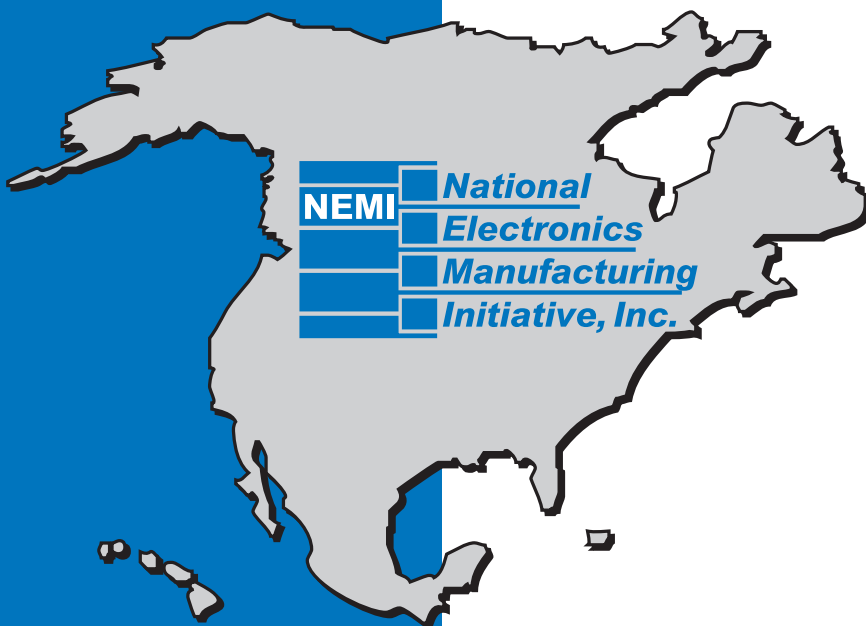


2002 NEMI Annual Report



*Connect with and
Strengthen your
Supply Chain*

LETTER FROM THE CHAIRMAN & CEO



Chairman
Dr. Nasser Grayeli



CEO Jim McElroy

While our overall economy has stabilized and even shown some modest growth over the last few quarters, the electronics industry continues to struggle through its worst and longest downturn. The impact has been across the board with some sectors (e.g. telecom, capital equipment) being hit much harder than others. Predictions of upturns from the pundits routinely slip out as the overall demand picture remains weak. When we were near the last peak, some were arguing that our industry was no longer cyclical. Now we all dream about the next up cycle but fewer are willing to predict the timing. Clearly, we are in an extended period of greater uncertainty and volatility where peace on earth seems as elusive as ever. Of course there are some bright spots – truly differentiated companies have shown a remarkable ability to grow market share and remain relatively more profitable throughout the downturn. And, the electronics industry continues to make a significant contribution to improvements in productivity of the region’s economy. As our industry matures, restructuring continues with outsourcing (of multiple functions) and migration to other regions as major elements of many corporate strategies. Often these changes are shaped by the need to reduce cost and the promise of emerging markets in areas such as China.

In this environment, NEMI has continued to evolve to ensure that we add value to our member companies. Interest in NEMI deployment programs has never been stronger as we build momentum in existing as well as new Technology Integration Groups (TIGs) and projects. The Business Leadership Team has provided a parallel view to the Technical Committee to focus on the business/supply chain challenges that we face. In the current environment of reduced spending and restricted travel, we have accelerated our use and mastery of web-based and telephonic tools and processes – with noticeable positive impact on collaboration productivity. All of these factors have contributed to a better than 20% net growth of membership in 2002.

Both activity levels and results have been at an all-time high this year. We have just completed the 2002 Roadmap - our fifth edition of this value-packed document - which represents the efforts of a broad cross-section of industry, academia, and government. In addition to managing five TIGs with 16 active projects, we organized nine forums on important industry topics, ranging from lead-free assembly to manufacturing in China.

As a virtual enterprise, NEMI is completely dependent on the support and participation of our members. Our efforts are focused on common needs and challenges, and the companies that gain the most value are the ones that use their participation in NEMI to fill specific company needs and to develop business opportunities. Your belief in our mission and your continued participation are crucial to the successes that we collectively enjoy. We are grateful for both your commitment and contributions to the cause.

Sincerely,

A blue ink handwritten signature that reads "N. Grayeli". The signature is enclosed in a blue oval.

Dr. Nasser Grayeli
Chairman, NEMI Board of Directors
Vice President Technology & Manufacturing
Intel Corporation

A blue ink handwritten signature that reads "J. McElroy".

Jim McElroy
Executive Director & CEO
NEMI

FOREWORD

NEMI's mission is to assure the global leadership of the North American electronics manufacturing supply chain. We accomplish this through collaborative deployment of needed manufacturing technologies (identified by our biennial technology roadmapping effort) and strengthening of the infrastructure (e.g., supplier capabilities), or supply chain. NEMI is a user-driven organization where OEMs and EMS providers define industry needs then work closely with suppliers to guide them in developing and commercializing solutions.

Change in our industry is one of the few constants that we can point to. One aspect of that change is the ongoing geographical migration of technology and manufacturing. In the late '80s through early '90s the investments, successes, and growth of Japanese electronics companies was a major force that shaped the electronics industry. Through the '90s other shifts followed: NAFTA, Taiwan, and Eastern Europe. Today, the major topic of discussion centers around China with its attractive infrastructure and huge market potential. The migration of volume manufacturing to China that we are currently witnessing is particularly noteworthy due to both its speed and its intensity. Clearly, this trend is reshaping the supply chain infrastructure of the industry in a major way.

While NEMI has continued to focus on the North American supply chain, the global nature of business has demanded change. Over the last several years, we have modified membership criteria, increased collaboration with other regions to help ensure global solutions, and started to address business practice challenges associated with the widely distributed supply chain. Recently, we held a forum on manufacturing in China as a first step in trying to understand how to modify our value proposition to meet the changing needs of our members in the current environment. As we consider these changes, we will treasure the value of the network of current NEMI members and the framework/process for collaboration that we have honed over time.

NEMI pioneered and continues to enhance the concept of the virtual consortium. In this model, now widely deployed in many industry sectors, the overhead function is kept to a minimum. The critical work is carried out by the member companies, within their own environments, assuring ownership of the projects and, more importantly, the results. We have chosen to focus on *implementation* programs as the key strategy to achieve rapid deployment of any given technology and/or business practice. Programs are driven by the conclusions of industry-wide roadmapping, leading to definition of gaps in the infrastructure. All efforts are conducted through the combined forces of member companies, and, therefore, the end results are accomplished with significantly greater resource utilization than a single company could accomplish acting alone. Furthermore, the technologies and/or business practices developed have a greater chance of broad industry acceptance. Benefits of NEMI participation go beyond those enjoyed by the member companies and the North American supply chain. The skills and knowledge of the individuals involved in NEMI projects are enhanced. In a number of cases, this broader knowledge has helped lead individuals to new assignments with increased responsibilities within their companies.

Our overall focus remains on striving to develop and maintain a world class manufacturing supply network for our members. Getting better results in shorter time for lower cost is the compelling argument for your continued support of NEMI.

HIGHLIGHTS OF

NEMI's 2002 ACCOMPLISHMENTS

The electronics industry is changing at a rapid pace and NEMI is changing along with it to insure that we continue to provide value for our member companies. We are embarking on our fifth cycle of technology roadmaps, our deployment efforts continue to broaden and build momentum within the electronics industry, and we are achieving all of this in the midst of a severe economic downturn.

Roadmapping

The Roadmap continues to be the foundation of NEMI's activities. It reaches beyond our own membership to involve a broad spectrum of organizations in the critical task of defining future industry needs. This input allows us to identify those areas where a collaborative approach can provide the most effective response, and to develop targeted projects and programs that address technology gaps and business needs. More than 350 individuals from some 170 organizations were involved in developing the 2002 Roadmap.

This latest Roadmap shows that, for the most part, our 2000 projections were optimistic. Although our technology forecasts were on target, we did not foresee the breadth and depth of the industry downturn which heavily impacted revenues industry-wide, thus delaying many of the growth scenarios forecast by the 2000 Roadmap. The downturn has also driven an accelerated move to lowest cost geographies for volume board assembly.

Deployment Projects

We had 16 active projects during 2002, five of which were launched this year, and five of which were completed. The current economic climate has sharply curtailed member travel to meetings, so our web and teleconferencing service has become key

to project management. Most projects have one-hour teleconferences at least weekly; those with sub-groups may have three to five teleconferences each week. Our project teams are also making good use of the FTP site for exchanging large files.

Our highest impact projects this year have been those associated with lead-free electronics. We completed our original project, started a new one focusing on hybrid assembly and rework, and have two projects actively investigating issues relating to tin whiskers. Another area that generated much interest — and attracted several new members — is optoelectronics. New projects in both the Board Assembly and Optoelectronics TIGs are focusing on some of the issues that drive up manufacturing costs, thus delaying the implementation of fiber in the “last mile” of the communications network.

Broadening Our Scope

The Business Leadership Team strengthened its efforts this year by continuing work on “the Perfect BoM,” holding a forum on engineering collaboration, and conducting a workshop on product take-back. The Board of Directors sponsored a forum on manufacturing in China. In each case, opportunities for further member collaboration have been identified.

Strengthening Our Membership

Participation of existing members has broadened with the expansion of our portfolio of activities (a critical step to achieving higher value). NEMI added 15 new members to the roster this year giving us the highest growth rate ever achieved (better than 20%). New members represent a broad slice through the supply chain: OEM, EMS, and suppliers.

LEADERSHIP

As a member-driven organization, NEMI relies heavily on its membership, not only for resources to conduct roadmapping and deployment, but also for leadership of the consortium. Like the industry that we represent, our leadership reflected a high level of change this year.

Board of Directors

The Board of Directors sets top-level strategy for NEMI and helps ensure the overall management of the consortium. The NEMI Council of Members elects directors to three-year terms. Dr. Nasser Grayeli, Vice President of Technology and Manufacturing for Intel, was elected Chairman of the NEMI Board of Directors at the March 2002 Board meeting. Due to changes of responsibilities, Dr. Bill Beckenbaugh, Sanmina-SCI, resigned from the Board this year. We are currently working to fill that vacancy. At the March Council of Members meeting, we re-elected three directors: Dr. Marc Benowitz, Director, Engineering Infrastructure, Lucent Technologies, Inc.; John Pomeroy, President & CEO, Dover Technologies International, Inc.; and Dr. Iwona Turlik, Corporate Vice President, Motorola, Inc.

NEMI Board of Directors



***Nasser Grayeli,
Chairman***



Marc Benowitz



Michael Coady



Blair Davies



Vincent DePalma



Jim Fahey



Richard Kubin



John Pomeroy



Iwona Turlik

Outstanding Leadership Awards

This year, we inaugurated Outstanding Leadership Awards to recognize individuals and teams who have made significant contributions to NEMI programs. Awards for individual leadership were presented to John Cartwright, Intel Corporation, and Barbara Goldstein, NIST, for their involvement with the Factory Information Systems TIG. Their efforts were integral to the development of several new IPC standards and RosettaNet “Partner Interface Processes” for shop floor and supply chain communication. In addition, an Outstanding Leadership Team Award was presented to the leaders of the Lead-Free Assembly Project for their role in making it practical for North American companies to remain competitive in markets where “lead-free” is either a key selling point or mandated by legislation. Team members include: Edwin Bradley, Motorola; Rick Charbonneau, StorageTek; Jasbir Bath, Solectron; Carol Handwerker, NIST; Richard Parker, Delphi Delco; and John Sohn, Lucent (retired). Clearly, these dedicated individuals have made a significant impact on our industry!

Technical Committee

The Technical Committee implements the programs and direction established by the Board of Directors. The primary focus of this leadership group is the deployment and roadmapping programs, which are managed by the Directors of Planning and Roadmapping. Bill Barthel, Manager of Manufacturing Technology Development at Plexus Corp., and Sundar Kamath, Senior Vice President of Sanmina-SCI and head of their Global Technology Solutions Division, joined the Technical Committee during 2002. Srinivas Rao, Vice President, Technology, at Solectron Corporation, and Leslie Guth, Director, Advanced Technology & Platforms, Supply Chain Networks, Lucent Technologies, were appointed Co-directors of Planning. The Committee approved formation of five new projects during the year and also provided technical review of, and input for, the 2002 Roadmap.

NEMI Technical Committee



Galen Reeder
Co-Chair



Ron Gedney
Co-Chair



Jim Arnold



Carol
Handwerker



Bill Bader



Allan Fraser



Koen Gieskes



Leslie Guth



Robert Pfahl



Srinivas Rao



Al Viehbeck



George White



Bill Barthel



Sundar Kamath

EXPANDING BEYOND TECHNOLOGY

NEMI continues to focus the majority of its activities on manufacturing-related technologies; however, through the efforts of the Business Leadership Team and the Board of Directors, we are putting increasing emphasis on business challenges that face the industry.

Throughout this year, the task force on the Perfect Bill of Materials has continued their work. A comprehensive white paper was released in Q1 which led to a web-based seminar early in Q3. The participation was beyond our expectations and reinforced the notion that this remains a broad area of opportunity for improving efficiency of the new product introduction (NPI) cycle. Building on this momentum, we organized two additional task teams to focus on solution provider engagement and the issues associated with AVL/AML. To continue the educational aspects of this work, articles as well as conference papers are planned.

In April, Sun Microsystems hosted a NEMI forum on engineering collaboration. Increasing distribution of the design process raises a number of challenges for manufacturers, from protection of intellectual property to conducting short cycle design trade-offs across several “design chain” partners. In addition to having excellent overviews from AMR Research and Price Waterhouse Coopers, several early adopters shared their experiences with the group. Discussion sessions identified numerous opportunities for further collaboration and these are now under consideration.

In October, NEMI member StorageTek hosted a forum to discuss product take-back regulations, particularly those pending in the European Union, and their potential impact on North American electronics manufacturers. AeA, EIA, and Allen & Overy (a law firm with expertise in European

environmental regulation) provided overviews of legislation, and several NEMI members shared their strategies for approaching the impending regulations. A group discussion then identified a number of issues and opportunities for further action. We plan to form a small steering group to refine and prioritize these results.

“The NEMI Business Leadership Team has proven that it can drive significant value creation for the membership,” according to Richard Kubin, Leader, Global Supply Chain Engineering, Nortel Networks, and a member of the NEMI Board of Directors. “I’m confident we can increase the effectiveness going forward by enhancing the mission and participation of this group and leveraging this pool of business expertise across more NEMI activities.”

In November, the Board of Directors sponsored a forum on Manufacturing in China. We were very fortunate to have a number of speakers who brought insightful and practical knowledge to the participants. Overviews were provided by the World Bank, Prismark Partners, and the Tianjin Economic Technological Development Area. NEMI member speakers gave a perspective across the supply chain (OEM, EMS, component, equipment and materials). Break-out discussion

groups focused on NEMI member needs, barriers to doing business in China, and mitigation of intellectual property issues. The next step planned is to have a session in China during the first half of next year.

“Clearly the opportunities in China are significant as NEMI member strategies reflect,” according to Dr. James Fahey, Director PWB Technology & Business Development, Shipley Company, and NEMI Board member. “NEMI’s ability to bring together supply chain partners for their combined benefit was once again demonstrated at this forum.”

“The NEMI Business Leadership Team has proven that it can drive significant value creation for the membership.”

*Richard Kubin,
Nortel Networks*

ROADMAP

Preparing the NEMI Roadmap is a complex undertaking. The latest “edition” includes 23 chapters covering a full range of technologies and business practices. There is a new Connectors chapter; and the Factory Information Systems, Enterprise Information Technology and Supply Chain Management chapters have been consolidated into a single chapter called Product Lifecycle Information Management (PLIM).

The accuracy and centrality of the Roadmap were ensured in a number of ways. This year, as in the last cycle, the March kick-off meeting was dedicated to inputs from the Product Sector Champions, who started work some three months prior to the meeting and were able to make a fairly complete set of product emulators available to the TWG chairs at the March meeting. The kick-off also focused on findings of the 2001 SIA Silicon Roadmap.

Again this year, we asked TWG chairs to put increased emphasis on business issues and gap analysis to guide us in project planning. As with previous Roadmaps, the 2002 Roadmap has maintained strong linkages with other organizations and other national roadmaps. A June workshop was held where chapters were presented to, and reviewed by, a broad industry audience. It is gratifying to see that, for the most part, the validation of the 2000 Roadmap showed predictions to be amazingly accurate from a technical sense. However, the drastic market downturn made our predictions of timing optimistic in several areas. Some of the key validation parameters that changed (other than market timing) are:



Dr. Arden L. Bement, Director of NIST, was the guest speaker for June Roadmap workshop and spoke about NIST's nanotechnology initiatives.

- PWB assemblers are now experiencing an accelerated shift in high volume assembly to the lowest cost areas of the globe – specifically, China.
- To continue along Moore's Law after 2005, silicon will require packaging improvements, via technologies such as silicon in package (SiP).

- The introduction of integral passives is being delayed by cost, testing capability and risk factors of implementation.
- A large increase in the use of 0201s was projected; however, they are not being used as broadly as predicted in 2000 because they cannot be resolved easily by AOI (automated optical inspection), and they tend to “tombstone.”

Paradigm shifts identified in the 2002 Roadmap are:

- High speed interconnect (based on organic substrates) is now a reality. Impedance control, signal integrity, and electro magnetic interference (EMI) are routinely considered in most designs of electronic assembly. Thus, the organic substrate contributes a circuit function for the electronics assembly beyond simple connectivity. In addition, PWB fabricators will increasingly become responsible for delivering boards with correct electrical performance.
- Complex integrated circuits are expected to have up to 15 metal layers within the next 10 years.
- Capital spending on IT-related capability has been drastically reduced. Solid returns must be justified with a solid business case for those efforts that are funded.
- EMS providers have expanded their capabilities in order to supply cradle-to-grave design, sourcing, manufacturing, fulfillment and repair services.

The overall picture that comes through is one of unprecedented business retrenchment in the industry. Through 2005, our Roadmap groups see spotty growth that will seem muted compared to the 2000 Roadmap predictions. Some of the business issues identified in the 2002 Roadmap that will affect the industry include:

- Continued commoditization of electronics.
- Continued globalization of outsourcing.
- Evolution of innovative business models.
- Broader emergence of original design manufacturers (ODM).

ROADMAP *continued*

- Rapid construction and decommissioning of plants.
- Distributed liability and postponement of ownership.
- Management of product end of life.
- Increased emphasis on standards-based solutions.
- Growing momentum of web-based services.

Future cost reductions will depend more on mastering the management of the supply chain, modeling to achieve faster design and time to market, and test and measurement tools and capabilities rather than manufacturing floor efficiencies.

MEMS, Bluetooth, WiFi (wireless fidelity), nanotechnology and optoelectronics can be considered “disruptive” technologies, in that they will have a major impact on the way we work as well as the way we live. The 2002 Roadmap is rich in data and has much more information than can be presented here. All members will receive two copies of the Roadmap on CD-ROM; additional copies can be ordered through the NEMI website (<http://www.nemi.org>).

DEPLOYMENT

NEMI’s five Technology Integration Groups (TIGs) saw activity in 16 projects this year.

Five projects were completed:

- Lead-Free Assembly
- Data Exchange Convergence
- Fiber Handling
- Bromine-Free Laminates
- Virtual Factory Information Interchange

... and we formally launched five new ones:

- Fiber Optic Splice Improvement
- DPMO (Defects per Million Opportunities)
- Lead-Free Hybrid Assembly and Rework
- Tin Whisker Modeling
- Fiber Optic Signal Performance

Optoelectronics TIG



Alan Rae, Cookson Electronics

The newest of the NEMI TIGs was one of the most active in 2002. Projects in the Optoelectronics TIG are focused on some of the assembly issues that must be resolved to make optoelectronic components cost-effective in volume production of electronic systems. Much of the work is aimed at development of standard manufacturing techniques, which are needed to help industry lower costs, and increase volumes and yields.

“NEMI is playing a critical role in developing standards-based solutions that will allow industry to move forward in implementing optoelectronic products.”

— Alan Rae, Cookson Electronics

“The standards that do exist are not harmonized, and they are only partly relevant. They don’t address the issues of producing the types of products being considered by electronics manufacturers,” said Alan Rae, Cookson Electronics and chair of the NEMI Optoelectronics TIG. “NEMI is playing a critical role in focusing industry attention on the key issues, pushing for consensus, and developing

standards-based solutions that will allow industry to move forward in implementing optoelectronic products.”



**Dave
Silmsner,
Alcatel**



**Tatiana
Berdinskikh,
Celestica**

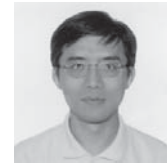
The Fiber Optic Signal Performance Project has already amassed significant data regarding the effects of various anomalies on the performance of fiber optic signals, including some of the most common hazards found in manufacturing processes. The project is working to define criteria and standard specifications for fiber connector end face inspection, and will also develop guidelines for cleaning procedures and contamination prevention.

The Optoelectronic Fiber Handling Project, a joint project between NEMI and IPC, completed development of a specification for an optical fiber carrier system that will facilitate handling and processing of optical fiber during fiber optic component manufacturing. The proposed standard (IPC-3841) is currently being reviewed by industry. This specification will allow, for the first time, automation of an optical component with an attached fiber (“pigtail”) during subsequent assembly, a significant cost advantage over hand assembly.

Board Assembly TIG



**Paul Williams,
Intel**



**Aichyun Shiah,
Solectron**

The Board Assembly TIG enjoyed continued momentum in 2002 with a high level of activity in projects formed last year and two additional projects launched this year — the DPMO Project and the Fiber Optic Splice Improvement Project.

The Test Strategy Project is nearing completion of its year-long effort to identify solutions for addressing the loss of physical access and fault coverage at in-circuit test (ICT). The group has characterized the capabilities of several automated inspection systems to detect board assembly structural defects, determining which approaches find which defects. They are also completing an inspection strategy cost-modeling tool that will estimate the costs of finding and repairing assembly defects using various test and inspection strategies. The project plans to present its findings at APEX 2003.



**Amit Verma,
Teradyne**



**David Mendez,
Solectron**



**Tim Kruse,
Plexus**

The newly formed DPMO (Defective Parts per Million Opportunity) Project is working to collect and publish DPMO data by package/technology type. This data will allow manufacturers to quickly and accurately estimate manufacturing costs and delivered quality in order to make strategic decisions on the investment of their resources. This project builds on the work of a previous NEMI project that developed a standard defining how DPMO rates should be calculated (IPC-9261).



Prashant Chouta, Cookson

Other areas of new activity in the Board Assembly TIG were the Fiber Optic Splice Improvement Project, which is developing industry-standard acceptance criteria for fiber splices, and optoelectronic soldering automation, where NEMI is working to organize a coordinated effort to address some of the key issues of assembly automation.



Richard Parker, Delphi Delco Electronics Systems



Edwin Bradley, Motorola



Richard Charbonneau, StorageTek®



Carol Handwerker, NIST



John Sohn, NEMI



Jasbir Bath, Solectron

Three follow-on projects are already under way to close the knowledge gaps related to the new lead-free solder.

Environmentally Sustainable Electronics (ESE) TIG

The Lead-Free Assembly Project is now complete and the final report in publication. This high-profile project can boast a number of significant accomplishments. Among them are:

- Recommended a specific lead-free alloy to industry (Sn3.9Ag0.6Cu).
- Demonstrated manufacturability of lead-free processes with the recommended alloy (it is do-able!). Motorola has a cell phone in production today that uses the NEMI alloy.
- Demonstrated reliability of lead-free interconnection process with both tin-lead and lead-free component lead coatings. The lead-free was found to be better than or equal to the tin-lead solder.
- Demonstrated that industry can produce PWBs for lead-free soldering.
- Recommended modifications to JSTD 020 for lead-free assemblies, which was released by IPC in 2002.
- Developed an extensive database to support conclusions.

In addition to the final project report, the Lead-Free Assembly team is completing a book for IEEE Press/John Wiley & Sons that is largely based on the project work.

The Lead-Free Hybrid Assembly and Rework Project was launched in 2002 to develop robust lead-free assembly and rework processes for PWB. Work is focusing on hybrid assemblies, representing high-end office computer products that utilize both surface mount technology (SMT) and pin-in-hole (PIH) components.



Jerry Gleason, HP



Charles Reynolds, IBM



Swaminath Prasad, ChipPAC, Inc.

Since tin-plated leads are the prime candidates for lead-free componentry, we are seeing a high level of interest in, and a great deal of activity related to, tin whiskers. NEMI's Tin Whisker Accelerated Test Project continues its efforts to identify a test method for predicting tin whiskers. There is currently no accelerated test that can evaluate the potential growth of tin whiskers, and industry needs this capability to reliably detect the inclination of a particular plating chemistry to grow whiskers. To date, the team has identified that temperature cycling seems to accelerate whisker growth, but the acceleration factor is still elusive.

A second project — the Tin Whisker Modeling Project — is attempting to model the base cause



George Gaylon,
IBM

of whisker formation. The team has completed a thorough literature search, and has brought together researchers from industry, national laboratories and academia to try to understand the mechanisms behind whisker growth. Although theories abound, no solution to the problem has been found to date. This effort is closing in on the one or two most likely hypotheses and is

developing plans to prove/disprove them. There are also plans to bring users and suppliers together to see if a mitigation strategy can be developed, while work continues to understand the base cause.

Irina Boguslavsky, Shipley Company, helped co-chair the Tin Whisker Modeling Project through October and made many significant contributions. However, due to job changes, Irina yielded her position to George Galyon, IBM.



Irina Boguslavsky,
Consultant

Factory Information Systems TIG

The Data Exchange Convergence Project presented its final recommendation at APEX in January. This year-long industry effort, coordinated by NEMI, was focused on developing a single standard to be used in the exchange of CAD/CAM data for printed circuit board fabrication and assembly.



Barbara Goldstein,
NIST



John Cartwright,
Intel

IPC created Standards Committee 2-17 to develop the project's

recommendation into an IPC standard. The IPC committee is chaired by Dana Korf (Sanmina-SCI) and Henry Jurgens (Celestica), both of whom were co-chairs of NEMI's Convergence Management Team. The group is targeting the second quarter of 2003 for the first release of the data exchange standard. This release will cover board fabrication and assembly, supporting data transfer among OEMs, fabricators and assemblers. Specifications will be developed so they are easily extensible, ensuring that additional features and capabilities can be easily added in future releases.



Hamid Azimi,
Intel

Substrates TIG

NEMI, the National Center for Manufacturing Sciences (NCMS), and IPC/ITRI joined with a number of industry partners to form the Advanced Embedded Passives Technology (AEPT) Consortium in 1998. This program, which received matching funds from NIST's Advanced Technology Program (ATP), will be completed in March 2003. The consortium has:

- Developed and demonstrated board fabrication processes to produce passive components from four new material systems.
- Using emulator designs, shown feasibility of embedding passive components in FR-4 boards.
- Developed design rules as well as cost models to assist designers in choosing between embedded and discrete passives.
- Completed reliability tests to demonstrate robustness of embedded passives.
- Developed equipment and techniques for trimming embedded resistors to +/-1% initial tolerance on large panel formats.
- Developed a neural network model for high frequency designs (>2GHz) and validated with empirical data.

R&D ADVOCACY

Through our roadmapping and gap analysis efforts, areas are identified that would benefit from research and development programs. While NEMI deployment activities focus on implementing existing technologies, we need to ensure that a steady stream of R&D results will fuel future technology deployment in order to provide long-term competitive advantage to member companies. To this end, NEMI works with government agencies, universities, and other consortia to focus R&D resources on the needs defined by industry.

NEMI member organizations as well as other institutions, such as the Centre for Microelectronics Assembly and Packaging (CMAP), Binghamton University's Integrated Electronic Engineering Center (IEEC), the Packaging Research Center (PRC) at Georgia Institute of Technology, and The National Center for Manufacturing Sciences (NCMS), continue to align their electronics R&D programs to the needs identified in the NEMI roadmaps.

Universities, along with other consortia and industry associations, are directly involved in NEMI's technology roadmapping and deployment projects. In fact, academic participation in the 2002 Roadmap has increased relative to previous cycles and now includes participants from Europe as well as North America. This participation helps to create strong relationships between industry and academia that are leveraged beyond our programs. An example of this leverage is the work of the Tin Whisker Modeling Project. The group is planning a workshop at the TMS annual conference next March to engage academia in developing a basic understanding of tin whisker growth mechanisms.

Nanotechnology is an area of growing interest as we begin to see the first glimmers of practical applications emerging. The Georgia Institute of Technology approached NEMI to provide industry guidance to a proposed new manufacturing center on nanotechnology. A committee, chaired by Dr. Srinivas Rao of Solectron, was formed in support of this effort. The committee will provide industry review and feedback to support and guide the final proposal. If the new center is funded, a long-term relationship with NEMI is part of the plan to ensure strong industry input and adoption of results.

We continue to cooperate with government R&D initiatives such as the NIST Advanced Technology Program (ATP), Virginia State's Center for Innovative Technology, and the Canada Foundation for Innovation (CFI). While we do not participate directly in government-funded R&D programs, we do collaborate with these agencies to support industry outreach programs, provide input regarding areas for investment (based on our gap analysis), and/or to participate in proposal evaluations.

SECRETARIAT

Personnel

Ron Gedney has decided to retire effective the end of this year. Ron has made significant contributions to the NEMI cause in his role as Vice President of Operations. We wish Ron well as he moves to Florida where the weather is more conducive to activities such as golf. We are pleased that Bob Pfahl, Motorola (retired), has agreed to step into the position vacated by Ron. Bob is a long-term participant of NEMI spanning the time from formation through the present.

Financial

The NEMI budget adopted by the Board of Directors for 2002 was essentially "break-even." Our year-end outlook shows that spending will be on target while revenue will be some 8% over plan, providing a small addition to our reserves.

Teleconferencing & Web Conferencing

NEMI has a contract with Raindance Communications for use by staff and project leaders. Mainly used for teleconferencing, we also can post material to the Raindance web site that can be used by teleconference participants during meetings. This program has been key to moving our projects forward. Most project teams teleconference weekly, and some meet three to four times a week. Although we have experimented with, and have available on demand, an interactive web/telecon service, it has not seen as much use due to interference with member company firewalls.

Web & FTP sites

We have completely re-designed and updated our public and members-only web sites. The FTP site is helping our project teams exchange large files. We also upgraded our servers and operating system during 2002.

Membership

The slump in the electronics industry has affected our members in two ways: (1) more attention to the member value equation – especially when paying dues; (2) an increase in membership as

companies look for ways to leverage their resources.

Our membership efforts have a dual thrust. First, we focus on increasing involvement of existing members as well as their return on NEMI participation. Each year, we do an analysis of member participation to identify companies with limited involvement. The Secretariat then works with those companies to diagnose the reasons for low activity and identify ways to change the situation. Utilizing this process, we have positively impacted the participation profile of several members during 2002.

Secondly, we strive to increase membership by adding companies that will be important to the success of our deployment programs. New members in 2002 are: 3SAE Technologies Inc., Aerotech World Trade Ltd., Aurora Instruments Inc., Centre for Microelectronics Assembly and Packaging (CMAP), E2open, FCI, Heraeus Inc., Jabil Circuit Inc., kSARIA Corp., LACE Technologies, Nextrom Photonics SA, Orbotech Ltd., Sumitomo Electric Lightwave Corporation, Sun Microsystems Inc., and Vytran Corporation.

NEMI Staff

Executive Director & CEO: **Jim McElroy**

Vice President of Operations & Treasurer:

Ron Gedney

(transitioning to Bob Pfahl)

Office Manager:

Linda Anderson-Jessup

Staff Manager of Planning:

Dave Godlewski

Counsel:

Chris Hanback

(Holland and Knight)

Consultants:

Jack Fisher, Substrates

Charles Richardson, Staff Manager of Roadmapping

John Sohn, Lead-Free Assembly Project

George Till, Roadmap Publication

Cynthia Williams, Director of Communications

Georg Anderson, Computer Support

NEMI LEADERSHIP

Board of Directors

Chairman: Nasser Grayeli, Intel Corporation
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Sundar Kamath, Sanmina-SCI
Robert Pfahl, Motorola, Inc. (retired)
Srinivas Rao, Solectron Corporation
Al Viehbeck, 3M
George White, Georgia Institute of Technology

Roadmap Leadership Team

Jim Arnold, Director of Roadmapping, Motorola, Inc.
Chuck Richardson, Staff Manager, Roadmapping, NEMI

Technology Working Groups (TWGs)

Board Assembly

Alex Chen, Celestica / Kirk Van Dreel, Plexus

Connectors

John MacWilliams, Consultant

Digital Silicon Technology

Paolo Gargini, Intel Corporation /
Alan Allan, Intel Corporation

Technology Working Groups (TWGs) (Continued)

Displays

Robert Pinnel, U.S. Display Consortium /
J. Norman Bardsley, U.S. Display Consortium

Energy Storage Systems

Dan Doughty, Sandia National Laboratories

Environmentally Conscious Electronics

Robert Pfahl, Motorola (retired) /
Mark Newton, Apple Computer

Final Assembly

Mike Reagin, Delphi Delco Electronic Systems /
Reijo Tuokko, Tampere University

Interconnect Substrates – Ceramic

Howard Imhoff, Midas Vision Systems /
R. Wayne Johnson, Auburn University

Interconnect Substrates - Organic

Jack Fisher, Consultant / Dieter Bergman, IPC

Mass Data Storage

Tom Coughlin, Coughlin Associates /
Roger F. Hoyt, IBM Corporation

Modeling, Simulation & Design Tools

Sanjeev Sathe, IBM Corporation /
Koneru Ramakrishna, Motorola

Optoelectronics

John Stafford, Consultant / Laura Turbini,
CMAP

Packaging

Joseph Adam, Skyworks Solutions /
Bill Bottoms, 3 MT Solutions

Passive Components

Larry Marcanti, Nortel Networks /
Joseph Dougherty, Penn State University

Product Lifecycle Information Management

Collaborative Design

John Cartwright, Intel Corporation

Manufacturing

Ben Poole, Sanmina-SCI

Supply Chain Management

Barbara Goldstein, NIST

RF Components

Vijay Nair, Motorola, Inc. / Steve Kenney,
Georgia Institute of Technology / Eric Strid,
Cascade Microtech

Test, Inspection & Measurement

Michael J. Smith, Teradyne / David Doyle,
Orbotech, Ltd.

Thermal Management

Richard Chu, IBM Corporation / Yogendra Joshi,
Georgia Institute of Technology

Product Sector Champions

Automotive and Defense / Aerospace

D.H.R. Sarma, Delphi Delco Electronics Systems /
William E. Murphy, Lockheed Martin

Consumer Products

John Thome, Consultant

Large Business Systems

Evan Davidson, IBM Corporation / Scott Mitchell,
Sun Microsystems

Office Systems

Terry Dishongh, Intel Corporation / Josh Moody,
Hewlett-Packard Company

Portable Products

John Thome, Consultant / Kingshuk Banerji,
Motorola

Supercomponent

George White, Georgia Institute of Technology

Business Leadership Team

Vinay Asgekar, AMR Research, Inc.

Blair Davies, Celestica, Inc.

Nancy Jaster, Lucent Technologies

Richard Kubin, Nortel Networks

Jim McElroy, NEMI Secretariat

Charles Miller, Solectron Corporation

Aziz Safa, Intel Corporation

Rod Walker, Altus Consulting

Project Leadership Team

Srinavas Rao, Co-Director of Planning, Solectron

Leslie Guth, Co-Director of Planning, Lucent
Technologies

David Godlewski, Staff Manager of Planning,
NEMI

Technology Integration Groups (TIGs) and Projects

Board Assembly TIG

Paul Williams, Intel Corporation /
Aichyun Shiah, Solectron

DPMO (Defective Parts Per Million Opportunities) Project

Tim Kruse, Plexus /

David Mendez, Solectron Corporation

Optoelectronic Soldering Automation Project

Prashant Chouta, Cookson Electronics

Fiber Optic Splice Improvement Project

Peter Arrowsmith, Celestica

Test Strategy Project

Amit Verma, Teradyne / David Mendez,
Solectron

Environmentally Sustainable Electronics TIG

Lead-Free Assembly Project

Edwin Bradley, Motorola / Richard Charbonneau,
StorageTek

Alloy Group

Carol Handwerker, NIST

Process Group

Jasbir Bath, Solectron

Component Group

Richard Parker, Delphi Delco

Reliability Group

John Sohn, Lucent, retired

Lead-Free Hybrid Assembly and Rework

Charles Reynolds, IBM Corporation /

Gerald Gleason, Hewlett-Packard Company

Tin Whisker Accelerated Test Project

Swaminath Prasad, ChipPAC / Mark Kwoka, Intersil
Corp. / Jack McCullen, Intel Corporation

Tin Whisker Modeling Project

George T. Galyon, IBM Corporation / Maureen
Williams, NIST

Factory Information Systems TIG

John Cartwright, Intel Corporation /

Barbara Goldstein, NIST

Data Exchange Convergence Project

Convergence Management Team: Henry Jurgens,
Celestica, Inc. / Dana Korf, Sanmina-SCI

Convergence Technical Team: Bill Honeycutt,
Motorola, Inc. / John Minchella, Celestica, Inc.

Virtual Factory Information Interchange Project

Barbara Goldstein, NIST / John Cartwright, Intel

Corporation / Joanne Friedman, META Group, Inc. /
John Minchella, Celestica, Inc.

Optoelectronics TIG

Alan Rae, Cookson Electronics

Fiber Optic Signal Performance Project

Dave Silmsner, Alcatel Canada /

Tatiana Berdinskikh, Celestica

Fiber Handling Project

Dan Nelson, IPC Consultant

Optoelectronics for Substrates Study

Jack Fisher, Consultant

Substrates TIG

Hamid R. Azimi, Intel

Advanced Embedded Passives

Technology Project (managed by NCMS)

Larry Marcanti, Nortel Networks

High Frequency Material Effects on HDI

Formation Project

Paul Brown, Alcatel Canada, Inc.

NEMI Publications & Forums

Contributed Articles

- "Where Optoelectronics and Business Cycles Intersect," Ron Gedney, *PC Fab*, January 2002.
- "Environmental Work Goes On," Edwin Bradley, *Electronic News*, January 21, 2001.
- "Plug and Play Standards Signal New Era in Electronics Manufacturing," Bob Neal, Agilent Technologies, *EP&P*, January 2002.
- "What I Learned About the Environment Last Year," Brenda Baney, Delphi Delco Electronics Systems, *PC Fab*, January 2002.
- "Optoelectronics Roadmap," David W. Bergman, IPC, and Andrew D. Dugenske, Georgia Institute of Technology, *EP&P*, February 2002.
- "Understanding Roadmaps," Jack Fisher, *PC Fab*, April 2002, p. 16.
- "NEMI: Convergence Project Focuses Industry Effort on Developing a Single Standard for CAD/CAM Data Exchange," Jim McElroy, *GOOD-DIE Newsletter*, April 2002.
- "The Quest for a Single CAD/CAM Data Exchange Standard," Henry Jurgens and Dana Korf, *Circuits Assembly Online Exclusive*, May 2002.
- "Are Lead-Free Solder Joints Reliable?" John Sohn, *Circuits Assembly*, June 2002, p. 32.
- "Pathways to Low-Cost Optoelectronics," Alan Rae, Cookson Electronics, *SMT*, July 2002, p. 42.
- "CAD/CAM Data Exchange – Cooperative Competition is Key!" Jim McElroy, *EP&P*, August 2002, p. 24.
- "NEMI Project Investigates Test Strategies," Amit Verma, Teradyne, *Circuits Assembly*, August 2002, p. 35. (This was a sidebar to the article "Blending Test Strategies for Limited-Access Boards," by Stig Oresjo, Agilent Technologies, p. 34)
- "Smart BoMs," Kenneth Chow, Celestica, and Steve Christensen, Nortel Networks, *Design Engineering*, September 2002, p. 12.
- "Searching for the Perfect BOM," Kenneth Chow and Jim McElroy, *Circuits Assembly* (cover story), October 2002, p. 26.

Conference Papers & Presentations

- Pb-Free Solder for Electronic, Optical and MEMS Packaging Manufacturing, Carol Handwerker, NIST, UCLA, September 5-6, 2002.
- Doing Business in China — "Electronics Manufacturing Migration," Jim McElroy, Semiconductor Assembly Council (SAC), September 13, 2002, Sunnyvale, CA.
- "Technology Roadmap Overview," Chuck Richardson, presented to the Atlanta chapter of SMTA, September 19, 2002, at Georgia Institute of Technology, and to SMTA International, September 25, 2002, at the Donald Stephens Convention Center, Rosemont, IL.

Conference Papers & Presentations (Continued)

Panel: Lead-Free Solder, Carol Handwerker, NIST, and Paul Vianco, Sandia National Laboratories (for Swaminath Prasad, ChipPAC), Lead-Free Soldering Technology Symposium, SMTA International, September 22-26, 2002, Donald Stephens Convention Center, Rosemont, IL.

CALCE Lead-Free Forum Workshop, Carol Handwerker, NIST, sponsored by the Computer Aided Life Cycle Engineering (CALCE) consortium, University of Maryland, October 10, 2002, College Park, MD.

"Improving Supply Chain Communications (Dismantling the Tower of Babel)," Jim McElroy, NEMI, and Barbara Goldstein, NIST, presented at the *Convergence 2002* Transportation Electronics Conference (October 21-23, Detroit), Society of Automotive Engineers.

"A Preview of the National Electronics Manufacturing Initiative's (NEMI's) Year 2002 Optoelectronics Roadmap," John W. Stafford, consultant, Electronics Packaging Symposium — Optoelectronics: Packaging and Manufacturing 2002, State University of New York Binghamton University, October 21-23, 2002, Binghamton, NY.

Panel: "North American Manufacturing: *What will the Future Bring?*" Jim McElroy, NEMI, IPC Annual meeting — SMEMA Council, November 4, 2002, New Orleans.

"Roadmap of Lead-Free Assembly in North America," Jim Arnold, Motorola, presented at JISSO / PROTEC Forum 2002 and Second Lead-Free World Summit, November 19-20, 2002, Tokyo.

"Environmental Programs and Strategies in the U.S. Electronics Sector," Robert C. Pfahl Jr, keynote presentation at the Going Green—CARE INNOVATION 2002 Conference, November 25, 2002, Vienna, Austria.

"Status of Pb-Free Activities in North America," Robert C. Pfahl Jr, Going Green—CARE INNOVATION 2002 Conference, November 26, 2002, Vienna, Austria.

Panel: "Optoelectronics — Mainstream or Tributary? (NEMI's Optoelectronics Initiatives)," Alan Rae, Cookson Electronics, Fiberoptic Automation Conference (co-located with NEPCON West and Assembly West), December 4-6, 2002, San Jose, CA.

NEMI Forums

APEX 2002 forums:

- Spanning the Virtual Factory - Managing Supply Chain Communications (January 21, 2002)
- NEMI Lead-Free Project Report (January 23, 2002)
- CAD/CAM Data Convergence (January 24, 2002)
- Tin Whiskers Forum (January 24, 2002)

Engineering Collaboration Forum (May 23, 2002)

Perfect BoM Web Forum (July 17, 2002)

IPC/NEMI Symposium on Lead-Free Electronics (September 18-19, 2002)

Product Take-Back and Recycling Workshop (October 10-11, 2002)

Executive Forum: Manufacturing in China (November 12, 2002)

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