Material Enclosed

- iNEMI Overview
- Membership
- Technology Roadmap
- Collaborative Initiatives & Projects
About iNEMI


5 Key Deliverables:
• Technology Roadmaps
• Collaborative Deployment Projects
• Research Priorities Documents
• Proactive Forums
• Position Papers

International Electronics Manufacturing Initiative (iNEMI) is an industry-led consortium of over 100 global manufacturers, suppliers, industry associations, government agencies and universities. A Non Profit Fully Funded by Member Dues; All Funding is Returned to the Members in High Value Programs and Services; In Operation Since 1994.

Visit us at www.inemi.org
Global Operations

• iNEMI is headquartered in Herndon, Virginia, USA.

• Opened an office in Shanghai and added a team member in Europe in 2007.

• Dr. Haley Fu is leading operations in Asia, based in Shanghai, China.

• Grace O’Malley is representing iNEMI in Europe from her base in Ireland.
iNEMI Methodology

Technology Roadmap Process
ID key market trends & Evolution
Potential disruptive technologies
Looking 10 years into the future

Further Refine Opportunities
Use technology working groups
Use organized workshops
To ID collaborative projects

Critical Analysis of Roadmap
Extract key gaps and challenges
Both Short & Long Term

Organize & Direct Projects
Teams formed to clearly identify scope/deliverables
Call for member participation
Manage collaborative R&D process
Ensure delivered results
Highlights of iNEMI 2013

• Good solid additions on the membership side. Added 9 new members in 2013:
  – 4 additions primarily for MEMS; 1 for the Environment
  – 3 for Power Electronics; 1 for Equipment Projects

• Excellent webinars and support in Medical Implantable, Low CTE Mold Compound, Counterfeit Components, & Multiple RM chapters

• Solid Workshop on Automotive, PWB/Laminate, & Medical Symposium

• Connector survey complete and 2 new initiatives are in early definition; Chairs from Alcatel Lucent, IBM, and Intel

• Three new environmental projects underway

• Excellent learning from Cu Wire Bonding; Need to maximize visibility of same.

• 2015 RM kick off in October

• Very Good relationship building with BOD meetings at Berkeley & Binghamton

• NIST Amtech grant submittal done on Photonics with MIT.
INEMI
International Electronics Manufacturing Initiative

Membership
International Member Growth Across The Total Supply Chain (Q1 2013)

<table>
<thead>
<tr>
<th>INEMI Member Business Type</th>
<th>Incorporated Location; Number of Members</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>North America</td>
</tr>
<tr>
<td>OEM</td>
<td>14</td>
</tr>
<tr>
<td>ODM/EMS (inc. pkg. &amp; test services)</td>
<td>5</td>
</tr>
<tr>
<td>Suppliers (materials, software, services)</td>
<td>9</td>
</tr>
<tr>
<td>Equipment</td>
<td>8</td>
</tr>
<tr>
<td>Universities &amp; Research Institutes</td>
<td>8</td>
</tr>
<tr>
<td>Organizations</td>
<td>11</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>55</strong></td>
</tr>
</tbody>
</table>

✓ Total **Global** Supply Chain Integration
✓ 70% Growth in past 3 years
## Areas of “Critical Mass”

### Laminate/Substrate Suppliers
- Samsung Electro Mechanics
- Endicott Interconnect Tech.
- Shengyi Sci. Tech
- Elec & Eltek
- Ibiden
- NGK/NTK

### Equipment Firms
- Micronic/Mydata
- Assembleon
- Hover Davis
- PVI Systems
- Akrometrix
- Speedline
- Universal
- Teradyne
- Nordson
- Agilent
- Corelis
- Acutronic

### Research Institutions
- SUNY Binghamton
- Georgia Tech
- UC Berkeley
- Fraunhofer
- Griffith U
- Peking U
- CEA/Leti
- RIT
- CALCE
- IMEC
- NIST
- ASU
- ITRI
- MIT
- Aalto U
- Purdue

### OEMs & Semiconductors
- Alcatel Lucent
- Microsoft
- Cochlear
- Juniper
- Lenovo
- Med El
- Delphi
- Cisco
- Infineon
- Hillcrest Labs
- MSEI
- BSCI
- Intel
- Dell
- IBM
- BlackBerry
- HP
- TI
- Emerson
- Agilent

### Chemicals, Adhesives, Metals
- Hitachi Chem
- NAMICS
- Inventec
- Heraeus
- Nippon
- Henkel
- Indium
- Dow

### ODM / EMS Firms
- Sanmina SCI
- Wistron
- Flextronics
- IEC
- Celestica
- Plexus
- Valtronic

### Packaging Firms
- STATS ChipPAC
- ASE Group
- Amkor
iNEMI Organization; How Work Gets Done

**Regional Steering Committees**
Help ensure that iNEMI addresses member needs in Europe & Asia

**Board of Directors**
Set strategic objectives & priorities
Ensure financial ethics & responsibility

**Focus Area Steering Committees**
Drive progress on key priorities
Ensure membership support

**Direct Roadmap Development**
- Product Needs
  - 6 Product Emulator Groups
- Technology Needs
  - 21 Technology Working Groups

**Technical Committee**
Develop & integrate technology strategies & plans
Drive/coordinate all technical activities

**Research Committee**
Stimulate research to address gaps identified by iNEMI roadmaps

**Direct Collaborative R&D**
The Technical Plan & Gaps are Defined By:
- 8 Technology Integration Groups
- Gap Analysis
- Workshop Identified Gaps
- Member Identified Needs
Unique Attributes of iNEMI

10 year Technology | Business Roadmap
Delivered every two years like clockwork
Unique Gap Analysis
Technical/Business Evolution Details

Proven Collaborative R&D Methodology
Time tested over 19 years
20-25 active collaborative R&D projects

Strong Global Membership
Depth and Breadth of Supply Chain Leaders
Strong set of Universities & Research Institutes

Ability to Execute
Integrated supply chain approach
Solving complex manufacturing issues
Drive widespread adoption and impact

iNEMI Reputation
Track record of sustainability leadership
In demand for knowledge/science input
Results oriented workshops
Why Organizations Participate

Collaborate & Leverage Precious R&D Resources
Engage with key supplier, customer, and competitor experts
Using a proven methodology and expert project managers

Business Opportunity
Develop relationships with supplier and customer experts
• Leading to more business success down the road

Better anticipation of technology trends and inflexion points

Networking in the Industry
Learning from knowledge experts within the iNEMI membership

Access to In Depth Reports and Studies
Detailed project data and analysis for members only
Membership Rights – Data & Events

• Any staff of your company world wide can create account at iNEMI web site and access member only information
• Monthly iNEMI member newsletter
• Free access to:
  – iNEMI Technology Roadmap ($3,000 per copy for non-members)
  – Member only Technical Plan
  – iNEMI Project Completion Webinars
  – Project Reports and Publications
• Can join any project by agreement to the project statement (PS) and SOW
• Can raise project ideas or proposals to meet your needs
• Free or discounted fee for participating in iNEMI workshops and forums
• Pick and choose the Technical Groups of your interest
Small & Efficient Non Profit
Funded Fully By Member Dues

Celebrating our 20th Anniversary in 2014
  • Many Long Term Members

Annual dues based on revenue level of the company

Annual dues rates have NOT changed in 19 years

Special Rates for Universities, Research Institutes, and Start Ups
  • Some “Skin in the Game” to encourage participation
## Annual Participation Fees

<table>
<thead>
<tr>
<th>Participating Members</th>
<th>(For Profit)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Corporate Sales (USD)</strong></td>
<td><strong>Membership Dues</strong></td>
</tr>
<tr>
<td>$0-5M</td>
<td>$5,000</td>
</tr>
<tr>
<td>$5-10M</td>
<td>$10,000</td>
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<tr>
<td>$10-100M</td>
<td>$15,000</td>
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<tr>
<td>$100M-1B</td>
<td>$25,000</td>
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<tr>
<td>$1-10B</td>
<td>$40,000</td>
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<tr>
<td>$10-15B</td>
<td>$55,000</td>
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<tr>
<td>$15B+</td>
<td>$75,000</td>
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</table>

<table>
<thead>
<tr>
<th>Affiliate Members</th>
<th>(Not-For-Profit)</th>
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</thead>
<tbody>
<tr>
<td><strong>Category</strong></td>
<td><strong>Membership Dues</strong></td>
</tr>
<tr>
<td>University</td>
<td>$5,000</td>
</tr>
<tr>
<td>RI/Org./Gov. Lab/R&amp;D Center</td>
<td>$10,000</td>
</tr>
</tbody>
</table>
2013 Technology Working Groups (TWGs)

- **Modeling, Simulation, and Design**
- **Connectors**
- **Test, Inspection & Measurement**
- **Optoelectronics**
- **Large Area, Flexible Electronics**
- **Passive Components**
- **Thermal Management**
- **Solid State Illumination**
- **Packaging & Component Substrates**
- **Energy Storage & Conversion Systems**
- **Photovoltaics**
- **Mass Storage (Magnetic & Optical)**
- **Semiconductor Technology**
- **MEMS/Sensors**
- **Environmentally Conscious Electronics**
- **Ceramic Substrates**
- **Solid State Illumination**
- **Organic PCB**
- **Thermal Management**
- **Information Management Systems**
- **Board Assembly**
- **Energy Storage & Conversion Systems**
- **Final Assembly**
- **Customer**
- **Solid State Illumination**
- **Information Management Systems**
- **Red=Business**
- **Green=Engineering**
- **Purple=Manufacturing**
- **Blue=Component & Subsystem**
# Roadmap Development

*Product Sector Needs Vs. Technology Evolution*

<table>
<thead>
<tr>
<th>TWGs</th>
<th>Product Emulator Groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semiconductor Technology</td>
<td>Portable / Consumer</td>
</tr>
<tr>
<td>Business Processes</td>
<td>Office / Large Systems</td>
</tr>
<tr>
<td>Design Technologies</td>
<td>Defense and Aerospace</td>
</tr>
<tr>
<td>Manufacturing Technologies</td>
<td>Medical Products</td>
</tr>
<tr>
<td>Comp./Subsyst. Technologies</td>
<td>Automotive</td>
</tr>
<tr>
<td></td>
<td>Netcom</td>
</tr>
</tbody>
</table>

- **Semiconductor Technology**
  - Prod Lifecycle Information Mgmt.
- **Business Processes**
  - Modeling, Thermal, etc.
- **Design Technologies**
  - Board Assy, Test, etc.
- **Manufacturing Technologies**
  - Packaging, Substrates, Displays, etc.
Fourteen Contributing Organizations

- **Interconnect Substrates—Ceramic**
- **Semiconductors**
- **Organic Printed Circuit Boards**
- **Supply Chain Management**
- **Magnetic and Optical Storage**

**iNEMI Roadmap**

- iNEMI / ITRS / MIG/PSMA Packaging TWG
- iNEMI / ITRS MEMS TWG
- iNEMI / IPC / EIPC / TPCA Organic PWB TWG
- iNEMI Information Management TWG
- iNEMI Mass Data Storage TWG
- iNEMI Optoelectronics TWG
- iNEMI Board Assembly TWG

**Contributing Organizations**

- MEMS INDUSTRY GROUP™
- IPC
- iMAPS
- EIA
- SMTA
- IEEE
- CPMT
- Microphotonics Center
- OIDA
- INEMI
Statistics for the 2013 Roadmap

• > 650 participants -- Big Thanks to All Contributors!!
• > 350 companies/organizations
• 18 countries from 4 continents
• 20 Technology Working Groups (TWGs)
• 6 Product Emulator Groups (PEGs)
• > 1900 pages of information
• Roadmaps the needs for 2013-2023
• Workshops held in Europe (Berlin, Germany), Asia (Hong Kong, China) and North America (ECTC, San Diego) in June 2012
• A Full Global Perspective

• Available to iNEMI members on 12/22/12 at: www.inemi.org
• Shipping/Downloading to industry beginning April 4 at www.inemi.org
Collaborative Projects
LEVERAGING BROAD INDUSTRY EXPERTISE TO FORECAST AND ACCELERATE IMPROVEMENTS IN THE ELECTRONICS MANUFACTURING INDUSTRY FOR A SUSTAINABLE FUTURE
Motivation to Participate in Collaborative Projects

• Cost Reduction by leveraging resources – Typically in the 8X to 20x range on key projects and thrusts:
  – Reduce resource demands and $ investments for each company.
  – Ensure technology readiness when required.
  – Projects can result in cost reduction (ex. Copper wire bonding).
  – Access to thought leaders and senior problem solvers from across the supply chain.

• Reduce risk of technology introduction
  – Reliability – Hard to measure the negative impact of poor reliability, but can be disastrous.
  – Source of supply – Also hard to apply general cost impact numbers to being late to market – Can also be huge.

• Create globally aligned specifications and methods – pre competitive level playing field reduces cost
SUCCESS STORIES
ADDRESSING KEY ECO-SUSTAINABILITY & TECHNOLOGY CHALLENGES

**Pb-free Component Warpage Characterization**

**Pb-free Rework Reliability Characterization**

**Pb-free BGA in SnPb Process Assembly**

**Pb-free Early Failures**

**Pb-free Component & Board Finish Reliability**

**PCBA Reliability Qualification**
SUCCESS STORIES

ADDRESSING KEY ECO-SUSTAINABILITY & TECHNOLOGY CHALLENGES

Eco-Impact of PVC Alternatives

LCA Estimator

Creep Corrosion

Rare Earth Metals

Tin Whisker Susceptibility

Characterization of Pb-free Alloy Alternatives
8 New Projects Approved & Launched in 2013

1. Rare Earth Metals
   • Project launched January 2013
   • Draft of white paper on “Rare Earth Metals – Current Status; Future Outlook” in process

2. PCB / PCBA Reliability Qualification Process
   • Project launched January 2013

3. Advanced Si-node Pb-free Underfill Reliability
   • Project launched February 2013

4. DC-DC Power Module Project, Phase 1 (Technical Specification Development)
   • Project launched March 2013

5. Qualification Test Development for Creep Corrosion, Phase 1
   • Project launched April 2013

6. Boundary Scan, Phase 3 (Investigation into Challenges of Using .BSDL Files)
   • Project launched May 10, 2013 – Sign-up Extended to June 14

7. MEMS Reliability Methodology for Inertial Sensors
   • In Sign Up

8. MEMS Test Methods for Inertial Sensors
   • In Sign Up
13 Ongoing Projects Started Prior to 2013

1. BIST "Use Case" Function Classification Project (Phase 3)
2. Packaging Equipment Requirements
3. Improving UL Certification of Laminates and PCBs
4. Developing Manufacturing Strain Guidance of Pb-Free PCBAs
5. Warpage Characteristics of Organic Packages
6. Component Specification for Medical Products
7. Qualification Methods for Portable Medical Products
8. Structural Test of External Memory Devices – Industry Awareness
9. Copper Wire Bonding Reliability
10. Characterization of Pb-Free Alloy Alternatives
11. Pb-Free Rework Optimization, Phase 3 (Reliability Evaluation)
12. Pb-Free Early Failure
13. Counterfeit Components Project
The Project Process - 5 Steps

1. SELECTION ✔
2. DEFINITION ✔ Open for Industry input
3. PLANNING ✔ (The Initiative Phase) iNEMI Technical Committee (TC) Approval Required for Execution
4. EXECUTION / REVIEW
5. CLOSURE Limited to Committed iNEMI Members
Initiatives Under Development

1. Development of Cleanliness Specification for Lens-Based Optical Transceivers and Connectors

2. Defining Reliability Requirements for Implantable Medical Devices – Phase 2

3. Board Assembly and/or Test Equipment utilization optimization.

4. Identify and communicate/share best known practices for recycling, for metals recovery, and for resource efficiency at EOL processing.

5. MEMS University/Industry Collaboration

6. PCB Surface finish evaluations by market segment. Haley Fu
Initiatives Under Development (con’t.)

7. Address key technology challenges and measurement capabilities needed to deliver ultra-low loss high reliability PCB laminate and board performance.

8. Impact of Low CTE Mold Compound on 2\textsuperscript{nd} level joint reliability

9. Develop a stakeholder aligned methodology/stepwise approach to develop and assess new or alternative materials.

10. Create a quantifiable set of metrics and potentially a tool for measuring a product’s true recyclability and reuse. Eco design for recycling/sustainability including toxicity assessment and critical usage/application.

Further details available on [www.inemi.org](http://www.inemi.org)
Overall iNEMI Research Approach
Directed By The Research Committee

<table>
<thead>
<tr>
<th>Name</th>
<th>Organization</th>
<th>Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alan Rae</td>
<td>Nano Materials Innovation Center</td>
<td>Chair</td>
</tr>
<tr>
<td>Bob Pfahl</td>
<td>iNEMI</td>
<td>Secretary</td>
</tr>
<tr>
<td>Carol Handwerker</td>
<td>Purdue</td>
<td>Co-Chair</td>
</tr>
<tr>
<td>Charles Richardson</td>
<td>iNEMI</td>
<td>Ex-Officio</td>
</tr>
<tr>
<td>Barbara Goldstein</td>
<td>NIST</td>
<td>Member</td>
</tr>
<tr>
<td>D.H.R. Sarma</td>
<td>Delphi</td>
<td>Member</td>
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<tr>
<td>Jie Xue</td>
<td>Cisco</td>
<td>Member</td>
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<tr>
<td>Ravi Mahajan</td>
<td>Intel</td>
<td>Member</td>
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<tr>
<td>Voya Markovich</td>
<td>EIT</td>
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<tr>
<td>Lili Deligianni</td>
<td>IBM</td>
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<td>Rolf Aschenbrenner</td>
<td>IZM</td>
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<td>Rao Tummala</td>
<td>Georgia Tech</td>
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</tbody>
</table>
Society Driven

Health & wellness  Transport & mobility  Security & safety

Energy & environment  Communication  E-society

Source: NXP
Key Mega Trend

Key Mega-Trends (>\$1,100 billion spend\(^{(1)}\))

- Energy Efficiency
- Connected Mobile Devices
- Security
- Health

require

High-Performance Mixed-Signal Solutions

Application-optimized analog and digital solutions that help our customers to truly differentiate their products in terms of features, cost and time to market

to address

Highest Growth Segments in 8 Priority Application Areas

- Automotive
- Identification
- Wireless infra
- Lighting
- Industrial
- Mobile
- Consumer
- Computing

Source: NXP
Research Agenda Process

• Gather Inputs
  – Traditional Process of Technology Chapters Accountable for identifying Research Needs
  – Extraction of those needs by the iNEMI Research Committee
  – Utilize focused workshops to further identify needs; Examples
    3. MEM’s WS – Pittsburgh – May 2011
    4. Environmental WS Berlin October 2012

• Refine and Optimize:
  – Roll up all inputs and prioritize critical needs by August 2013
Step 4: Create Research Proposals; Environmental Examples in 2012

1. Establishing Shared, peer reviewed, data bases (Elsa Olivetti; MIT)
2. Simplified LCA For Key Product Segments
3. Simplified LCA For Electronic Materials (Carol Handwerker; Purdue)
4. Developing Sample Business Cases on Sustainability
5. Improved Knowledge of User Behavior
6. Eco-Reliability (Nils Nissen; IZM, Colin Fitzpatrick; Limerick University)
7. Environmental Evaluation of alternative biopolymers (Nils Nissen; IZM)
8. White List of Acceptable Polymeric Materials
9. Material Hazard Informatics (Julie Schoenung; University of California Davis)
10. Sustainable Design and Electronics (Callie Babbitt; RIT)
A Winning Example of Joint iNEMI Research Initiated
Purdue University and Tuskegee University in close collaboration with Global Electronics Industry - iNEMI plus 5 members - and International Academic Partners - Fraunhofer IZM - Berlin, Shanghai Jiao Tong University, Tsinghua University – Beijing, Indian Institute of Management – Udaipur, Universidad EAFIT – Medellin Columbia

**Vision**

Create a new integrative, collaborative model for graduate research and education needed to enable *meaningful and measurable improvements in the global sustainability of electronics.*

Funded by NSF in June 2012
$3.2M for 28 two-year fellowships over 5 years

External Advisory Board and opportunities for collaboration with industry, NGOs, research institutions
Three Research Thrusts

1. Polymers from Nature for Construction & Disassembly
   - Natural Nanocomposites for Structural Applications in Casings and Boards,
   - Bio-based Lignin and Soy-based Resins for Circuit Board Construction
   - Biomimetic Marine-Derived Bioadhesives for Device Construction & Disassembly
   - Green Replacements for Brominated Flame Retardants

2. Sustainable Product Design and Manufacturing
   - Novel LCA Approach for Electronic Products
   - Electronic Product Manufacturing Process Characterization and Improvement
   - LCA-based Design of Electronics
   - Recycling and Reuse of Electronic Devices

3. System and Supply Chain Issues
   - Integrating Sustainability Indicators across the Supply Chain
   - Corporate Sustainability Behavior – Stakeholder Perception – Corporate Valuation
   - Consumer Behavior
   - System-wide Effects of Laws and Regulations
Some Options for Discussion

• Pick a project or two that is well aligned to your priorities and areas or research and academic interests.

• ID a person to join the Research Committee – Typically a very small time commitment in even years, a few days of commitment in the summer of odd years.
  – When the Research Priority document is extracted and created from the Roadmap document.

• Where you have leadership research and desire visibility and potentially partners, create a proposal and pitch to iNEMI in a webinar

• Participate selectively in workshops and in the Roadmap Development

• Other Ideas?
www.inemi.org

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Grace O’Malley - Europe
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Haley Fu - Asia
haley.fu@inemi.org