iNEMI®

International Electronics Manufacturing Initiative

# Closing Technology Knowledge Gaps

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*iNEMI*

*June 18th, 2009*

Advancing manufacturing technology

# Agenda

- **Introduction**
  - **iNEMI and the Technology Roadmap**
- **2009 Roadmap Overview**
  - **Methodology**
  - **Situational Analysis**
  - **Technology Issues and Needs**
- **Technology Project Areas**
  - **Energy and Environment**
  - **Miniaturization**
  - **Medical Electronics**
- **Summary**

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# Introduction

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# International Electronics Manufacturing Initiative

- **iNEMI organization:**
  - Corporate membership
  - Not-for-profit, R&D consortium
  - Collaboration defined by organization by-laws, intellectual property policy, and project agreements.
- **Member companies/organizations:**
  - Leadership OEM, EMS, and Supplier companies
  - Government labs
  - Academic Institutions.
- **Small staff provides services to facilitate global collaboration (USA, Asia & Europe):**
  - Support to help organize & manage projects
  - Communication services for collaboration
  - Manage Relationships with other Organizations.

# OEM/EMS Members



















# Supplier Members






























# Association/Consortium, Government, Consultant & University Members













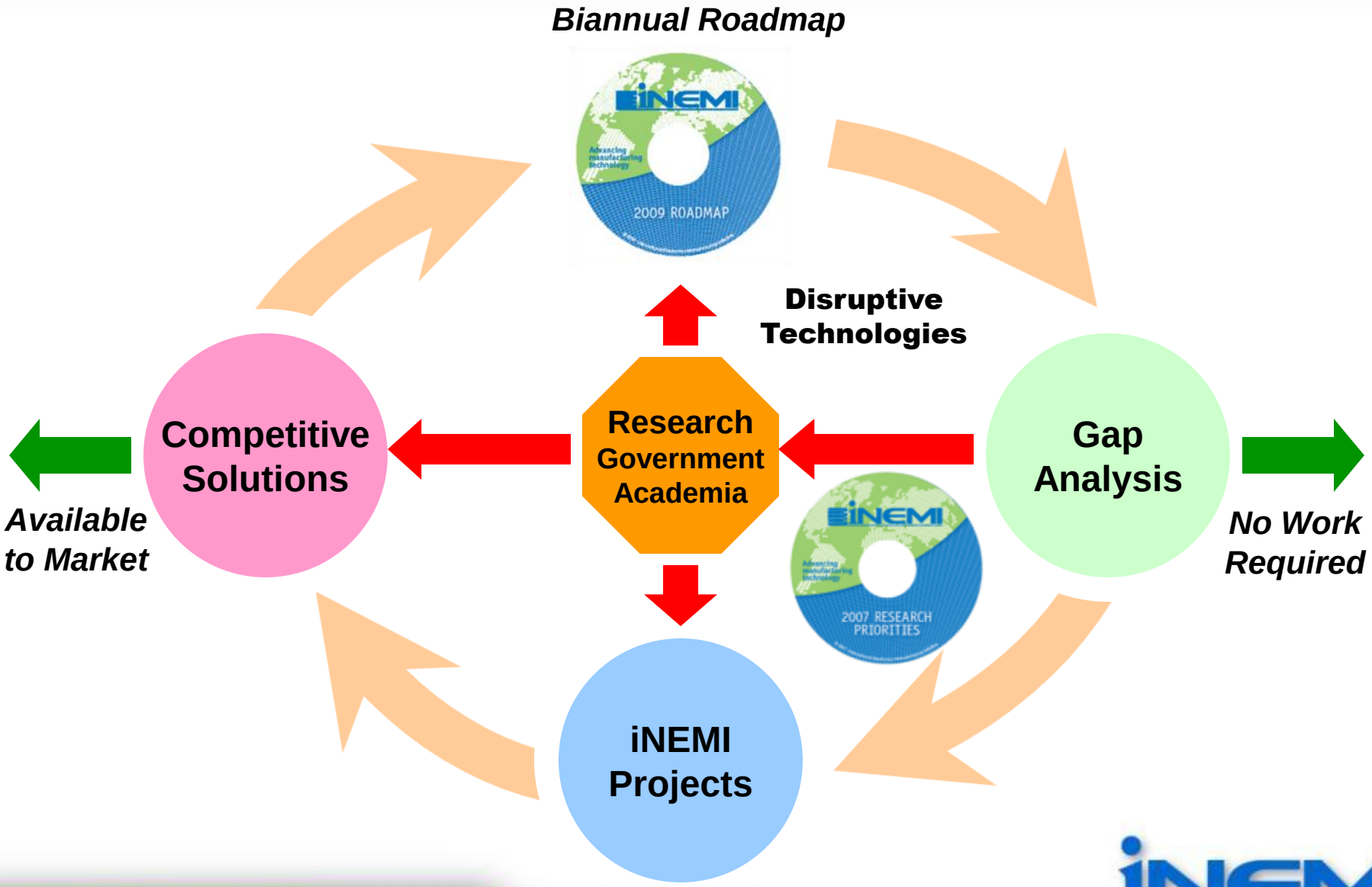
# Deliverables

*"Advancing Manufacturing Technology"*

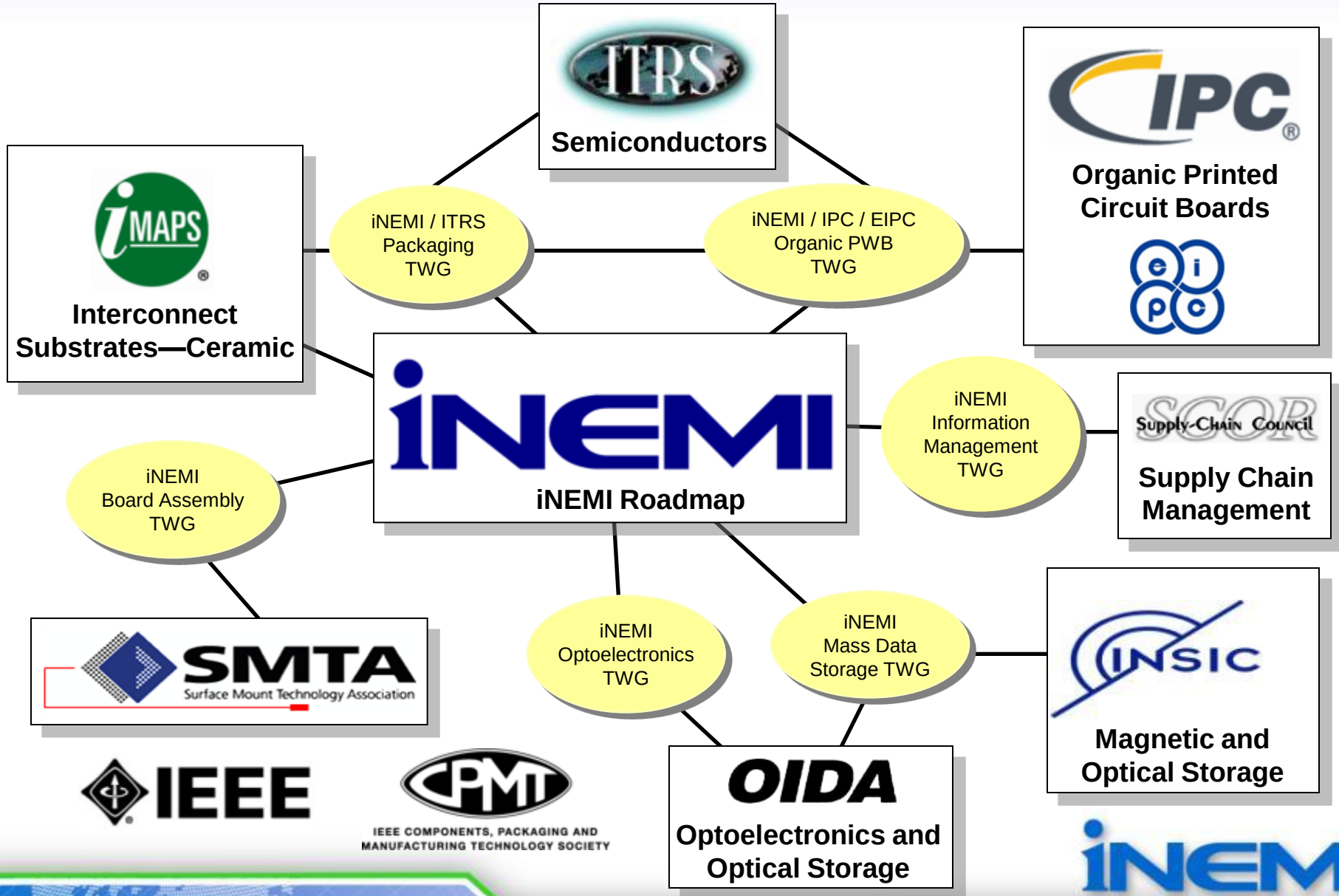
**iNEMI provides five important deliverables:**

1. **Technology roadmaps**
2. **Technology deployment projects**
3. **Research priorities**
4. **Forums on key industry issues**
5. **Position papers to focus industry direction**

# iNEMI Methodology



# Nine Contributing Organizations



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# 2009 iNEMI Roadmap

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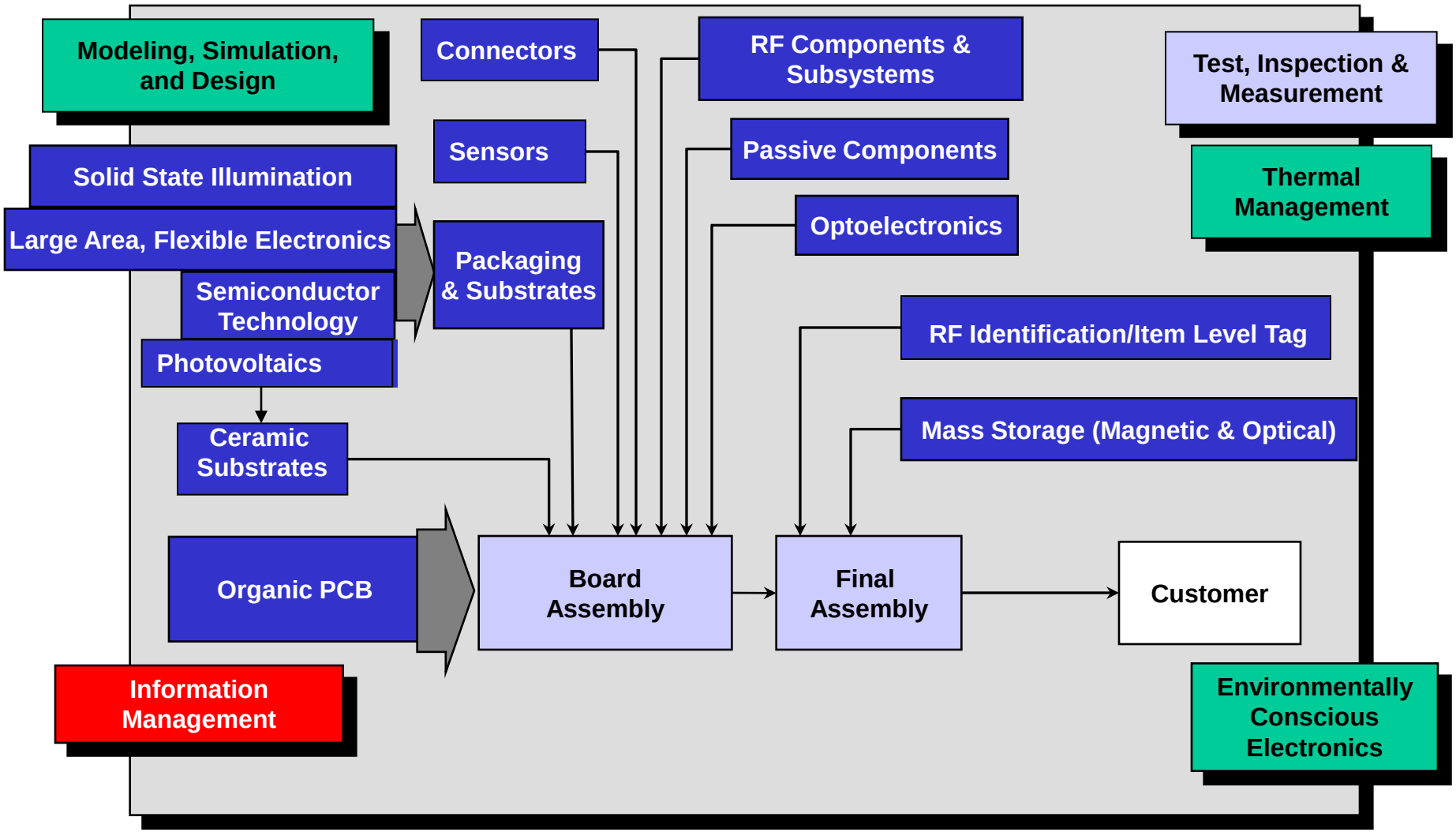
# Statistics for the 2009 Roadmap

- 8th Roadmap in 14 years
- > 550 participants
- > 250 companies/organizations
- 18 countries from 4 continents
- 20 Technology Working Groups (TWGs)
  - New roadmaps on Solid State Illumination, Photovoltaics and RFID Item-Level Tag
- 5 Product Emulator Groups (PEGs)
- > 1400 pages of information
- Roadmaps the needs for 2009-2019

# 2009 - 20 Technology Working Groups (TWGs)




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

# 2009 TWG Leadership

| Business Processes / Technologies | Chair(s) | Co-Chair(s) |
|---|---|---|
| Information Management | Eric Simmon, NIST | Jeff Pettinato, Intel |
| Design Technologies | | |
| Modeling, Simulation & Design Tools | Yishao Lai, ASE | S.B. Park, Binghamton U. |
| Environmentally Conscious Electronics | Bob Pfahl, iNEMI | |
| Thermal Management | Ravi Prasher, Intel | Azmat Malik, Consultant |
| Manufacturing Technologies | | |
| Final Assembly | John Allen, Celestica | Reijo Tuokko, Tampere U. |
| Board Assembly | Dongkai Shangguan, Flextronics | Aaron Unterborn, Flextronics<br>Ravi Bhatkal, Cookson |
| Test, Inspection & Measurement | Mike Reagin, Delphi | Michael J. Smith, Teradyne |

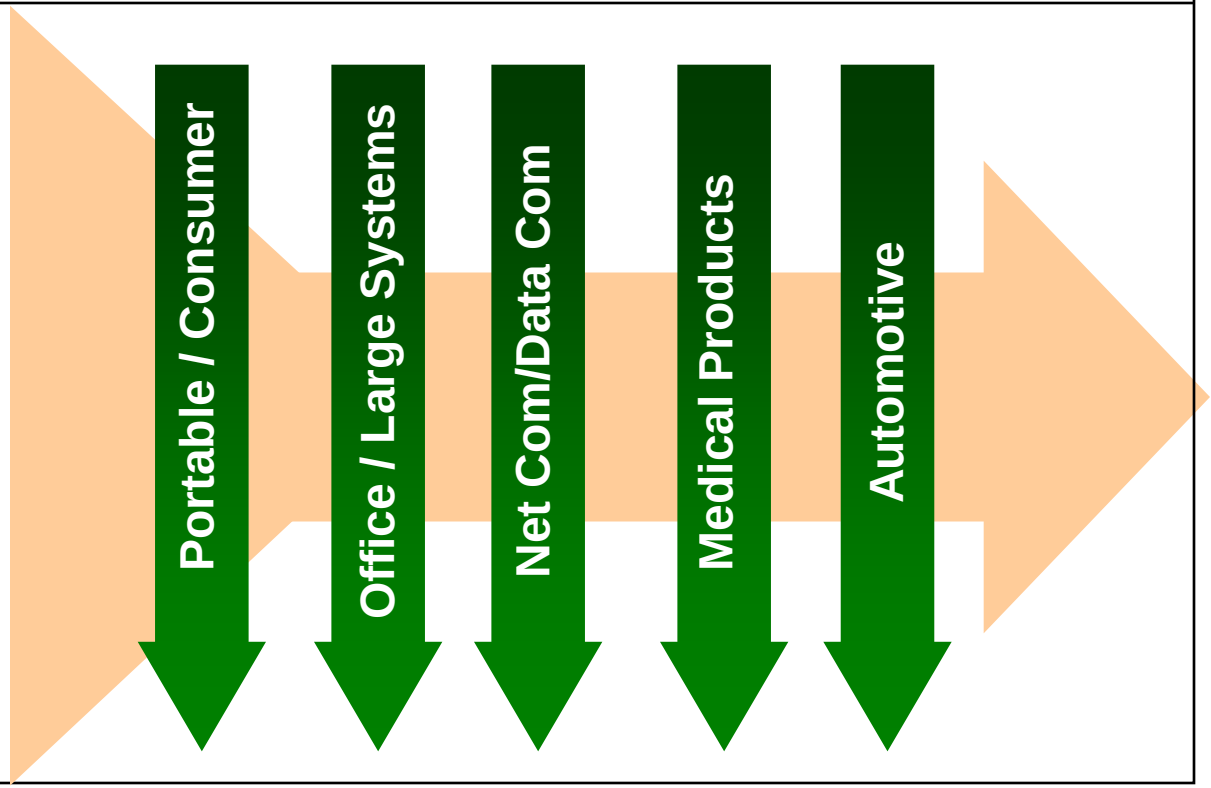
***Technology Working Groups:***

- ***Identify trends for numerous technology & infrastructure areas***
- ***Contrast these trends with anticipated product needs***
- ***Predict evolution of technology and/or business practices***
- ***Identify gaps and "showstoppers" in existing technology***
- ***Develop recommendations for their respective areas***

# Roadmap Development

## *Product Sector Needs Vs. Technology Evolution*

| TWGs | Product Emulator Groups |
|---|---|
| **Semiconductor Technology** | |
| **Business Processes**<br>**Prod Lifecycle Information Mgmt.** | |
| **Design Technologies**<br>Modeling, Thermal, etc. | |
| **Manufacturing Technologies**<br>Board Assy, Test, etc. | |
| **Comp./Subsyst. Technologies**<br>Packaging, Substrates, Displays, etc. | |



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# 2009 Situational Analysis

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# Situation Analysis

- **Business**
  - **Shift in manufacturing competence from OEMs to EMS and ODMs**
  - **Maturity in commodity phase of life cycle demanding cost reduction**

- **Regulatory**
  - **Environmental legislation in various segments requires electronic industry to share detailed material content**
  - **Environmental changes now being made for market advantage**

# Situation Analysis

- **Markets:**
- **Convergence (Driven by wireless/portable products)**
  - **Medical-Consumer**
  - **Automotive-Entertainment**
  - **Communication-Entertainment**
- **Growth of Automotive Electronics (in car)**
- **Medical Electronics focus shifting towards diagnostics/prevention vs. therapy.**
  - **Motivations: reduce cost & improve outcomes**
  - **High volume consumer oriented**
  - **Challenge for getting quick regulatory acceptance**

# Situation Analysis

- **Technology**
  - **Miniaturization and Thinner**
  - **Quality, reliability, cost**
  - **Counterfeit Products**
  - **Time to market**
  - **Increasing Material Restrictions**
  - **Increased focus on Energy Reduction**
    - **Both product & manufacturing**
    - **Life-cycle approach**

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# 2009 Technology Issues and Needs

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# Strategic Infrastructural Changes

- **The restructuring of the electronics industry over the last decade from vertically integrated OEMs to a multi-firm supply chain has resulted in a disparity in R&D needs versus available resources**
- **Restructuring has created skill gaps at various nodes of supply chain**
- **Critical needs for research and development exist in the middle part of the supply chain (IC assembly services, passive components and EMS assembly) and yet these are the firms least capable of providing the resources**
- **A partial solution has been the development of vertical teams to develop critical new technology while sharing the costs**

# Key Technology Issues

- **Semiconductors:**
  - **Scaling and next generation technology**

- **Packaging: More than Moore**
  - **New level of packaging blending Semiconductor back end and assembly/packaging, infrastructure.**
  - **Stacked Die**
    - **Cooling**
    - **Through hole via process and reliability**
    - **Assembly accuracy required for PoP, stacked die, etc. not consistent with today's Board Assembly equipment.**
  - **New capability to close the gap between chip and substrate interconnect density:**
    - **Silicon Interposer**
    - **Organic**

# Identified Needs

## Design Technologies

- **Predictive tools for determining delaminating of new materials**
- **Thermal management for  3-D structures with stacked die**
- **Co design of mechanical, thermal, bio and electrical performance of entire chip, package and associated heat removal structures**
- **Design tools for emerging technologies such as embedded components and nano-materials**
- **Integrated design and simulation tools for high functionality in mixed mode wireless chips and modules**

# Identified Needs

## Manufacturing Technologies

- Manufacturing processes to accelerate miniaturization
- Assembly processes that support 3-D structures and low temperature processing
- Improved equipment accuracy for assembling stacked die, SIPS etc.
- Warpage Reduction
  - Wafer
  - Package
  - PWB
- Lower testing costs, particularly for new non-digital technologies

# Paradigm Shifts

- Wafer level packaging coming of age
- Flip Chip finally is an alternative to wire bonding
- Packaging materials changing over the next decade
- Printed electronics moving from R&D into initial applications
- Migration of where and how passive devices are used
- Touch Screens becoming main stream.
- MEMs oscillators replacing quartz crystals.
- Emergence of photovoltaics.
- Energy Efficient Lighting.
- Flash memory instead hard drives for lower power
- ODMs for Cell Phones: - especially for low cost

# Energy & the Environment

## Environmentally Conscious Electronics Roadmap

- New global environmental requirements continue to multiply – faster than industry can effectively respond
- Industry needs to be more proactive in developing solutions that:
  - Are based on science and engineering, delivering value to customers
  - Are available in advance of new regulations
  - Can influence future regulations and stakeholder groups for more sustainable results
- Sustainability will be a major undertaking for industry as well as society
- Electronic solutions can help to empower people to live a more sustainable lifestyle

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# Closing Technology Knowledge Gaps

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# Closing Technology Knowledge Gaps

- **A proven approach for identifying the technology needs and gaps of the industry through our roadmapping process**
- **A strong track record of developing supply chains to introduce new materials, processes, and technologies into production**
- **A research vision with three major thrusts:**
  - **Energy and the Environment**
  - **Miniaturization**
  - **Medical Electronics**

# Projects Arising from iNEMI's Roadmap

**30 projects on going:**

- **Energy and the Environment**
  - **Pb-Free Alloy Alternatives – Phase 1**
  - **Halogen Flame Retardant; HFR- Free Substrates***
  - **Eco-Impact Evaluator for ICT Equipment***
- **Miniaturization**
  - **Boundary Scan Adoption**
  - **Functional Test Coverage Assessment**
  - **Nano-Solder Technology**
- **Medical Electronics**
  - **Medical Reliability for Multi-Layer Ceramic Capacitors**

*** New projects available for iNEMI Member sign-up**

## iNEMI Pb-Free Alloy Alternatives Participating Companies


## HFR-Free Leadership Development Participating Companies


## Pb-Free Nano-Solder Participating Companies


## Boundary Scan Adoption Participating Companies


## Medical Components Participating Companies


## Functional Test Coverage Assessment Participating Companies

# iNEMI Pb-Free Alloy Alternatives

## Develop the Framework for Testing New Pb-Free Alloys

### Project Leaders: Greg Henshall (HP); Steve Tisdale (Intel)

**Strategy:**

- Phase 1 - Identify and categorize alternative Pb-free solder alloys beyond the common ones in use
- Phase 2 – Characterize Pb-Free Alloy Alternatives

**Tactics:**

- Characterize the thermal fatigue and acceleration behavior of alternative alloys through accelerated thermal cycle testing
- Develop a set of test data requirements that will allow OEMs and others to evaluate alloy properties against their internal requirements

**Deliverables & Issues:**

- 3 areas of interest
  1. Characterize the thermal fatigue and acceleration behavior
  2. Develop the framework for testing new alloys
  3. Propose requirements and methods to IPC Solder Products Value Council to consider for standardization

**Status:**

Phase 1 – Identify and Categorize Alternative Alloys Completed

Phase 2 – Characterization of Pb-Free Alloy Alternatives

- Project Requirements Completed
- Start Phase 2 – 3Q2009

# HFR-Free Leadership Program Objectives: Address Low-Halogen Transition Issues

## Program Leader: Steve Tisdale (Intel)

- Identify technology limitations involved in transitioning to HFR-free PCB materials
- Identify key mechanical performance characteristics and determine if they are in the critical path for the halogen-free PCB material transition
- Investigate the critical electrical parameters of new HFR-free materials
- Identify candidate materials, review prior work to define key performance characteristics and test criteria
- Design test vehicle(s) and test methods, leveraging standards where possible
- Assess technology readiness, identify gaps, technical risks, flag unexplored issues and make recommendations for future work
- Assess manufacturing capability and supply capacity

# HFR-Free Leadership Initiative

## HFR-Free Signal Integrity

**(Chair: Stephen Hall, Intel; Co-Chair: David Senk, Cisco)**

***Goal:***

- **Investigate the critical electrical parameters of new HFR-free materials**
- **Ensure there is no degradation of electrical signals in HFR-free PCB materials**
- **Assess technology readiness and identify gaps, plus assess manufacturing capability and supply capacity**

***Status:***

- **Project Documents Approved**
- **Project Start Date 30 June 2009**

## HFR-Free PCB Materials

**(Chair: John Davignon, Intel)**

***Goal:***

- **Identify key mechanical performance characteristics and determine if they are in the critical path for the halogen free PCB material transition**
- **Identification of technology limitations involved in transitioning to HFR-free PCB materials**
- **Assess technology readiness and identify gaps, plus assess manufacturing capability and supply capacity**

***Status:***

- **Project Documents Approved**
- **Project Start Date 30 June 2009**

# Boundary Scan Adoption Project

## Phase 1 – Identify Boundary Scan Tools and Use

### Project Leaders: Steve Butkovich, Cisco System

**Strategy:**

- Many suppliers do not support boundary scan or do so incorrectly.
- Wider availability of complying devices is necessary to enable cost efficient and effective board test for future designs.
- Tools to support boundary scan need to be developed and integrated into manufacturing test equipment.

**Tactics:**

- Encourage semiconductor vendors to include the technology in their products.
- Promote the development of tools by ATE vendors to support boundary scan based board test.

**Deliverables & Issues:**

- *Phase I* - Survey users of Boundary Scan devices and board test development tools.
- Identify the current levels of Boundary Scan used and projected short term use
- *Phase II* - Initiate project based on survey results – SOW Planned 3Q-09

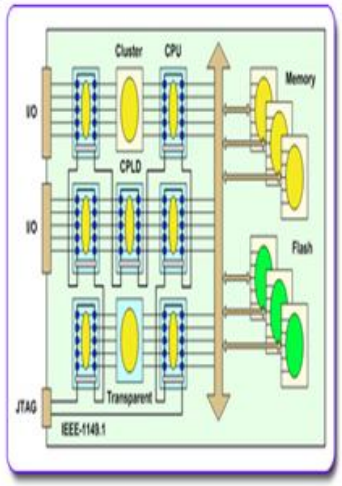
**Status:**

Survey users of Boundary Scan - *Complete*

Analyze survey results - *Complete*

Project Final Report – *In Process*

Phase II – Initiate decision based on results



# Functional Test Coverage Assessment - Phase 1

## Create a Functional Test Coverage Assessment Method

### Project Leaders: Tony Taylor (Intel)

**Strategy:**

- Creating more consistency in functional test coverage assessment opens more opportunity to automate or standardize reports, enabling more informed decision making on issues pertaining to test.

**Deliverables & Issues:**

- Consistent terminology defined
- Compilation of usage models
- Distribute industry survey
- Compile and publish survey results
- Develop project plans for Phase 2

**Tactics:**

Phase 1

- Define terminology
- Compile usage models
- Compile and distribute industry survey

Phase 2

- Create list of deliverables from project to support usage models
  - Compile a list of defects
  - Add functional test specific defects
  - Define assessment methods
  - Develop guidelines

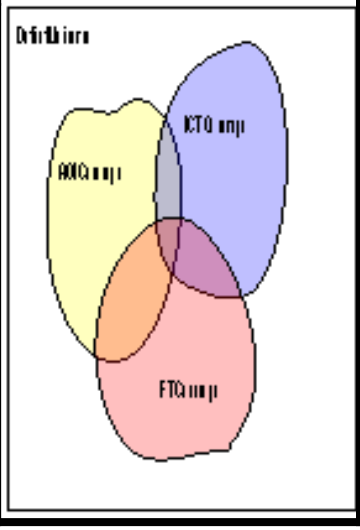
**Status:**

- Define Usage Models
  *In Process*
- Final Report

*Scheduled 3Q-09*

- Phase 2 Project Plans

*4Q-09*



# Pb-Free Nano-Solder Project – Phase 1

## Investigate Use of Nanotechnology to Suppress Solder Reflow Temperatures

## Project Leader: Andrew Skipor (Motorola)

**Strategy:**

- Research and develop nano-solder materials and paste systems that can effectively suppress the melting point temperature of Pb-free solders

**Tactics:**

- Phase 1: Research, develop and demonstrate a nano-solder paste
- Phase 2: Demonstrate manufacturability with paste
- Phase 3: Demonstrate joint reliability
- Phase 4: Develop/demonstrate manufacturing equipment

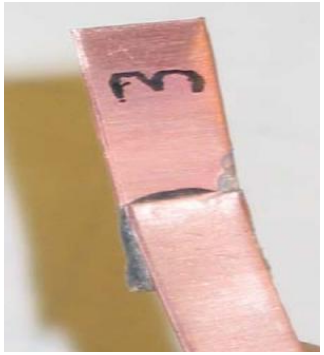
**Deliverables & Issues:**

- The project successfully demonstrated production of nano-scale particles of oxide-free tin and confirmed significant melting point depression.
- First project made significant strides in improving coalescence of nano-particles
- Team discovered a functional nano-solder will need to increase the nano-particle loading to >40% (vol%) to achieve a solder joint similar to a traditional joint

**Status:**

- Phase 1 – *Complete*
- Phase 2 – *Under Review*

**Two copper plates joined with MMP-nanosolder paste at 180°C**



# Medical Reliability for Multi-Layer Ceramic Capacitors

## Accelerated Life Test Methods for Determining Long Term MLCC Failures

### Project Leader: Anthony Primavera (Micro Systems Engineering)

**Strategy:**

- Design - Creation of a test vehicle for use in long term life and accelerated testing of MLCC components
- Test - Determination of accelerated life test methods of long term leakage and break down failures
- Results - Compile results, assess significance, make recommendations

**Deliverables & Issues:**

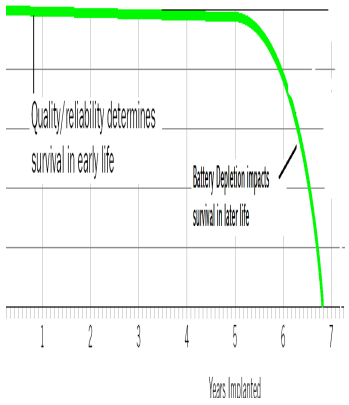
- Collection of Data and Data Mining resulting failures for trends and insight
- Failure analysis of Test output "Failures as defined in Phase 1"
- NIST to coordinate FA with Suppliers
- Phase II Report

**Tactics:**

- Design and Fabrication of Test vehicle
- Population of test board with functional MLCC's
- Creation of fixtures and test equipment cables and peripherals at NIST
- Testing of DOE variables from Phase I at NIST Boulder Facility
- Collection of Data and Data Mining

**Status:**

- Design & Build Test Vehicle *Complete*
- Populate Test Build – *Complete*
- Testing & Data Mining – *Complete*
- Final Report – *In Process*



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# Summary

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# Summary

- Consumer electronics has become the major driving force for our industry:
  - New technology to enable miniaturization
  - Relentless cost reduction
  - Volume manufacturing capability
- Packaging is Key Enabler providing higher density & smaller size:
  - More than Moore
  - 3D configurations, Improved performance
- New global environmental requirements continue to multiply – faster than industry can effectively respond
  - iNEMI and its members plan to play a significant role in preparing industry for these future needs.
- Sustainability will be a major undertaking for industry as well as society
- Electronic solutions can help to empower people to live a more sustainable lifestyle.

# Concluding Thoughts

## Impact of the Recession

- **Will delay new technologies requiring significant investments (both capital and R&D)**
- **Will strengthen vertical development teams (across design / supply chain)**
- **Will increased consortial activity on environmental efforts (reduce total industry investments)**
- **Will make Industry work together to determine their priorities for closing Technology Gaps**

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