PTH knee and a low amount of solder dross. The focus of this paper is on how this SnCuNiGe alloy performed in both wave solder and mini-pot rework.

Experimental Setup
An existing 14 x 18 inch (355.6 x 457.2 mm) server test board (designed from an actual product) that has daisy chained patterns on the bottom of the board at the PTH connector locations was used. This board is 10 layers, immersion silver finish and is 0.093 inch (2.36 mm) thick. Complimentary daisy chained edge cards were used to verify electrical continuity after wave solder and mini-pot rework. Two connector types were examined in this experiment, PCI Extended and FBDIMM. These were selected because they were the two longest connectors on the test board. The pin hole diameter for the PCI Extended connector was 40 mils (1.016 mm) and the FBDIMM pin hole diameter was 28 mils (0.7112 mm). Figure 1 shows the server test board used for this experiment with connector cross-section locations identified.

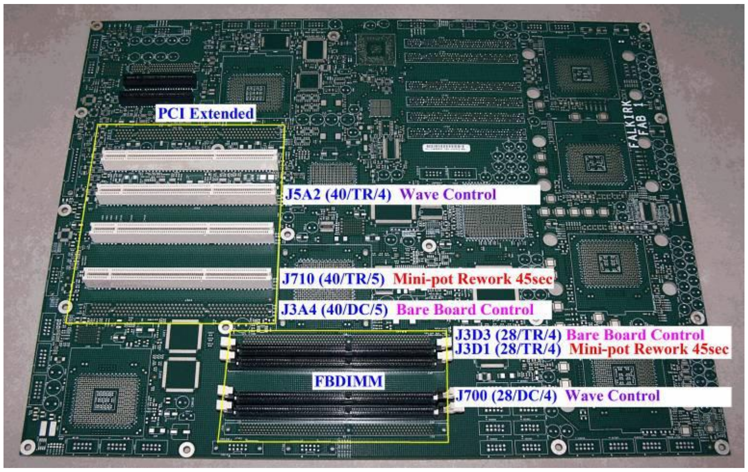


Figure 1 – Server Test Board with Connector Cross-section Locations Labeled

This experiment had three legs using two wave solder alloys and two mini-pot solder alloys. All boards were from one vendor and manufactured date code. The first experimental leg was the control leg consisting of a SAC305 wave solder alloy and SAC305 rework alloy. This is the most widely used solder alloy-process combination in the industry today. The second experimental leg consisted of a SAC305 wave solder alloy and SnCuNiGe rework alloy. This only requires a change in the solder alloy in the mini-pot. The final experimental leg consisted of a SnCuNiGe wave solder alloy and SnCuNiGe rework alloy. This requires a change in both wave solder and the mini-pot compared to what is currently used. Table 1 shows the experiment setup for each leg.

Table 1 – Experiment Setup

Experimental Leg	Board Quantity	Wave Solder Alloy	Mini-pot Solder Alloy
1	3	SAC305	SAC305
2	3	SAC305	SnCuNiGe
3	3	SnCuNiGe	SnCuNiGe

The SAC305 wave soldering process for experimental legs 1 and 2 was run on Intel Corporations internal manufacturing line and the SnCuNiGe wave soldering process for experimental leg 3 was run at an outside facility. Table 2 shows the wave solder process setup for each alloy.

Table 2 – Wave Solder Process Parameters

Wave Process	Wave Soldering Machine	Flux	Flux Application	Top Side Preheat Temp	Atmosphere	Pot Temp	Chip Wave	Main Wave	Dwell Time (sec)
SAC305 (Internal)	Vitronics Soltec®	Kester 979® (No Clean)	High Pressure Spray	130-135°C (266-275°F)	Nitrogen	265°C (509°F)	Off	On	5.1
SnCuNiGe (External)	Electrovert Econopak Gold®	AIM 715® (Organic Acid)	Foam Fluxer	130-135°C (266-275°F)	Air	265°C (509°F)	Off	On	5.0

The mini-pot rework was run at Intel Corporation on our machine. A modified baffle was used to reduce the solder flow out of the rework nozzle in the middle of the connector. Figure 2 shows this modified baffle. Equipment and machine settings are shown in Table 3.

Figure 2 – Modified Solder Mini-pot Baffle

Table 3 – Mini-pot Equipment and Machine Settings

Equipment/Material Description	Model/Part #	Temperature Setting
LF Solder Mini-pot (Air-Vac®)	PCBRM12	530°F (277°C)
Rework Nozzle (Air-Vac®)	FWL19-192	N/A
Preheat Oven (Yamato®)	DKN 600	293°F (145°C)
Flux (Kester®)	186-15	N/A

The SAC305 alloy mini-pot rework step for experimental leg 1 was run first. The pot was then drained and cleaned before the SnCuNiGe alloy was added. The rework step for experimental leg 3 was run first after the alloy change was made. The rework step for experimental leg 2 which contained the SAC305 wave boards was run last. This was done to minimize any SAC305 solder contamination in the mini-pot. All PCI Extended and FBDIMM connectors were reworked as fast as possible then left on the pot to complete 45 seconds total time. The 45 second rework time was selected to allow a significant amount of time margin for each rework. A resistance check was conducted after all the rework was completed. All mini-pot connectors reworked with the SAC305 alloy had electrical opens except for one PCI Extended connector. All connectors reworked with the SnCuNiGe alloy passed electrical tests. Table 4 shows the results of electrical tests and resistance opens for all the mini-pot rework.

Table 4 – Mini-pot Rework Results at 45 Seconds

Experimental Leg	Board #	Connector Type	Resistance Test	Number of Electrical Opens
SAC305 Wave / SAC305 Rework	1	PCI Extended	Fail	4
		FBDIMM	Fail	18
	2	PCI Extended	Fail	3
		FBDIMM	Fail	1
	3	PCI Extended	Pass	0
		FBDIMM	Fail	9
SAC305 Wave / SnCuNiGe Rework	1	PCI Extended	Pass	0
		FBDIMM	Pass	0
	2	PCI Extended	Pass	0
		FBDIMM	Pass	0
	3	PCI Extended	Pass	0
		FBDIMM	Pass	0
SnCuNiGe Wave / SnCuNiGe Rework	1	PCI Extended	Pass	0
		FBDIMM	Pass	0
	2	PCI Extended	Pass	0
		FBDIMM	Pass	0
	3	PCI Extended	Pass	0
		FBDIMM	Pass	0

Sample Preparation and Measurement Method

All cross-sections were ground and polished from an outer row across the total length of the connector to the center of the pin. The whole PCI connector was cross-section at one time and had very little warpage after potting. The FBDIMM connector was cut into two sections between pins 68 and 70 where the through-hole support pin is located. This ensured that no solder pins would be damaged. This had to be done because some samples showed a large amount of warpage across the whole length of the connector after potting. Figure 3 shows the cross-sectioning locations for both connector types.

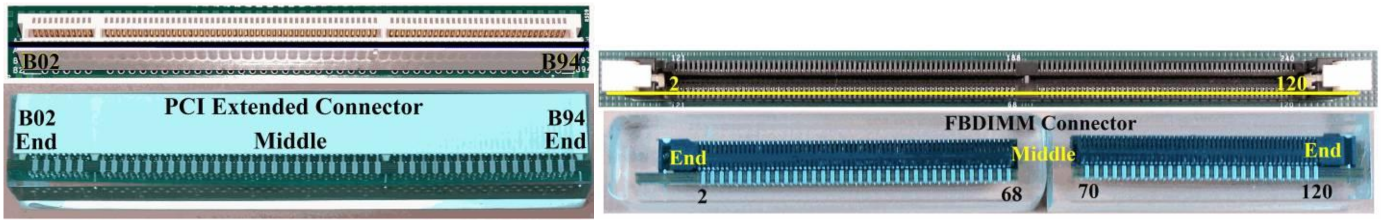


Figure 3 – Cross-sectioning Locations for the PCI Extended Connector (left) and the FBDIMM Connector (right)

Each PTH has a left and right knee in a cross-sectional view. These locations are shown in Figure 4.

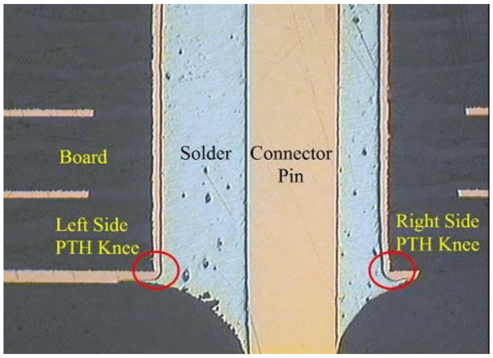


Figure 4 – Cross-section of a Single PTH with a Soldered Connector Pin

At each PTH knee location three measurements were made. These were the lowest copper thickness measurements along the X and Y and in an angular direction. Figure 5 shows the measurement locations within the microscope field of view.

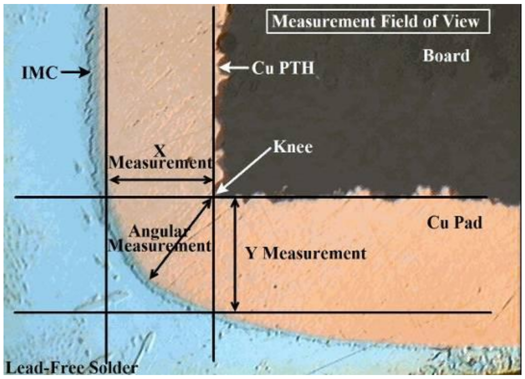


Figure 5 – Copper Thickness Measurements of the PTH in the Knee Region within the Measurement Field of View

Each connector cross-section had the same locations measured each time to keep the data consistent. Figure 6 shows the measurement locations for each connector type with the total number of measurements per location (both right and left sides are included).

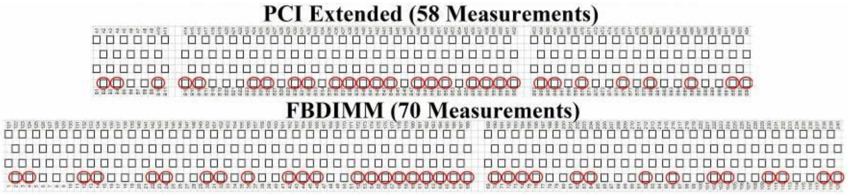


Figure 6 – Measurement Locations for Both Connector Types with the Total Number of Measurements

Experimental Results and Discussion

The first analysis was comparing all three experimental legs with as-received, post wave solder and mini-pot rework copper thickness at the PTH knee. Figure 7 shows the minimum copper thickness measured at the PTH knee for both connector types with corresponding box plots for each data set.

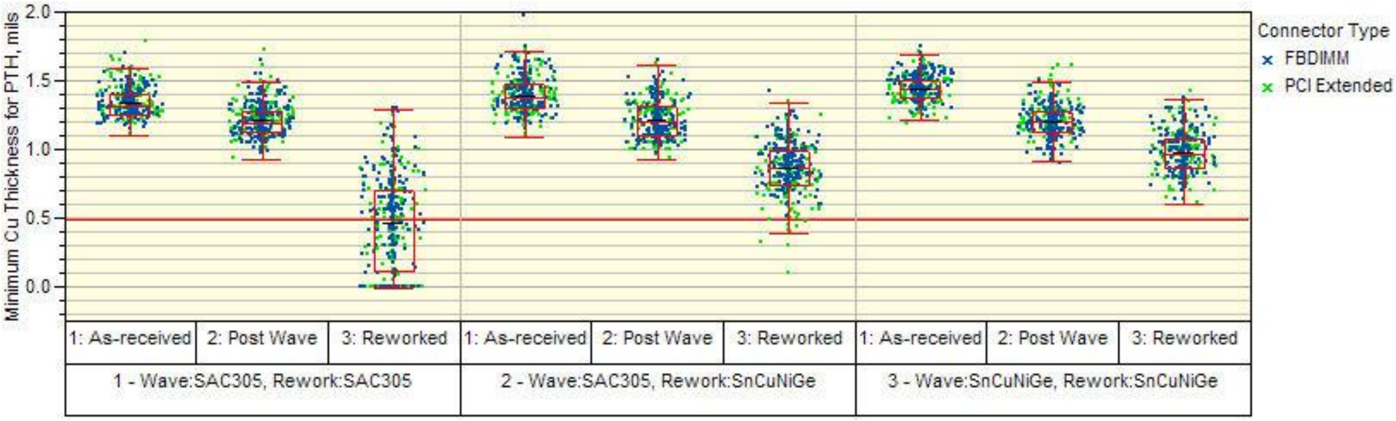


Figure 7 – Comparison of the Three Experimental Legs with As-received, Post Wave and Reworked PTH Cu Thickness

Each box plot has data from 3 boards with both connector types included. The PTH reliability limit for copper thickness at the PTH knee is depicted by the red line at the 0.5 mils (12.7 µm) level. Any copper thickness value measured below this line is a failure.

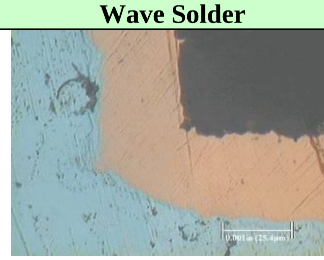
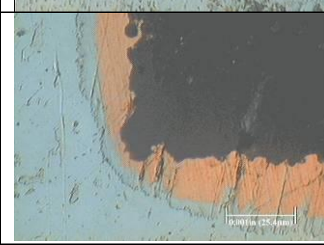
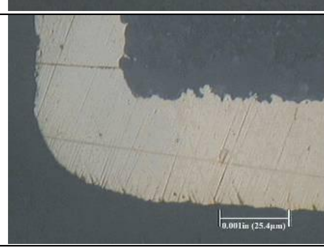
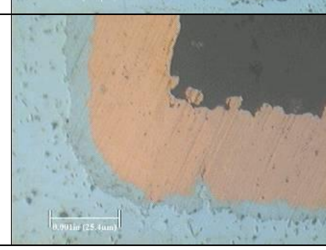
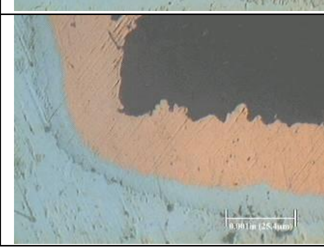
The standard wave solder and mini-pot rework processes presently used at many high volume manufacturing sites utilize SAC305 alloy. The data shows a significant amount of copper loss at the PTH knee during the mini-pot rework process at 45 seconds. About half the data points fall below the 0.5 mils reliability line for both connector types and many have no copper left at the PTH knee. The copper breaks at the PTH knee directly correlate to the electrical opens noted in Table 4. This, of course, is the main issue that is trying to be solved.

The SnCuNiGe mini-pot rework process that used SAC305 wave soldered boards (experimental leg 2) has considerably less copper loss at the PTH knee when compared with the SAC305 mini-pot rework process. However, some of the PCI extended connector measurements fall below the reliability limit for the copper thickness at the PTH knee. Nevertheless, this is a large improvement from the SAC305 mini-pot rework alloy results (experimental leg 1).

The SnCuNiGe process for both wave solder and mini-pot rework (experimental leg 3) shows the least amount of copper loss at the PTH knee. There are no copper thickness PTH knee measurements from either connector type that are below the reliability failure limit.

Table 5 shows photos of PTH knees that exhibited the thinnest copper for the PCI Extended connector after the various process steps for all three experimental legs. The difference in the amount of copper removed at the PTH knee is easily apparent from these photos.

Table 5 – Photos of PTH Knees for the PCI Extended Connector after Various Process Steps

Experimental Leg	Bare Board	Wave Solder	Mini-pot Rework
SAC305 Wave / SAC305 Rework			
SAC305 Wave / SnCuNiGe Rework			
SnCuNiGe Wave / SnCuNiGe Rework			

The number of PTH failures per experimental leg was counted for each board. Figure 8 shows a plot of the number of these failures after mini-pot rework.

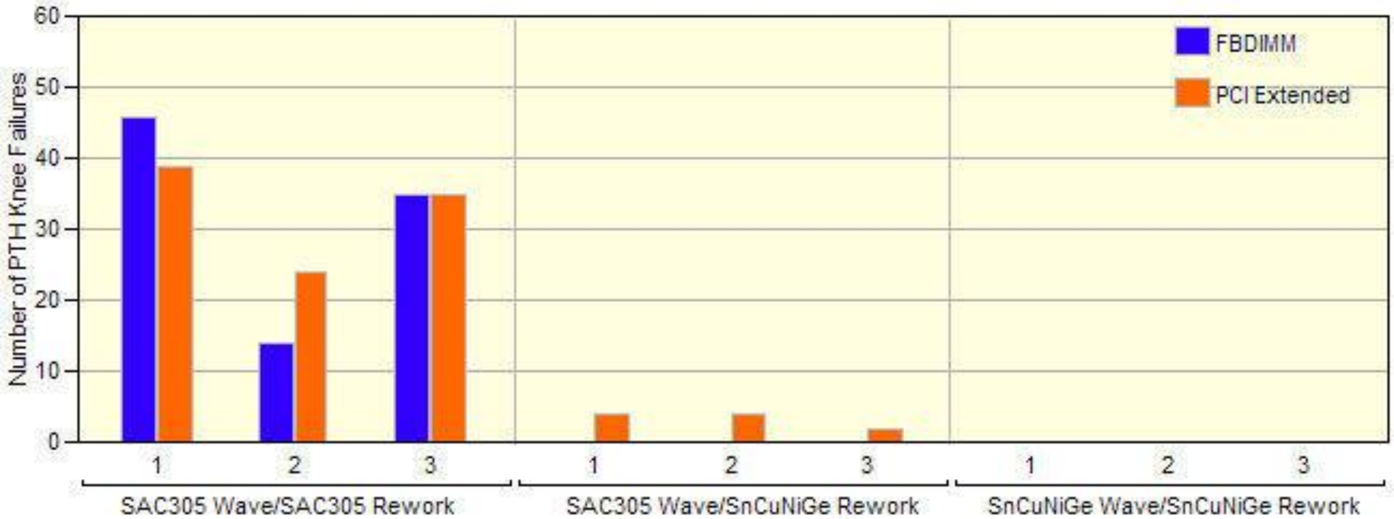


Figure 8 – Comparison of the PTH Knee Failures after Mini-pot Rework

From the plot it is apparent that the largest number of failures occurred on the boards which were wave solder and reworked with the SAC305 alloy (experimental leg 1). This leg also shows some board to board variability for the number of failures. There is no significant difference between the two connector types for the number of PTH knee failures.

The boards that were wave soldered with the SAC305 alloy and reworked with SnCuNiGe (experimental leg 2) also had PTH knee failures but these were significantly less than the all SAC305 wave and rework leg. All the failures in this leg were for the PCI Extended connector.

There were no PTH knee failures on the third experimental leg with the SnCuNiGe alloy used in both the wave solder and mini-pot rework. Converting both the wave and rework processes to a SnCuNiGe alloy gave the best results, minimizing PTH knee copper removal to a level that should not affect the through-hole solder joint reliability.

The amount of copper removed for each experimental leg by process was analyzed next. Figure 9 shows how much copper is removed at the PTH knee for both wave solder and mini-pot rework for all three experimental legs.

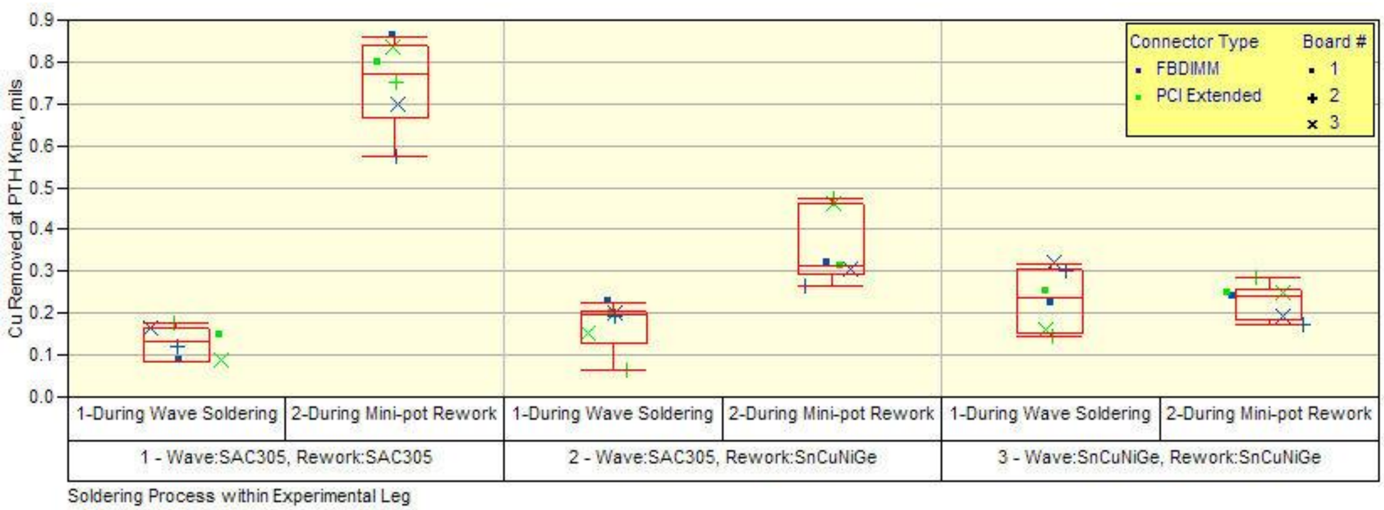


Figure 9 – PTH Knee Copper Removal by Process for All Three Experimental Legs

The values in this figure were calculated by subtracting the mean values of the relevant data sets. For instance, to calculate the amount of copper removed during wave soldering, the mean value of the copper thickness data set after wave soldering was subtracted from the mean value of the copper thickness data set for the as-received boards of the same experimental leg. Similarly, to calculate the amount of copper removed during mini-pot rework, the mean value of the copper thickness data set after mini-pot rework was subtracted from the mean value of the copper thickness data set for the wave soldered boards of the same experimental leg.

There is a significantly less amount of copper removed (52%) from the PTH knee when SnCuNiGe is the mini-pot alloy as compared to the SAC305 mini-pot alloy for SAC305 wave soldered boards. The amount of copper removed at the PTH knee after SnCuNiGe mini-pot rework using SnCuNiGe wave boards was even less at 69%. However, wave soldering with SnCuNiGe solder removed a slightly larger amount of copper from the PTH knees than when using the SAC305 solder alloy. This amount is still low when compared to that removed in the rework process using SAC305 solder. It is apparent that the copper removed using SnCuNiGe during wave solder is slightly more than when using the SAC305 alloy. Since it is the total copper removed during both wave solder and mini-pot rework processes that is of paramount importance in determining the PTH knee reliability, an analysis of the total copper removed was conducted for all three legs of this experiment. Figure 10 below shows the total copper removed for each experimental leg.

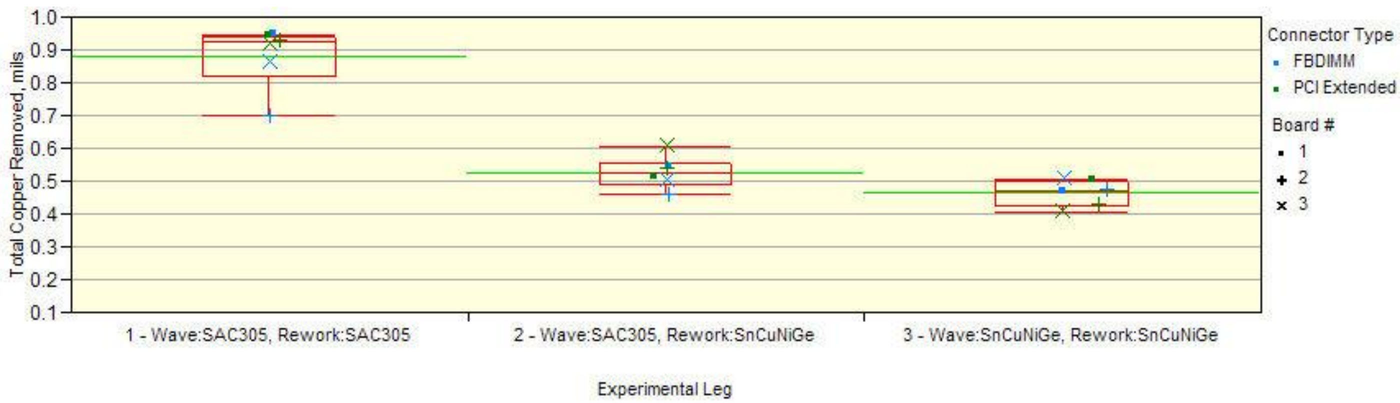


Figure 10 – Total Copper Removed for all Three Experimental Legs

The total copper removed was calculated by subtracting the mean value of minimum copper thickness at the PTH knee after rework from the mean value of minimum copper thickness at the PTH knee for the as-received boards. This calculation was done for each connector (PCI Extended & FBDIMM) on each of the three boards for each experimental leg. The SAC305 wave solder and SAC305 mini-pot rework process (experimental leg 1) showed the largest copper loss of all three legs. The amount of copper loss was in the 0.70 to 0.95 mils (17.78 to 24.13 µm) range. The SAC305 wave solder and SnCuNiGe mini-pot rework process (experimental leg 2) showed much less copper loss compared to experimental leg 1. This was in the 0.45 to 0.60 mils (11.43 to 15.24 µm) range. The SnCuNiGe wave solder and SnCuNiGe mini-pot rework process (experimental leg 3) showed the least amount of copper loss. This was in the 0.40 to 0.50 mils (10.16 to 12.70 µm) range. However, it is apparent that just changing the mini-pot alloy to SnCuNiGe from SAC305 leads to a significant reduction in the amount of copper removed during the mini-pot rework process, and hence, significantly reducing the risk of PTH reliability failures due to thin copper at the PTH knee.

The copper thickness at the PTH knees, after mini-pot rework, has been shown to vary across the length of the connector. The middle section is always lower than the ends after mini-pot rework. Figure 11 shows the PCI Extended connector data with the as-received, post wave and mini-pot reworked copper thickness measurements for all three experimental legs.

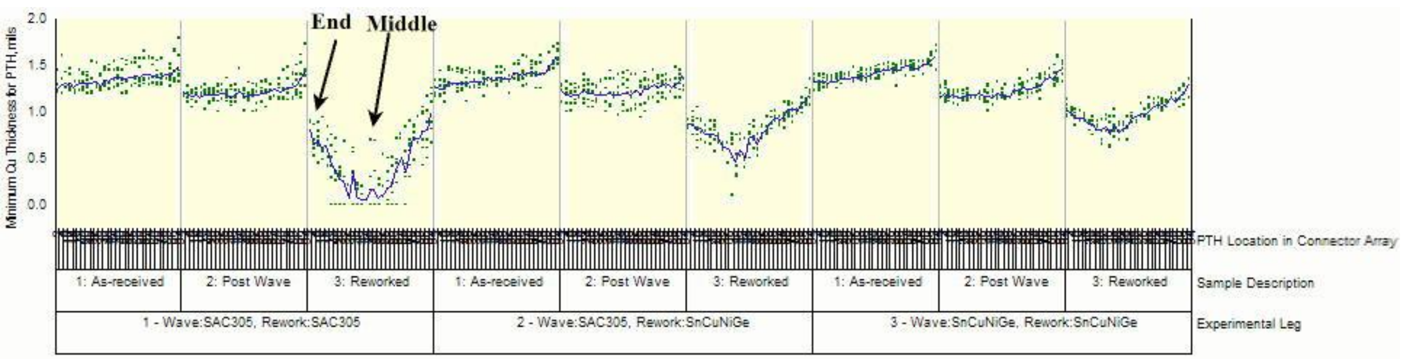


Figure 11 – PCI Extended Connector Comparing All 3 Experimental Legs with Cu Reduction at the PTH Knee by Process

For all three experimental legs, the as-received and the post wave data shows a slight copper thickness increase from left to right. The post wave solder process shows this same trend. Essentially, the copper loss during the wave solder process is independent of the location of the PTH knee along the connector row. However, the mini-pot reworked samples show a large copper reduction in the middle of the connector as compared to the ends. This trend is common for all three experimental legs though the amount of copper loss is significantly more for the SAC305 wave solder and rework leg (experimental leg 1) than the other two experimental legs. This trend has been noticed before in the previous work [1] as well as by other investigators [5-7]. Due to the mini-pot design, the flow rate of the solder is much higher for the plated-through holes in the middle than at the end of the connector.

Figure 12 shows the FBDIMM connector data with the as-received, post wave and mini-pot reworked copper thickness measurements for all three experimental legs.

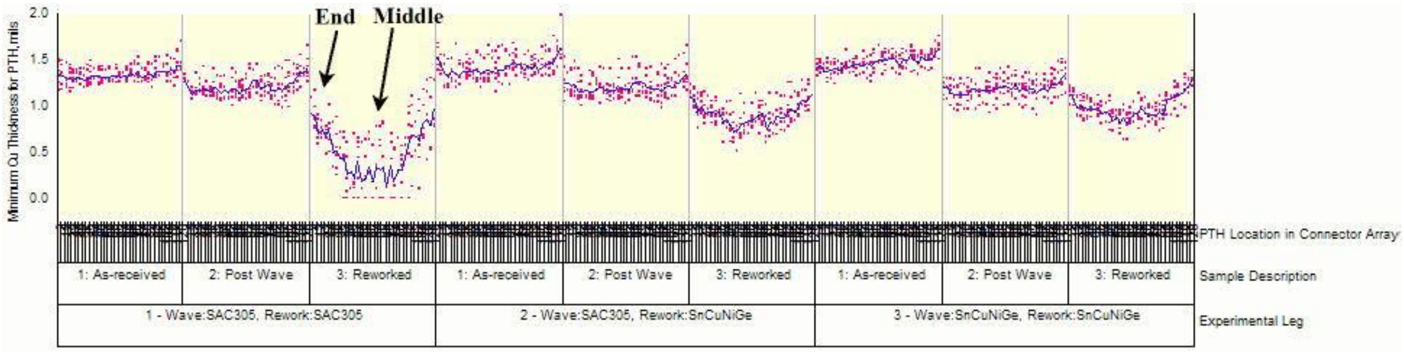


Figure 12 – FBDIMM Connector Comparing All 3 Experimental Legs with Cu Reduction at the PTH Knee by Process

The data trends in this case are similar to that for the PCI Extended connector. The as-received and the post wave data shows a slight copper thickness increase from left to right as shown in the figure. The mini-pot rework data shows a marked reduction in the copper thickness for the PTH knee in the connector middle. This decrease in the middle part of the row is less pronounced for the FBDIMM than the PCI Extended connector. Both connector types were reworked with the same nozzle so this could not be the reason for the difference. The only differences were in the plated through-hole diameter and pin pitch spacing between the two connector types.

Summary

Copper erosion/dissolution at the PTH knee has been shown to cause reliability problems on board products. This experiment looked at using an alternate alloy (SnCuNiGe) to mitigate copper erosion/dissolution during wave soldering and mini-pot rework. The experiments were designed to compare this alternate alloy with the most widely used alloy, SAC305.

All experimental legs showed a low amount of copper loss at the PTH knee during the wave solder process. The SAC305 wave solder process removed 0.07 to 0.23 mils (1.78 to 5.84 µm) of copper and the SnCuNiGe wave solder process removed 0.15 to 0.32 mils (3.81 to 8.13 µm) of copper. Significant differences between the two solder alloys showed up in the mini-pot rework process. After wave soldering with SAC305 solder, subsequent mini-pot rework with SAC305 solder removed 0.58 to 0.86 mils (14.73 to 21.84 µm) of copper whereas mini-pot rework with SnCuNiGe solder removed 0.27 to 0.48 mils (6.86 to 12.19 µm) of copper. However, the biggest improvement was from using the SnCuNiGe alloy in both the wave solder and mini-pot rework process with only 0.18 to 0.29 mils (4.57 to 7.37 µm) copper removed. All copper measurements were above 0.6 mils (15.24 µm) for this experimental leg at a 45 second rework cycle. All PTH solder joints had adequate hole-fill after wave solder and mini-pot rework.

The mini-pot rework removes a significantly larger amount of copper at the PTH knee for plated through-holes located in the middle sections along the connector length than for plated through-holes at the end of the connector. With using SAC305 in the solder mini-pot many copper breaks occur in the PTH knee for both connector types for plated through-holes in the middle sections while the plated through-holes at the end still have sufficient copper left at the knee. Using the SnCuNiGe alloy in the mini-pot eliminated the copper breaks in the middle of the connector regardless of whether it was SAC305 or SnCuNiGe wave soldered boards.

Conclusions

Use of SnCuNiGe solder alloy for mini-pot rework significantly reduced copper erosion and dissolution at the PTH knee region when compared to the currently used SAC305 alloy for two different connectors on a 93 mils (2.362 mm) thick server board. This result was true irrespective of whether SAC305 or SnCuNiGe was the alloy used during the wave soldering of the boards prior to mini-pot rework. Therefore, the SnCuNiGe alloy is recommended for mini-pot rework.

Future Work

A second board supplier is being examined to determine the variability in the wave solder and mini-pot rework process. Large as-received copper thickness variations have been observed in a previous study [1]. These experiments aim to determine the impact that such in-coming copper variation as well as other aspects of the copper plating characteristics have on the amount of copper removed by erosion and dissolution.

Previous studies [8-15] have shown that such IMC characteristics have a marked effect on the copper erosion and dissolution in molten solder. The IMC morphology, composition and thickness variation with the solder alloy (SAC305 vs. SnCuNiGe), soldering process (wave vs. mini-pot rework) and location of the PTH along the connector length (end vs. middle) will be studied to determine the impact that IMC characteristics have on copper dissolution and erosion.

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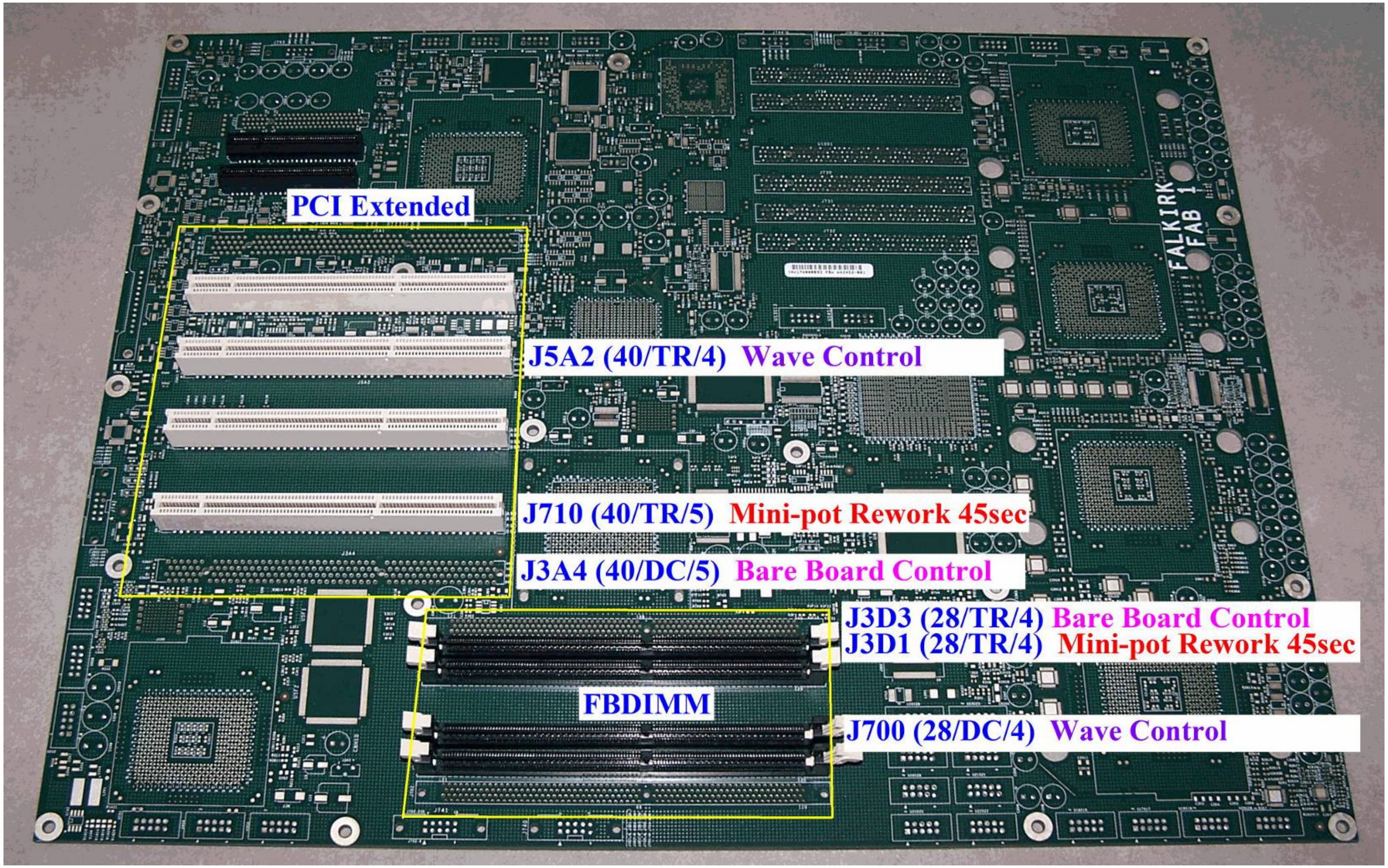
- **Future Work**

Introduction

- Excessive copper (Cu) erosion was observed in lead-free (LF) mini-pot rework for plated-through-hole (PTH) connectors that can potentially lead to quality and reliability issues
- In previous work, alternative alloys for mini-pot rework were screened for their ability to diminish this copper erosion
  - Some alloys showed lower mean values for copper erosion but had significant spread in the data that ruled them out
  - Excessive dross and wettability issues ruled out others
- **SnCuNiGe** was chosen for this study
  - Lowest variation across PTH knees
  - No significant dross or wettability issues

Contents

PCB Test Vehicle



- Server motherboard (14 x 18in)
- 10 layers, 93 mils thick
- High Tg FR4 laminate
- ImAg board finish

- Two connector types – PCI extended and FBDIMM (longest on board)
- 3 PTH pattern locations for each of the two connector types x-sectioned

Experiment Setup

Experimental Leg	Board Quantity	Connector Quantity		Wave Solder Alloy	Mini-pot Solder Alloy
		PCI Extended	FBDIMM		
1	3	9	9	SAC305	SAC305
2	3	9	9	SAC305	SnCuNiGe
3	3	9	9	SnCuNiGe	SnCuNiGe

- Three boards per experimental leg
- Leg 1 was control leg
  - SAC305 alloy for both wave and rework
- Leg 2 was mixed alloy leg
  - SAC305 alloy for wave and SnCuNiGe alloy for rework
- Leg 3 was SnCuNiGe alloy for both wave and rework

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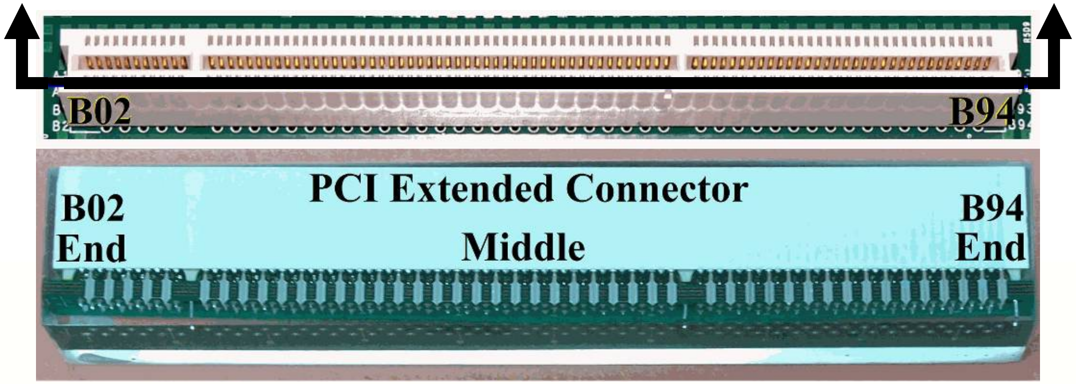
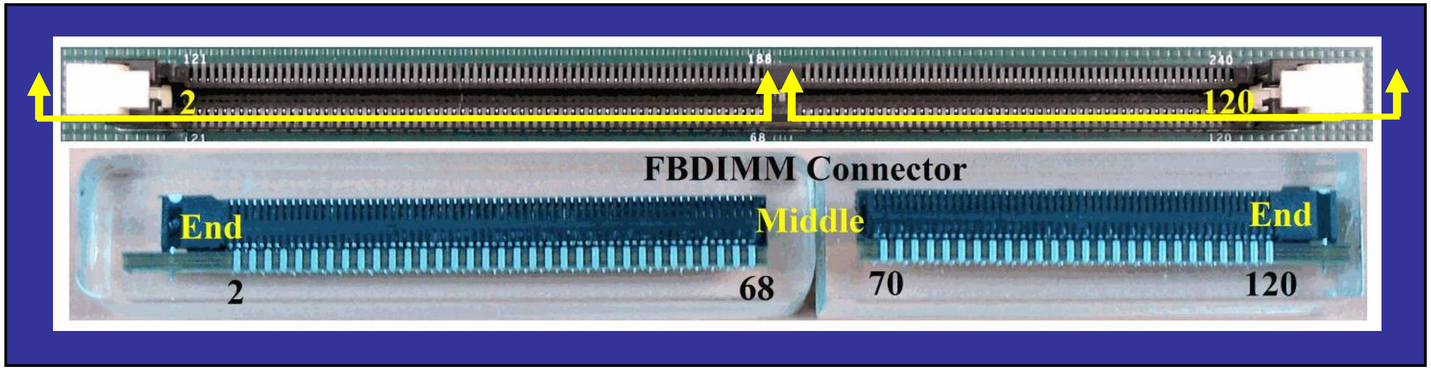
- Introduction
- Test board & Experimental Setup
- **PTH Cu Knee Measurement Method**
- Results and Discussion
- Conclusions
- Future Work

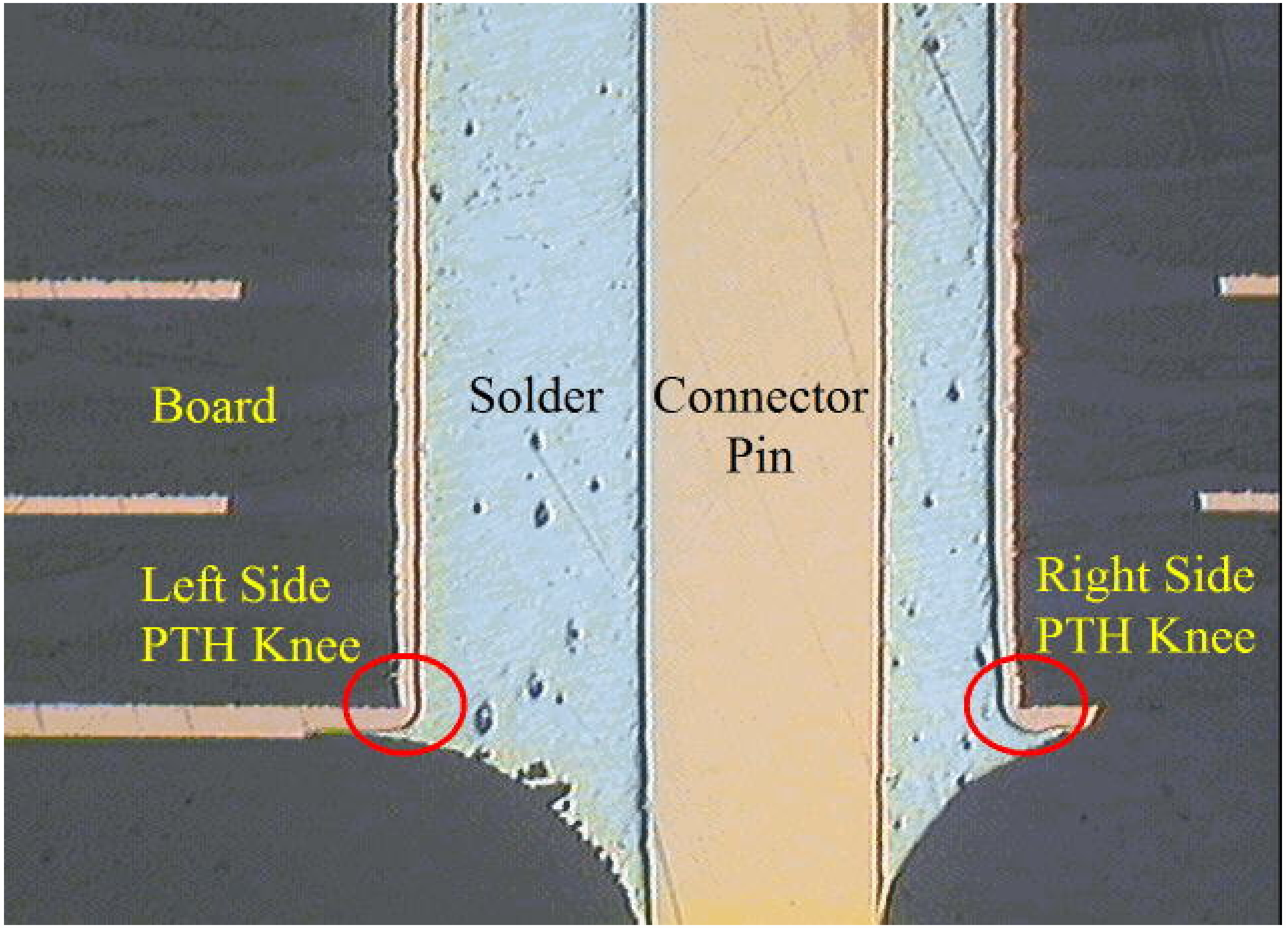
Cross-Section Locations on Connectors





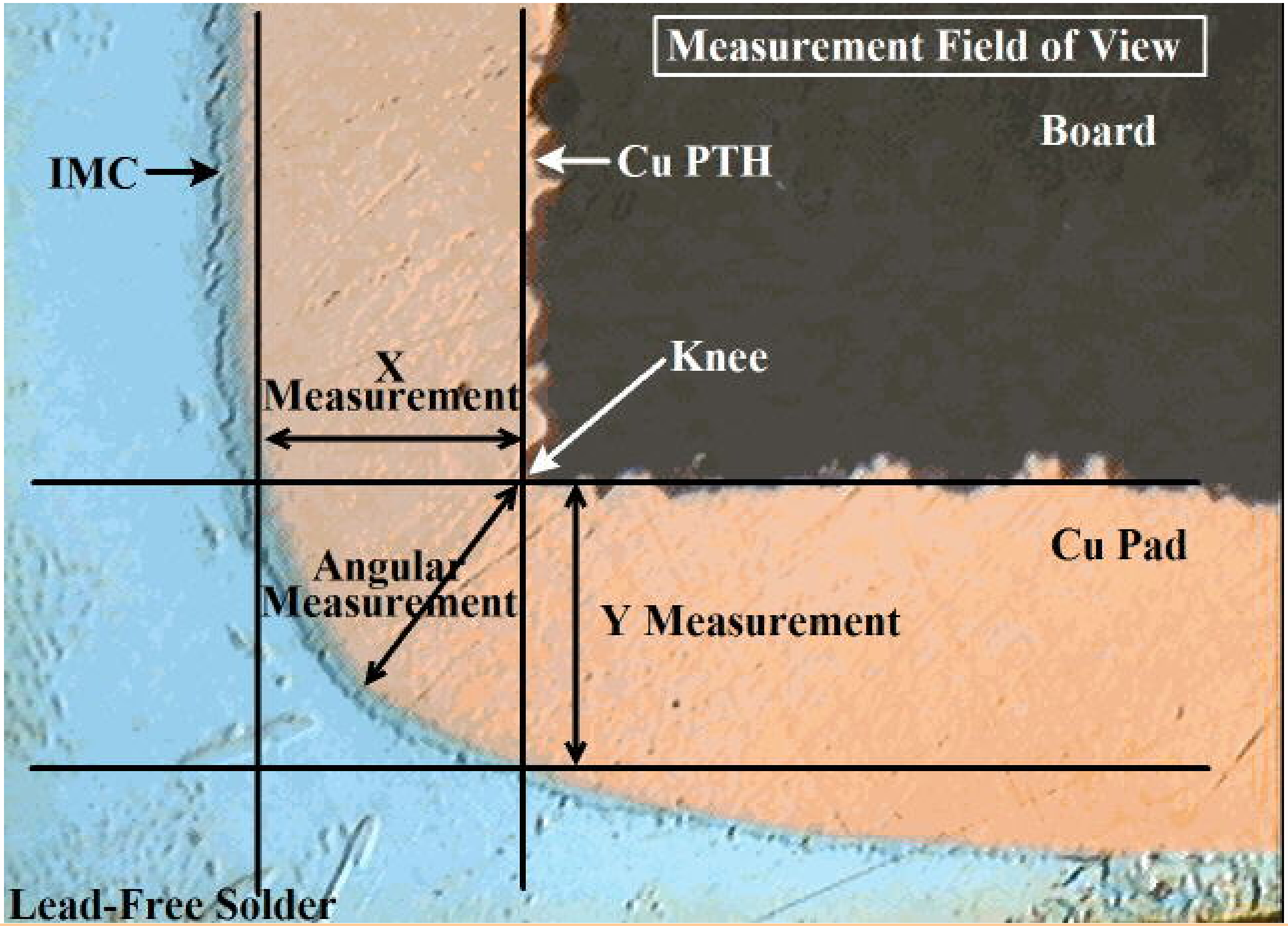
- Cross-sections were made on the outside row for each connector type
- FBDIMM connector was cut in two at the support pin due to excessive warpage during sample preparation

Measurement Locations at the PTH Knee



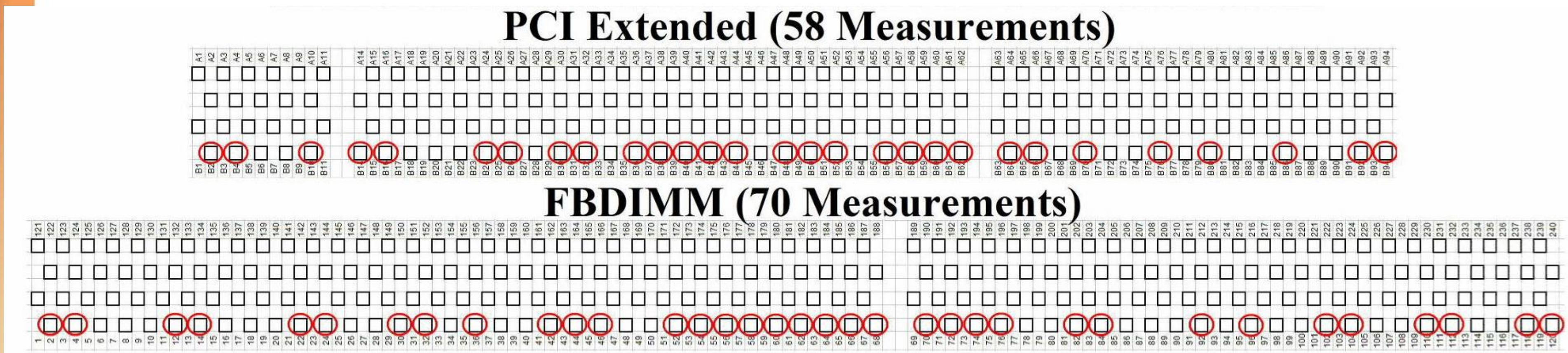
- **Copper thickness at the PTH knee measured on both sides of the cross-sectional view**

Metrology for Measurement of the Copper thickness at the PTH knee



- Three measurements made per PTH knee
  - X axis, Y axis & θ axis (angular)
- Lowest value of all three measurement locations at each knee side was used in statistical analysis
  - θ axis (angular) was not always lowest value

PTH Connector Pins Layout



- ➢ **PTHs identified by red circles above were those whose copper thickness at both sides of the knee was measured**
  - **Measurements across the entire length of the connectors**
  - **Sufficient number for statistical analysis**

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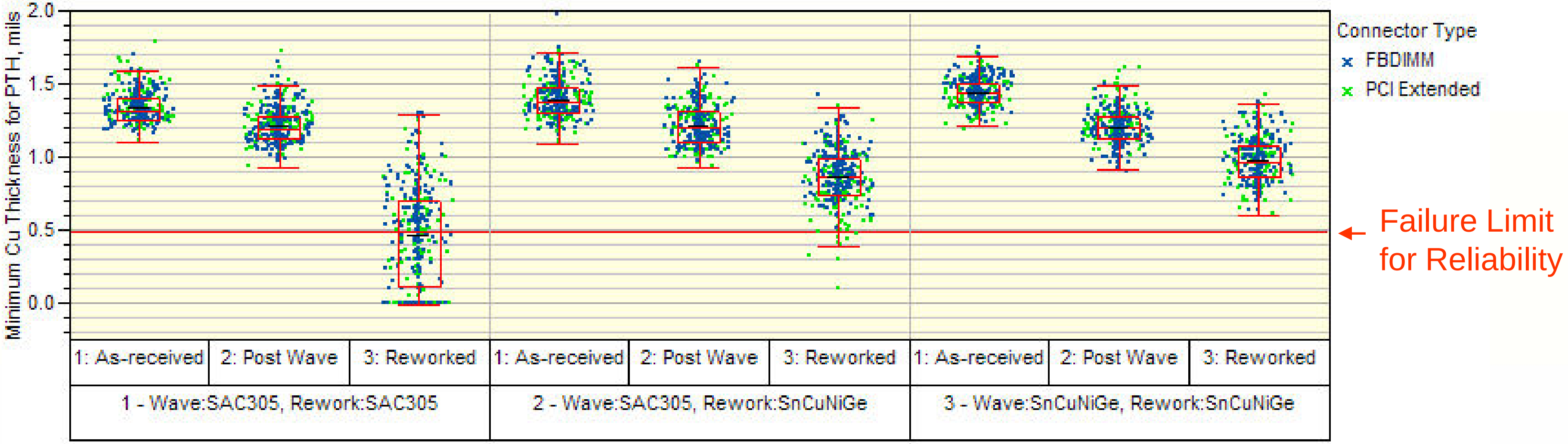
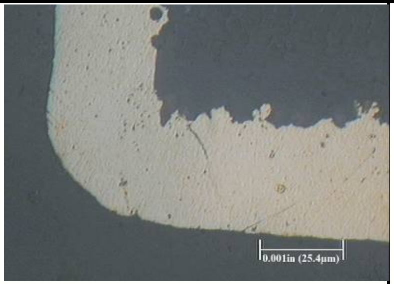
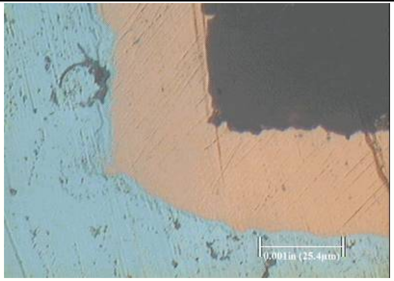
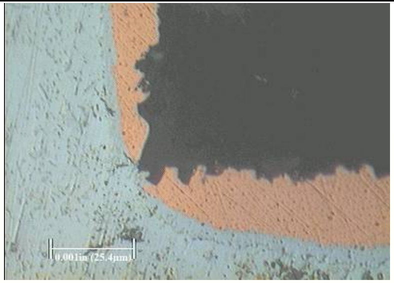
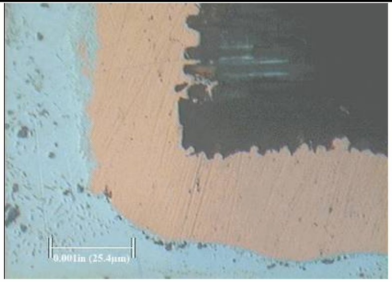
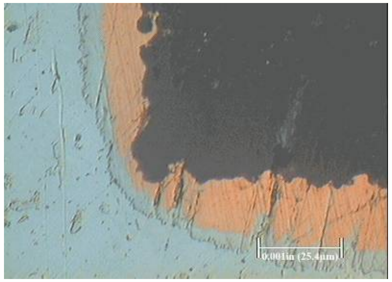
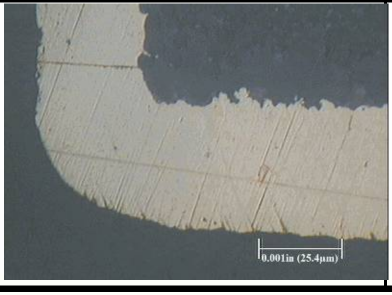
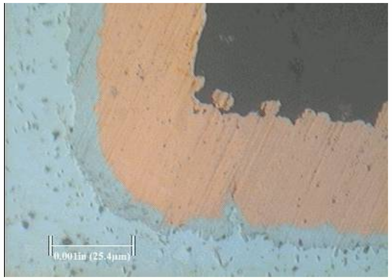
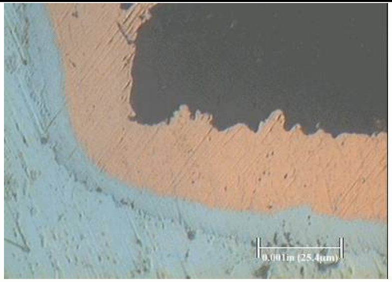
PTH Copper Thickness Comparison for All Three Legs of the Experiment



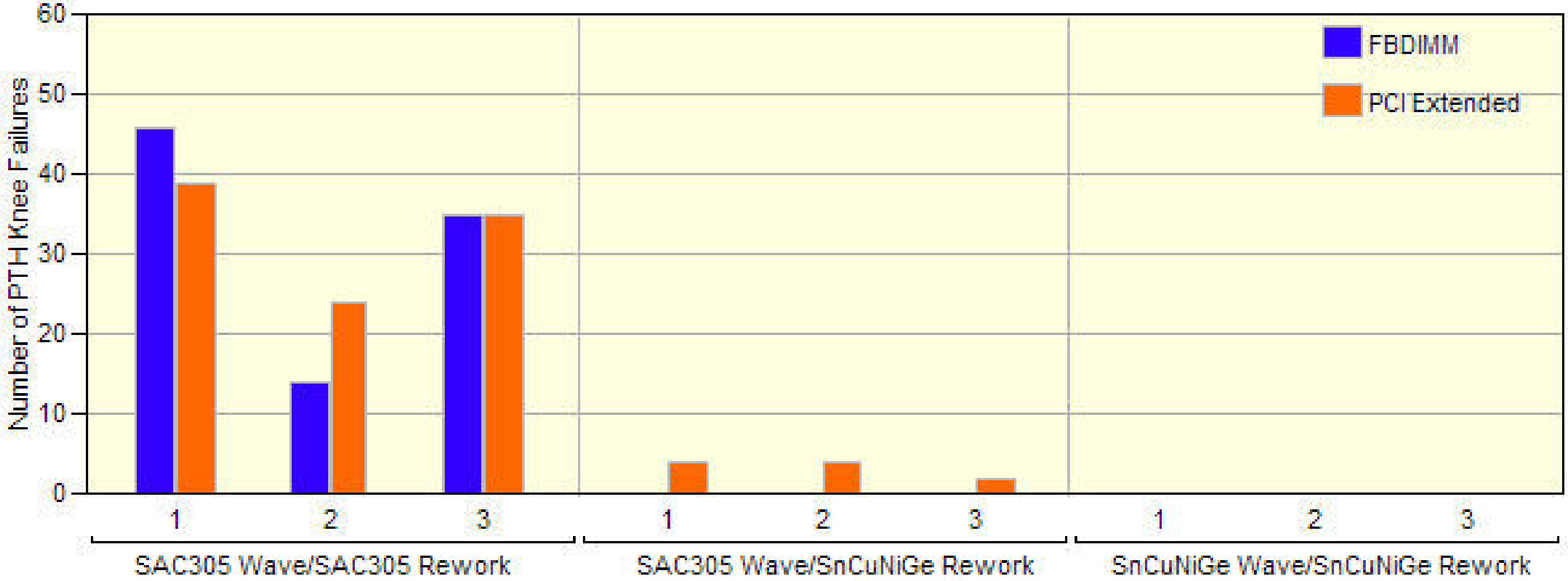
- The data spread was largest for the mini-pot rework process for all three experimental legs
- Use of SnCuNiGe as mini-pot alloy significantly reduces copper removal during the rework process
- This reduction is slightly more when the SnCuNiGe is also the wave solder alloy when compared to SAC305
  - Spread of data after mini-pot rework is also reduced

Photos of PTH Knees for the PCI Extended Connector after Various Steps along the Assembly Process

Experimental Leg	Bare Board	Wave Solder	Mini-pot Rework
SAC305 Wave / SAC305 Rework			
SAC305 Wave / SnCuNiGe Rework			
SnCuNiGe Wave / SnCuNiGe Rework			

- **The increasing trend of copper erosion at the PTH knee with each step is apparent**
- **A copper break at the PTH knee is shown for board reworked with the SAC305 solder**

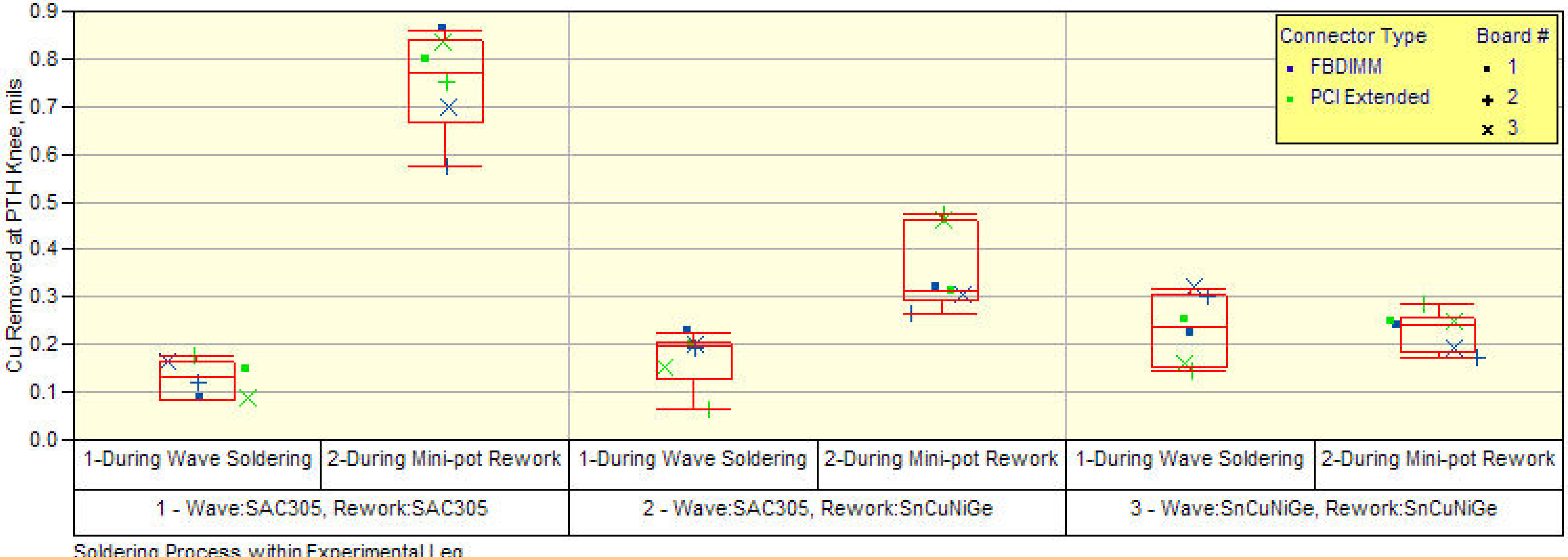
Comparison of the Amount of PTH Knee Failures after Mini-pot Rework



- **Boards wave soldered and reworked with SAC305 solder exhibited the highest number of PTH knee failures (below 0.5mils)**
- **A small amount of failures were exhibited on boards that were wave soldered with SAC305 and reworked with SnCuNiGe alloy**

Comparison of Copper Removed at PTH Knee for Various Alloy-Process Combinations

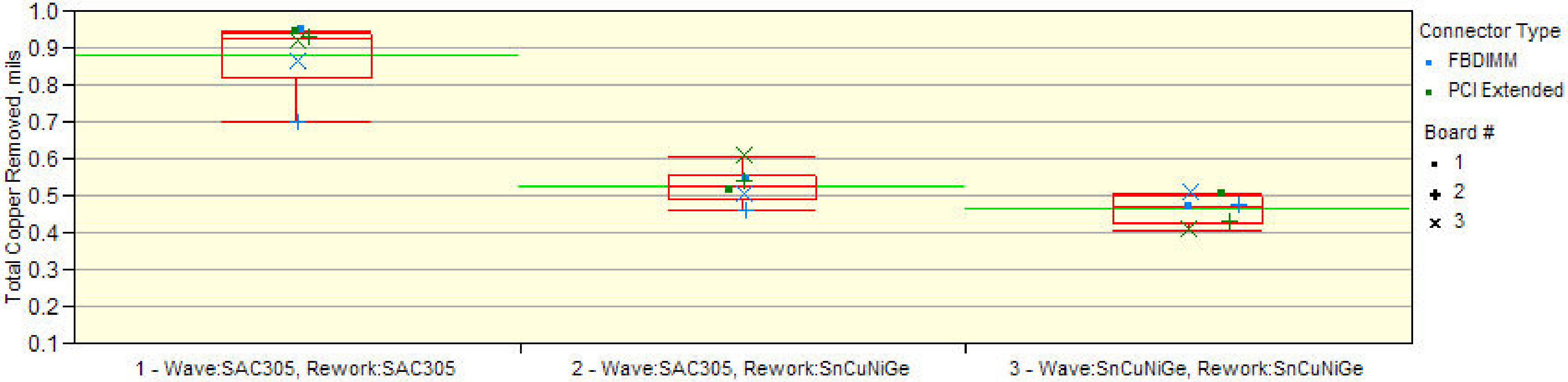
✓ Cu Removed at PTH Knee values in this figure were calculated by subtracting the mean values of the relevant data sets for each connector on each board



- ➢ **Significantly less copper removed (52%) from the PTH knee when SnCuNiGe is the mini-pot alloy as compared to the SAC305 mini-pot alloy for SAC305 wave soldered boards**
- ➢ **The amount of copper removed at the PTH knee after SnCuNiGe mini-pot rework using SnCuNiGe wave boards was even less (69)%**
- ➢ **However, wave soldering with SnCuNiGe solder removed a slightly larger amount of copper from the PTH knees than the SAC305 solder alloy**
  - ➢**Thicker IMC formed?**

Total Copper Removed for all Three Experimental Legs

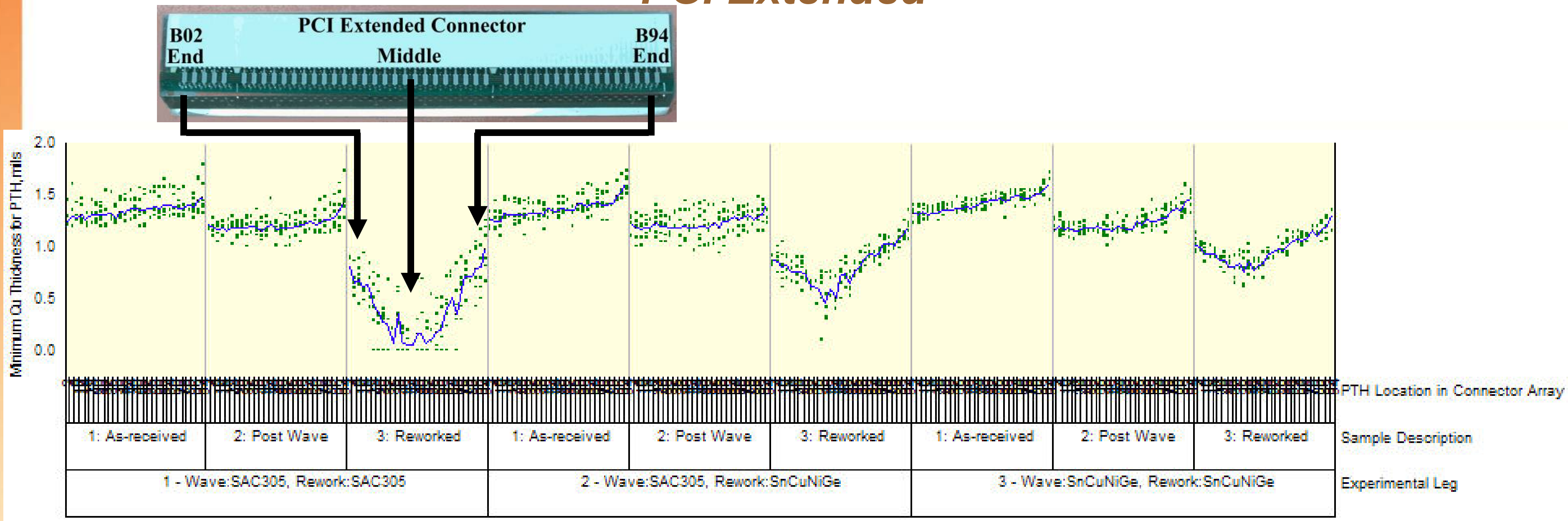
✓ Total Cu Removed in this figure was calculated by subtracting the mean value of minimum Cu thickness at the PTH knee after rework from the mean value of minimum Cu thickness at the PTH knee for the as-received boards



- **Significant copper loss with experimental leg 1**
  - **SAC305 Wave & SAC305 Rework**
  - **Range from 0.70 to 0.95 mils**
- **The other two legs reworked with SnCuNiGe had significant less copper loss**
  - **Almost 50% of the SAC305 wave – SAC305 rework leg**

Copper Thickness at PTH Knee with PTH Location Along Connector Length

-- PCI Extended --



- ➢ **Slight increasing trend from left side to right side of connector in copper thickness of the PTHs on as-received boards**
- ➢ **Copper loss during the wave solder process is independent of the location of the PTH knee along the connector length**
- ➢ **Mini-pot reworked samples show a larger copper reduction in the middle of the connector as compared to its ends**
  - **Flow Rate during mini-pot rework is higher in the middle**
- ➢ **Similar trends for FBDIMM connector**

Contents

Conclusions and Recommendation

- Use of SnCuNiGe solder alloy for mini-pot rework significantly reduced copper erosion and dissolution at the PTH knee region when compared to the currently used SAC305 alloy
  - Two connector designs
  - 93 mils (2.362 mm) thick server board
- An all SnCuNiGe alloy for both wave solder and reworked performed best
  - A large improvement was still gained using SAC305 wave boards on a SnCuNiGe rework process
- SnCuNiGe alloy is recommended for mini-pot rework of PTHs

Contents

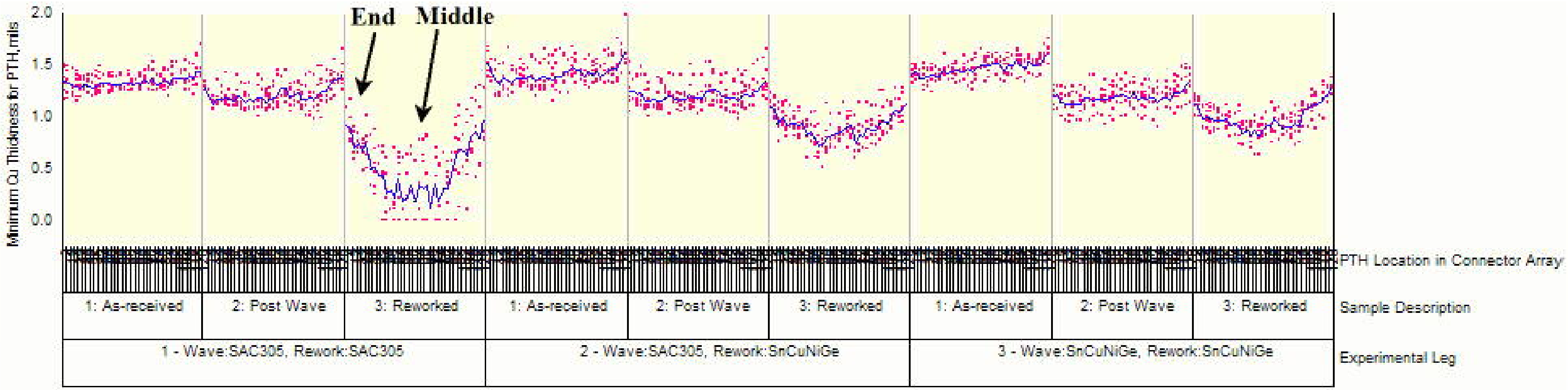
Future Work

- Work is currently underway on a second board supplier to study the in-coming copper variations and plating characteristics under the exact same rework conditions
- IMC morphology, composition and thickness variations with both SAC305 and SnCuNiGe alloys under both wave and rework conditions will be studied
  - Differences from the end and middle of the connector will be examined

Back-up

Copper Thickness at PTH Knee with PTH Location Along Connector Length

-- FBDIMM --



- Slight increasing trend from left side to right side of connector in copper thickness of the PTHs on as-received boards
- Copper loss during the wave solder process is independent of the location of the PTH knee along the connector length
- Mini-pot reworked samples show a larger copper reduction in the middle of the connector as compared to its ends