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International Electronics Manufacturing Initiative

BEYOND RoHS:
EFFORTS TO STRENGTHEN THE ELECTRONICS MANUFACTURING SUPPLY CHAIN

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Outline

- Introduction to iNEMI
- Highlights from 2007 iNEMI Environmental Roadmap
  - Increasing need for global harmonization
- Current Situation
  - Industry readiness
  - Evolving to a Pb-free Supply Chain
- Next Steps
  - Technology Needs Beyond RoHS
  - Proactive Evaluation of Alternative Flame Retardants
- Conclusions

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Introduction to iNEMI

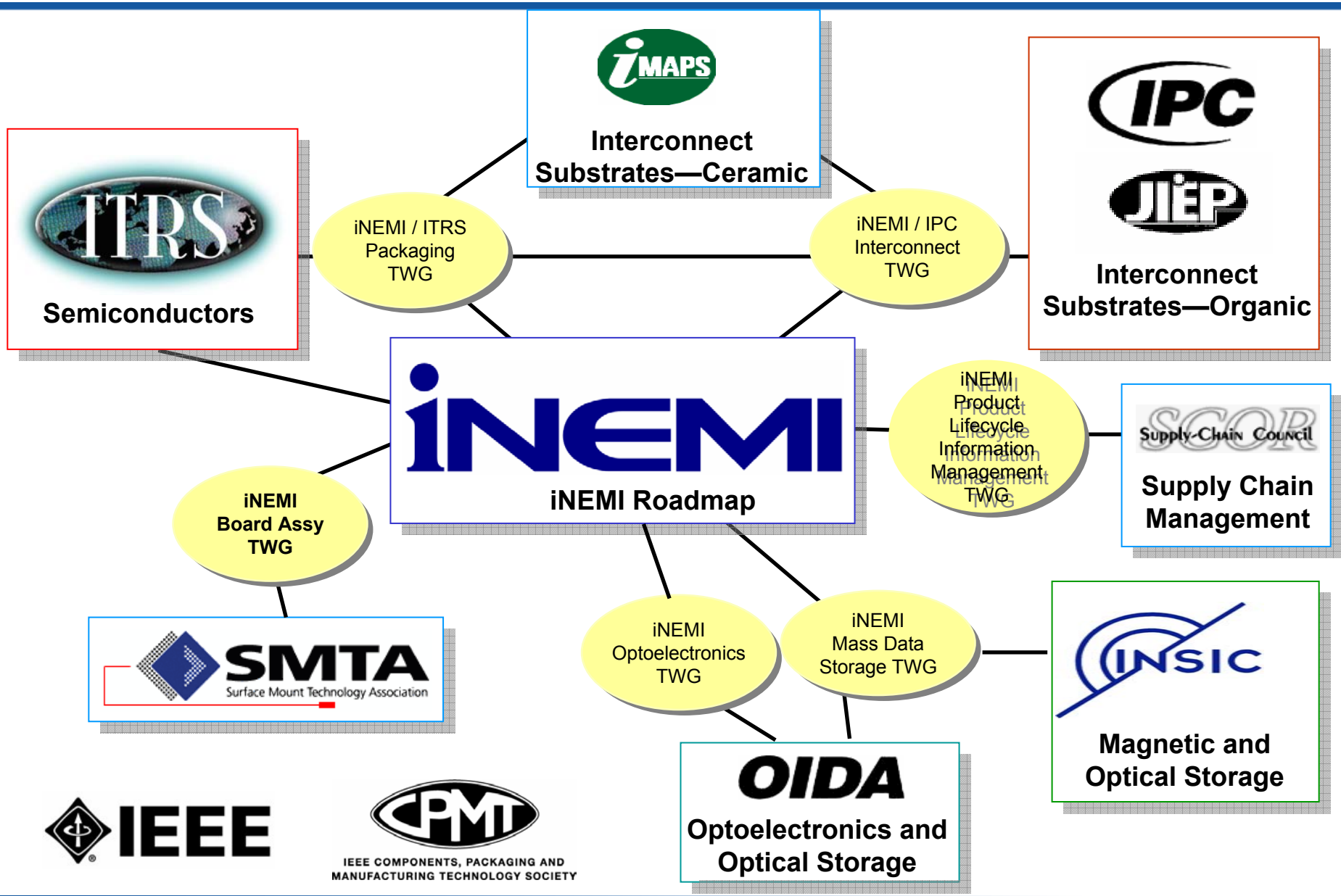
1. *Roadmapping the Industry Needs*
2. *Closing the Gaps through Projects*

2004 Roadmaps

19 Individual Roadmap Chapters

- Semiconductor Technology
- Packaging
- Mass data storage
- Board Assembly
- Final Assembly
- Environmentally Conscious Electronics
- Interconnect Substrates Organic
- Interconnect Substrates Ceramic
- Connectors
- RF Components & Subsystems
- Optoelectronics
- Passive Components
- Energy Storage Systems
- Display
- Modeling, Simulation & Design Tools
- Thermal Management
- Test, Inspection & Measurement
- Product Lifecycle Information Management
- Sensors

Roadmap Alliances



Statistics for the 2004 Roadmap

- > 470 Participants
- > 220 Companies/organizations
- 11 Countries from 3 Continents
- 7 Product Emulator Groups (added SiP, Medical)
- 19 Technology Working Groups (added Sensors)
- Over 1200 Pages of Information
- Roadmaps the needs for 2005-2015

Closing Gaps: Environmental Projects to Eliminate Pb Solder

- 1998 Roadmap identified the technology gap.
- Phase I project developed the alloy, process, components and reliability from 1999-2002.

  Results:

  – The iNEMI efforts accelerated the establishment of SAC alloys as the standard and reduced the effort in each member company.
- Phase II projects have expanded the technology base to include assembly and rework of large complex PWB assemblies.

Closing Gaps: Environmental Projects to Eliminate Pb Solder

- 2002 Roadmap identified a number of business Issues to convert to a Pb-free supply chain.
- Five Phase III project teams addressed these supply chain transition issues.
- Four Phase IV projects are on going to close the following technology gaps:
  - Wave/selective solder
  - Mixed assemblies (Pb-free BGA's in a SnPb assembly process)
  - Pb-free surface finishes
  - Pb-free rework optimization

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Highlights from 2007 iNEMI Environmental Roadmap

2007 ECE Roadmap Focus Areas

To remain competitive, the electronics industry must continue to keep pace with emerging:

- **material restrictions,**
- **end-of life requirements,**
- **customer preferences for energy efficient products,**
- **holistic design requirements**

Strategic Issues from Roadmap

1. To minimize supply chain chaos and reduce the need to manufacture region-specific products it is critical that emerging international requirements of a given topic do not substantially differ in scope. Harmonization through international standardization is essential.

2. The area of Corporate Social Responsibility (CSR) is being driven by multiple factors, including globalization of the world economy, the failure of firms to effectively police themselves and the ability of the Internet to provide almost instant access to information. With environment as one of the pillars of CSR and an area of increasing global concern, there will be increasing need to demonstrate that a firm is actively engaged.

Strategic Issues from Roadmap

An Increasing Need To Influence & Optimize The Global Regulatory Process

1. Set Regulatory Goals Which Allow Flexible Compliance Strategies
   - Recognize Diversity Of Products & Business Operations
2. Support Harmonized International Standards
   - Standards Effectively Preserve Regulatory Objectives
   - Can Be Integrated Efficiently Across Different Business Models And Extended Supply Chains
   - Ensures The Benefits Of Technology Reach Consumers & The Community In The Most Efficient Way

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Current Situation

Industry Readiness

- 9 of 11 Telecommunications OEMs Polled took Pb-free Exemption for Solder In Network Infrastructure Equipment
- A dual component supply chain has resulted
  - Pb-free components for high volume consumer market
  - Traditional SnPb components for
    - Telecommunications
    - Servers
    - Military products
    - Medical electronics
- Reliability of Pb-Free Components with Eutectic Solder has not been fully demonstrated for long life products.
- Some Telecom service providers are now demanding that mission critical equipment remain with SnPb solder.
- Suppliers are not willing to provide traditional components to small high reliability market.

Objectives

- Gain a common understanding of the supply chain challenges facing High Reliability OEMs/EMS providers who are:
  - Taking Pb exemption (e.g. telecom switching, high end servers, etc.)
  - Out of Scope of RoHS (e.g. measurement equipment)
- Share experiences between OEMs/EMS providers on current state of supply base
- Understand impact of high volume transition to lead-free components and the lack of compatibility for those staying with Sn-Pb assembly processes
- Influence supply base to meet ongoing needs of these industry segments.

High Reliability RoHS Compliance

Scope:

1. **Address availability of SnPb compatible BGA's for High Rel.**
2. **Communicate clear requirements for Tin Whisker mitigation and testing practices.**
3. **Communicate manufacturing issues for thermally complex assemblies.**
4. **Communicate unique requirements for RoHS 5/RoHS 6 subassemblies.**

Status:

Three position papers released -

- **Recommendations to Electronics Industry Component Supply Base**
- **Pb-Free Manufacturing Requirements for High-Complexity, Thermally Challenging Electronic Assemblies**
- **RoHS5 & RoHS6 Subassembly Modules**

Next steps:

- **Sn-Pb BGA Availability Workshop – January 24, 2007**
- **More info. available at: inemi.org/cms/projects/ese/SnPb_BGAs.html**

Evolving to a Pb-Free Supply Chain

- Fifty years of experience with Eutectic Solder
- Transition is just beginning.
- Industry has converged on a few key parameters
  - Solder alloy is typically SnAgCu (SAC), in varying compositions, such as SAC 305 (3% Ag, 0.5%Cu) or SAC405 (4% Ag, 0.5%Cu).
  - Surface finishes are typically one of three: Organic Solderability Preservative (OSP), Immersion Silver (ImAg) or Electroless Nickel Immersion Gold (ENIG).
  - Solder reflow temperatures are in the range of 230-250ºC.

Active Projects to Support Transition

Expected Completion 2007-2008

- Pb-Free BGAs in SnPb Assemblies
- Pb-Free Defects Per Million Opportunities
- Pb-Free Nano-Solder
- Pb-Free Rework Optimization
- Pb-Free Wave Soldering
- Substrate Surface Finishes for Pb-Free Assembly
- Tin Whisker Accelerated Test
- Tin Whisker Modeling

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Next Steps Beyond RoHS

iNEMI-IPC

"Life After EU RoHS" Forum

Objectives of the Forum

- Provide a broad overview of the evolving regulatory environment, including the current status of, and issues relating to, the emerging environmental regulations that the electronics industry is preparing for:
  - EU REACH
  - EU EuP
  - China RoHS
  - Other environmental regulations (e.g., state laws in the United States)
- Share information about industry efforts underway:
  - Policy monitoring
  - Policy advocacy
- Identify gaps that remain to be closed:
  - Policy
  - Technology
  - Identify potential new efforts to close the identified gaps

Meeting Format

- Global Overview and European Regulations (RoHS,EuP,REACH)
  - JP Brisson, Allen & Overy
- China RoHS
  - Tom Valliere, Design Chain Associates
- North & South American Regulations
  - Fern Abrams, IPC
- iNEMI Proactive Approach
  - Bob Pfahl, iNEMI
- Panel Discussion
  - All Speakers

Conclusions from Forum

- There are no new major technology challenges from China RoHS.
- Six substances restricted in China RoHS are common with EU RoHS (as well as concentration values).
- Mandatory government testing is anticipated for China RoHS (no self declarations).
- China RoHS mandates unique product marking, product information and packaging labeling.
- Currently no exemptions for China RoHS – but the restrictions only apply to product placed in the catalogue (TBD- but marking, information and packaging labeling required for ALL products).
- Biggest new challenge facing supply chain beyond RoHS is the proliferation of Green Programs from OEMs, many of which are establishing unique requirements to differentiate their products and services. These programs continue to drive the discussion around the needs for greater materials content data.

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Proactive Evaluation of Alternative Flame Retardants

iNEMI/US EPA Bromine-free Substrate Projects

Proactive Programs

"Industry should take a proactive approach, work with stakeholders, and direct our activities where there is technical/ecological evidence we could and should be doing a better job to protect the environment. We should involve stakeholders in the process of evaluating alternative technologies to determine trade-offs between product functionality, environmental impact, reliability, safety, and cost."

Bromine Free Substrates

- Participants:
  - US EPA
  - Electronics industry through iNEMI
  - Other Stakeholders including NGOs
- Environmental Objective
  - Evaluate environmental risk of brominated and alternative flame retardants in PWB substrates
- Unique Characteristics
  - Industry lead proactive study to evaluate:
    - The technology risks of alternatives
  - EPA lead partnership to evaluate:
    - The environmental risks

iNEMI Halogen-free Project

Project Objectives:

- **Build on industry knowledge and capability,**
- **Consider unique market segment requirements,**
- **Identify technology readiness and gaps,**
- **Stimulate supply capability, and**
- **Recommend standards development opportunities**

Anticipated Outcomes

1. Define electrical requirements based on market segment application

2. Validate electrical and mechanical properties
   - Loss tangent and Dk modeling over required range of signal speed
   - Mechanical performance validation for lead free assembly

3. Validate material supplier and PWB manufacturer infrastructure capability

4. Estimate costs – volume market leader for new material may not achieve cost parity with best-in-class FR4

Is / Is Not

This Project IS	This Project Is NOT
Technical evaluation of key electrical and mechanical properties	EHS assessment
Focused on those attributes which are of most value to supply chain.	Biased towards specific laminate suppliers, geographies, or market segments.
Build on learning from prior investigations	Repeat of prior work
Recommendations for standards development or further investigation	Standard Development
Focused on circuit board	Electronic components, Cables

Phase 1: Design

Goal: *Review prior work and make recommendations for testing needed. Investigation should take into account the needs of electronic product sectors represented by iNEMI membership.*

- **Identify market segment requirements**
- **Identify candidate materials (synch with EPA)**
- **Identify key performance characteristics and test criteria**
- **Design test vehicle(s) and test methodologies, leverage standards where possible.**

Phase 2: Test

Goal: *Develop, manage, and execute performance testing*.

- **Develop evaluation schedule**
- **Procure parts and test vehicles**
- **Assign teams to carry out completion of the testing in a standardized fashion**

  .
- **Perform mechanical and reliability testing on test vehicles.**

Phase 3: Results

Goal: *Compile results, assess significance, make recommendations, and publish report.*

- **Assess performance relative to market segment requirements.**
- **Assess technology readiness / identify gaps**
- **Assess manufacturing capability and supply capacity**
- **Publish results**

US EPA Design for Environment Program: Alternatives Assessment of Flame Retardants for the Electronics Industry

- **Goal: To identify and evaluate commercially available flame retardants and their environmental, human health and safety and environmental fate aspects in FR-4 printed circuit boards.**
- **Scope: The partnership will incorporate life-cycle thinking into the project as it explores the potential hazards associated with flame retardants and potential exposures throughout the life cycle of flame retardants as used in FR-4 printed circuit boards. As appropriate, the scope will include aspects of the life cycle where public and occupational exposures could occur. For example, consideration of exposures from incineration or burning at the end of life will be included, as will exposures from manufacturing and use.**

Project Is / Is Not:

This Project IS	This Project Is NOT
An EHS assessment of both halogenated and halogen-free materials	Technical evaluation of key electrical and mechanical properties of halogenated and halogen-free materials (iNEMI project)
Assessment of environmental and human health endpoints (environmental endpoints include ecotoxicity, fate and transport)	Comprehensive environmental or human health risk assessment
Based on sound science	
Voluntary	Regulatory
Multi-Stakeholder Partnership	

Participants and Roles

EPA will encourage the participation of individuals from different disciplines and interests to contribute on the range of tasks outlined in the project plan.

- Participants to date include:
  - OEMs (environmental & product safety representation) and trade associations
  - Component and board manufacturers
  - Chemical companies (raw material suppliers, flame retardant suppliers, etc) and trade associations
  - NGOs – environmental groups, worker unions
  - Standards organizations
  - Universities
  - Governments – US EPA and Sweden Kemi
- Other participants could include:
  - Federal governments
  - State governments
  - Local governments
  - Other national governments
  - Electronics recyclers
  - Public interest groups

Summary of Proactive Approach

- **Search for Environmentally Benign Alternatives Should be Based on Good Science and Technology.**
- **Technology and business risks and the impacts of original process/materials and alternatives should be evaluated prior to legislative action.**
- **Voluntary programs have been effective in the electronics industry.**
- **Stakeholders should be involved in the process from the beginning (Both within the firm and within the community).**

www.inemi.org

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