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Roadmap Trends and Emerging Technologies

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Topics

- **2007 Roadmap**
- **2007 Research Priorities**
 - **Key Gaps**
 - By Roadmap Areas
 - By Research Areas
- **Projects to address iNEMI Strategic Thrusts**
- **Conclusions and Summary**



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2007 iNEMI Roadmap

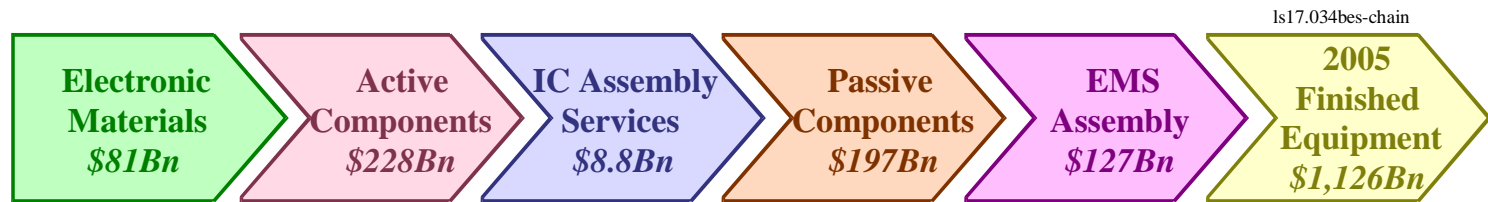
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The Changing Industry

- **Consumers are concerned about the impacts that electronics products may exert regarding safety, energy usage, and environmental impact.**
- **The increasing scope of outsourced operations requires loosely coupled business processes spanning multiple companies and continents.**
- **Business models in the electronics industry have changed - leading to significant shifts in roles and responsibilities across the supply chain.**

Strategic Concerns

Value Creation in the Supply Chain



Typical Companies

Sumitomo Bakelite, DuPont, Ablestik	Intel, STMicro, LSI Logic	Amkor, ASE, SPIL	Tyco, Molex, AVX, Sharp	Solectron, Sanmina-SCI, Flextronics	Dell, HP, Cisco, Nokia, Teradyne, Visteon, Siemens
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Gross Margin	30%	45%	17%	25%	6%	30%
Operating Margin	10%	15%	8%	8%	2%	8%
R&D	7%	15%	2%	5%	<1%	8%
Margin Value	\$8Bn	\$34Bn	\$0.7Bn	\$16Bn	\$3Bn	\$90Bn
R&D Value	\$6Bn	\$34Bn	\$0.2Bn	\$10Bn	\$1Bn	\$90Bn
% Total R&D	4%	24%				64%

Source: Prismark Partners



Converging Markets

- **Medical-Consumer**
- **Automotive-Entertainment**
- **Communication-Entertainment**
- **Computing-Entertainment**

Emerging Technology

- The end of traditional semiconductor scaling.
- Reduction of emphasis on the microprocessor frequency metric, and the corresponding increase in importance of the system's throughput metric.
- Higher bandwidth to and from the microprocessor.
- Increased need for improved cooling & reduced power.
- Minaturization including 3D Packaging.
- Disruptive technology offers opportunity for innovation. In order to ensure success, the supply chain must be willing to invest with a long-term perspective in mind.
- The 2007 roadmap did not identify a major need for optical transmission within high performance printed wiring boards during the next decade.
- Growth in silicon device size is slowing.



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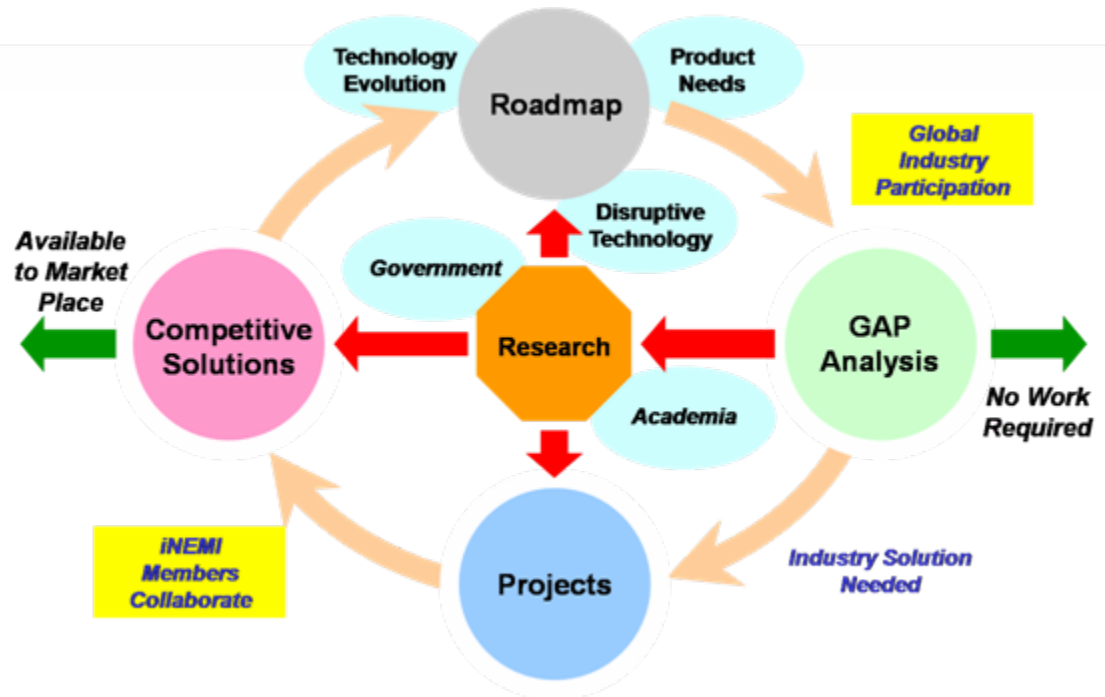
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**2007
Research
Priorities**

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Leadership through Innovation

- A research vision with three major thrusts:
 - Energy & the Environment
 - Miniaturization
 - Medical Electronics



Research Priorities

- 2007 Research Priorities Released in Sept.
- 10 year R&D priorities identified
- Available at <http://www.inemi.org/cms/ri/>
- Contents:
 - Technology Research Needs by Product Sector
 - Priorities Summarized by Research Area
 - *Manufacturing Processes*
 - *System Integration*
 - *Materials & Reliability*
 - *Energy and the Environment*
 - *Design*
 - Significant Gaps and Issues from Roadmap
 - Options for Innovation



Key Gaps by Roadmap TWG Area

- **Board Assembly**
 - Low cost fine line/via PCB Technology
 - Inspection and test capability
 - Board flex standards
 - Design for Manufacturing standards
- **Environmentally Conscious Electronics**
 - Alternatives to Cd, Hg, CrVI, PBB, and PBDEs
 - Industry involvement in policy making on material restrictions
 - Scientific methodologies to assess environmental impact of materials
 - Effective basic energy efficiency metrics
- **Substrates**
 - Low cost, fine line/via PCB Technology
 - Moisture reliability
 - High Tg
 - Low cost, low loss tangent materials

Key Gaps by Roadmap TWG Area

- **Medical**
 - Component reliability standards and standard test methods
 - Standardized characterization process for RoHS-compliant components
 - Development of advanced printed circuit board and flexible printed circuit technologies
 - Safety study of clinical and home-health wireless environment.
- **Thermal Management**
 - Cooling of 3-D Stacked Dies
 - Closed Loop, Liquid Cooling Solutions
 - Data Center cooling strategies
- **Board & System Test**
 - Test access for miniaturized products
 - Increased adoption of boundary scan in digital and analog devices
 - Tools to determine defect coverage.
 - Standards for board flexure of lead-free BGAs
 - Test solutions for High Density Interconnect

Key Gaps by Research Area

Manufacturing Processes

- There is a need for a new methodology/strategy for R&D to be conducted in the global outsourcing environment
- The infrastructure to produce high volume, low cost, high density interconnect substrates for portable electronic products
- Inspection/test technologies need to keep up with density of board designs and component packages

The top priority shifted:

- from development of reduced cost manufacturing processes that support rapid miniaturization
- to development of a new methodology/strategy for R&D to be conducted in the global outsourcing environment

Key Gaps by Research Area

Energy and the Environment

- **Accepted and sound scientific methods to evaluate environmental impact of materials that are also accepted by regulators, NGOs and industry**
- **New innovative energy sources**
- **R&D to develop a sustainable infrastructure**

The top two research priorities essentially remain the same

Key Gaps by Research Area

Materials and Reliability

- Improved Pb-free alloys for better area array shock, lower cost, lower temperature and reduced copper dissolution issues
- Halogen free material for substrates and PCBs
- Second level underfill solution needed that is reliable / reworkable and cost effective

The top research priority in this area was identified as the number four priority in 2005. The number two research priority for 2007 did not show up during the 2005 process.

There was a significant increase in the number of materials gaps identified.

Key Gaps by Research Area

System Integration

As disparate technologies continue to be combined into product architectures, integration challenges face the industry that will limit the ability to improve cost, size and reliability. While there is still a need to continue improvements to the IT infrastructure (the top system integration research priority in 2005), the top research needs identified in 2007 are:

- **3D interconnect structures with associated thermal management**
- **Standardized test methods / figures of merit for printed electronics**
- **The capability to do system level comparisons (performance, power, and cost) between optical and RF technology from the device level to the system level.**

Key Gaps by Research Area

Design

- Improved, integrated and standardized DfX tools for compatibility across supply chains
- Low cost solutions for carrying >10Gb/s signal rates between components on a PCB
- Better tools for concurrent design of packages and PCB for better system optimization.
 - Includes metrology and
 - Methodologies for:
 - Materials characterization and
 - performance validation

Neither of the first two topics were identified in the 2005 Research Priorities.



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iNEMI Projects to address Strategic Thrusts

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Emerging Scenario for iNEMI Projects

- **Meet needs of members (both users & suppliers) in key segments:**
 - **High volume/portable**
 - Expand & strengthen miniaturization projects
 - **Medical electronics**
 - Build momentum for collaboration in this segment by completing initial Medical Electronics Projects
 - **High reliability (Telecom, Computing)**
 - Establish “End Game” for High Reliability segments for Pb-free conversion:
 - Close remaining knowledge gaps
 - Work source of supply issues (BGAs) in the interim
 - Advanced Thermal Management Technologies

Miniaturization

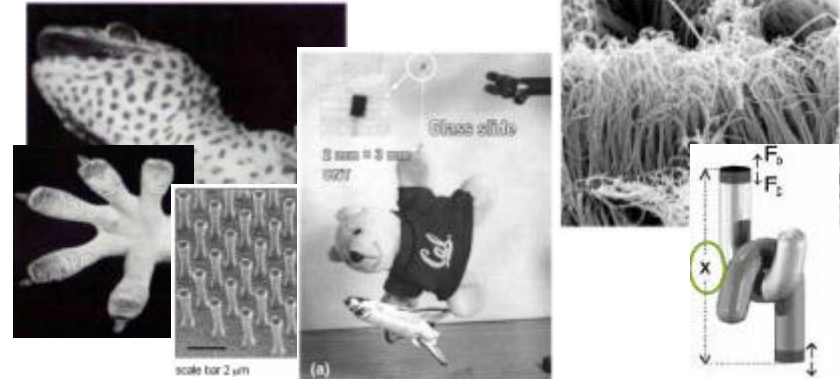
- **Established Projects**
 - Nano Attach Project
 - Pb-free Nano-solder Project
- **New Project**
 - **Functional Test Coverage Assessment Project – Launched July 2007**
- **Initiatives**
 - **High Temperature Co-planarity Requirements for Components and PWBs**
 - **RFID Item Level Tag Roadmap and Gap Analysis**

iNEMI Nano-Attach Project

Goal: Develop low-temperature or room temperature assembly processes that have the potential to improve field reliability, streamline manufacturing, and reduce cost

Strategy:

- Use nanotechnology based dry adhesive technologies, e.g., nano-velcro or biomimetic systems (“gecko foot”) to replace high temperature solder attach systems
- Project Lead: Hope Chik (Motorola)



Tactics

- **Phase 1: Discovery and Concept Development** - Define requirements necessary to adapt nano-structure attachment schemes in electronic assembly
- **Phase 2: Evaluation and Proof of Concept** - Identify and evaluate currently available nano-attach technologies and explore these approaches
- **Phase 3: Demonstration and Prototype** - Proof-of-concept material evaluation and fabrication of assembled prototypes

Milestones & Issues

- **Phase 1 – Discovery**Q407
- **Phase 2 – Evaluation**Q208
- **Phase 3 – Demonstration**Q408
- **Issues:**
 - ✓ Is the technology mature enough to have a high probability of success in Phase 2 and 3

Printed & Organic Electronics Roadmap

Goal: Develop industry-wide Printed & Organic roadmap to establish supply chain

Strategy:

- Publish internationally accepted printed and organic electronic roadmap.
- Project Lead: Motorola



Tactics

- Phase 1: Agree to partner with Organic Electronics Association to deliver a combined iNEMI and OEA Roadmap
- Phase 2: Initiate roadmap drafting effort and agree to outline for combined document

Milestones & Issues

- Phase 1.....Q407
- Phase 2Q108
- P&O Roadmap issuedQ109
- ISSUES:

Medical Electronics

- **Established Project**
 - **Medical Grade Component Reliability Specifications**
- **Initiative**
 - **Substrates for Medical Devices**

Energy & the Environment

- **Established Projects**
 - Tin Whisker Phase II Project
 - Lead-Free Rework Optimization Project
 - Pb-free Wave Soldering Assembly Process Project
 - Lead-Free Rework Optimization Project
 - Pb-free BGAs in SnPb Assemblies Project
 - Halogen-Free Project Phase II
- **New Initiatives**
 - BGA Metallurgy Proliferation
 - Advanced Thermal Management Technologies (under discussion)
- **High Reliability Task Group**
 - Prioritization of remaining Pb-free knowledge gaps
 - Strategy for closing gaps
 - Industry coordination for Pb-free transition



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Halogen Free and Beyond: Journey to a Sustainable World

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Top Implementation priorities from 2007 ECE Roadmap

- **A strategy and action plan to facilitate low risk conversion of high-reliability applications to Pb-Free solders**
- **R&D to develop a sustainable infrastructure and viable recycled materials market for use in new products and other applications**
- **Proactive programs to convert to bromine free material alternatives**

iNEMI Halogen-Free PCB Project

Project Schedule

- **Phase 1 (Design) Feb '06 – Sep '06 (Complete)**
- **Phase 2 (Test) Jul '07 – Mar '08**
- **Phase 3 (Results) Nov '07 – Apr '08**
- **Release Results Apr '08 (iNEMI members)
Apr '08 (APEX - Public)**
- **Phase 4 (Next Steps)**
 - **Open iNEMI meeting at APEX to discuss Phase 4 - Next Steps**
 - **Wednesday, April 2, 2008 from 1:00pm -3:30pm**

Halogen Free and Beyond

Other Opportunities to Demonstrate Corporate Social Responsibility (CSR)

- **Additional proactive programs to convert to bromine free material alternatives (i.e. beyond PWB efforts)**
- **Develop sound scientific methods to evaluate environmental impact of materials**
- **Develop technology and market for recycled electronic materials**
- **Use additive processes to eliminate waste**
- **Reduce energy use while increasing performance**

Next Steps

- **iNEMI Board of Directors has called for a Sustainability Workshop to evaluate opportunities for industry collaboration**
- **Invite Industry and Academic Speakers to speak**
- **Establish Breakout Groups to brainstorm options and priorities**
- **Establish Action Groups on selected topics based on outcome of meeting**
- **All are welcome to participate in this event**
- **Watch the iNEMI web site for details (www.inemi.org)**



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Conclusions and Summary

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Conclusions

- **Consumer Electronics has become the major driving force for our industry:**
 - **New Technology to enable miniaturization**
 - **Relentless cost reduction**
 - **Volume manufacturing capability**
- **Disruptive technology offers opportunity for innovation. To ensure success, the supply chain must invest with a long-term perspective in mind.**

Summary

- **The 2007 iNEMI Research Priorities identifies R&D needs that must be met.**
- **Given the limited resources that industry, academia, and governments can apply, it is crucial that we focus our R&D efforts on these high priority knowledge gaps.**

Major opportunity for all to address:

- **Develop and execute a strategic vision of sustainable electronics.**

www.inemi.org

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