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iNEMI Statement of Work (SOW)
iNEMI Environmentally Conscious Electronics TIG
iNEMI BFR-Free High-Reliability PCB Project

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Co-Project Leader: TBD
iNEMI Coach: TBD

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Purpose:

Identify technology readiness, supply capability and reliability characteristics for “BFR-free” alternatives to conventional printed wiring board materials and printed wiring board assemblies, based on the high-reliability market segment requirements.

Background and Motivation:

The European Union’s Restriction on the use of certain Hazardous Substances (RoHS) Directive prohibits the use of polybrominated biphenyls (PBBs) and polybrominated diphenyl ethers (PBDEs) in nonexempt electronic equipment. These compounds can be used as flame-retardants, and some of these substances have been shown to present unacceptable risks to human health and the environment.

Although PBBs and PBDEs are typically not used in circuit board materials, stakeholders are beginning to urge the electronics industry to take a precautionary stance on the use of other non-regulated halogenated organic substances, such as the use of brominated epoxies for circuit board applications.

Goals of the Project:

1. Identify commercially viable materials
2. Benchmark past work and key in on critical knowledge gaps and technical issues
3. Build on industry knowledge and capability, including the iNEMI BFR-Free PCB Material Evaluation Project (*formerly Halogen-Free PCB Project*)
4. Design test vehicles and test methodologies
5. Leveraging prior investigations, carry out the necessary testing to characterize viable materials
6. Analyze results
7. Publish recommendations

Is / Is Not:

This Project IS:	**This Project IS NOT:**
Technical evaluation of key electrical and mechanical properties	An EHS assessment
Focused on those attributes which are of most value to supply chain	Biased towards specific laminate suppliers, geographies, or market segments
Built on learning from prior investigations	Repeat of prior work
Focused on completely Br / Cl free SMT and Wave Solder Assembly & Rework Capability*	Focused on standard processing
Focused on circuit board materials and solder joint reliability – Board / Component Interaction	Focused only on materials characterization
	Open to non iNEMI members

* Surface Mount Flux / Paste and Wave Solder must be free of elemental Br / Cl

Scope of Work:

Phase I: Design

Review prior work and make recommendations for testing needed. Investigation should take into account needs of electronic product sectors represented by iNEMI membership.

1. **Identify candidate materials**

   Poll the supplier base, keying in on candidate materials that are commercially viable with consideration for market segment applications.

2. **Identify key performance characteristics and test criteria**
   Assess prior studies and identify critical knowledge gaps or technical issues. Make recommendations for performance tests needed. Review results of prior industry and member company investigations.

3. **Design test vehicle(s) and test methodologies, leverage standards where possible:**
   Specify test vehicle criteria required for performance testing. Agree on a minimal number of test vehicle designs and test requirements.

Phase II: Test

Develop, manage, and execute performance testing.

1. **Develop evaluation plan and schedule**
   Outline key mechanical and electrical performance characteristics, and resource and time constraints. Focus on: Electrical Characteristics, Delamination and Via & PTH reliability; Pad Cratering and Solder Joint Reliability. Output broadband frequency dependent dielectric constant and loss tangent of candidate halogen-free laminate materials (10KHz - 20GHz). Determine compatibility of candidate laminate materials with higher temperature assembly process reflow environments (mixed solder: 245C / Pb-free, 260C).
2. **Procure parts and test vehicles**

   Obtain needed evaluation materials. Consider lead times needed to synch with evaluation schedule. Solicit participation from supply partners.
3. **Assign teams to carry out completion of the testing in a standardized fashion**

   Each test should be carried out in a manner that produces meaningful results. Industry standards should be followed where applicable. Testing should be coordinated to allow correlation of results and sharing of test materials.
4. **Perform mechanical and reliability testing on test vehicles**

   Leverage capabilities and expertise of participating members and supply partners. Follow test procedures carefully and record positive and negative results.

Phase III: Results

Compile results, assess significance, make recommendations, and publish report.

1. **Assess technology readiness / identify gaps**

   Flag unexplored issues and identify technical risks that need to be resolved before materials can be widely adopted. Make recommendations for future work.
2. **Assess manufacturing capability and supply capacity**

   Work with suppliers and EMS's to identify barriers to supply chain viability. Interpret implications of performance testing in terms of manufacturing capability.
3. **Publish results**

   Compile and edit concise summary of methods, meaningful results, and recommendations. Goal is to release the final report to members by early 2010 with a public release at APEX 2010.

Anticipated Outcome

- **Validate electrical and mechanical properties**
    - Loss tangent and Dk modeling over required range of signal speed
    - Mechanical performance validation for lead free assembly and rework (delamination)
    - Critical Test Parameter Evaluation (CAF, IST, flex, etc.)

- **Validate Board Level Reliability Capability**
  - PCB Modulus / Thickness Impact on Mechanical Capability
  - HF Board Level Assy / Rework Process Characterization
  - Mechanical Characteristics (Pad Crater / Ball Pull, etc.)
  - CTE Characteristics
  - SJR (Shock / TC, etc.)
  - HF Component / HF PCB

Participant Profile:

iNEMI's member companies will encourage the participation of individuals from different disciplines and divisions within their organizations to contribute on the range of tasks outlined in the project plan. The group should contain members from or work closely with representatives of:

- OEMs
- Component and board manufacturers
- Assembly EMS providers
- Rework equipment providers
- Dielectric material suppliers

Resources Required from Participants:

The BFR-Free High-Reliability PCB Project asks each participating company to commit to the following:

1) Provide at least one man-month or equivalent in-kind support (e.g. materials, test samples, equipment, etc.) annually.

2) In the event project expenses are incurred, the costs will be shared evenly among participants.

3) Design and/or assemble test samples for evaluation, and/or carry out tests and evaluations as negotiated and agreed to, with other members of the project, to fulfill the Statement of Work.

4) Document results and publish findings to iNEMI members.

5) Commit to internally promote the adoption within the participating company and its supply chain partners of any recommended standards, tools, or processes that are developed.

Project Formation Participants:

Agilent	Mike	Davisson	mike_davisson@agilent.com
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Project Participant Commitment Matrix:

Phase I Tasks	Team Leader	Company Support	Key Contact
Identify Candidate Materials		Clariant Intel	Adrian Beard Gary Long / Lori Avishan
• Material Supplier		Doosan Nan Ya Hitachi ITEQ	Minsu (Tim) Lee Louis Lin Terry Fischer Quang Uong
Identify Key Performance Characteristics		Intel	Gary Long / Lori Avishan
Test Vehicle Identification		Intel	Gary Long / Lori Avishon
• Provide Component Test Vehicle			
• Provide PCB Test Vehicle		Intel – MEB II	Gary Long / Lori Avishan
• Provide TV / PCB Design Service			
• Provide PCB Assembly Capability			

Phase II Tasks	Team Leader	Company Support	Key Contact
Develop Test Plan / Schedule		Intel	Gary Long / Lori Avishon
Procure Components & PCBs			
TEST Plan / Schedule			
• IST		Doosan	Minsu (Tim) / Kwangho Doo
• CAF		Doosan (Partial)	Minsu (Tim) / Kwangho Doo
• Flexural Modulus		Doosan	Minsu (Tim) / Kwangho Doo
• Cu Peel Strength		Doosan ITEQ	Minsu (Tim) / Kwangho Doo Quang Uong
• Tg / z-Axis CTE		Doosan ITEQ	Minsu (Tim) / Kwangho Doo Quang Uong
• Solder Mask Adhesion		ITEQ (Tentative)	Quang Uong
• Insulation resistance			
• Solder Float / Cross Section		Doosan ITEQ	Minsu (Tim) / Kwangho Doo Quang Uong
• Microhardness			
• Permittivity (Dk) and Loss Tangent (Df) up to 30GHz		Intel	Gary Long / Lori Avishan
• Moisture Diffusivity Impacts on Insertion Loss		Intel	Gary Long / Lori Avishan
• Capacitance			
• CAT Trace and Space			
• Drill Registration		Intel	Gary Long / Lori Avishan
• Temp Cycle (HATS)		Nan Ya Plastic Corporation (Test Only – No FA Capability)	Peter Liang / Louis Lin
• Transient Bend			

• Rework		ITEQ (Tentative)	Quang Uong
• Board Side Ball Pull			
• TCT		IST – Integrated Service Tech	Jeffrey Lee
• Mechanical Shock		IST – Integrated Service Tech	Jeffrey Lee
• Monotonic Bending		IST – Integrated Service Tech	Jeffrey Lee
• FA		IST – Integrated Service Tech	Jeffrey Lee

Phase III Tasks	Team Leader	Company Support	Key Contact
Write Project Team Report			
• Executive Summary		Clariant Albemarle	Adrian Beard Susan Landry
• Introduction		Clariant Albemarle	Adrian Beard Susan Landry
• Purpose of the Project		Clariant Albemarle	Adrian Beard Susan Landry
• Materials & Methods		For Doosan's Test Intel	Minsu(Tim) /Kwangho Doo Gary Long / Lori Avishan
• Results		For Doosan's Test Intel	Minsu(Tim) /Kwangho Doo Gary Long / Lori Avishan
• Conclusions		Intel	Gary Long / Lori Avishan
• Analysis of Success		All Project Team Members	Project Team
• Write Generic iNEMI Report		Intel	Stephen Tisdale
• Write External Paper			

Task Schedule:

- Phase I (Design) — Sept'08 – Dec'08
- Phase II (Test) — Jan'09 – Oct'09
- Phase III (Results) — Nov'09 – Feb'10
- Release Results — Feb'10 – Project Participants
  - Mar'10 – iNEMI Membership
  - Apr'10 – Public Presentation (IPC/APEX)

Phase I	Sep-08	Oct-08	Nov-08	Dec-08	Jan-09	Feb-09	Mar-09	Apr-09
Review prior work and make recommendations for testing needed	X	X	X	X				

Phase II	Jan-09	Feb-09	Mar-09	Apr-09	May-09	June-09	July-09	Aug-09	Sept-09	Oct-09
Develop, manage, and execute performance testing	X	X	X	X	X	X	X	X	X	X
Procure Components & PCBs										
Test Plan / Schedule										
• IST										
• CAF										
• Flexural Modulus										
• Cu Peel Strength										
• Tg / z-Axis CTE										
• Solder Mask Adhesion										
• Insulation resistance										
• Solder Float / Cross Section										
• Microhardness										
• Permittivity (Dk) and Loss Tangent (Df) up to 30GHz										
• Moisture Diffusivity Impacts on Insertion Loss										
• Capacitance										
• CAT Trace and Space										
• Drill Registration										
• Temp Cycle (HATS)										
• Transient Bend										
• Rework										
• Board Side Ball Pull										
• Other Testing										
• Other Testing										
• Other Testing										
• Other Testing										

Phase III		Nov-09	Dec-09	Jan-10	Feb-10	Mar-10	April 10				
Compile results, assess significance, make recommendations, and publish report		X	X	X	X						
• Assess performance relative to market segment requirements											
• Assess technology readiness / identify gaps											
• Assess manufacturing capability and supply capacity											
• Report results in white paper											
• Present Results to iNEMI Membership – Webinar						X					
• Present Results to industry (Example APEX) – Paper – Presentation							X				

Project monitoring plans

- How will you ensure open lines of communication among participants?
  - Bi-weekly conference calls.
  - Meeting minutes provided through email.
  - Follow-up with individuals on an as-needed basis.
  - Workshops and face-to-face meetings as appropriate.
- Planned teleconference schedule.
  - Bi-weekly conference calls.
- Request progress reports as tasks are completed.
- Dates of technical reviews (2 per year) and progress reports and what they will contain.
- Practice risk analysis by anticipating problems and having alternate solutions ready.
  - What happens if??

- Use opportunity analysis to identify new areas or topics that might be addressed in additional projects. This will prevent the scope of the current project from expanding and keep the project focused on original goals.

- Review project requirements with suppliers before the project begins.

Outcome of the project

- Successful completion of this project will include the publication and presentation of the knowledge gap analysis in the public domain.

- Deliverables of this project include the following:

  - Workshop and associated slides for project members summarizing preliminary assessment of the state of knowledge.
  - Final slides and publication of our knowledge assessment.
  - Project results will be shared with the industry in order to drive alignment throughout the supply chain.
  - Knowledge assessment results will be shared through presentations and industry meetings and publication in an archival journal subject to group participant approval process.
  - Updated standards will be shared through publication of the new standards.

NOTE: All changes to SOW must be approved by the TC (version control)