iNEMI Overview
International Electronics Manufacturing Initiative

The Value Proposition for Collaboration

October 9, 2014
Today’s Objectives

- Get to know iNEMI

- See benefits of collaborative activities of interest:
  - iNEMI Roadmap (open to non members)
  - Projects
What is iNEMI?

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.

www.inemi.org
Our Mission

Forecast and Accelerate improvements in the Electronics Manufacturing Industry for a Sustainable Future
Why Organizations Participate

Better anticipation of technology trends & inflexion points

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

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

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

Access to In Depth Reports and Studies
Detailed project data and analysis for members only
Who participates in iNEMI

Supply Chain Management
- Information Technology
- Logistics
- Communications
- Business Practices

Product Lifecycle Solutions
- Build to Order
- Software Solutions
- Lifecycle

Manufacturing
- Materials Transformation
- Equipment
- Materials
- Components

Collaborative Design
- Materials
- Customer Equipment

Order Fulfillment
- Materials Transformation
- Build to Order
- Lifecycle

Design
- Components
- Materials
- Build to Order

Marketing
- Materials Transformation
- Build to Order
- Lifecycle

Order Fulfillment
- Materials Transformation
- Build to Order
- Lifecycle

Customer
### Roadmap
- Anticipate technology requirements
- Identify gaps
- Focus R&D priorities

### Collaborative Projects
- Eliminate gaps
- Deliver learning & critical data
- Leverage efforts & resources of participants

### Forums & Workshops
- Share solutions & best practices
- Prioritize key challenges
- Network with customers & suppliers
Global Operations Supports Membership

Bill Bader
CEO
(Headquartered in Virginia, USA)

57 members HQ in North America

Steve Payne
European Manager
(Based in UK)

17 members HQ in Europe

Dr. Haley Fu
Managing Director
Asia Pacific
(Based in Shanghai, China)

26 members HQ in Asia Pacific
Today’s Challenges

- **Capitalize on business opportunities evolving from new technologies**

- **Reduce risks and costs**
  - *in new business and technology development*
  - *on the journey to a sustainable world*

- **Influence the industry and drive improvements**
  - *be a leader and collaborate with leaders*

- **Engage with the global supply chain**
Ease of Use Improvements has Driven Growth

User Interface + Smaller Form Factor + Lower Prices + New Services

Source: Morgan Stanley Estimates
Consumer Segment driving Technology Changes

• Smart phones dominated unit volume growth for portable products, and the overall market volume growth has been driving other areas:
  – Increased focus on shrinking form factor and low power
  – High level of integration (SoC, SiP)
  – 3D packaging and Embedded Die market leaders
    • Significant focus on sustainability, eco-design and recycling
    • The MEMS/sensor technology for unleashing entertainment, medical, and security as well as perceptual computing

• Convergence of Entertainment, Computing, Communication drives integration
  – The world of OS and applications and middleware challenges, will drive major shifts and consolidations to enable seamless computing and interoperability
  – The pace of product enhancements is growing rapidly.
Overall Key Trends

- Quality, reliability, cost still paramount
- Miniaturization and Thinner; Speed of Change Escalating

- Convergence
  - Medical-Consumer
  - Automotive-Entertainment
  - Communication-Entertainment

- Infrastructure (Business Model) changes:
  - Fabless Semiconductor Fabrication
  - Redundant Elements
  - EMS and ODM roles grow; R&D Challenges

- Supply chain
  - Rare Earth and Conflict Materials
  - Counterfeit Products
  - Product Personalization

- Environmental
  - Carbon foot printing
  - Energy Storage
Strategic Concerns

• Restructuring from vertically integrated OEMs to multi-firm supply chains

• Critical needs for R&D - Middle part of the Supply Chain is least capable of providing resources

• Industry collaboration

• The mechanisms for cooperation throughout the supply chain must be strengthened.
  – Cooperation and risk sharing among Research institutes, OEMs, ODMs, EMS firms and component suppliers is needed to focus on the right technology and to find a way to deploy it in a timely manner
Capitalize on business opportunities evolving from new technologies

- Via roadmap
- Via long-term research
iNEMI Roadmap is Unique in Electronics Industry

Outlook for the next 10 years, updated every other year, global participation, covers the full supply chain for electronics manufacturing

Statistics of 2013 Roadmap (10th roadmap)
- 650+ participants
- 350+ companies/organizations
- 18 countries from 4 continents
- 20 Technology Working Groups (TWGs)
- 6 Product Emulator Groups (PEGs)
- 1,900+ pages of information
- Roadmaps the needs for 2013-2023
## Roadmap Development

### Product Sector Needs vs. Technology Evolution

<table>
<thead>
<tr>
<th>Product Emulator Groups</th>
<th>Technology Working Groups</th>
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<tbody>
<tr>
<td>Portable / Consumer</td>
<td>Semiconductor Technology</td>
</tr>
<tr>
<td>Office / Large Systems</td>
<td>Business Processes</td>
</tr>
<tr>
<td>High-end (e.g. netcom, server)</td>
<td>Design Technologies</td>
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<tr>
<td>Automotive</td>
<td>Manufacturing Technologies</td>
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<td>Medical Products</td>
<td>Comp./Subsyst. Technologies</td>
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<td>Defense and Aerospace</td>
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</tbody>
</table>

- **Semiconductor Technology**: Prox Lifecycle Information Mgmt.
- **Business Processes**: Modeling, Thermal, etc.
- **Design Technologies**: Board Assembly, Test, etc.
- **Manufacturing Technologies**: Packaging, Substrates, Displays, etc.
Many Contributing Organizations

- **iNEMI**
  - **Roadmap**
  - **Information Management TWG**
  - **Mass Data Storage TWG**
  - **Optoelectronics TWG**
  - **Board Assembly TWG**
  - **Optoelectronics TWG**
  - **Passives TWG**

- **Interconnect Substrates—Ceramic**

- **Semiconductors**
  - **iNEMI / ITRS / MIG/PSMA Packaging TWG**
  - **iNEMI / ITRS MEMS TWG**
  - **iNEMI / IPC / EIPC / TPCA Organic PWB TWG**

- **Organic Printed Circuit Boards**
  - **Supply Chain Council**
  - **Supply Chain Management**

- **Magnetic and Optical Storage**
  - **MEMS TWG**
  - **Passives TWG**

- **Other Organizations**
  - **MEMS Industry Group**
  - **Power Sources Manufacturers Association**
  - **ELA**
  - **SMTA**
  - **IEEE**
  - **CPMT**
  - **Microphotonics Center**
  - **OIDA**
Key Outputs of the iNEMI Roadmap

• Short term
  – Information on technology evolutions and industry needs for the short to mid term
  – Technical plan for iNEMI Technical Committee
    • Where should we focus our efforts
    • Project areas/specific projects
    • Topics for further investigation – workshops/forums

• Long term
  – Research Priorities Report
    • Highlight the longer term needs of the industry
    • Highlights where academic research should be focused and funded
    • Identify key areas that need further investigation
      – AMTech grant for CIPSM
NIST Advanced Manufacturing Technology Consortia (AMTech) Program

- The AMTech Program allocated $539,990 for the iNEMI / MIT CIPSM Consortium for a 19-month program
- CISPM will establish a community of Academics, Technologists and Companies to:
  - define gaps and roadblocks for an integrated photonic technology roadmap
  - build a common manufacturing platform for cost-effective, high-volume manufacturing
Reduce risks and costs

➢ Via collaborative projects
Benefits of Collaborative Projects

• **Reduce cost by leveraging resources**
  – Reduce cost by investigating new technologies
  – Reduce resource demands and $ investments for each company
  – Stimulate standards and common specification development
  – Work on issues facing all your suppliers/customers
  – Disseminate efficient business practices

• **Reduce risk of technology introduction**
  – Gain knowledge and accelerate deployment of new technologies
  – Developing industry infrastructure, source of supply
  – Ensure reliability and technology readiness when required

• **Reduce environmental risks**
  – Ensure sustainable solutions are put in place and in sync with industry
Profile of Successful iNEMI Projects

• Addresses knowledge gap of industry
  – Common problem solved by working together
  – Often a pre-cursor to standards development

• Brings together a segment of supply chain to provide industry-wide response

• Direct alignment with member companies’ commercial interests.
iNEMI Projects - Quick Facts

- iNEMI manages and facilitates projects
- Members define and execute projects and share the cost
- Projects are aligned with member interest and roadmap identified needs
- 20+ ongoing projects; 8+ members participating per project
- Projects typically last 12-18 months
- Projects general categories
  - Research: explore and investigate new materials and processes
  - Optimization: “Fine tune” the materials and/or processes (often includes reliability or accelerated life testing); develop a tool
  - Specification: define a usable range for each set of optimized materials and/or processes (often output white paper, standards)
Current Projects Areas

- Packaging & Component Substrates
- Test, Inspection & Measurement
- Environmentally Sustainable Electronics
- Optoelectronics
- Board Assembly
- Interconnect PCB - Organic
- Electronic Connectors
- MEMS/Sensors
- Medical
- Automotive
**Initiative raised**
- Member company/Workshop/Survey output
- Committee members/Project teams
- Roadmap gaps/Technical plan/Research priorities

**Planning**
- Facilitated by iNEMI staff/Identify leaders
- Develop statement of work & project statement agreement
- Approve by iNEMI Technical Committee

**Project execution outputs**
- Knowledge/results for the project team members
- White paper/Industry survey report
- Common specification/Recommendation on standard
- Presentation/paper at conference/Project report/webinar
Environment: Pb-Free Projects

- iNEMI’s ground-breaking work with Pb-free assembly moved significantly furthered knowledge and understanding of Pb-free materials and processes
  - Characterized new materials and demonstrated reliability
  - Accelerated establishment of SAC alloys as the standard

- Follow-on efforts addressed Pb-free rework, Pb-free wave soldering, component & board marking (input for JESD97 and IPC-1066), materials declarations (input for IPC-1752), and more

- iNEMI’s comprehensive work in tin whiskers also yielded important contributions
  - Accelerated test for tin whiskers (formed the basis of JEDEC standard JESD22-A121)
  - Tin whisker modeling (provided input for the IPC/JEDEC document JP002)
  - Recommendations for mitigation techniques (adapted as JESD201)
Environment: Eco-Impact Evaluator for ICT Equipment Project

- Measuring environmental impact is important for the electronics industry to assess and reduce its carbon footprint
- iNEMI’s Eco-Impact Evaluator for ICT Equipment Project developed a simplified proof-of-concept tool for estimating environmental impact of ICT (information and computer technology) equipment
  - Software tool estimates greenhouse gas emissions for an ICT product over its life cycle stages
  - Allows companies to quickly and easily evaluate and optimize design trade-offs
- Several project participants tested the tool
  - Found it to be within 5% accuracy

“For us, taking something that might normally require 10-20 hours to complete and getting it down to half an hour or an hour is a huge deal.” — John Malian, Sustainability Engineer, Cisco
iNEMI Position Statements / Whitepapers

• Establish iNEMI members position on a topic, to help accelerate convergence on key issues that industry faces.

• Examples of White Papers:
  – Rare Earth Metals -- Current Status & Future Outlook (2014)
  – Development of a Methodology to Determine Risk of Counterfeit Use (2013)
  – Harmonization of Environmental Data Management (2012)
  – The Limits of Temperature, Humidity and Gaseous Contamination in Data Centers and Telecommunication Rooms to Avoid Creep Corrosion on Printed Circuit Boards (2012)
Medical: Qualification Methods for Portable Devices
Project scope:
• Develop a set of procedures/recommendations acceptable to the medical electronics industry for assessing reliability of portable medical electronic devices. An industry wide approach to qualifying the reliability performance of medical devices will enable the industry to grow faster.
  – An industry wide qualification method that is supported across the supply chain will reduce redundant costly testing and increase confidence in the qualification procedure.
  – shorten the time to market and time to integrate new technologies
  – provide regulatory bodies with standardized criteria for acceptance of new devices or device designs.

Key learnings:
• Ensuring that a medical device can be designed, manufactured and operated reliability is a complex and multi faceted process. Basic Safety and ESSENTIAL PERFORMANCE establish the foundation for the manufacturer’s Risk Management actions.

• This project team has identified a process flow which can guide the development of the qualification methods by end use manufacturers for portable devices.
• Important gaps in the available standards for portable medical devices have been identified.
Ultra Low Loss Laminate/PCB for High Reliability & Performance
Project Background & Objectives

• **Problem Statement**
  – Currently there are very limited options for low cost high performance PCB materials capable of high volume manufacturing (HVM) process. High Layer Count / Multi-layer Constructions are becoming more and more complex with fewer material options.

• **Opportunity**
  – Drive competitive cost / high performance laminate capability by providing more material choices capable of HVM processing.

• **Scope of Work**
  – The project will consist of designing, building, and evaluating a test vehicle or vehicles to examine the performance and reliability of selected laminate materials that fit the defined envelope set by the work group.
  – Evaluation of new materials based on electrical and thermo-mechanical capabilities for high layer count / multi-layer applications.
Material Selection

Proposed Material Envelope

– Electrical Targets:
  • Dk – 3-4.2 @ 1GHz
  • Df – <= 0.005 @ 1GHz

– Thermo Mechanical Targets:
  • Tg – >160C
  • Z-CTE – <3.0% from 50 to 260C
  • Flexural or Young’s Modulus target?

– Construction:
  • Capable of multiple dielectric thicknesses from 3 mil to 10 mil
  • VLP or HVLP copper for cores
– UL V-0 rating
– Low halogen vs. brominated optional
The project will **evaluate the impact** of the use of **low-CTE mold compounds** on the reliability of second level solder joints for common package types.

- **Quantification** of life time impact through:
  - review of existing data (literature & within project team)
  - Finite Element modelling (FEM)
  - experimental testing

- **Recommendations** to ensure acceptable reliability performance for certain package types under certain operation conditions will be developed.
Recent years: transition to the use of lower CTE mold compounds in a wide variety of package types (BGA, QFN, QFP, etc.)

The lower CTE values are being achieved by an increased fraction of SiO\textsubscript{2} as filler in the mold compounds. These lower CTE materials are often known as Green Mold Compounds (GMC) since the elimination of halogen-containing flame retardants is one of the drivers for the change to the low CTE mold compounds.

Package with low-CTE mold compound increase the thermal expansion mismatch with PCB → solder joints are more stressed
Recent results (©imec)

- Result 1: BGA225 12x12 mm (0.5 mm pitch)

Impact of mold CTE: Life time (11ppm BGA) \(\sim 2.2\) * Life time (8.5ppm BGA)

Impact of mold CTE is far greater than the chosen solder composition
Recent results (©imec)

- Result 2: QFN64 9x9mm (0.5 mm pitch)

QFN’s with 7 ppm/°C: (almost) all failed after 2000 cycles
QFN’s with 12 ppm/°C: no failures after 2000 cycles
Purpose of the Project (1)

• To increase the understanding of the relationship between the 2nd level solder joint reliability, the mold compound CTE and the component type, termination configuration and dimensions, based on industry feedback, available experimental findings, new reliability testing and FEM based simulations.

• To study the reliability performance of different package types with mold compounds of different CTE values.

• To develop recommendations in terms of the CTE values for selected package families in certain applications (e.g. BGA, QFN, QFP-EP, TSOP, LGA)
Purpose of the Project (2)

• Anticipated results will include:
  – For component and package suppliers: recommendations for minimum mold compound CTE to achieve the application dependent required reliability under specified test / operating conditions
  – For electronics designers and manufacturing: recommendations for package type selection to achieve the requested reliability.

• To evaluate mitigation solutions such as underfilling, special lower-CTE boards or increased solder joint stand off when mold compound CTE cannot be increased.
To date – 2014 Completed Projects

<table>
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<tr>
<th>Project Name</th>
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<tbody>
<tr>
<td>1. Built in Self Test (BIST) Project Phase 3</td>
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<tr>
<td>2. Component Specifications for Medical Products</td>
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<tr>
<td>3. Copper Wire Bonding Reliability</td>
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<tr>
<td>4. DDR Memory Task - Boundary Scan Phase 2</td>
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<tr>
<td>5. Pb-Free Surface Mount Assembly and Rework Phase 3</td>
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<tr>
<td>6. PCBA Reliability Qualification Processes for Enterprise Products</td>
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<tr>
<td>7. Rare Earth Metals Assessment and Supply Chain Actions</td>
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<td>8. Standard Reliability Performance Qualification Methods for Portable Devices</td>
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<tr>
<td>Project Name</td>
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<tr>
<td>Alternative Materials Assessment Project</td>
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<tr>
<td>Automotive Material Challenges</td>
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<tr>
<td>Boundary Scan Project, Phase 3</td>
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<tr>
<td>Characterization of Pb-Free Alloy Alternatives</td>
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<tr>
<td>Connector High Speed Signalling Metrology Program: Phase 1</td>
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<tr>
<td>Connector Standard Reliability Test Recommendations Program: Phase 1</td>
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<tr>
<td>DC-DC Conversion Project</td>
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<tr>
<td>Development of Cleanliness Specification for Expanded Beam</td>
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<tr>
<td>Impact of Low CTE Mold Compound on 2nd Level Solder Joint Reliability - phase 1</td>
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<tr>
<td>MEMS Test Methods and Capabilities - Data Sheets for Inertial Sensors</td>
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<tr>
<td>Metals Recycling</td>
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<tr>
<td>Qualification Test Development for Creep Corrosion, Phase 1</td>
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<tr>
<td>Quantifying Recycling and Repair Metrics</td>
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<tr>
<td>Strain Guidance of PCBAs</td>
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<tr>
<td>Ultra Low Loss Laminate/PCB for High Reliability &amp; Performance</td>
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<tr>
<td>Warpage Characteristics of Organic Packages</td>
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</table>
iNEMI Project Benefits

• No limitations to Project theme
• Over 90% of proposals result in SUCCESSFUL Projects
• Can be proposed at ANY time
• Swift implementation from idea to Project commencement (3 months)
• Results typically achievable in 12-18 months
• Experienced iNEMI staff provide Project Management
• High Financial Leverage thru Membership resources: €1 euro of your own R&D budget can result in over €10 resource being applied to Project
• Project participants share costs and give their time
• Global networking opportunities
Influence the industry and make changes

➢ Be a leader and collaborate with leaders
Lead & Learn

• iNEMI membership provides the critical mass required to affect significant changes
  – Set direction for future technologies
  – Influence supply base to develop solutions that will support product roadmap needs
  – Drive standardization to reduce cost and complexity

Tell me and I forget. Teach me and I remember. Involve me and I learn.

- Benjamin Franklin
iNEMI Organization

- **Roadmap Development**
  - Product Needs
  - Product Emulator Groups
  - Technology Needs
  - Technology Working Groups

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

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

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

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

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

- **Collaborative R&D**
  - Technical Plan & Gaps Defined By:
    - Technology Working Groups
    - Workshops Identified Gaps
Engage with the global supply chain
Proactive Forums and Networking

**On-line**
- Webinars
- Project meetings
- Committee/Group Meetings

**On-site**
- Symposium
- Workshops/Forums
- Member meetings

- Roadmap highlights
- Project reports
- Research series

- Identify latest development
- Address key gaps & issues
- In-depth discussion leading to projects
- Networking
<table>
<thead>
<tr>
<th>Workshop Scope</th>
<th>Location</th>
<th>Dates</th>
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<tbody>
<tr>
<td>Packaging &amp; Substrates</td>
<td>Toyama, Japan</td>
<td>April 22(^{nd}) and 23rd</td>
</tr>
<tr>
<td>Board Assembly &amp; Test</td>
<td>Shenzhen, China</td>
<td>August 25(^{th}) and 26(^{th})</td>
</tr>
<tr>
<td>Medical Electronics</td>
<td>Portland Oregon, USA</td>
<td>September 18 &amp; 19 Co-Hosted with SMTA and MEPTEC</td>
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<tr>
<td>Environmentally Conscious Electronics</td>
<td>Vienna, Austria</td>
<td>November 17(^{th}) as part of Care Innovation</td>
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Why iNEMI

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

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

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

• iNEMI Reputation
  • Track record of sustainability leadership
  • In demand for knowledge/science input
  • Results oriented workshops
Flextronics depends on roadmaps coming from iNEMI. We need that level of support and visibility from a consortium like iNEMI that has a lot more visibility into the industry. — Murad Kurwa, Flextronics

These are the type of projects that not one company can do or drive it on its own. It really requires a collaborative effort across the entire supply chain. — Mostafa Aghazadeh, Intel

iNEMI is providing me an incredible window into the industry and the opportunity to be connected at a very low cost with everybody in the industry. — Jean-Luc Pelissier, Universal Instruments
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