INEMI Rework Roadmap

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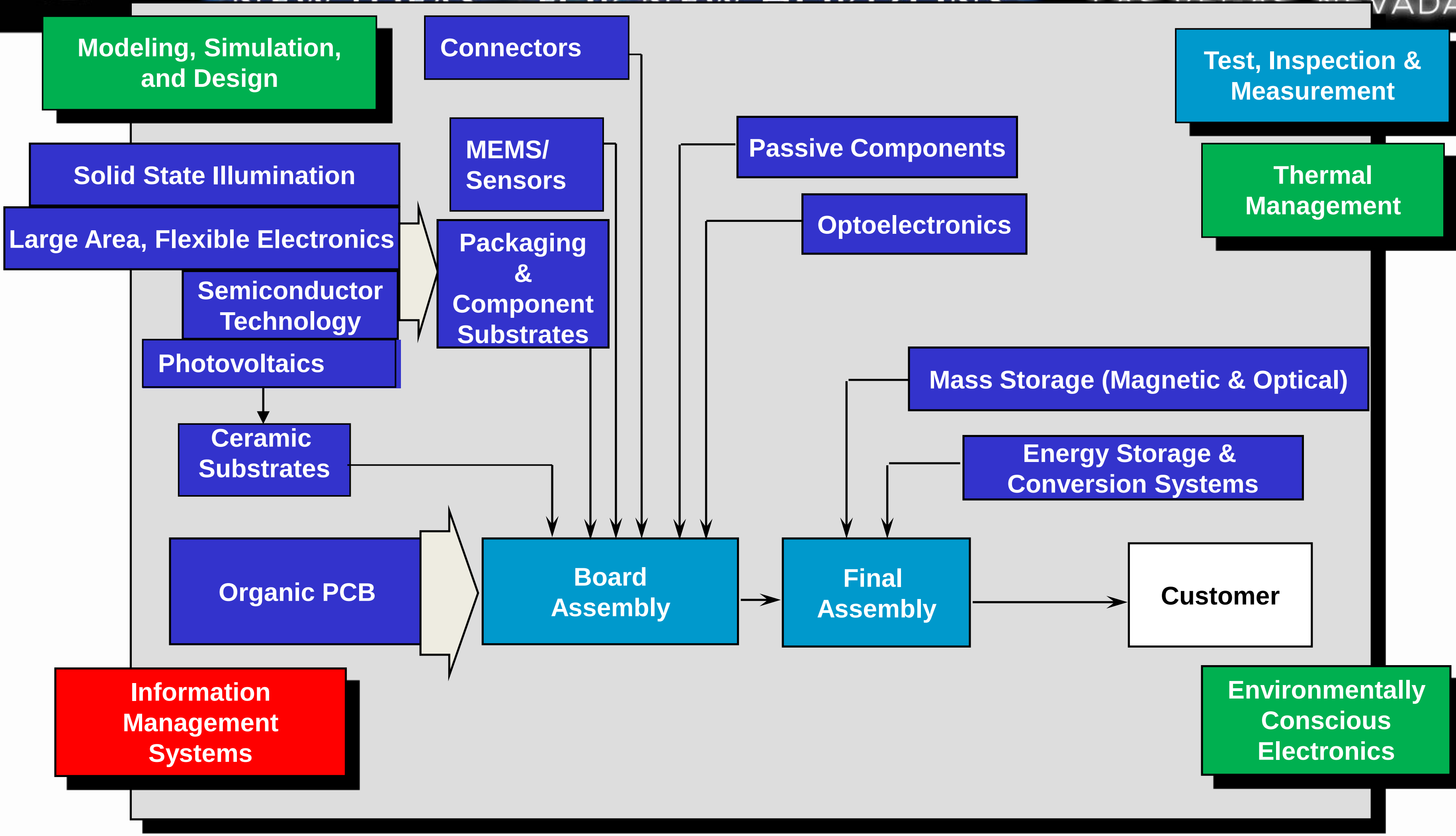
INEMI Roadmap

- TWG - Technical Working Group
  - Develops the roadmap technology chapters
  - Presently 20 groups/chapters for the roadmap
  - Roadmap released every 2 years



Red=Business Green=Engineering Aqua=Manufacturing Blue=Component & Subsystem

2013 Technology Working Groups (TWGs)

Statistics for INEMI 2013 Roadmap

- > 650 participants
- > 350 companies/organizations
- 18 countries from 4 continents
- 20 Technology Working Groups (TWGs)
- 6 Product Emulator Groups (PEGs)
- > 1,900 pages of information
- Roadmaps the needs for 2013-2023
- Workshops held in Europe, Asia and North America
- Global Perspective

- Available to iNEMI members from 12/22/12 at: www.inemi.org
- Shipping/Downloading to industry began April 4, 2013 at www.inemi.org

INEMI Board Assembly Technical Working Group (2013)

Board Assembly Sections and Chairs (99 pages)

- Assembly Materials: Keith Howell, Nihon Superior
- Repair & Rework: Jasbir Bath
- Press-fit: Dennis Willie, Flextronics
- SMT Placement: Girish Wable, Jabil
- NPI: Michael Gerner, Plexus

Overall Board Assembly Section Chair and Co-chair

- Dr. Paul Wang, Mitac
- Frank Grano, GE

- 51 participants from 33 companies

INEMI Rework and Repair Section (2013)

- Updated hand soldering, PTH rework and area array rework sections from 2011 roadmap in relation to tin-lead and lead-free rework soldering technologies.

Some focus areas included:

- Rework of temperature sensitive components
- Rework of new/emerging components such as QFN/BTC and PoP components.
- Understanding if there are changes in the types of alloy materials used during lead-free rework.

Group consisted of OEMs, EMS, soldering material and rework equipment suppliers and rework training companies.

Hand Solder Rework

Hand Solder Rework

Soldering Process	Parameter	Units	2011	2013	2015	2017	2023
Pb-free	Soldering iron peak temperature used	°C	375	375	375	375	375
	Total contact time	sec	6	6	6	6	6
	Smallest lead-frame pitch to be reworked by hand	mm	0.4	0.4	0.3	0.3	0.3
	Smallest type of discretes being reworked	-	0201	0201	01005	01005	01005
	Type of wire alloy used	-	SAC305/ SnCuNi (low tip dissolution alloys)	SAC305/ SnCuNi (low tip dissolution alloys)	SAC305/ SnCuNi (low tip dissolution alloys)	SAC305/ SnCuNi (low tip dissolution alloys)	SAC305/ SnCuNi (low tip dissolution alloys)

Component pitch down to 0.3mm,
Component size down to 01005[Imperial]/ (0402 metric)

PTH Rework (Challenges)

Table 22: Convection Connector Rework Temperatures (Ref: VJ Electronix)

	Overall Board Bottomside Preheat Temperature	Localized Bottomside PCB Temperature	Localized Topside PCB Temperature
Single Point Rework	125 – 150°C	240 – 260°C	235 – 250°C
Connector Removal	125 – 150°C	240 – 260°C	240 – 260°C
Barrel Scavenge	125 – 150°C	240 – 260°C	250 – 270°C
Connector Replace	125 – 150°C	240 – 260°C	240 – 260°C

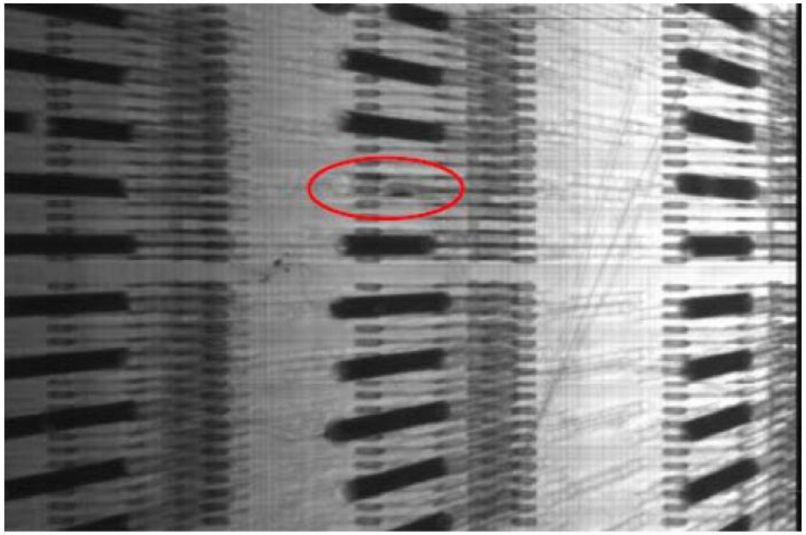
Board Preheat temperatures: 150C

Board Peak Temperatures: up to 270C

Figure 9: Copper Dissolution and Insufficient Hole fill (Ref: Celestica 200

Copper dissolution/ Insufficient Holefill

Figure 7: Missing solder in TH barrel pin to rework. Ref: VJ Electronix



PTH rework (SnPb versus Lead-free)

Pin Through Hole Rework

Soldering Process	Parameter	Units	2011	2013	2015	2017	2023
SnPb	Type of preheat used	-	Convection/ IR	Convection/ IR	Convection/ IR	Convection/ IR	Convection/ IR
	Rework approach (See note)	-	1, 2	1, 2	1, 2	1, 2	1, 2
	PTH rework by hand	%	5	5	5	5	5
Pb-free	Type of preheat used	-	Convection/ IR	Convection/ IR	Convection/ IR	Convection/IR	Convection/IR
	Rework approach (See note)	-	1, 2	1, 2	1, 2	1,2	1,2
	PTH rework by hand	%	10	10	10	10	10

Note: Rework Approach Options: 1-Remove and replace within one cycle, 2-Remove in one cycle, remove solder (by hand/ automated), then replace in another cycle

More challenges to remove and replace component in one cycle
More rework by hand-soldering for lead-free

Pin Through Hole Rework

Soldering Process	Parameter	Units	2011	2013	2015	2017	2023
Pb-free	Alloy type used	-	SAC305/ SnCuNi (low copper barrel dissolution)	SAC305/ SnCuNi (low copper barrel dissolution)	SAC305/ SnCuNi (low copper barrel dissolution)	SAC305/ SnCuNi (low copper barrel dissolution)	SAC305/ SnCuNi (low copper barrel dissolution)
	Type of preheat used	-	Convection /IR	Convection /IR	Convection /IR	Convection /IR	Convection /IR
	Board preheat temperature if preheat is used(depends on board thickness)	°C	125-155	125-155	125-155	125-155	125-155
	Max. Pot temperature	°C	260-275	260-275	260-275	260-275	260-275
	Total component contact time	Sec	10	15-30	15-30	15-30	15-30
	Minimum remaining board copper thickness required	Um	12.7	12.7	12.7	12.7	12.7
	Rework approach (See Notes 1 & 2)	-	1, 2	1, 2	1, 2	1, 2	1, 2
	Typical Pin to Hole Area Ratios (Note 3)		0.15-0.35	0.15-0.35	0.15-0.35	0.15-0.35	0.15-0.35
	PTH rework by hand	%	10	10	10	10	10

Note 1: Rework Approach Options: 1-Remove and replace within one cycle, 2-Remove in one cycle, remove solder (by hand/ automated), then replace in another cycle

Note 2: The number of reworks will be dependent on the total component contact time which cannot be exceeded and the minimum remaining board copper thickness limits.

PTH Rework

SnAgCu and SnCuNi alloys

Board preheat up to 155C

Up to 275C solder pot temperatures

Up to 30 seconds component contact time.

Area Array Rework

– Rework of New/Non-Standard Components
– Site Dressing Rework Process
– Re-Attach Rework Process

Figure 11: Ref: Sjoberg, J., et al, Flextronics, "Process Development and Reliability Evaluation for Inline Package on Package (PoP) Assembly", SMTAI, 2007

Soldering Process	Parameter	Units	2011	2013	2015	2017	2023
	Maximum package temperature	°C	245-260C	245-260C	245-260C	245-260C	245-260C
	Minimum reworkable pitch	mm	0.4	0.4	0.4	0.4	0.3
	Minimum solder joint temperature	°C	235	235	235	235	235
	Target delta T across solder joints	°C	<10	<10	<10	<10	<10
	Typical rework profile length (time)	min	8	8	8	8	8
	Time Above Liquidus (TAL)	sec	60-90	60 - 90	60 - 90	60 - 90	60 - 90
	Number of allowable area array reworks at a specific location	#	3	3	3	3	3
	Type of rework (Conv./IR/Other) (Other is Laser and Vapor Phase Rework)	%	85/15	85/15	85/15	80/20	70/20/10
	Type redress approach (Non Contact/Solder Wick)	%	20/80	20/80	20/80	30/70	40/60
	Preheat temperature (topside board temperature)	°C	125	125-150	125-150	125-150	125-150
	Currently observe secondary reflow of adjacent reflow (0.150" [3.8mm] away)	-	Yes	Yes	Yes	Yes	Yes

Area Array Rework

Board preheat: up to 150C

260C max. peak temp.

Target temp. delta <10C

No. of reworks: up to 3

Increased non-contact site redressing

Area Array and Non-Standard Package Rework

Soldering Process	Parameter	Units	2011	2013	2015	2017	2023
Pb-free	Maximum package size	mm	50	50	55	60	75
	Minimum package size	mm	5	2	1.5	1.5	1
	Smallest type of discretes being reworked	-	0201 (Imperial)	0201 (Imperial)	01005 (Imperial)	0201 metric	0201 metric
	Minimum re-workable pitch	mm	0.4	0.4	0.4	0.3	0.3
	Target delta T across solder joints	°C	<10	<10	<10	<10	<10
	Typical rework profile length (time)	min	8	8	8	8	8
	Time Above Liquidus (TAL)	sec	60 - 90	60 - 90	60 - 90	60 - 90	60 - 90
	Number of allowable area array reworks at a specific location	#	3	3	3	3	3
	Type of rework (Conv./IR/Other) (Other is Laser and Vapor Phase Rework)	%	85/15	85/15	85/15	80/20	70/20/10
	Type redress approach (Non Contact/Solder Wick)	%	20/80	20/80	20/80	30/70	40/60
	Type of medium deposit for BGA component rework (Paste on PCB/Paste on Part/Flux only) (See Note)	%	40/40/20	40/40/20	40/40/20	40/40/20	40/40/20

Area Array Rework (Component size)

Up to 75mm package size

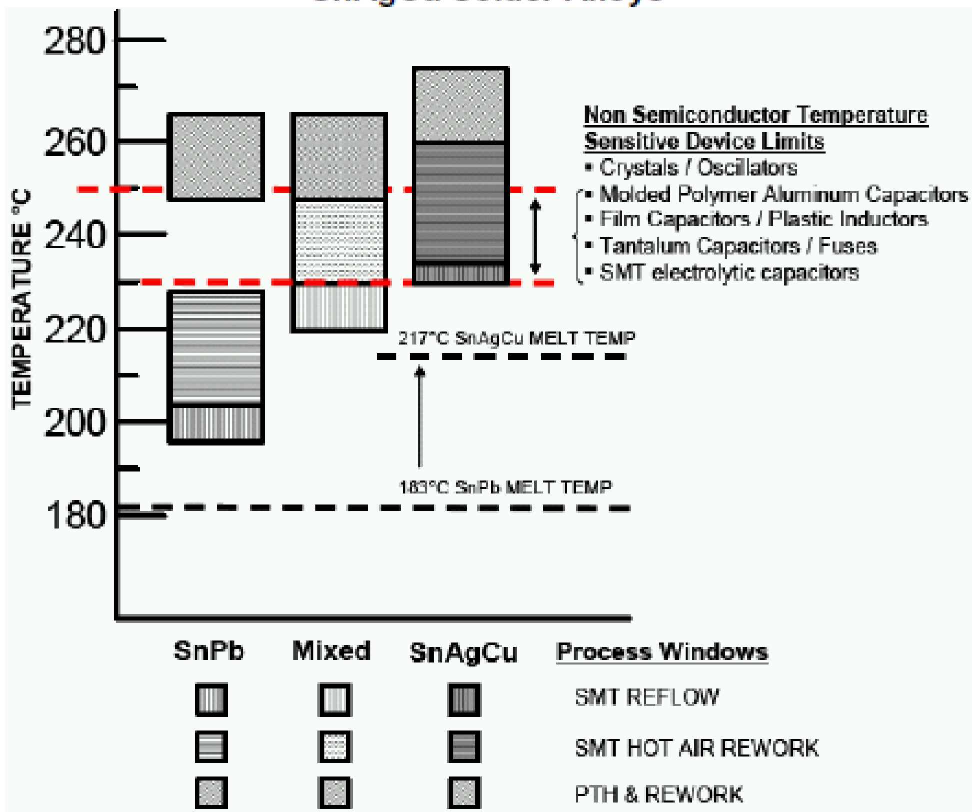
Down to 1mm package size

0201 metric chip

Challenge to have <10C target delta T

Rework of Temperature Sensitive Devices

Figure 13: Rework Process Temperature Range Corresponding to Tin-Lead and Lead-Free SnAgCu Solder Alloys



Source of data: Pymento, L., et al, IBM, "Process Development with Temperature Sensitive Components in Server Applications", IPC APEX, 2008 Conference

REWORK OF TEMPERATURE SENSITIVE COMPONENTS

- Reduced lead-free rework temperature process window for temperature sensitive components (e.g. aluminum capacitors, inductors, fuses, fiber optics, LED's, etc.).
- J-STD-075 standard includes labeling criteria for temp. sensitive components to identify specific maximum reflow temperatures.
- Continued development by suppliers of these components to extend temperature capability.
- In addition, methods of reworking temp. sensitive components without exceeding the current allowable temp. limitations required.
- Hand solder rework typically used for these temperature sensitive components which creates less temperature issues during rework.
- The use of lower temperature lead-free solder alloys during rework such as Sn58Bi (138C melting temperature) is also being explored.

Rework of Non-Standard Components

Examples include Package-on-Package (PoP), QFN (or MLF), SMT area array connectors and shields.

BTC (Bottom Termination Components)

- Multiple ways being used to rework QFN/BTC (or MLF) components with no standardization in the industry on the appropriate rework method to use.
- Issues related to QFN (MLF) also include paste deposition
  - Ability to ensure proper deposition of paste on the internal, staggered rowed 0.4mm terminals can be challenging, especially when pitches down to 0.3mm.
- Mini-stencil paste deposition methods will have to be improved.
- Areas to address include: removal and replacement of the parts, stencil design, solder paste selection, voiding reduction, package body temperature monitoring.
- Studies will need to be done to determine the affect of voiding on the solder reliability of BTC/QFN/LGA components after rework (in terms of mechanical, thermal and electrical reliability).

Rework of Non-Standard Components (Cont.)

PoP (Package on Package Components)

- Establishing a process of reworking an individual component is a challenge.
- A common practice today is to remove the entire package; however this can cause unnecessary scrap depending on the location of the defect.
- New nozzle designs and process techniques (some rework systems do not require special nozzles) adjusted to remove top package only, or the entire stacked device
- Challenge will be on how to reduce the warpage of the individual packages during the rework operations leading to head-in-pillow defects.
- Pad redress processes for ensuring pad flatness, cleanliness and integrity on top of the bottom component will also have to be addressed.

SMT area array connectors

- Main issue related to height and thermal mass of the connector, on a large, thermally massive PCB.
- The connector body often blisters, melts and/or discolors, during reflow.
- Development work into new nozzle designs to assist in reworking this connector.

Technology Gaps (Hand Soldering Rework)

- Development of processes to rework 01005[0402 metric] components
- Development of hand soldering fluxes to be electrically reliable on the board even if not sufficiently heat activated.

Technology Gaps (PTH Rework)

- PTH rework for large, complex and high thermal mass PCB assemblies
- Increase in thermal mass causes the need for increased contact times, to enable sufficient heat transfer to successfully remove and replace a PTH connector.
- Increasing board preheat prior to rework and/or pot temperatures up to 275° C especially for the higher temperature SnCuNi based alloys
- Components for lead-free PTH rework are typically only rated up to 270° C.

- Advent of halogen free laminates may result in further gaps with respect to laminate survivability during rework.

- Cost and high copper dissolution properties are driving a change away from using the common SAC305/SAC405 alloys during PTH rework.
  - There are many alternative lead-free alloys available for PTH rework such as SnCuNi based alloys and low melting temperature alloys.

Technology Gaps (PTH Rework)- Cont.

- Gap remains in terms of impact of mixing differing lead-free solder alloys during PTH rework.
  - Contamination of mini-pot a concern, as well as reliability of a mixed PTH joint.
- Issue may also force the need to utilize alternative methods of reworking PTH connectors, such as convection, infrared, laser, vapor phase, etc.
  - Other alternative methods of removal and replacement of PTH components using BGA rework equipment is being explored.
- Key gap is obtaining good hole fill for lead-free PTH rework on thicker boards while maintaining board copper barrel thickness.
- The current temperature of the components is limiting the pot temperatures during lead-free PTH rework to obtain good hole fill on thicker boards.
- Need to increase the IPC board standard [IPC 6102] to increase the copper barrel thickness, so that the copper knee thickness after wave soldering and wave rework are above 0.5mils (12.7um)
- Flux development is also need to be electrically reliable on the board even if not sufficiently heat activated.

TECHNOLOGY GAPS (AREA ARRAY REWORK)

- Establish a process for reworking large BGA and BGA socket components (greater than 50mm) assembled on thermally massive PCBs, while conforming to J-STD-020 standard.
- Establishing a process for reworking temperature sensitive devices.
- Design standardization on recommended board space “keep out areas” around these area array components without damaging adjacent components.
- Establish a process for reworking new/non-standard component types (i.e. PoP, BTC/QFN)
  - Have common industry procedures for rework for these types of components. (IPC 7711: Repair and Rework procedures for BTCs) [See Procedure 5.8.1.1. and 5.8.1.2 and 5.8.1.3 from 7711 for QFN/BTC rework processes]
- Use of these IPC standards must also take into account the reliability of the flux used in rework to ensure it is properly heat activated during rework
- Rework processes to be developed for non-standard components (shields) or large land array components where center pad not symmetrical & broken down into separate pad areas under part.

Technology Gaps (Area Array Rework)- Cont.

- Further development is needed on site redressing processes during area array rework to prevent:
  - lifted board pads
  - solder mask damage
  - copper pad dissolution

- Development is needed to understand the benefits and disadvantages of the paste printing during array area reattach process during rework on:
  - component
  - paste printing on board
  - paste dispensing on board
  - flux dispensing

Prioritized Research & Development (Hand Soldering Rework)

- Process for hand soldering 01005[0402 metric] components in a cost effective manner.
- Guidelines for external bench-top pre-heaters to aid in hand soldering of lead free assemblies.

PRIORITIZED RESEARCH & DEVELOPMENT (PTH REWORK)

- Work is needed to understand the correlation between the copper plating type and copper knee dissolution.
- Recommend parameters for alternative rework methods of reworking PTH connectors, such as convection, infrared, laser, vapor phase, etc.
- Study reliability of single pin repair for connectors exhibiting insufficient solder on one or a few pins.
- Development of the PTH rework process to obtain good hole-fill for lead-free PTH rework on thicker boards while maintaining board copper barrel thickness.
- Development of IPC standards to increase the copper knee thickness of boards so copper knee dissolution during wave rework and wave soldering is less of a concern to reliability.

PRIORITIZED RESEARCH & DEVELOPMENT (AREA ARRAY REWORK)

- Process for reworking large BGAs and BGA sockets (greater than 50mm) using area array rework equipment
- Industry Standardized Process for rework of BTC/QFN/MLF and PoP components using area array rework equipment
- Processes to rework large and thin BGAs and PoP components to reduce component warpage affects during rework leading to Head-in-Pillow component soldering issues.
- Process for reworking temperature sensitive devices using area array rework equipment
- Process for reworking non-standard components using area array rework equipment.
- Process for adhesives rework

PRIORITIZED RESEARCH & DEVELOPMENT (OTHER CHALLENGES)

- For single piece RF shields the reliable removal and replacement is challenging for hand soldering or machine rework especially with components in close proximity to the shield.
- The removal of the RF shield will affect adjacent components which can affect the thermal and mechanical reliability performance of the nearby components.

Prioritized Research & Development (General)

- Increased training of operators and engineers in the correct procedures to rework and repair product boards.
- Development of liquid and tacky flux for hand soldering and PTH rework operations which do not lead to reliability concerns if not properly heat activated.

INEMI Roadmap Assembly Materials Gaps

Parameter	Definition	2011	2013	2015	2017	2023
Solder Paste	Alloy	SAC/ Modified SnCu/ Low Ag SAC	SAC/ Modified SnCu/ Low Ag SAC	SAC/ Modified SnCu/ Low Ag SAC	SAC/ Modified SnCu/ Low Ag SAC	SAC/ Modified SnCu/ Low Ag SAC
	Alloy (Low Temp)				Low Temp	Low Temp
	Alloy (Lead-free) High Temp>260C	High Temp	High Temp	High Temp	High Temp	High Temp
	Halogen-free					
Bar Solder	Alloy	SAC/ Modified SnCu/ Low Ag SAC	SAC/ Modified SnCu/ Low Ag SAC	SAC/ Modified SnCu/ Low Ag SAC	SAC/ Modified SnCu/ Low Ag SAC	SAC/ Modified SnCu/ Low Ag SAC
Wave Solder Flux	VOC Free					
	Halogen free					
Flux-cored Solder Wire	Alloy	SAC/ Modified SnCu/ Low Ag SAC	SAC/ Modified SnCu/ Low Ag SAC	SAC/ Modified SnCu/ Low Ag SAC	SAC/ Modified SnCu/ Low Ag SAC	SAC/ Modified SnCu/ Low Ag SAC
Repair Gel/Pasty Fluxes	Flux-cored Solder Wire			More Benign	Left on Board	Left on Board
Repair Liquid Fluxes	Repair Gel/Tacky Fluxes			More Benign	Left on Board	Left on Board
	Repair Liquid Fluxes			More Benign	Left on Board	Left on Board

INEMI Roadmap Assembly Materials R&D Priorities

Repair Flux

- Improvements in tacky fluxes for CSPs
- Development of fluxes with benign residues without heat activation in the solder

INEMI Rework and Repair Section (2015)
NEXT STEPS/ UPDATES

- Focus on updating hand soldering, PTH rework and area array rework sections from 2013 roadmap in relation to tin-lead and lead-free rework soldering technologies.

Some sections to focus on include:

- Updates to rework of components such as QFN/BTC and PoP components
- Lead-free PTH rework of thicker boards.

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