Environmentally Friendly Materials

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Agenda

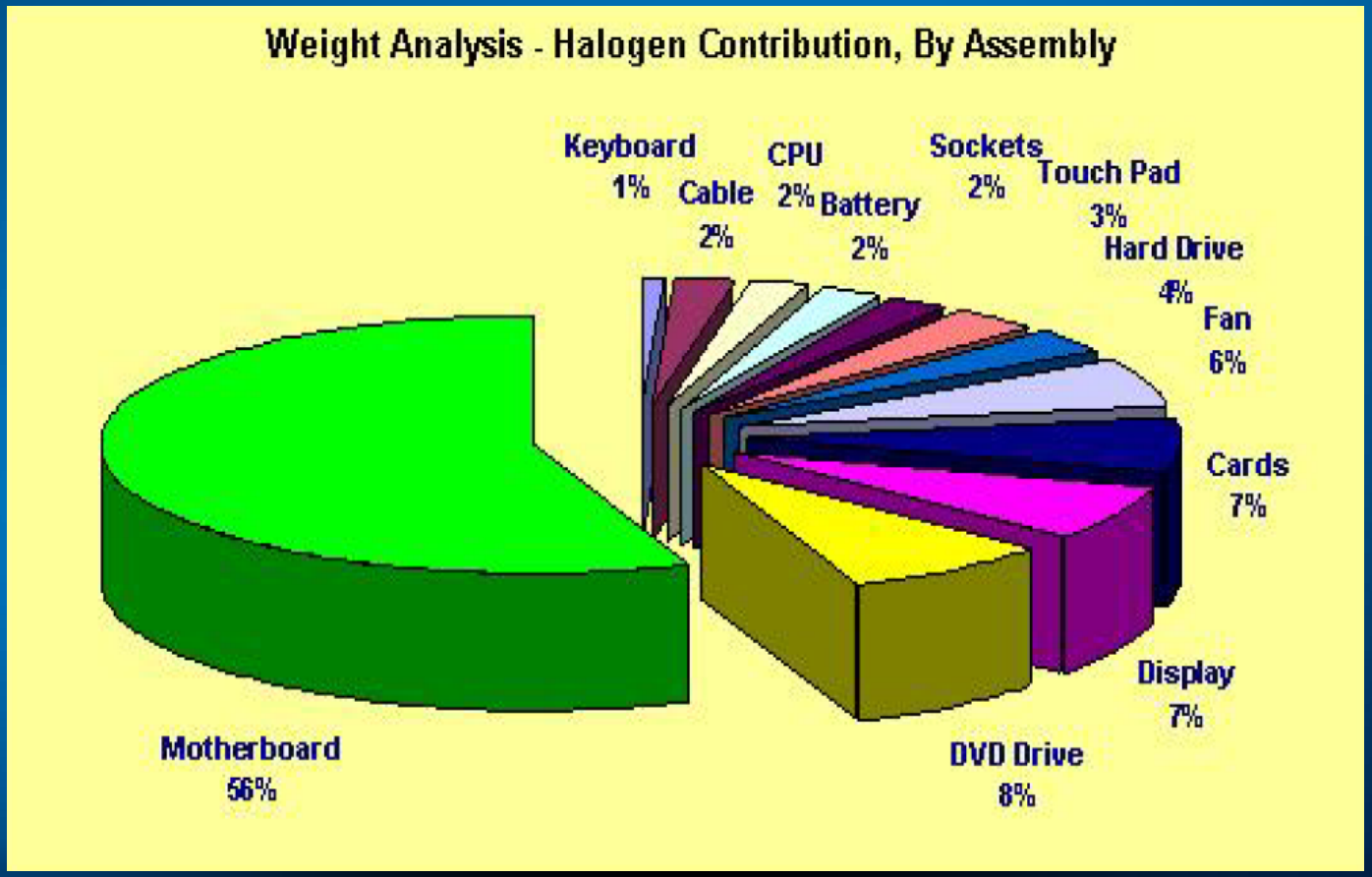
- Halogen Free (HF) --- Conversion Drivers
- **Definitions / Standards**
- **HF Conversion Challenges**
  - **Compliance methodology, reliability, performance, design**
- **Intel HF Roadmap**
- **PVC Risks/Concerns**
- **Summary**

Halogen Free (HF) Conversion Drivers

- Global Environmental Responsibility
  - Bio-accumulation
  - Toxicity of flame retardants & vinyl chloride
  - Dioxins released during EOL burning
- Legislation (implemented and pending)
- Non-Governmental Organization (NGO) pressure to address environmental issues

Supporting an environmentally sustainable future

Typical Halogen Content in System Ingredients



Note : 209 components analyzed, power adapter not included

Data Source: Dell

Halogen-free - What is different?

Halogen-free changes the flame retardant used for epoxy laminate materials

- Current halogenated flame retardant (TBBPA) is part of the backbone of the epoxy chain.

Halogen-free flame retardants come in 2 primary forms

- Fillers – metal hydroxides
- Epoxy backbone modifications – Organo-phosphorous or nitrogen compounds

Halogen-free changes the fundamental composition of resin material with no one choice dominant

“HF” Standards / Definitions

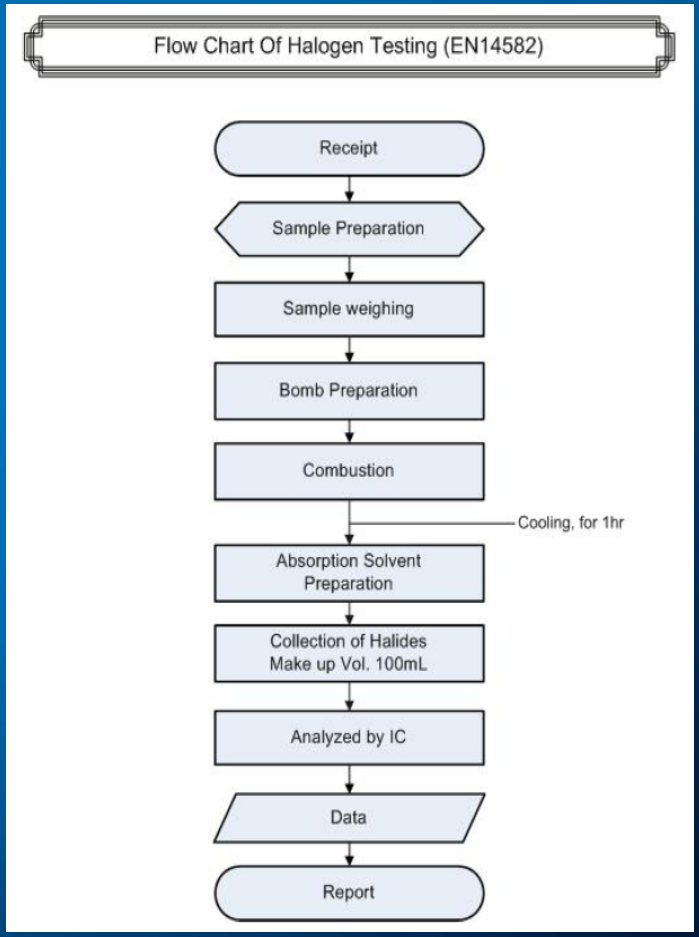
Standard	Description	Requirement
JPCA-ES-01-1999	Japan Printed Circuit Association (JPCA) definition of “Halogen Free “	Br<0.09wt% (900ppm) Cl <0.09wt% (900ppm)
IEC 61249-2-21/IPC-4101B	International Electro technical Commission (IEC) and IPC definition of Halogen Free “	900ppm max. Cl 900ppm max. Br 1500ppm total Cl+Br

- Based on Current Specs: Halogen free does not mean “zero halogens”
- Fluorine, Iodine, and Astatine (Group VIIA halogens) are not restricted in the industry definition of “halogen-free”
- These standards are applicable to PCB/component laminate materials
- Some customers have different requirements than the standards listed here
  - Nokia: Br, Cl and their compounds, and Sb2O3 <1000ppm of the wt of plastic resin + PVC free
  - Apple requires meeting <900ppm Cl or Br at the homogeneous material level for elemental Br/Cl
- Standard being developed : J-STD-709 to address all ingredients except PCB laminates

There is no single standard/definition accepted by all !

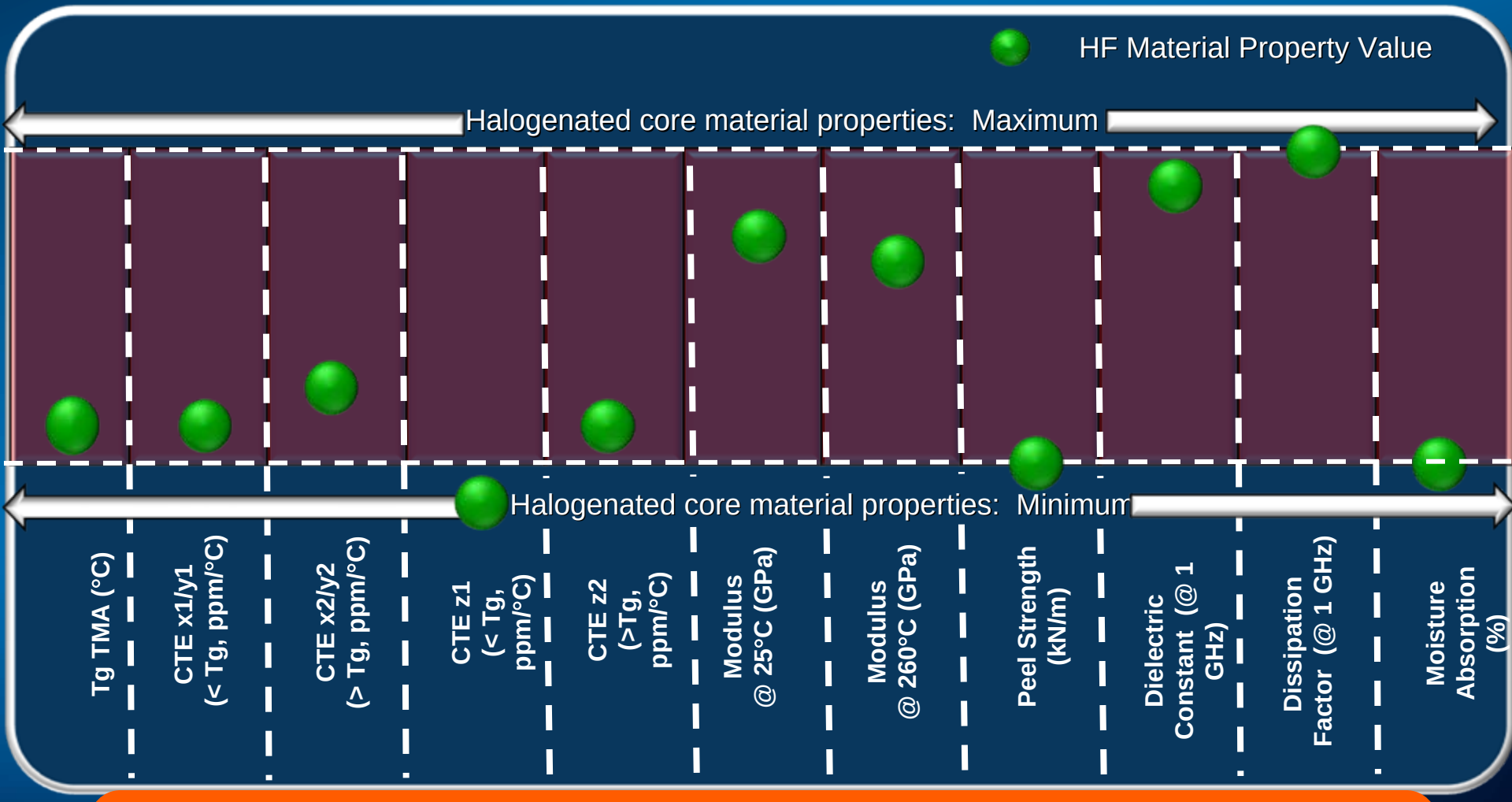
HF Conversion Challenges

- Compliance and Verification Methodology
  - EN14582
  - XRF
  - …….
- Industry Acceptable Standards
  - Beyond BFRs



Need Collaboration across entire Eco-system to create acceptable standards and verification methodology

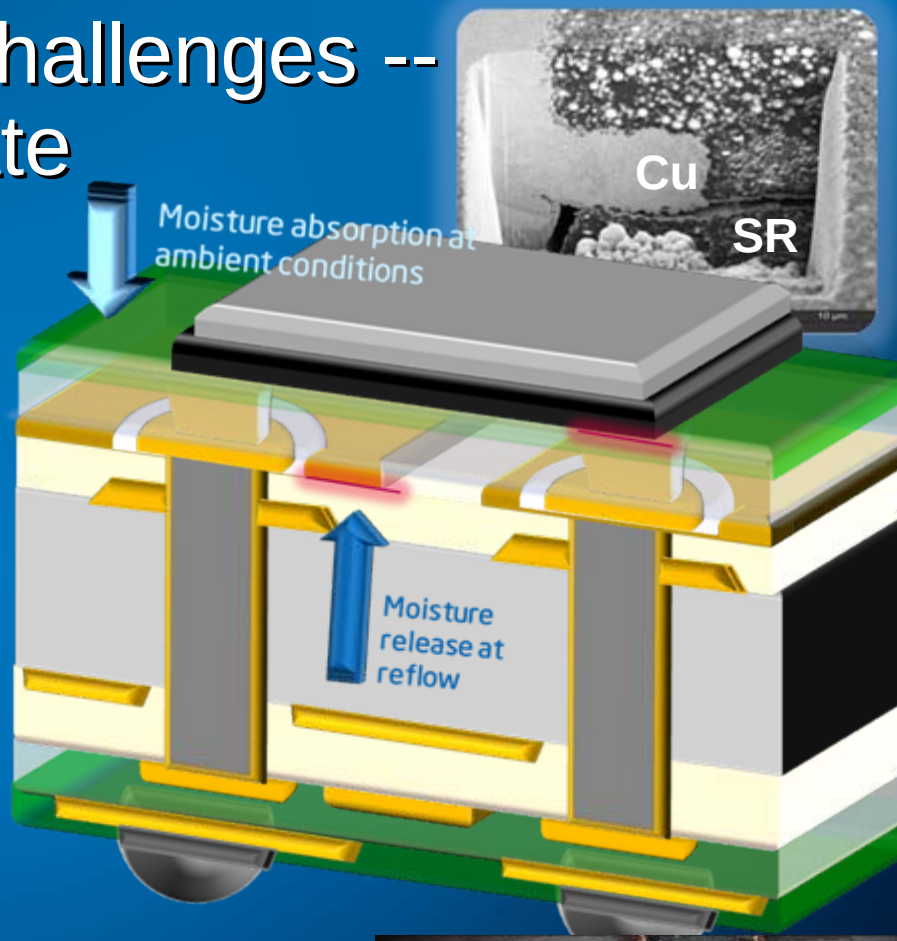
HF Substrate Core Materials



- *Properties of Evaluated HF Cores are comparable to Halogenated core properties*
- *Lower CTEz1 is preferred.*

HF Conversion Challenges -- Substrate

- **Reliability Performance Equivalency**
  - Right material selection wrt thermal stability of flame retardants
  - Better management of moisture exposure time in manufacturing environment
  - Right design to ensure no loss of adhesion
- **Business Impact**
  - Line item mgmt
  - Volume effect/cost



Requires Collaboration across entire Eco-system for comprehensive conversion strategies and material solutions

HF Conversion Challenges -- PCB

- Electrical – Impedance adjustments for higher Dk
- Mechanical – Pad adjustments to resist pad cratering
- Reliability – Margin analysis and redesign if necessary
  - Lower shock performance
- Board assembly solder paste, flux in early stages of TD
- Business impact

Summation of selected material properties of 8 leading HF PCB materials and their FR4 counterparts

Manufacturer		Halogen-free FR4				Standard FR4			
Property	Unit	Avg	Min	Max	Range	Avg	Min	Max	Range
Tg (TMA)	C	145	135	155	20	136	120	140	20
Td	C	356	335	370	35	328	305	360	55
CTE - Z below Tg	ppm/C	41	25	50	25	55	50	70	20
CTE - Z above Tg	ppm/C	216	140	260	120	282	250	350	100
Cu Peel Strength (1oz)	kN/m	1.45	1.2	1.9	0.7	1.82	1.4	2.2	0.8
Flexure Strength Y	psi	78K	70K	90K	20K	75K	60K	88K	28K
Flexure Strength X	psi	67K	60K	75K	15K	66K	50K	72K	22K
Dielectric Constant	"@1MHz"	4.8	4.2	5.2	1	4.6	4.2	4.8	0.6
Dielectric Constant	"@1GHz"	4.3	3.8	4.8	1	4.2	3.8	4.4	0.6
Dissipation Factor	"@1MHz"	0.01	0.006	0.016	0.01	0.016	0.013	0.02	0.007
Dissipation Factor	"@1GHz"	0.012	0.01	0.014	0.004	0.016	0.012	0.025	0.013
Moisture Absorption	%	0.12	0.02	0.3	0.28	0.16	0.05	0.3	0.25

HF MB is not a drop in solution; Massive volume of work remains!

Intel's Lead-free & Halogen-Free Technology Progression

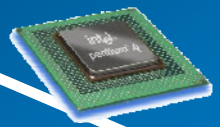
Driving Environmental Sustainability

Intel and IPC go Halogen-free

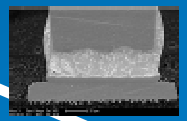
EMT Worldwide, January 21, 2008

The main goals of the symposium are to share halogen-free technology, provide a forum to discuss potential halogen-free concerns and identify opportunities to address them, and begin the process of industry alignment on halogen-free materials

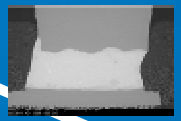
Lead Free Lead-frame & BGA



90nm Flip Chip Lead-Free BGA & Socket



65nm Lead-Free bump



45nm Flip-Chip Lead-Free

45nm Flip-Chip No HFR

What's Next?

- Improve Recycling
- Reduce Waste Stream
- Less Energy Consumption

Under Evaluation

Intel Shakes the Lead Out

Sumner Lemon, PC World, May 23, 2007

Chip giant will quit using lead in CPUs, starting with the Penryn line. Intel Corp. will stop using lead in its upcoming microprocessors, eliminating one of the most toxic components used in semiconductors from its product line.

Reduction in Hazardous Substances

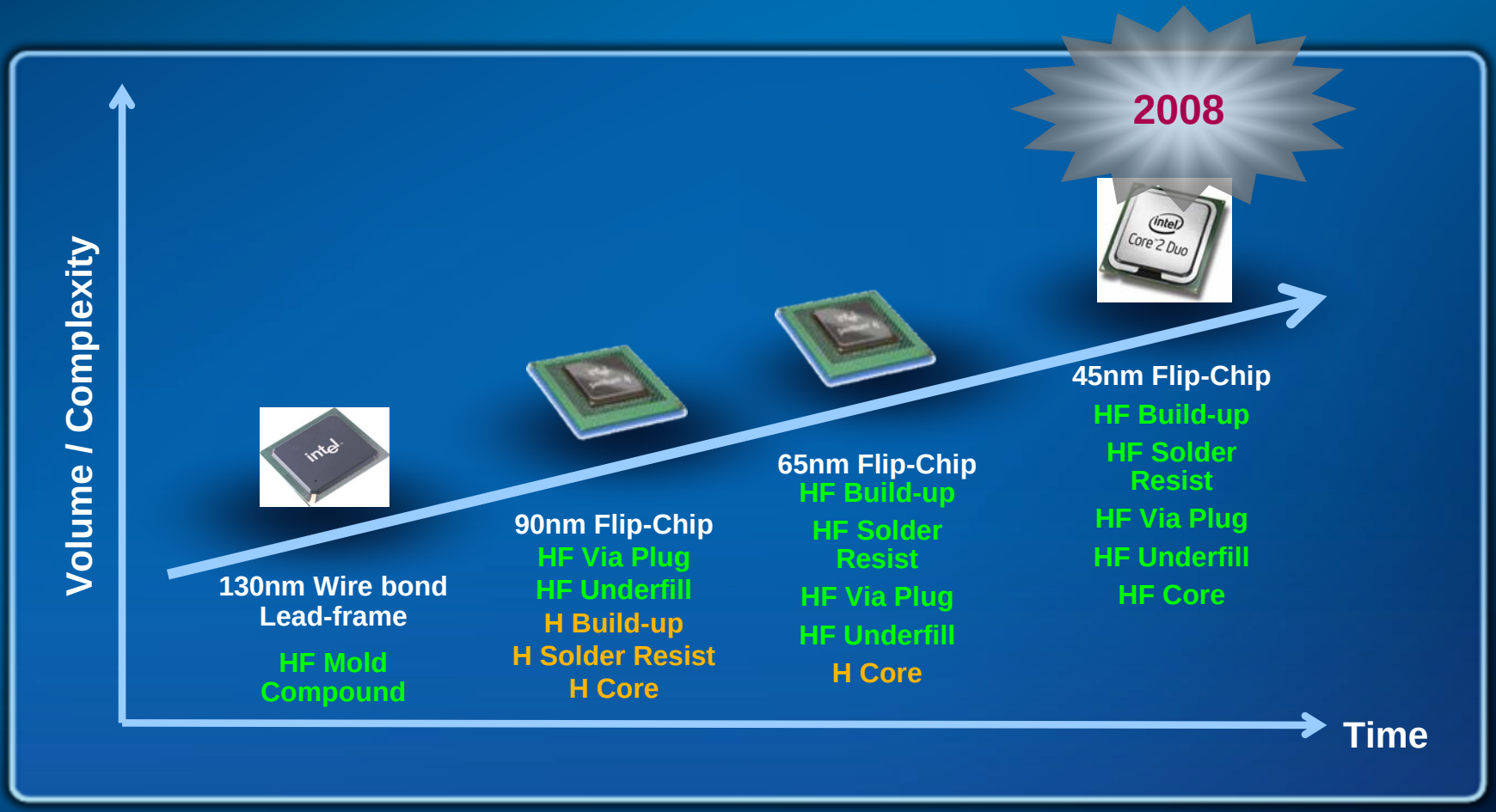
2003 2005 2007 2009 2011

Intel's Phased Approach to lead and halogen free

*45nm product is manufactured on a Lead Free process. Lead-free per EU RoHS directive July, 2006 (2002/95/EC, Annex A). Some EU RoHS exemptions may apply to other components used in the product package.

**45nm Applies only to halogenated flame retardants & PVC in components. Halogens are below 900 PPM bromine & 900 PPM chlorine.

Intel's Halogen Free Technology Progression



* Applies to components containing flame retardants & PVC only. Halogens are below 900 PPM bromine, 900 PPM chlorine, and 1500 PPM combined bromine and chlorine.

Intel's steady progress towards HF conversion eliminating BFRs from 45nm (CPU) and 65nm (Chipset)

Evaluating Fire Safety vs Ecology Risks

PVC

- How do we evaluate immediate safety concerns against long term ecology issues?

- Focus on Protecting Customers & Users
- Critical Safety Aspects of PVC Removal in All Applications must be Understood

Summary

Collaboration across the entire eco-system is required to develop:

- Agreed upon Standards
- Methods for verification
- Robust guidelines for matl solutions
- Equivalency (electrical, design, reliability)
- Business Strategy for conversion, line item mgmt , and cost impact

Back Up

Intel's Halogen-Free Position

- **Intel supports removal of Brominated Flame Retardants (BFR) and Polyvinyl Chloride (PVC) and is driving to Platform level compliance**
  - Silicon, by nature, meets this definition
  - BFR/PVC materials traditionally found in substrates and solders
  - All new component development to be based on HF technology
  - Board transition dependent on supply chain readiness

- **There is lack of scientific data that would warrant removal of elemental Bromine/Chlorine from electronic products**
  - Only one customer has requested to date

MBB JEDEC Specification

3.3 Dry Pack

3.3.1 Description Dry pack consists of desiccant material and a Humidity Indicator Card (HIC) sealed with the SMD packages inside a Moisture Barrier Bag (MBB). A representative dry pack configuration is shown in Figure 3-1.

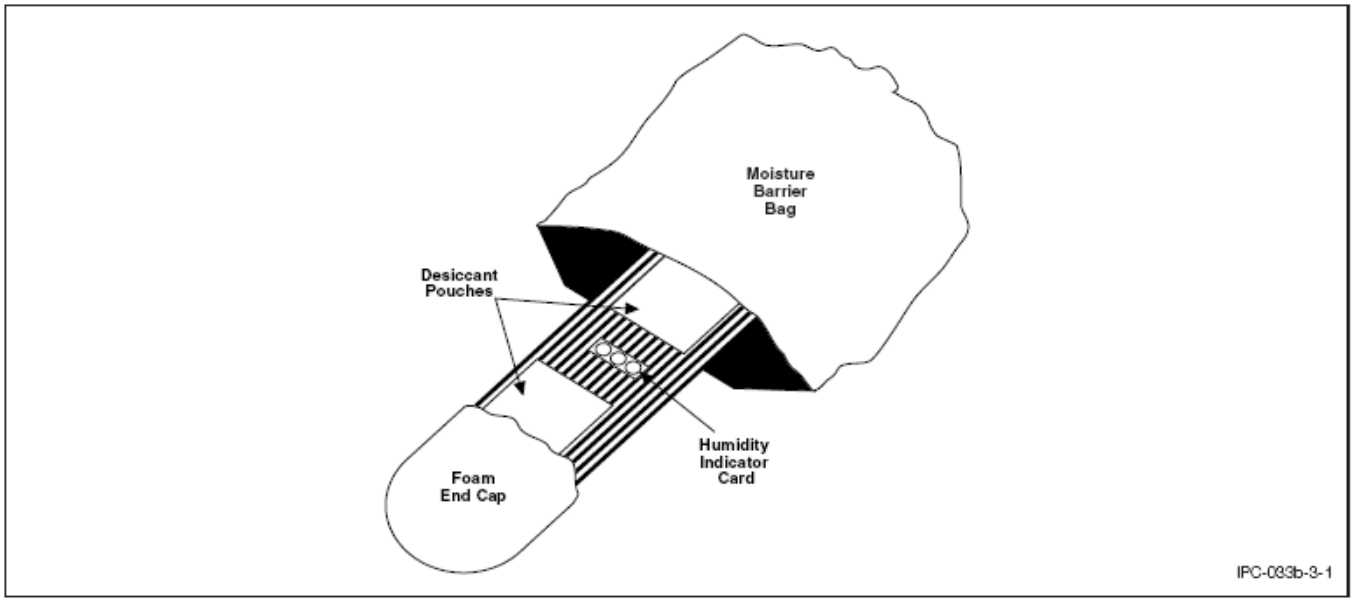


Figure 3-1 Typical Dry Pack Configuration for Moisture-Sensitive SMD Packages in Shipping Tubes

3.3.2 Materials

3.3.2.1 Moisture Barrier Bag (MBB) The moisture barrier bag **shall** meet MIL-PRF-81705, TYPE I requirements for flexibility, ESD protection, mechanical strength, and puncture resistance. The bags **shall** be heat sealable. The Water Vapor Transmission Rate (WVTR) **shall** be ≤0.002 gm/100 in^2 in 24 hrs at 40°C after flex testing per condition "E" ASTM F 392. The WVTR is measured using ASTM F 1249.

3.3.2.2 Desiccant The desiccant material **shall** meet MIL-D-3464, TYPE II. Desiccant **shall** be dustless, noncorrosive, and absorbent to amounts specified in the standard. The desiccant **shall** be packaged in moisture permeable bags or pouches. The amount of desiccant used, per moisture barrier bag, **shall** be based on the bag surface area and WVTR in order to limit the interior relative humidity in the MBB to less than 10% at 25°C.

Brominated flame retardants examples

TBBA: Tetrabromobisphenol A
PBDE: poly(Brominated diphenyl ethers)
Deca BDE: Deca-bromo diphenyl Ethers

UL94 V-0 Flammability Rating

- To meet UL94 V-0 flammability criteria, the samples must have:
  - Avg flame time < 5 seconds
  - Max flame time < 10 seconds

Core Material	Criteria	Number of Reflows at 260°C		
		0	5x	10x
Halogenated	Passed V-0 criteria?	Yes	Yes	Yes
Halogen Free		Yes	Yes	Yes

- H and HF cores meet UL94 V-0 flammability rating.
- Core shows margin even after 10X Pb-free reflows in hammer test.