



**PCB Material WG Strategy
Halogen-free Consortia
PCB Materials Breakout session**

Feb 18, 2009

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Baseline Assumption

Problem Statement:

- The majority of HF PCB Laminate Materials have Electrical and Thermo-Mechanical properties that make a smooth transition difficult.

Materials WG Goals

1. Define a Cost Effective/Reliable BFR Laminate for DT/NB/Server Markets
2. Develop a Laminate Technology Envelope and/or Test Methodology to define the required laminate properties or performance response
3. Propose a Timeline for BFR Laminate Suppliers to manufacture laminates in volume with these properties/performance criteria

Material WG Strategy Options

Material Property Path

Vs.

Test Suite Development Path

The consortia needs to decide on one strategy based on timelines and resources available.

Matr'l Property Strategy (Laminate based)

1. Correlate known defects/performance degradation to Laminate Material Properties
2. Define Metrologies & Methods to assess these Material Properties at Laminate Supplier Level
3. Consortia test and review Laminate Material properties and performance values
4. OEM/ODM Build TV and Products to verify PCB Reliability, SJR and Assembly Yields of these Laminates within Tech Envelope
5. Set Technology Envelope values for Laminates with corresponding Metrologies
6. Work with Supply Chain to verify Capacity of Laminate within Tech Envelope
7. Incorporate new Tech Envelope criteria into laminate data sheet

Test Suite Strategy (System based)

- Define all known defects/performance degradation
- Define System Based Test Suite
 - Define test methods to assess defect levels
 - Develop Common Test Vehicles for assessment
- Set up third party test house
- Consortia builds, test and review Material performance
- OEM/ODM builds Products to verify PCB Reliability, SJR and Assembly Yields of Laminates in Test suite
- Set Technology Envelope values for Laminates
- Work with Supply Chain to verify Capacity of Laminate within Tech Envelope
- Incorporate new Tech Envelope criteria into laminate data sheet

Tradeoffs

1. There will be tradeoffs, we need to define them
2. Can we do it with only 1 Tech Envelop? (Tg, mkts, FR-4 baseline?)
3. What material properties/performance characteristic are “Need to have” Vs. “Nice to have”
4. Cost Vs. Performance (designed for high end)
5. What performance properties are we willing to sacrifice/tradeoff?
6. What are the consequences if we do not succeed?
7. What is the ROI?
8. What other properties will be effected by changes? We can not lose other acceptable properties.

Actions Required/Commitments

- All Team Member need to commit to;
 - Defect to Material Properties Correlation
 - Metrology definition and development if needed
 - Analysis of Verification Boards and Laminate materials
 - Modify laminates & Test vehicles when needed

Actions Required/Commitments

- OEM/ODM's need to commit to;
 - Define requirements/goals/targets for laminate
 - Define defects or loss of performance margin
 - Correlate defects to material properties
 - Define Impact of not making this transition or not having the improved laminates (ROI)
 - Define what resources will be committed
 - Define timeline for Tech Envelope verification builds
 - Define what parts of Laminate Data sheet are useful
 - Build & Test Verification boards with Tech Envelop material

Actions Required/Commitments

- Laminate Suppliers need to commit to;
 - Define hierarchy of potential Material Changes & Effects of these Changes on other properties
 - Define what you need to make above happen
 - Define what you need from others to be successful
 - Define what metrologies are in place to measure the material properties
 - Estimate resources needed to develop the laminate data sheet data
 - Build the laminate with the Tech Envelope criteria

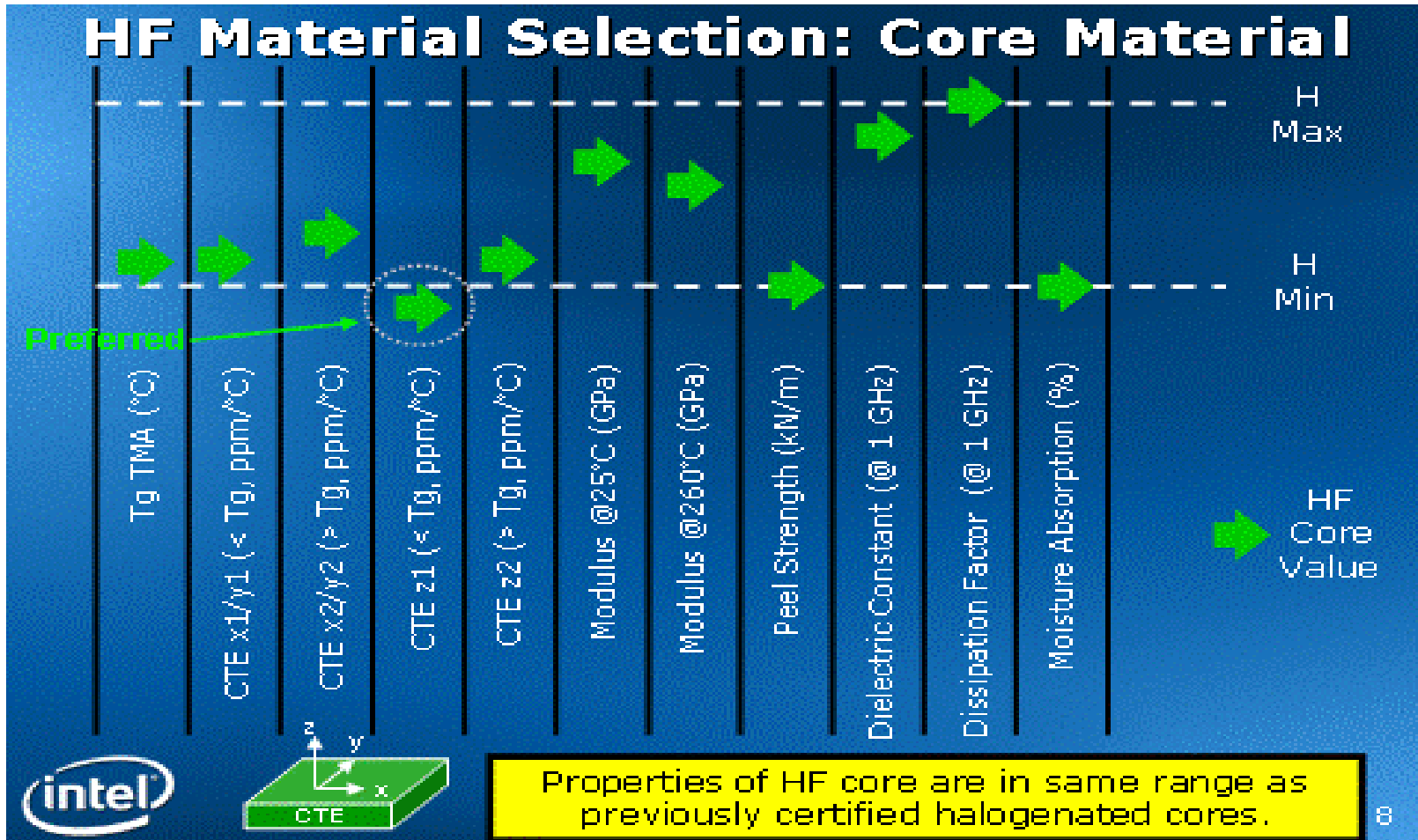
Deliverables

- Following deliverables need to be completed by WG
 - Deliver the first version of the Technology Envelope
 - Deliver the Defect or Performance degradation list
 - Deliver the Defects to Material Properties correlation
 - Deliver the second version of the Technology Envelope
 - Deliver Laminate Test Methodology & who test matrix
 - Deliver list of possible Laminate material changes
 - Deliver new laminates with Tech Envelop criteria
 - Build product test boards with new laminate material
 - Test and verify performance of new laminate materials
 - Deliver Final Technology Envelope

Technology Envelope

- Make up slide with ppt. version
- Add the original list of tech envelope for discussion
- What baseline to use
- Improve Vs. Do not worsen existing properties
- Material properties or performance characteristics

Graphical Tech Envelop



PCB Materials Development Input

Proposed Technology Envelope Properties

Material Property or Performance Metric	Impact of Property	Value/Range
Permittivity (Dk or Er)	Impacts impedance modeling and cross talk. Variation impacts electrical performance. Nominal property affects design rules and material selection.	Targeting a tighter range within the present FR-4 Spec (3.6-4.0)
Moisture Absorption	Impacts Dk and Df stability, delamination, isolation resistance. Diffusivity rate impacts moisture test results and final value recorded.	Lower is better
Flexural Strength	Modify test method for applicable data. Used for mechanical modeling simulation.	Higher flex Modulus/Stiffer laminates have shown less warpage and better assembly capabilities, but are more brittle and prone to Thermo Mechanical failures
Flammability	UL certification testing. Need to evaluate UL rating requirements.	Lower rating could allow more flexibility in formulations and other material properties
Young's Modulus	Determine temperature dependent flexibility of the material modeling input	No spec, some laminators are giving this data but not all. Need to determine if Flex Modulus or Stiffness would be better or sufficient.
Thermal Resistance (T260, T288)	Impacts laminate integrity, especially delamination	No spec or target value Higher is better
Fracture Toughness	Understand material property for pad crater mechanical modeling	No spec, not recorded on most laminator data sheets. No correlation to defects at this time. Should relate to Themo Mechanical performance.

PCB Materials Development Input

Proposed Technology Envelope Properties, continued

OK for now, No degradation	Impact of Property	Value/Range
Loss Tangent (Df)	Impacts HSIO margin. Maximum property affects system design rules (such as bus lengths) and material selection. Variation impacts performance.	Lower is better
CTE (Alpha 1, Alpha 2, %)	Impacts Via reliability and laminate integrity	Lower is better, but present values OK. HF materials appear to have lower CTE (X, Y & Z)
Decomposition Temperature (Td)	Used to understand material weight loss at temperature levels. Unsure of correlation to defects at this time	No spec

Other Areas of Interest	Impact of Property	Value/Range
Filler % and Particle size	Affects many properties (CTE, toughness, flexural, etc.)	No spec
Thermal Conductivity	Could effect SJR or reliability	

Test Methods	Impact of Test	Testing Level
Cold Ball Pull	Pad Crater/Cracking performance indicator/comparison	System or Bare Board Level
Shock	Product performance test for comparison	System Level
Vibe	Product performance test for comparison	System Level
Temp Cycle	Product performance test for comparison. MEB examines only the bare board performance	Bare PCB Level
IST/HATS	Understand via reliability and material integrity performance test	Bare PCB Level
Isolation and Moisture Resistance	Understand material integrity and board level reliability	Bare PCB Level

Skill Sets Needed for WG

- What skill sets are needed for the WG membership
 - Laminate Technologist
 - PCB Fabrication Technologist
 - Material Scientist (Polymer)
 - Test Methodology expert
 - Q&R and failure Analysis expert
 - Designer for TV's
 - Electrical Signal Integrity expert (from SI WG)

Back up Slides

HF Laminate Scorecard

Material	Scorecard															
	Dk	Df	Moisture Absorption	Tg	CTE	Flexure	Td	T260 /Cu	T288 /Cu	Peel Strength	IST	CAF	UL94V0	Shock	Vibe	Temp Cycle
L	Red	Green	Yellow	Yellow	Green	Red	White	White	White	White	Green	Green	White	Red	Red	Yellow
B	Red	Green	Yellow	Yellow	Green	Red	White	Green	Yellow	Green	Green	Green	Green	White	White	White
C	Yellow	Green	Yellow	Yellow	Green	Red	White	Green	Green	Green	Green	Green	Green	Red	White	White
D	Yellow	Green	Yellow	Yellow	Green	Red	White	Green	Green	Green	Green	Green	Green	White	White	White
E	Yellow	Green	Yellow	Yellow	Green	Red	White	Green	Yellow	Yellow	Green	Green	Green	White	White	White
F	Red	Green	Yellow	Yellow	Green	Red	White	Green	Yellow	Green	Green	Green	Green	White	White	White
G	Red	Green	Yellow	Yellow	Green	Red	White	Green	Yellow	Green	Green	Green	Green	Red	Red	Yellow
H	Red	Green	Yellow	Yellow	Green	Red	White	Green	Yellow	Yellow	Green	Green	Green	White	White	White
I	Red	Green	Yellow	Yellow	Green	Red	White	Green	Green	Green	Green	Green	Green	White	White	White
J	Red	Green	Yellow	Yellow	Green	Red	White	Green	Yellow	Green	Green	Green	Green	White	White	White
K	Yellow	Green	Yellow	Yellow	Green	Red	White	Green	Green	Green	Green	Green	Green	White	White	White

Slide 13





Slide 14

Slide 15

Slide 16

Slide 17

Slide 18

Color Code		Equal to or better than FR4 (No issue)
		Marginal vs FR4 (Issue not clear)
		Worse than FR4 (Clear Issue)
		No Data

Key Message: Laminate Properties will not meet requirements without significant intervention



MARKET AND GROWTH OF RIGID LAMINATE

Area (Mm ²)	2006	2007	2012	Value CAAGR ('07-'12)
FR 4 Total	256.8	284.4	430.3	8.6%
Notebook		18.0	39.1	16.7%
Desktop		35.3	40.4	2.7%
Mobile Phone		14.7	21.6	8.0%
Other (Server, consumer)		216.4	329.2	8.8%

Area (Mm ²)	2006	2007	2012	Value CAAGR ('07-'12)
HF FR 4 Total	11.4	20.9	60.9	23.9%
Notebook		3.9	13.8	29.0%
Desktop		1.8	5.2	23.6%
Mobile Phone		7.5	21.4	23.4%
Other (Server, consumer)		7.7	20.5	21.6%



If HF supplants standard FR4, CAAGR grows to almost 70%
 (assuming HF FR4 reaches FR4 volumes for '12)

CAAGR: Compound aggregate annual growth rate



HF materials sets

Supplier	Material ID	Tg	Dk	Df	Vendor Status	UL Testing		Laminate Availability
		Literature Value	Literature	Literature Value		Sample	Approval	
Doosan	DS-7402	150	4.4	0.015	?			
	DS-7402H	170	4.5	0.014	Available		Rev July 2007	
	DS-7402D	160	3.9	0.01	R&D	est Q1'09	Est Q1'10	Not available to PCB fab
EMC	EM-285	152□ (TMA)	4.5	0.011	Industry Leader			
	EM-370 (5)	152□ (DSC)	4.5	0.013	Available			
	EM-370	175□ (DSC)	4.5	0.012	Available			
Hitachi	LLZ-71G	175°C (TMA)	3.6	0.0055-0.007	Available	Dec-05	Rev Nov 2007	Very low volume-RF 2yrs
	BE67G H	140-150 (TMA)	4.8-5.0 (@1MHz)	0.007	Industry Leader			
	BE67G R	155	4.5-4.7	0.009-0.011	Available			
	HE-679G	185°C (TMA)	3.9	0.0085-0.0095	Development	Apr-08	est Feb 2009	Qual samples only
ITEQ	IT175-GD	170	3.8	0.008	R&D	TBD	TBD	Not available
	IT140G	155	4.5 (@1MHz)	0.015	Industry Leader			
	IT170-GR	175	4.5 (@1MHz)	0.009	Available		Rev Oct 2007	Available
	IT155-G	160	4.6 (@1MHz)	0.009	Available		Rev Feb 2008	Available
Nan Ya	NPGN150	143 (TMA)	3.8~4.0	0.012~0.013	Available		Rev July 2008	Available
	NPGN170	162 (TMA)	3.9~4.1	0.012~0.013	Available		Rev July 2008	Available
	NPG-150	150	3.8~4.0	0.012~0.014	Industry Leader			
	NPG-170	170	4.1	0.012~0.014	Available			
	NPG180	176 (TMA)	4.2~4.5	0.013~0.015	Development	TBD	TBD	Not available
Panasonic	R1566	148	4.8	0.01	Industry Leader			
Park-Nelco	N4000-7EF	150 (DSC)	3.9-4.1	0.013-0.016	Available	Aug-05	Rev Jan 2008	Available
Shengyi	S1155	135	4.7 (@1MHz)	0.01	Industry Leader			
	S1165	165	5.4 (@1MHz)	0.035	Available			
TUC	XX872 HF	185 (TMA)	3.8	0.008	R&D	est Q1'09	TBD	Internal TUC pilot run only
	TU-752	140 (TMA)	4.3	0.013	Available			
	TU-862	170	4.1	0.010-0.011	Development		Rev Oct 2008	Available

Color Code | Dk<4.0@1GHz

Industry Leader: Makes up 80% of Industry HF Laminate

Technology Envelope Strategy

1. Define Initial Technology Envelope

- List material properties that need a modified range of values
- List new material properties that do not appear on Suppliers datasheets

2. Correlate known defects/performance degradation to Laminate Material Properties

- Provide defect examples that we want to improve
- Provide Hypothesis for correlation of Defect to Material Properties
- Build a test suite to validate correlation
- Deliver the “Defect to Material Property” correlation

Technology Envelope Strategy

3. Define Metrologies & Methods to assess these Material Properties at Laminate Supplier

- Review existing test methods from all Industries
- Develop new test methods if needed
- Deliver Test Methods to Consortia and Industry

4. Build TV and Products to verify PCB Reliability, SJR and Assembly Yields of Laminates within Tech Envelope

- Identify and build vehicles to quantify the reliability of the laminates within this test envelope
- Deliver the Technology Envelope to Industry

5. Work with Supply Chain to verify Capacity of Laminate

Laminate Sheet Modifications

- Need to answer the following questions:
 - What parts of the laminate data sheet are used and by whom?
 - What metrologies/properties/performance characteristics are we going to add?
 - What metrologies/properties/performance characteristics are we going to modify to be more concise or have a tighter range?
 - What parts are we going to remove?

PCB Materials Development Input

- PCB Materials WG Goals:
 - Define a technology envelop to provide a set of FR-4 electrically equivalent HF PCB materials, and test methods/conditions which meets the quality and reliability requirements for all relevant market segments .
 - Ensure the Industry Laminate Suppliers have the capability and capacity to support the industry HF laminate requirements

Intel Halogen Free Strategy Update

Problem Statement

- Industry anticipating transition to BFR- free and ROHS compliant systems and requesting that Intel support industry effort to provide technical assistance and design guide for HF PCB's, along with ecosystem readiness.
 - ⇒ Lack of clarity on industry transition point (or trend) may result in separate and inconsistent or counterproductive efforts
 - ⇒ No common stack-up and material specs for both FR4 and HF today and therefore no accepted Standard Technology Envelope for BFR-free PCB Materials
 - ⇒ Lack of a singular effort will result in duplication of efforts, different stack-up and/or Technology Envelope

Consortia SOW – iNEMI Project

Purpose

- **Identify HFR-free PCB materials and technology envelope which allow drop in replacement capability of HFR-free Materials with standard FR-4 PCB Designs.**
- Identify technology readiness, supply capability and reliability characteristics for “BFR-free” alternatives to conventional printed wiring board materials and printed wiring board assemblies
- **Provide Industry Standard Technology Envelope for HFR-free Materials across all market segments**

Background and Motivation

- The electronics industry is taking a precautionary stance on the use of non-regulated halogenated organic substances, such as the use of brominated epoxies for circuit board applications
- Proactive environmental policy by major OEMs/ODMs/Suppliers to drive to an agreed upon transition date, enabling the supply chain to support the transition, and providing potential volume costs benefits

Consortia SOW – iNEMI Project

Goals:

- Identify commercially viable materials
- Define the electrical signaling requirements and test conditions as well as delivering design guide collaterals that demonstrates laminate interchangeability for all relevant market segments
- Define the material set parameters and test conditions for all relevant market segments
- Carry out the necessary testing to characterize viable materials
- Analyze results
- Publish material set envelope that meets all market segment requirements – signaling, mechanical, quality / reliability, SMT yield, and environmental requirements for use by industry
- Investigate possible development of an industry standard utilizing technology envelope generated in project