



iNEMI

International Electronics Manufacturing Initiative

Board Assembly Roadmap

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Technology Forum
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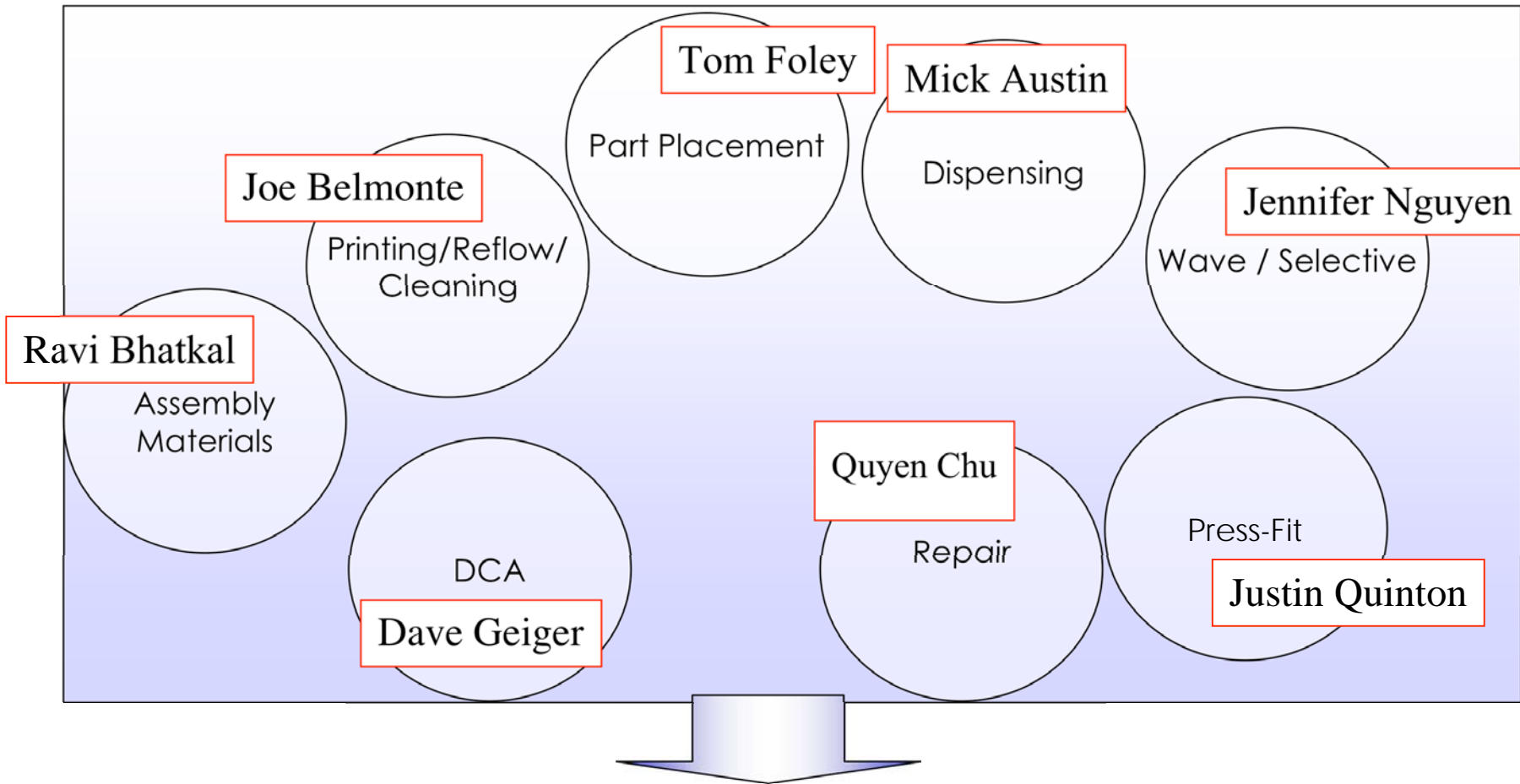
Advancing manufacturing technology

Agenda

- **Roadmap Development Approach**
- **Chapter Overview**
- **Key Trends**
- **Technology Gaps & Challenges**
- **Business Issues / Potential Barriers**

Focus Team Approach: Interactions

Board Assembly TWG



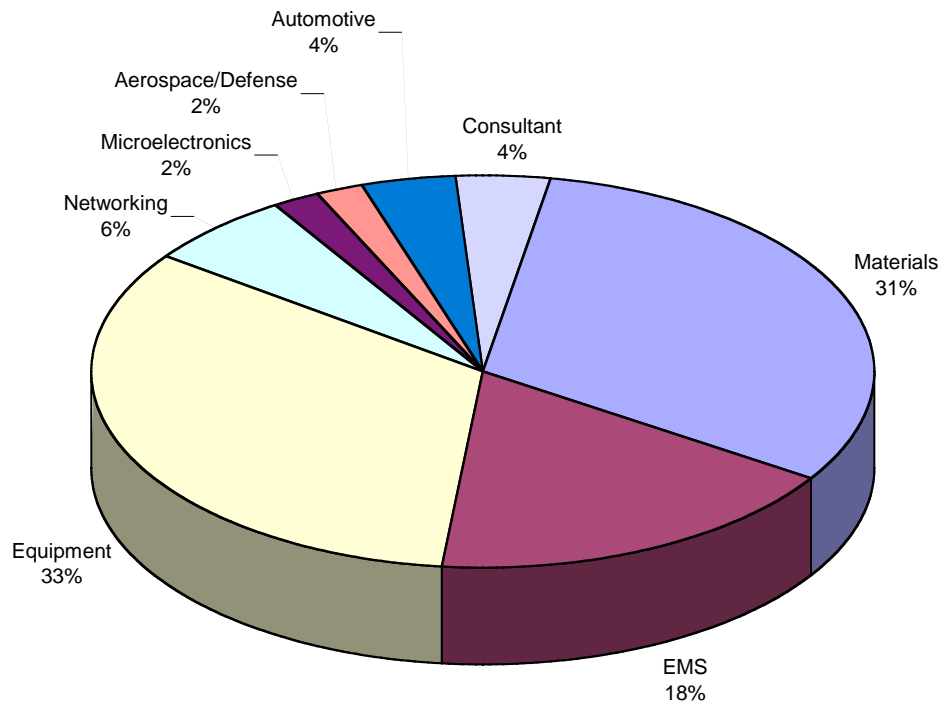
Equipment and Process Gaps / Research Needs
Show Stoppers / Technology Needs

iNEMI

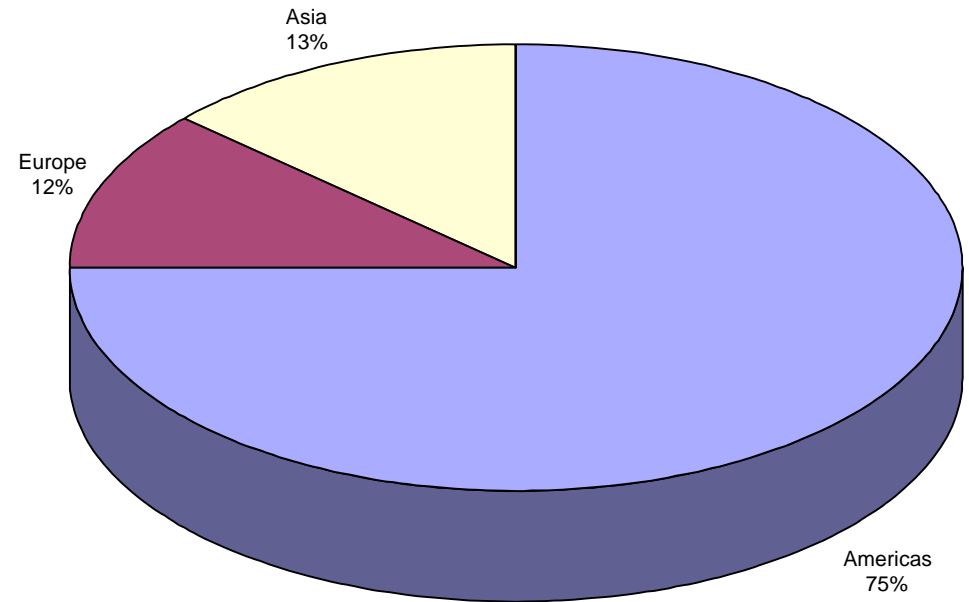
Team Members

Active Participants: 85

Participation by Industry (45 firms)



Participation by Region



Chapter Overview

Milestones

- **Team formation:**
March 2006
- **Final report :**
Sept. 2006

Contents

- Approximately
65 pages / 20,000 words
23 Tables / 9 Figures
- **Business / Technology**
- **Span: 10 yrs**
(2007-2017)

TABLE OF CONTENTS:

<u>Executive Summary</u>	3
<u>Introduction</u>	5
<u>Situational (Infrastructure) Analysis</u>	6
Business Trends	6
Component Trends	12
PCB Trends	14
Assembly Materials	15
SMT Process	15
Part Placement	16
Wave and Selective Soldering	16
Rework and Repair	17
<u>Roadmap of Quantified Key Attribute Needs</u>	19
Business Issues: Research and Development Trends	20
Cross Cutting: Assembly Materials Forecast	22
Process Technology: SMT Process Technology	23
Process Technology: Part Placement Technology Forecast	25
Process Technology: Wave and Selective Soldering Technology Forecast	26
Process Technology: Rework and Repair Technology Forecast	27
<u>Critical Infrastructure and Technology Issues</u>	29
Business Issues	30
Assembly Materials	37
Surface Mount Technology Process	42
Dispensing/Underfill	48
Part Placement	50
Wave and Selective Soldering	52
Pressfit	54
Rework and Repair	57
Direct Chip Attach	59
<u>Business Issues, Gaps and Showstoppers</u>	60
Cross Cutting Issues, Gaps and Showstoppers	62
Process Technology Gaps and Showstoppers	63
<u>Prioritized Research & Development</u>	66

Key Trends

Business Environment

- Higher level of service demands or opportunities placed on EMS
- EMS companies are expanding offerings to include services in a wider range of a product's life cycle
- Increased role of EMS and materials suppliers in R&D and process development
- Continued migration to low cost regions

Key							
OEM	Original Equipment Manufacturer	2005	OEM	OEM	OEM	OEM-ODM	OEM-ODM
ODM	Original Design Manufacturer	2007	OEM-ODM	OEM-ODM	OEM-ODM	OEM-ODM	OEM-ODM
EMS	Electronics Service Provider	2007	OEM-ODM	OEM-ODM	OEM-ODM	OEM-ODM	OEM-ODM
SUPP	Component Supplier	2005	EMS-OEM	EMS-OEM	EMS-OEM	EMS-OEM	EMS-OEM
EQUIP	Equipment (Hardware Drivers)	2007	EMS-OEM	EMS-OEM	EMS-OEM	EMS-OEM	EMS-OEM
OEM-CDM-SUPP	Combination of OEM, ODM, & Component Supplier	2007	OEM-ODM	OEM-ODM	OEM-ODM	OEM-ODM	OEM-ODM
EMS-OEM-EQUIP	Combination of EMS, OEM, & Equipment Supplier	2005	OEM-ODM	OEM-ODM	OEM-ODM	OEM-ODM	OEM-ODM
EMS-EQUIP	Combination of Equipment/Materials suppliers and EMS/ODM	2007	OEM	OEM	OEM	OEM-ODM	OEM-ODM
EMS-OEM	Combination of EMS & OEM	2007	OEM-ODM	OEM-ODM	OEM-ODM	OEM-ODM	OEM-ODM
OEM-ODM	Combination of OEM and ODM	2005	OEM-ODM	OEM-ODM	OEM-ODM	OEM-ODM	OEM-ODM
		2007	EMS	EMS	EMS	EMS	EMS
Process Technology Development		2005	OEM	EMS	EMS	EMS	EMS-EQUIP
		2007	EMS-EQUIP	EMS-EQUIP	EMS-EQUIP	EMS-EQUIP	EMS-EQUIP
Process Research and Development		2005	EMS-OEM	EMS-OEM	EMS-OEM-EQUIP	EMS-OEM-EQUIP	EMS-OEM-EQUIP
		2007	EMS-EQUIP	EMS-EQUIP	EMS-EQUIP	EMS-EQUIP	EMS-EQUIP
Test Functional Development		2005	EMS-OEM	EMS-OEM	EMS-OEM	EMS-OEM	EMS-OEM
		2007	EMS-OEM	EMS-OEM	EMS-OEM	EMS-OEM	EMS-OEM
Manufacturing Test (AOI / X-Ray) Development		2005	EQUIP	EQUIP	EQUIP	EQUIP	EQUIP
		2007	EMS-EQUIP	EMS-EQUIP	EMS-EQUIP	EMS-EQUIP	EMS-EQUIP
Reliability Evaluation		2005	OEM	OEM	OEM	OEM-ODM	OEM-ODM
		2007	EMS-OEM	EMS-OEM	EMS-OEM	EMS-OEM	EMS-OEM
Compliance Testing		2005	EMS-OEM	EMS-OEM	EMS-OEM	EMS-OEM	EMS-OEM
		2007	EMS-OEM	EMS-OEM	EMS-OEM	EMS	EMS
Application Engineering		2005	OEM	OEM	OEM	OEM	OEM
		2007	OEM	OEM-ODM	OEM-ODM	OEM-ODM	OEM-ODM
Failure Analysis		2005	EMS-OEM	EMS-OEM	EMS	EMS	EMS
		2007	EMS	EMS	EMS	EMS	EMS

Key Trends

Main Drivers for Development in Board Assembly

- Conversion Cost Reduction
- Reduction in Time-to-Add-EMS and NPI Time
- Increased Component I/O Density
- Transition to Environmental and Regulatory Compliance
- Higher Quality Expectations / Lower Defect Rates

Table 2: Forecasted conversion to Lead-free by product

	2005	2007	2009	2015	2017
PORT	SnPb	Pb-Free	Pb-Free	Pb-Free	Pb-Free
MED	SnPb	SnPb	Mixed	Mixed	Pb-Free
DEF	SnPb	SnPb	SnPb	SnPb	SnPb
AUTO	SnPb	SnPb	Pb-Free	Pb-Free	Pb-Free
OFF	SnPb	Pb-Free	Pb-Free	Pb-Free	Pb-Free
COMM	SnPb	SnPb	Pb-free	Pb-free	Pb-free

Key Trends

Board Assembly Conversion Cost

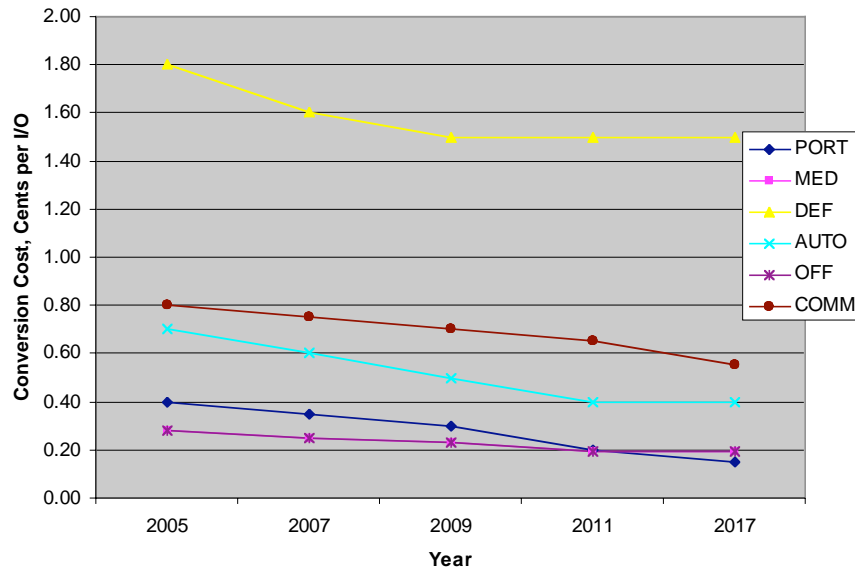


Figure 1: Board assembly conversion cost forecasts by product sector

Cost to take a group of parts and convert them to a functioning electronic assembly, i.e. price of a completed PCBA (including test, material procurement cost, etc.) minus the material cost

NPI Cycle Time

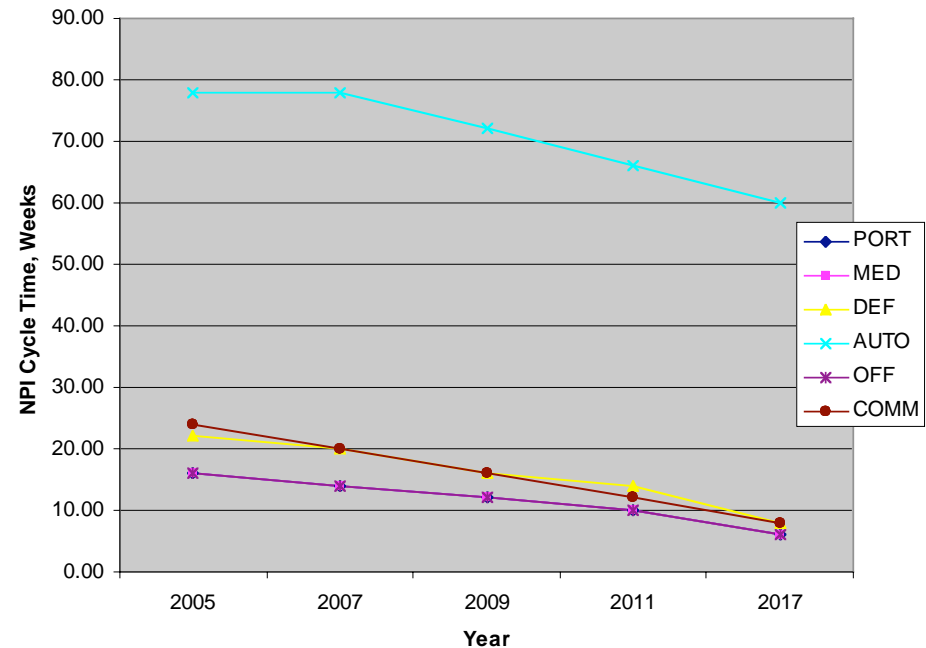


Figure 4: NPI Cycle Time by product sector

Time from when a design is released for alpha prototyping to the time when it is released for production - assuming that the prototype parts are available at release

(Source: iNEMI Product Emulator Groups)



Key Trends

Maximum Component I/O Density

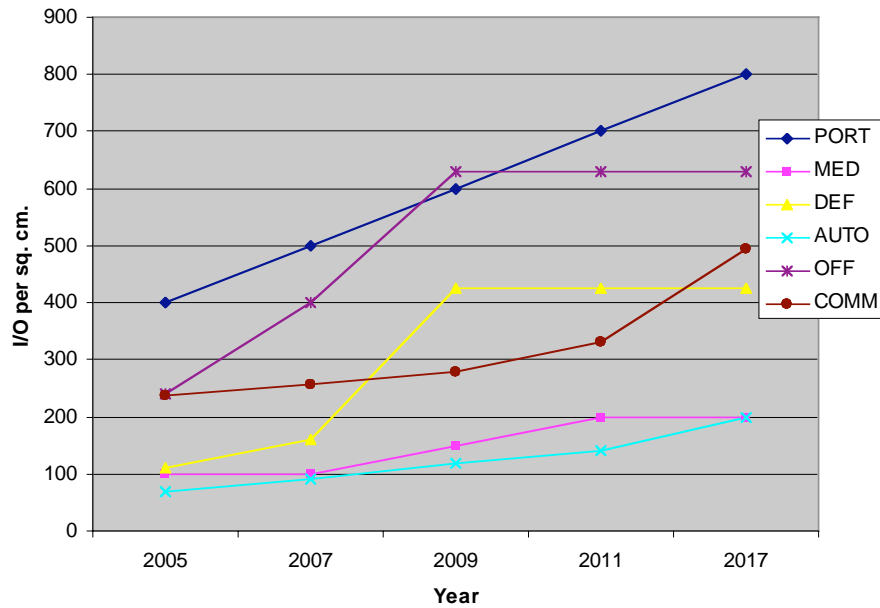


Figure 5: Maximum Component I/O Density by product sector

Minimum Package Pitch for Area Array Packages

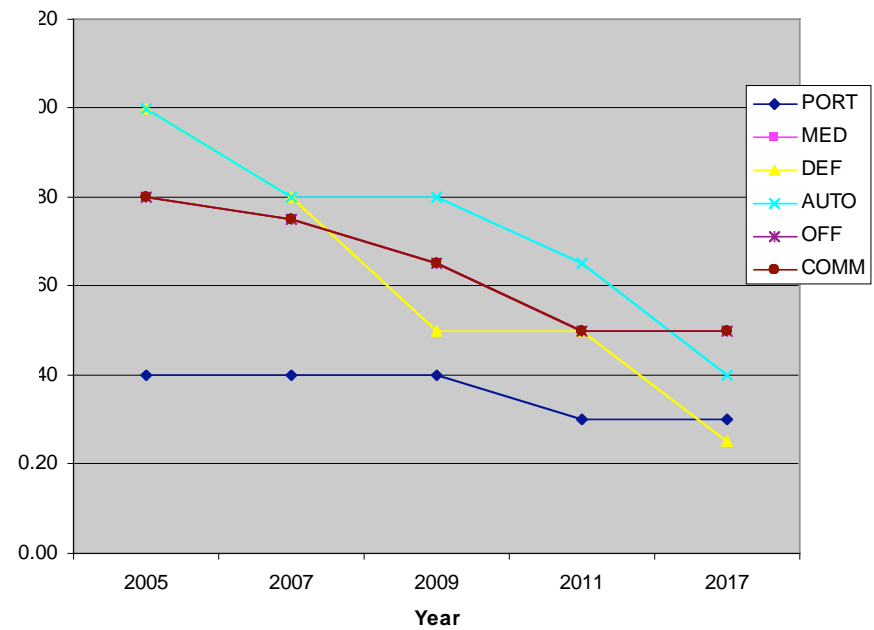


Figure 6: Minimum Area Array Package Pitch

Technology Gaps and Challenges

Materials

- **PCB / Substrate**
 - Higher use of flexible (especially for Portables) and low loss materials (especially for Communications and Medical)
 - Increased use of LCP
 - Availability of low cost board technology to handle very fine pitch high I/O devices
 - Decreasing pad diameters impacting the reliability of the second level assembly
 - Transition to embedded passives (in Portables)
 - Lead-Free applications
- **01005**
 - Component availability for the range of values required
 - Cost
 - Assembly process development

Technology Gaps and Challenges

Materials

Die attach

- **Preform use will increase, driven by thermal conductivity and CTE requirements**
- **Lead-free compatible**
 - Higher reflow temperatures and new materials
 - Compatibility with new solder masks
- **Low thermal resistance materials due to increased power density and thermal management**
 - Alternative fillers and fiber technology
- **Compatibility with stress-sensitive low-K material**
- **Thermal and moisture resistant polymers**
- **Non-Ag fillers to reduce cost**
- **Lower temperature cure to reduce assembly cost and reduce warpage for stress sensitive applications**

Technology Gaps and Challenges

Materials

Conformal Coatings

- Conformal coating materials/processes that are compatible with lead-free solder materials & processes, to help mitigate lead-free issues such as Sn-whisker formation
- Compatibility and wetting with various lead-free materials (mold compounds, solders, solder mask...)
- Low or non-VOC conformal coatings

Technology Gaps and Challenges

Materials

Solder

- **Fundamental understanding of lead-free solder material metallurgy, processability, and reliability**
- **Next generation solder materials**
 - **Replace the high cost Ag-containing alloys for certain cost-sensitive applications**
 - **Meet the need for ultra-low temperature attachment requirements for new polymer based products**
 - **Improve the SAC alloys in order to overcome several critical concerns and provide a wider process window**
 - **Copper dissolution during wave / selective soldering and rework**
 - **Reliability under high strain**
 - **Reliability under high strain rate (mechanical shock)**
 - **Reliability for smaller solder joints with low stand-off**
 - **Reliability of various “mixed” alloys due to reflow, wave soldering, rework**
 - **New interconnect technologies deploying nano-materials to support decreased pitch**

Technology Gaps and Challenges

Materials

- **Underfill**
 - **Reworkable underfills for large die/packages and fine pitch packages**
 - **Underfill chemistries to meet fill time and voiding requirements for components with low stand-off**
 - **Higher temperature lead-free reflow profiles require underfills to have improved thermal and hydrolytic stability**
 - **Underfill compatibility**
 - **Pre-applied underfills to both silicon and substrate to drive down cost**
 - **Selective encapsulation and bonding (such as corner bond)**
 - **Cycle time and consistency are some of the issues to be resolved**

Technology Gaps and Challenges

Processes

Paste Deposition

- **The widening range of required paste volume deposited on mixed technology assemblies is pushing traditional stencil design rules to their limit**
 - **Finer solder powder for fine pitch applications**
 - **Need for stencil, printing, and materials technologies to increase the consistency of the deposit**
 - **Increased stencil design accuracy (<12.5 μ m for 01005)**
 - **Increased transfer efficiency with lower area ratio**
 - **Thicker stencil, smaller aperture**
 - **Non-traditional technologies for solder paste deposition**
 - **Interconnect materials patterned on the PCB without the use of a mask, stencil or screen**

Technology Gaps and Challenges

Equipment

Placement Equipment

- **Capability to monitor the incoming component quality real-time, during the placement process (while still providing a reasonable ROI)**
- **Integration of press fit technology in the SMT process will improve productivity with the higher adoption of flexible tooling**
- **Odd form capabilities**
- **Flexible circuit assembly**
- **Increased capabilities with aggressive pricing**

Technology Gaps and Challenges

Processes & Equipment

Reflow Equipment

- More efficient reflow technologies, possibly combining reflow technologies such as thick film elements, microwave elements, positive thermal expansion elements, and induction heating, with conventional convection reflow
- Vapor phase

Lead-Free Wave & Selective Soldering

- Equipment upgrade
- Design guidelines
- Improvement in flux chemistries to promote wetting
- Achieving complete PTH hole-fill for large and thick boards

Technology Gaps and Challenges

Processes

Rework

- **Increasing package density and smaller components with lower stand-off challenge assembly cleaning and rework**
- **High component pin counts, larger component body sizes, and tighter component pitches/smaller land patterns, will challenge rework placement accuracy and reflow techniques, and impact rework yields**
- **Narrower process window for rework due to higher lead-free process temperatures**
- **Rework for fine pitch (0.4mm) devices and 01005**



Technology Gaps and Challenges

Processes

Rework

- **PTH**
 - Complete hole-fill and Cu dissolution for lead-free rework (using a min-pot)
 - Process to remove and replace PTH in a single step
- **Area array packages**
 - Mini-stencil paste printing
 - Special tooling for package size >50mm
 - MSL issue

Technology Gaps and Challenges

Processes & Equipment

Press-Fit

- **Development of automated connector placement equipment capable of pre and post inspection of the connector to ensure proper seating**
 - Placement process is slow and manually intensive
 - Limited automatic placement equipment due to lack of standardization of connector trays
- **Development of a methodology that is capable of doing 100% inspection of pins pressed into the same barrel from both sides**
 - **This methodology needs to be scaleable due to the large size of some of the backplanes**
 - Currently, if the pins are long enough to protrude through the board, a different inspection methods is required than if the pins cannot protrude through the board. There is currently no scalable solution for all situations
- **Need to develop common tooling to rework connectors**
 - Especially for rework an individual pin in a connector
- **Pins are spaced closer together over time, which increases the difficulty to meet the true position requirements**
- **Sn whisker (?)**



Technology Gaps and Challenges

Processes & Equipment

- **Development of automated printing, dispensing, placement, and rework equipment capable of the pitch requirements for SiP package assembly**
- **The increased need for 3D board assembly requires innovation in *every step* of the board assembly process**
 - **Paste deposition, component placement and attachment, inspection and test, etc.**
 - **Equipment supply base to support material handling of flexible/low loss substrates**
- **Optical interconnects will generate challenges for Board Assembly materials, methods and equipment**



Technology Gaps and Challenges

Inspection, Test and Reliability

- **Inspection/Test technologies need to keep up with the increasing density of board designs and complexity of component packages**
- **Industry standard for ion chromatography testing as related to product reliability**

Business Issues / Potential Barriers

- **Supply chain readiness to deal with the transition to lead-free**
 - **Ability for the supply chain to support both lead containing and lead-free BoM's**
 - **Ability to support the cost reduction targets with the transition to lead-free**
 - **Increased energy consumption, raw material cost increase, and short-term yield issues**
 - **EMS and OEM companies need to work on creative engineered solutions to bridge these gaps in the near term, and full turnkey solutions in the long term**

Business Issues / Potential Barriers

- **Emerging technologies**
 - With R&D transitioning to low cost geographies, government, academia and industry consortia will need to formulate ways to adopt and develop emerging technologies (such as nano-technology) into the board assembly process, in the global outsourcing environment
- **DFM in the global outsourcing environment requires closer interactions and collaboration across the supply chain**
 - Industry standards need to be further developed to facilitate and streamline information flow

Summary

- **Miniaturization is a key driver in electronics industry:**
 - IC Packaging
 - Board Assembly
 - Increased functionality of End Product
- **End product manufacturing is increasingly commoditized:**
 - Migration to low cost geographies
 - Relentless cost pressures
 - Low margin business
- **New technologies are required to keep pace:**
 - Green materials
 - Nanomaterials (e.g. temp. reduction of Pb-free solders)
 - Warm Assembly.
- **Have covered only highlights from 1 of 19 roadmaps**
- **Many more details in full Roadmap**

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