iNEMI

International Electronics Manufacturing Initiative

Lead-Free Rework Optimization Project

Project Chair: Jasbir Bath
Solectron Corporation

Project Co-Chair: Craig Hamilton,
Celestica

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Advancing manufacturing technology

Background

- **Reliability tests in the previous NEMI lead-free assembly and rework project (presented at APEX) indicated a need to initiate a follow on iNEMI Rework Optimization Project.**
- **Thermal fatigue life of certain components on the NEMI Payette board such as the CBGA937, uBGA256, CSP81 was reduced after rework.**
- **This project would evaluate and recommend best practices, rework equipment requirements, impact of adjacent component temperatures and procedures for best practice lead-free rework processing.**

Rework optimization project (4 areas of work)

1) Rework tolerances and repeatability (Rework equipment manufacturers)

2) Optimized heat transfer into reworked boards and work to reduce adjacent (Top and Bottom) component temperatures: use of heat shrouds, more uniform board heating, heat shields

3) BGA Socket and FCBGA component rework

4) Lead-free mini-pot wave connector rework

iNEMI Rework Optimization Project Participants

Members

- Solectron, Jabil, Celestica, Sanmina-SCI, Plexus, Foxconn, LACE Technologies
- Cisco, Alcatel-Lucent, SUN, HP
- TI, Tyco, Intel, IBM
- Indium, Kester, Senju
- O.K. Industries, ERSA

Non-members participating in certain parts of project

- SRT/VJ Technologies
- AirVac
- Finetech
- ECD
- Spencor Technic

Rework optimization project

Overall project chairs: Jasbir Bath, Solectron / Craig Hamilton, Celestica

1) Rework tolerances and repeatability
Chair: Jasbir Bath, Solectron

2) Optimized heat transfer into reworked boards and work to reduce adjacent component temperatures
Chair: George Forrest/ Joe Devaney, Alcatel-Lucent

3) BGA Socket and FCBGA package rework
Chair: Alan Donaldson, Intel

4) Lead-free mini-pot connector rework
Chair: Jenny Porter, Solectron
Co-Chair: Denis Jean, Plexus

5) Rework Reliability Testing/ Failure Analysis
Chair: Dave Love, SUN

1) BGA//CSP Rework Machine Repeatability and Tolerance Study Background

Currently we have little or no data on temperature repeatability of BGA/CSP rework equipment.

This is an issue for lead-free as the temperatures during lead-free BGA/CSP rework are likely to be higher than lead-free reflow soldering giving potential component/board temperature issues.

1) BGA//CSP Rework machine repeatability and Tolerance Temperature Study (Fixed Temperature Input: Measure Temperature Output)

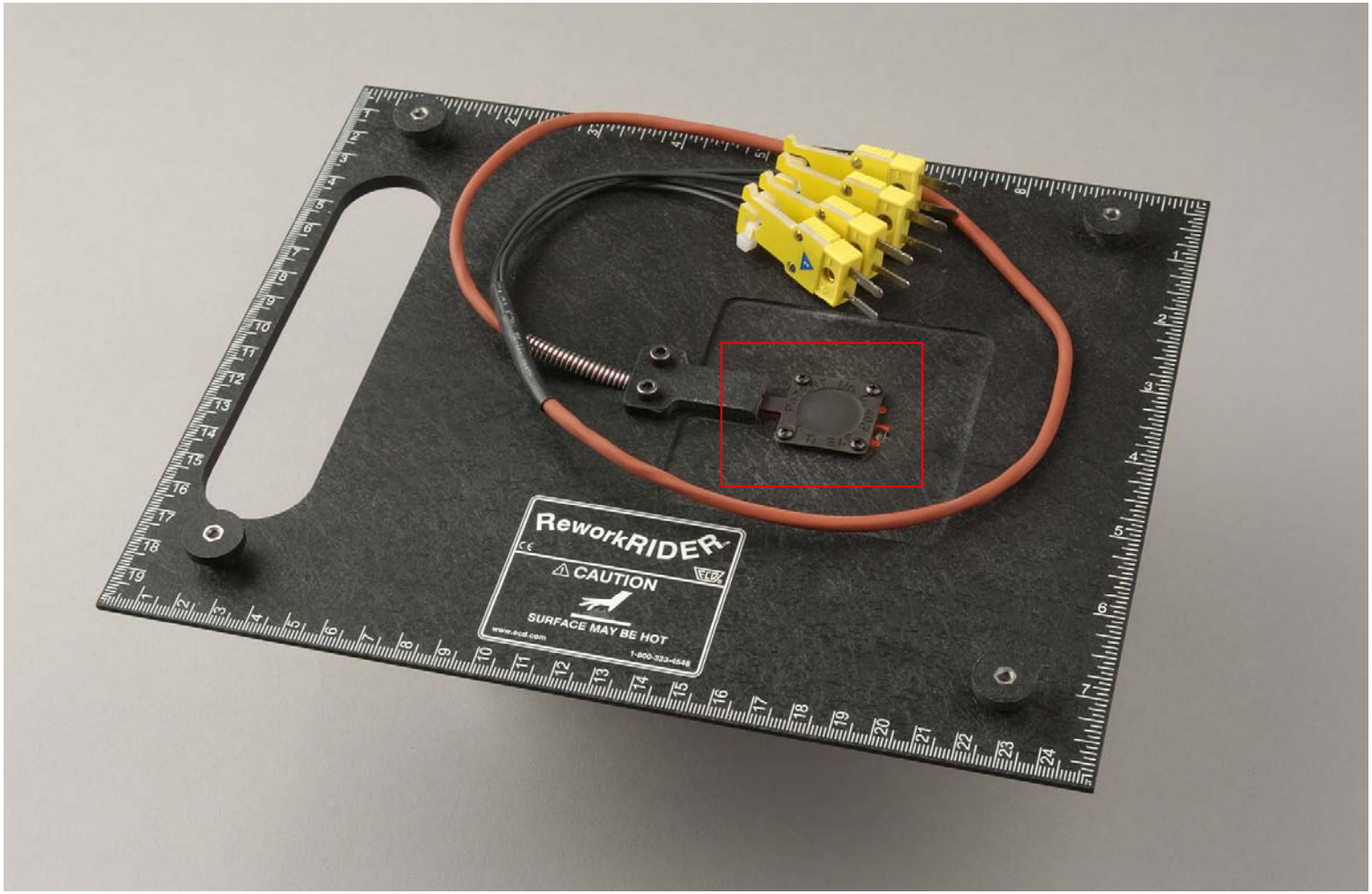
Stage 1: Rework manufacturer to use ECD rework rider to record temperatures using defined lead-free rework temperature set-points and rework time durations with a specific rework machine

Stage 2: Same test at rework manufacturer with ECD rework rider with same machine model but with different rework machine, using same rework temperature set-points and time durations as Stage 1

Stage 3: Same test conducted at OEM/ EMS site with ECD rework rider with rework equipment at site, using same rework temperature set-points and time durations as Stages 2 and 3

Compare data from each three stages to determine and improve rework machine temperature repeatability and tolerances

ECD ReworkRIDER™ (Records temperatures from a BGA/CSP rework machine)

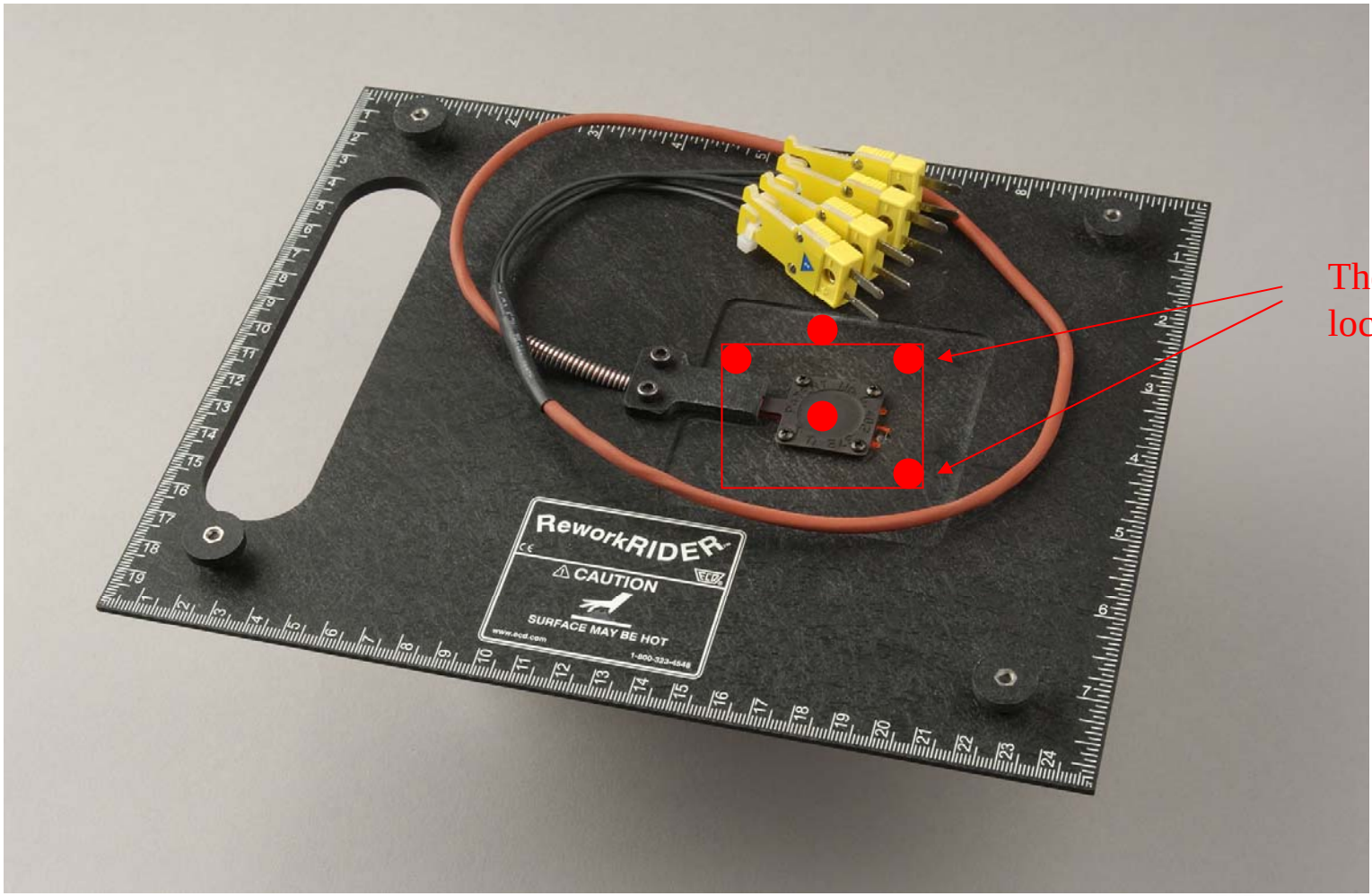


Rework Rider Retrofits

- 1. Two thermocouples at corners of imaginary 35mm package on topside (Locations on North-West and South-East corners)
- 2. One thermocouple location on the bottomside of the board on the corner of an imaginary 35mm package (North-East corner)
- 3. Two thermocouples at the center of an imaginary package (1 topside center and 1 bottomside of the board in the center)
- 4. One thermocouple at 150mils away from component in the North direction on topside of the board

- Total: 6 Thermocouple locations on the Rework Rider

ECD ReworkRIDER™ Thermocouple locations



BGA Rework Profile Development

- **Use a lead-free rework profile (230°C to 260°C peak soldering temperature[Time above Liquidous: 45 to 100sec]) developed on the 135mil NEMI Payette board for a lead-free PBGA544 component (35mmx35mm) and use this profile on the rework rider.**
- **Use this profile to understand and measure temperature repeatability of the BGA/CSP rework equipment using rework rider**

- **Run the same lead-free rework profile on the rework machine 10 times and measure the temperature peaks recorded at the 6 different temperature locations on the rework rider which is placed in the rework machine.**
- **<u>Ensure after each of the 10 runs the rework rider temperature is cooled down to room temperature</u>**

Rework Machine Supplier A Temperature Results

Single Rework Machine Temperature Repeatability Results(with 99% Confidence Level in Repeatability of Temperature Measurements)

- **TC1 Top Center Average Peak Temperature = 274ºC +/- 4ºC**
- **TC2 Top North West Component Corner = 309ºC +/- 6ºC**
- **TC3 150mils away from Component on Topside = 264ºC +/- 5ºC**
- **TC4 North East Corner on Bottomside = 318ºC +/- 5ºC**
- **TC5 Top South East Component Corner = 279ºC +/- 5ºC**
- **TC6 Bottomside Center = 272ºC +/- 5ºC**

- **99% of the all readings are within +/-5ºC around the recorded peak temperature at each thermocouple location**

- **For example: If the recorded lead-free top component body peak temperature reading on a board was actually 250ºC, 99% of the time, the actual reading could be 5ºC lower (245ºC) or 5ºC higher (255ºC) than this value based on the temperature repeatability of this single rework machine**

Rework Machine Supplier A Temperature Results

	Typical	Worst Case
• Machine Repeatability(Supplier site/Stage 1):	+/- 5ºC	TBD
• Machine/Machine Repeatability(Supplier site):Stage 2		TBD
• Machine/Machine Repeatability(at EMS/OEM):Stage 3		TBD
• Thermocouple Repeatability:	+/- 1ºC	+/- 2ºC

This work will also be conducted on 3 other rework machine supplier's equipment (Rework Machine Suppliers B,C and D)

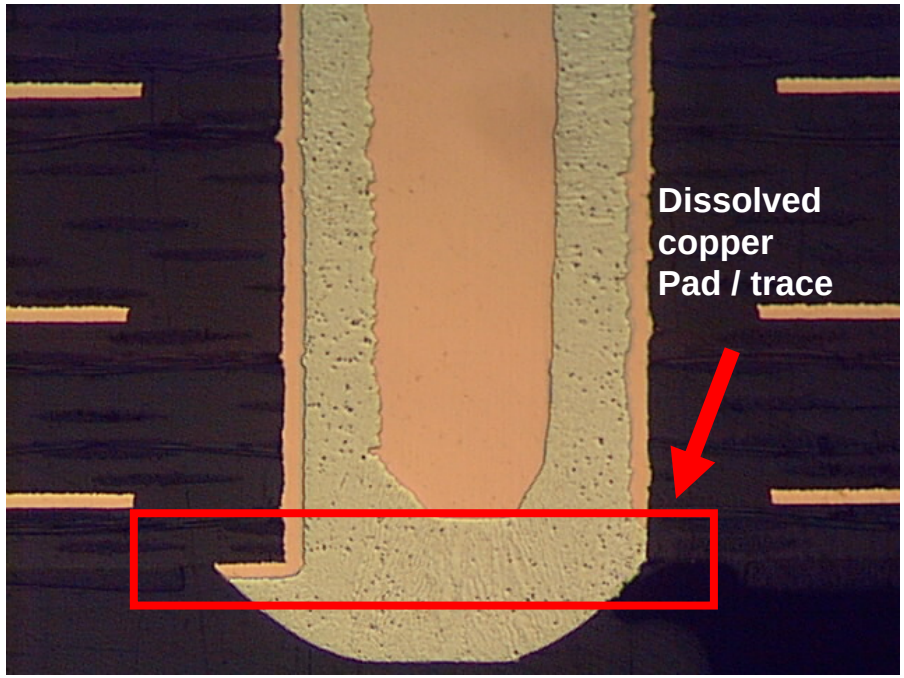
(4) Lead-free mini-pot connector rework development and optimization

Previous work covered only DIP16 on NEMI Payette. Extension to other connector components (DIMM, Centronics connector).

Collaboration work with NEMI lead-free wave project group using Phase 1 NEMI wave board

Previous iNEMI Mini-Pot Payette Board Results Showing PCB Copper Dissolution of Reworked PDIP16 Solder Joint (SnAgCu, NiAu board, 135 mil thick)

- **Challenge**
  - **–Simulate current production process**
  - **–Remove and replace a PDIP without board preheat**
- **Rework Observations**
  - **–Achieving sufficient holefill resulted in the copper pad/trace dissolution on the bottom-side**



Cross-section View of Solder Joint (274°C)

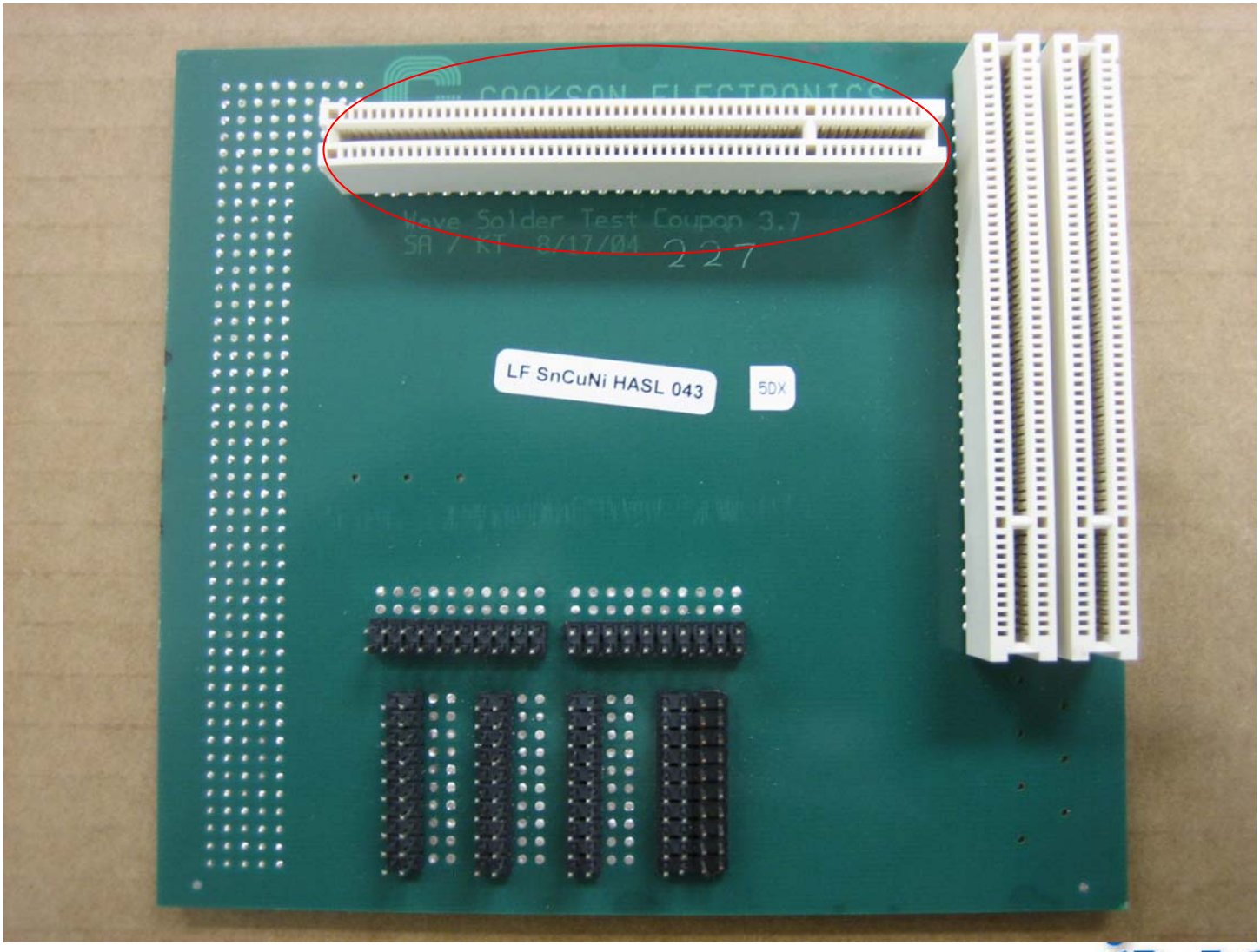
Total time in mini-pot= 60sec

Enough time to dissolve nickel layer

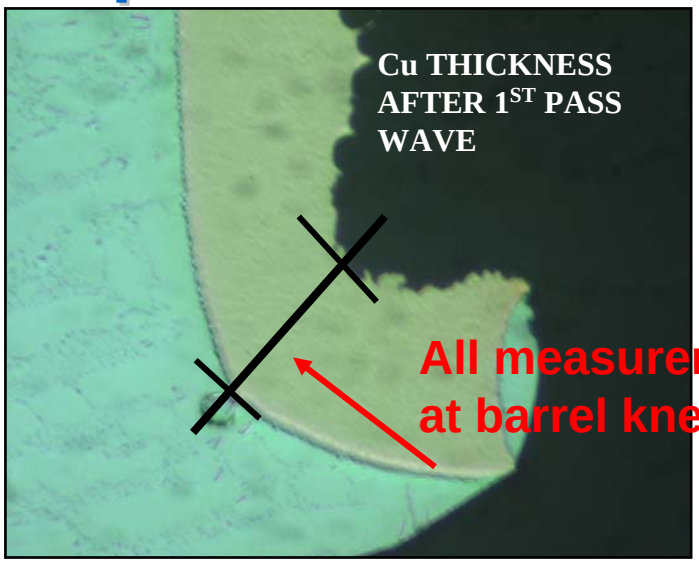
NEMI Mini-pot rework

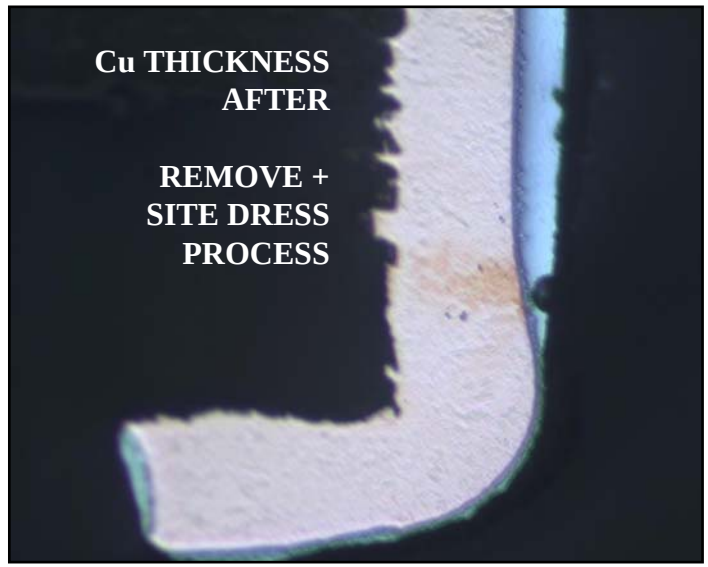
- **Initial work of group is concentrating on rework of a wave soldered connector on 62mil, 93mil and 140mil thick NEMI Lead-free Wave Group Boards wave soldered with Sn3Ag0.5Cu**
- **Mini-pot solder rework alloys under investigation include Sn3Ag0.5Cu and SnCuNi (Sn100C)**

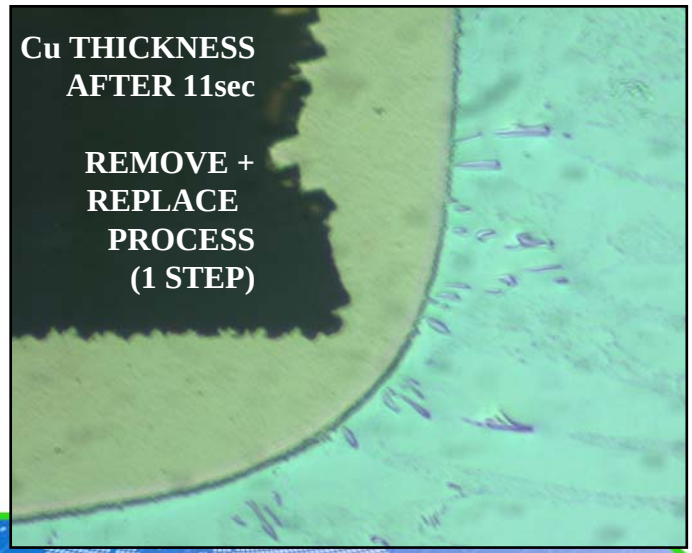
NEMI Wave Phase 1 Test Vehicle



SnAgCu 1st pass wave followed by SnAgCu mini-pot rework on 60mil thick NEMI Wave board







60 mil thick NEMI board (SnAgCu 1st pass wave then SnAgCu rework)

60 MILS THK BOARD	PIN1		PIN2		PIN3		PIN4		PIN5		PIN6		PIN7		PIN8		AVG
	L	Ri	L	Ri	L	Ri	L	Ri	L	Ri	L	Ri	L	Ri	L	Ri	
LF-SAC305 OSP# 19- 1ST PASS WAVE	46	38	47	38	46	38	49	41	50	39	47	39	50	40	52	38	43.6
LF-SAC305 OSP# 043- 11SEC (1STEP)	32	36	28	36	28	33	28	32	19	30	21	34	16	30	26	33	28.9
LF-SAC305 OSP# 001- REMOVE + DRESS	28	38	34	30	36	32	31	32	35	36	34	33	33	38	40	38	34.3
LF-SAC305 OSP# 052- REMOVE + DRESS + REPLACE (3STEP)	25	30	24	28	26	30	23	26	24	30	24	22	26	28	28	28	26.4

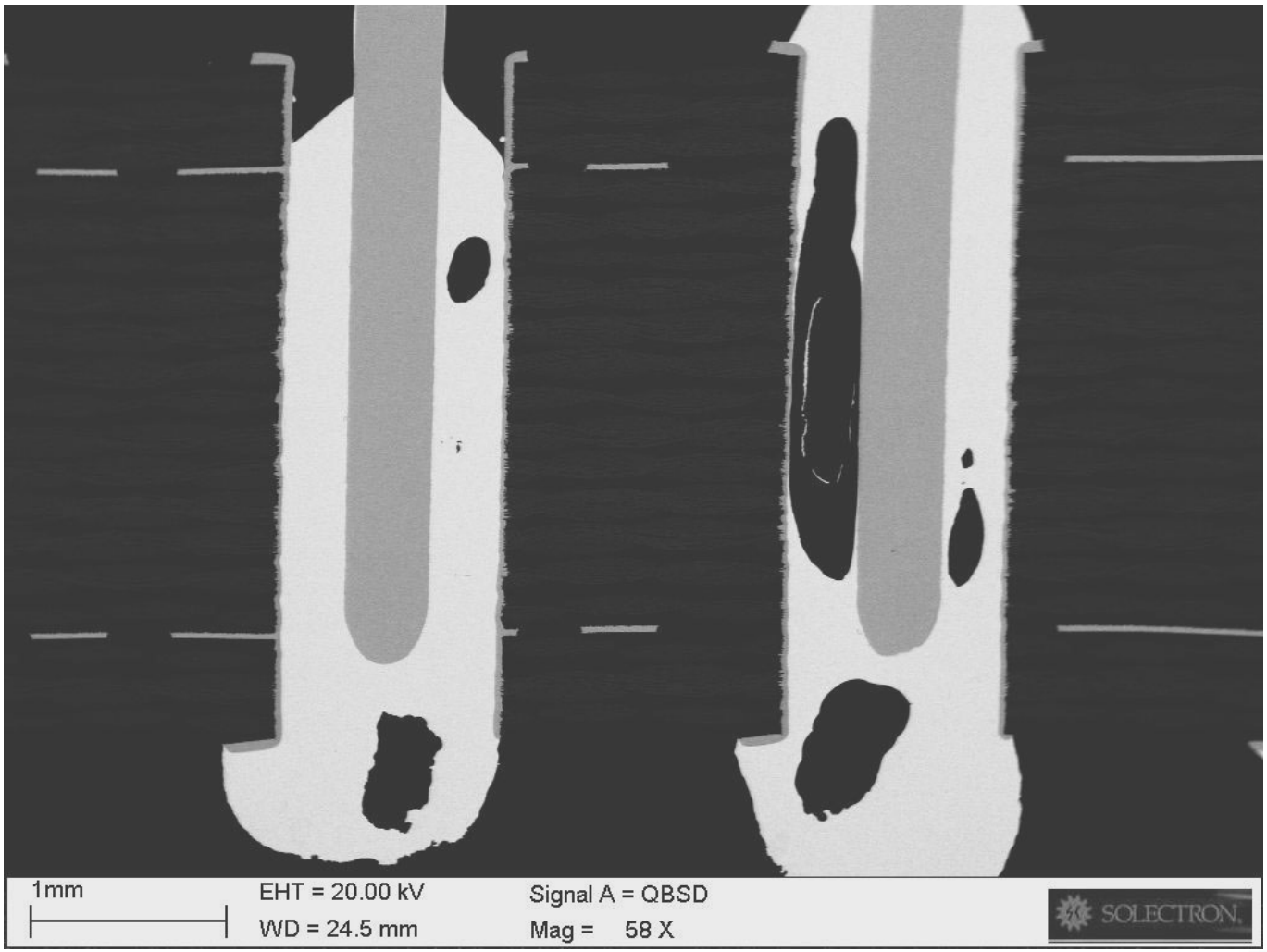
1ST PASS WAVE BOARD 43.6microns → **BRD # 001- Remove + Site Dress 34.3 microns 21.3% DECREASE IN Cu THK** → **BRD # 052- Remove + Site Dress+ Replace 26.4 microns 39.5% DECREASE IN Cu THK**

BRD # 043- 11sec Remove + Replace (1 step process) 28.9 microns 34% DECREASE IN Cu THK

ALL MEASUREMENTS TAKEN AT THE BARREL KNEE (Measurement in Microns)

L-LEFT KNEE, Ri- RIGHT KNEE,

145 mil thick board: 1st pass wave soldered with Sn3Ag0.5Cu then reworked with Sn3Ag0.5Cu

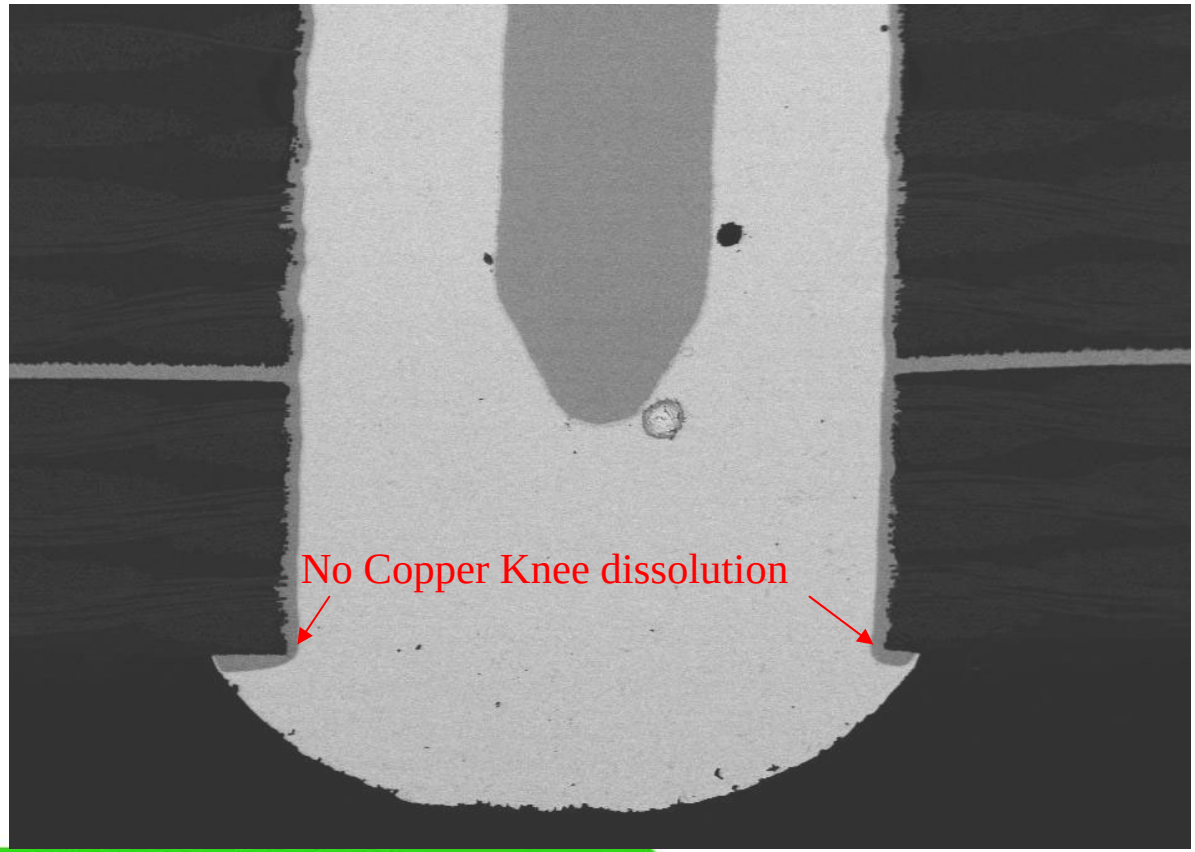


ALL MEASUREMENTS TAKEN AT THE BARREL KNEE

AFTER REPLACEMENT

145 mil thick board
1st pass wave soldered with Sn3Ag0.5Cu then reworked with SnCuNi (SN100C)

145 mils thick board	Pin 1		Pin 2		Pin 3		Pin 4		Avg. (microns)	Remove (sec)	Remove Replace (sec)
	left (microns)	right (microns)	left (microns)	right (microns)	left (microns)	right (microns)	left (microns)	right (microns)			
LF-SAC305 HASL #040	46	40	42	41	40	35	39	36	40	26	
LF-SAC305 HASL #028	21	22	23	30	14	26	14	26	22		38



Solder Alloy: SN100C
Solder Temp: 276ºC / 530ºF
Preheat: 150°C / 302ºF
Preheat Time: 300sec
Rwk Flux: Tacky/ Pasty Flux

ALL MEASUREMENTS TAKEN AT THE BARREL KNEE

Mini-pot Rework

- **Generally speaking there is evidence of reduced copper dissolution when reworking 1st pass SnAgCu wave soldered boards with SnCuNi(Sn100C) compared with rework using SnAgCu. More investigations and cross-sectional analysis in progress**
- **Further optimization and development work will be done on the NEMI Wave Phase 1 boards before moving to the iNEMI Payette Board which is 125mil thick (OSP coated)**
- **Mini-pot Rework on iNEMI Payette board will concentrate on the DIMM 278 connector and DIP16 component**

NEMI Rework Optimization Project Status

- At this time, most of the group's work has concentrated on Mini-Pot rework optimization and Rework Machine Temperature Repeatability
- Work on adjacent component temperatures during rework and FCBGA/ BGA socket/QFN rework will be done with the new 125mil thick iNEMI Payette test vehicle (7 x 17 inch) which has been redesigned and currently being tested for electrical continuity for the daisy chained components including:
  - FCBGA
  - BGA socket
  - DIMM 278
  - DIP16
  - CBGA
  - QFN