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International Electronics Manufacturing Initiative

Environmentally Friendly Electronics for the High Reliability Community

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Topics

- Background
- High Reliability Electronics
- iNEMI High Reliability Task Force
- Pb-Free BGAs in a SnPb Assembly Process
- Remaining Pb-Free Knowledge Gaps
  - Pb-Free Early Failure Project
  - Pb-Free Alloy Alternatives Project
  - BFR-Free High Reliability PCB Project
- Future Efforts
- Summary

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Background: The RoHS Transition

Significant Industry Efforts To Accomplish

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iNEMI and the Environment: 1998-2008
Pb-Free Projects

- **Since 1996 iNEMI has proactively roadmapped the technology needs to produce Environmentally Conscious Electronics (ECE)**
- **iNEMI members provided the technical and supply chain leadership to meet the two new EU directives on Electronic Products.**
  - **iNEMI performed the research to identify the preferred solder to replace Sn-Pb**
  - **iNEMI developed the processes and standards for the conversion**
  - **iNEMI developed the standards for environmental data transfer**
  - **iNEMI is currently addressing remaining knowledge gaps for high reliability applications.**

Transition to Pb-free Assembly

- 1998 Roadmap Identified the Gap
- Phase I Project developed the alloy, process, components and reliability from 1999-2002
- Phase II Project expanded the technology base to include rework, wave-soldering, and reliability of lead finishes
- Phase III Project teams addressed these supply chain transition issues identified in the 2002 Roadmap
- Phase IV Projects worked to optimize and standardize manufacturing processes
- Phase V Projects are currently addressing the needs for High Reliability Products

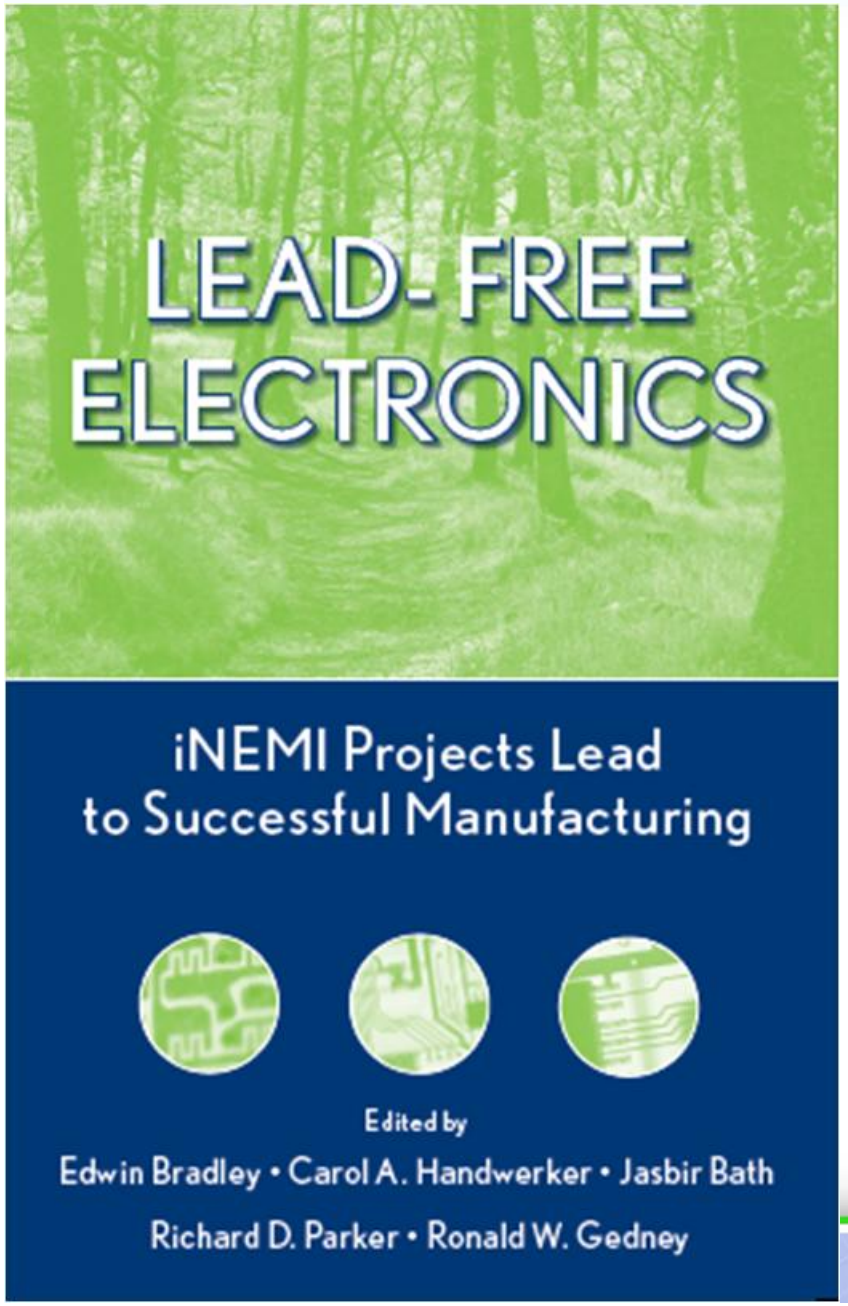
Results:

- The iNEMI efforts accelerated the establishment of SAC alloys as the standard and reduced the effort in each member company.

Available iNEMI Resources: Pb-Free Technology

- **Lead-free Watch Series**
  - **Co-sponsored by iNEMI and UP Media Group**
  - **18 Monthly Articles**
  - **Technology as well as management/business topics**
- **Project Reports (for members)**
  - **Lead-free Assembly (focus: portable electronics)**
  - **Lead-free Assembly & Rework (focus: high reliability electronics)**
  - **Pb-Free BGAs in SnPb Assembly (final report being prepared)**
- **Lead Free Electronics Book (based on iNEMI Projects)**

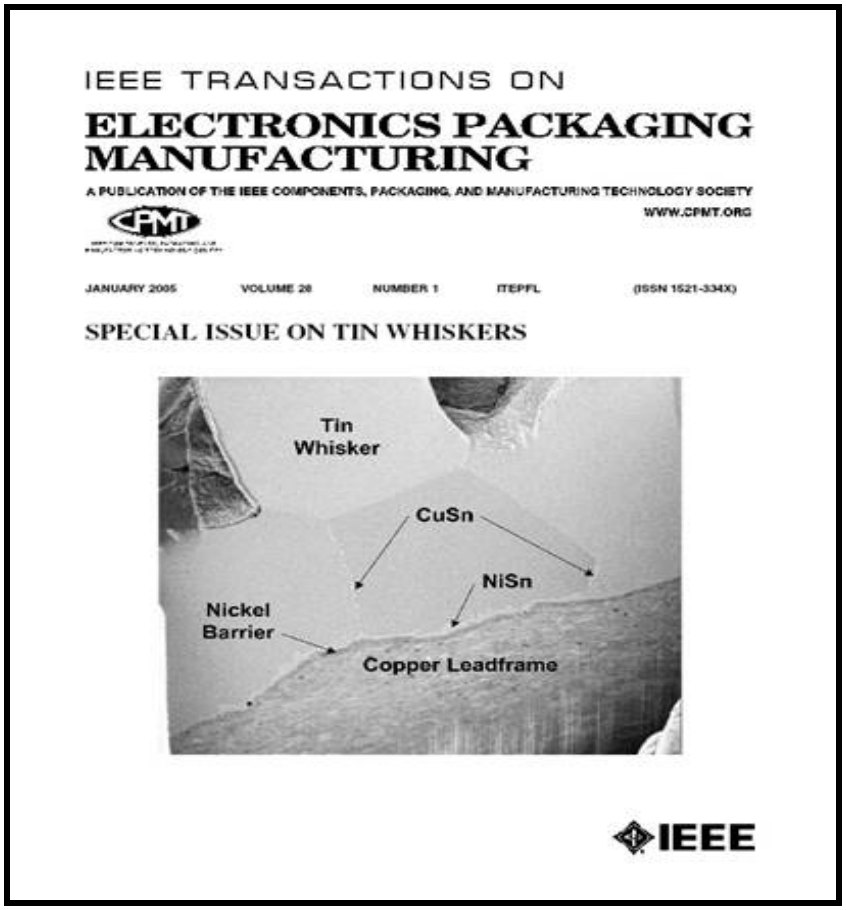
Published Results from first Phases



- **Published by IEEE**
- **Edited by Edwin Bradley (Motorola), Carol Handwerker (NIST/Purdue University), Jasbir Bath (Solectron), Richard Parker (Delphi Electronics & Safety) and Ron Gedney (iNEMI, retired).**
- **Available for purchase**

Available Resources: Tin Whisker R&D

- **Over 7 years of effort with key researchers from:**
  - **Academia**
  - **Industry**
  - **Government Labs (e.g. NIST)**
- **Documented results and recommendations available:**
  - **Standards & Specifications**
  - **Five IEEE/CPMT Workshops**
  - **Position Papers**



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High Reliability Electronics

Address RoHS Challenges for High Reliability Applications

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Pb-Free Conversion by Segment

Industry Segment	Status
Portable / Consumer	Full global conversion to Pb-free. Working improvements to mechanical shock.
Office Systems / Large Business / Communication Systems	Most have taken Pb exemption for mission critical electronics. Working to close Pb-free knowledge gaps.
Medical Products	Either out of scope or have taken Pb exemption.
Automotive	Mission critical electronics still using SnPb. Entertainment/communication systems moving to Pb-free.
Defense and Aerospace	Either out of scope or have taken Pb exemption. Working to ensure ongoing availability of SnPb components.

High Reliability Perspective

- **Sn-Pb assembly is well understood and reliable - primary reason for taking the Pb exemption.**
- **The components supply chain is rapidly converting to RoHS compliant offerings (Pb-free) with little motivation to continue to produce SnPb product.**
- **Taking the Pb exemption has changed the risk profile for High Reliability producers:**
  - **Avoiding risk of Pb-free reliability issues (shrinking over time as knowledge gaps are closed)**
  - **Taking on the supply risk of SnPb compatible parts (growing over time as more of supply base converts to Pb-free)**
- **Work is underway to provide the industry with better understanding of Pb-free alternatives.**

High Rel. OEM/EMS Participants

High Reliability Business Challenge

- Consumer electronics are Driving Component supply base.
- Total Available Market (TAM) for all High Reliability categories (Servers, Telecom, Military, etc.) is on the order of <10% of Revenue for component Supply Base.
- Most suppliers prefer to have their entire product line converted to Pb-free.
- Maintaining a dual supply chain to satisfy the High Rel segments is costly and adds complexity.
- There is uncertainty on how long the Pb-free exemptions will last or when High Rel. segment will convert.
- Today's alternatives are not very attractive:
  - Supply risk of not being able to secure SnPb compatible BGAs and other critical component and sub-assemblies.
  - Risk of rapid conversion of products prior to full understanding of long term reliability test results.

Scenarios

- **Long term solution is to reduce reliability risk of Pb-free components and assembly.**
  - **The economic incentive is compelling**
  - **Well worth technology investment**
  - **Could take several years to complete but this is cumulative, so strides made today are useable.**
- **What can we do in the short term to help encourage the availability of SnPb compatible BGAs?**
- **What can we do in the mid term to close remaining knowledge gaps that the High Rel. segments face?**
- **What can be done longer term to better understand and predict reliability of electronics hardware using Pb-free components and assembly?**

BGA Supply

- Formed iNEMI BGA Supply Group made up of High Reliability OEMs and EMS providers.
- Current High Rel Task Group represents Telecom, High End Computers, & Instrumentation. Expanded this effort to include other High Rel sectors such as:
  - Medical Electronics
  - Military/Aerospace
- Focus on ways to encourage Suppliers to support SnPb compatible BGAs.
- Results:
  - Estimated TAM for these High Rel components
  - Developed general business case for meeting needs
  - Organized workshop for BGA suppliers.

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Pb-Free BGAs in SnPb Assembly Process

Project now complete.

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Thrust Area: Energy & Environment

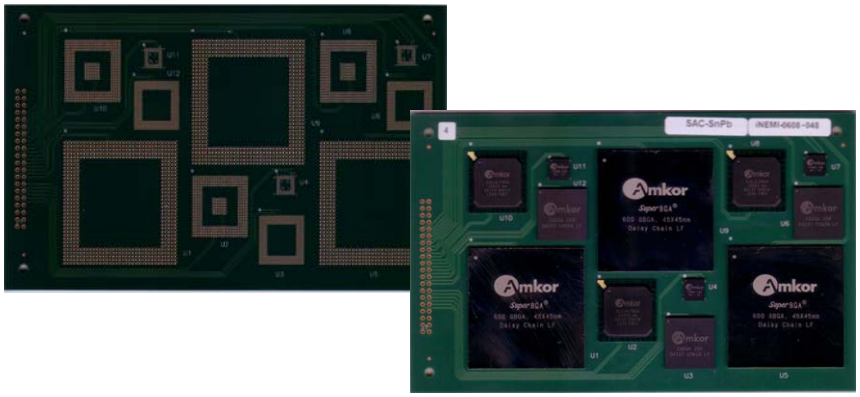
TIG: Board Assembly

Pb-Free BGAs in SnPb Assemblies Project

Goal: Identify the process parameters for assembling Pb-free SnAgCu BGAs under the temperature constraints of a conventional tin-lead (SnPb) assembly process.

Strategy:

- Conduct experiments to understand the reliability of Pb-free BGAs in a SnPb assembly process.
- Project Leads: Robert Kinyanjui (Sanmina-SCI), Quyen Chu (Jabil Circuit)



Tactics

- Phase 1: Characterize the peak temperature effects on the Pb-free BGAs in SnPb paste
- Phase 2: Study the reliability of the Pb-free BGAs processed within the temperature constraints of SnPb assembly conditions
- Phase 3: Develop a "generic" process guideline and risk assessment for assembling mixed –alloy solder joints

Milestones & Issues

- Phase 1……..COMPLETED
- Phase 2 ……..……COMPLETED
- Phase 3: ……..FINAL REPORT BEING WRITTEN

SUMMARY OF RESULTS

- For the two largest packages, PBGA324 and SBGA600, despite lack of complete solder alloy mixing, the solder joint reliability was better than that of either “pure” Sn-Pb or “pure” SAC solder joints

- Full Sn-Pb and SAC solder alloys mixing is not a sufficient condition to guarantee good reliability
  - For *small packages* with *low fatigue life requirements*, *full solder alloys mixing* and *homogeneous microstructure* is required
    - while for large packages with long fatigue/extended life requirement, full solder alloy mixing is not necessary for acceptable solder joint reliability

- In general, the OSP-copper had better performance than the ENIG surface finish. However, the failure locations were almost exclusively at the package side of the solder joint and within the bulk solder
  - At this time no microstructural correlation has been identified linking surface finish and improved or reduced reliability

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Remaining Pb-Free Knowledge Gaps

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Closing Remaining Knowledge Gaps

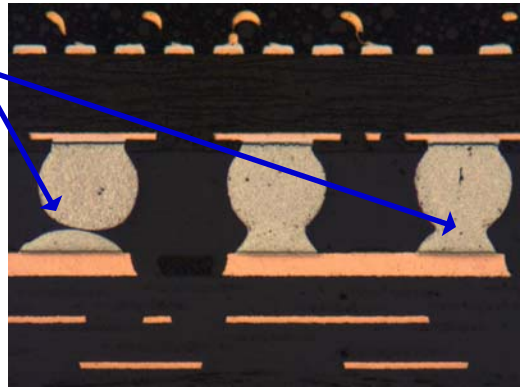
- **High Rel. Task Group undertook an effort to develop an industry view and communicate results to supply base.**
- **Tasks included:**

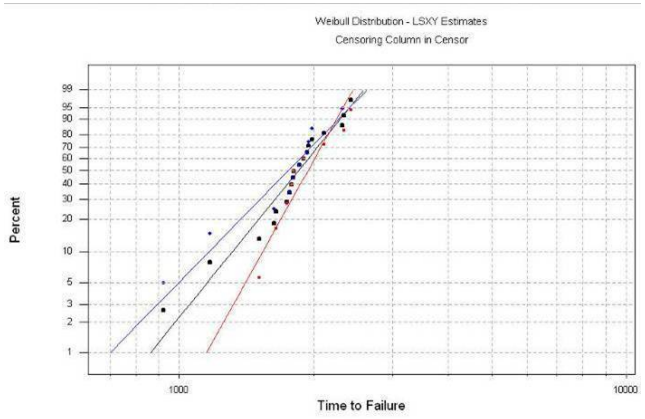
– Define list of key knowledge gaps for High Rel. Pb-free • Reliability • Manufacturing
– Prioritize gaps
– Create matrix of work underway to close gaps • Consider existing sources of data • Consider all industry/university cooperative efforts
– Create timeline for completion
– Establish projects for gaps not being addressed.

New Projects to Close Remaining Gaps

- **Pb-free Alloy Alternatives**
  - **Goal: Provide guidance on management of Pb-free alloy proliferation.**
  - **Strategy: Develop techniques for dealing with complexity.**
- **Pb-free Early Failure**
  - **Goal: Determine if we can detect and explain early solder failures in Pb free solder joints.**
  - **Strategy:**
    - **Use large sample size for greater statistical significance.**
    - **Test design to encourage Early Failures & Late Failures.**
- **BFR-Free High Reliability PCB**
  - **Goal: evaluate key electrical and mechanical properties of PCB materials.**
  - **Strategy:**
    - **Design: Review prior work & make recommendations for testing**
    - **Test: Develop, manage, and execute performance testing**

Unacceptable low Ag SAC solder joints reflowed at 230°C.





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Future Efforts

Becoming more proactive in our environmental collaborations

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Sustainability Summit

"The electronics industry must develop a strategic vision of sustainable electronics" iNEMI BoD

- **iNEMI will hold a Sustainability Summit, September 22-23, 2008 at Motorola, Schaumburg, Illinois, USA**
- **Motivation for the workshop is a recognition that the electronics industry should act strategically on environmental issues. The workshop will:**
  - **Invite Industry and Academic Speakers to speak.**
  - **Establish Breakout Groups to brainstorm options and priorities.**
  - **Establish Action Groups on selected topics based on outcomes.**
- **The goals of the workshop are to:**
  - **Evaluate opportunities for industry collaboration on proactive environmental programs.**
  - **Form and execute the required industrial collaborative programs.**
  - **Define academic research needs to support these programs.**
  - **Stimulate funding for the necessary research.**

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Summary

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Summary

- **Significant progress has been made by industry on environmental topics.**
- **Technology solutions are still relatively new:**
  - **Innovation occurring to address Pb-free performance issues (e.g. mechanical shock)**
  - **High reliability community still sees high risk.**
- **Focus of iNEMI efforts is now on closing knowledge gaps for mission critical applications.**
- **Industry sees benefits of becoming more proactive on environmental topics.**
- **iNEMI provides an efficient mechanism to develop and deploy technology across the global supply chain.**

www.inemi.org

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