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The Designers View of Lead Free

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Agenda

- *DFM Intro*
- *Why Lead Free*
- *Material Selection*
- *Lead Free Impact on Board Fabrication*
- *Land Characteristics*
- *Surface Finishes*
- *Quality Assurance and Testing*
- *Assembly Issues*
- *Placement Issues*
- *Component Selection*
- *Master Drawing Notes*

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Why Lead Free

Concern over:

- *Exposure*
- *Landfill*
- *4% of landfill is Electronics*
- *Shorter lifetime of products*

Issues:

- *No full life cycle analysis*
- *What are the alternatives?*
- *Cost of substitutes*
- *1% of lead used is Electronics*

RoHS Directive

RoHS Directive number 2002/95/EC

- *Restriction of Hazardous Substances in Electrical and Electronic Equipment.*

RoHS Directive

RoHS Requirements

From July 1st 2006 new electrical and Electronic equipment should not contain any of the following:

- Lead
- Mercury
- Hexavalent Chromium
- Cadmium
- Polybrominated Biphenyls (PBB)
- Polybrominated Diphenyls (PBDE)

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RoHS Directive

Scope

Includes all equipment dependant upon electrical currents or electromagnetic fields falling into the following categories:

1. *Large Household Appliances*
2. *Small Household Appliances*
3. *IT/Telecommunications*
4. *Consumer Equipment*
5. *Lighting Household (including electric light bulbs and household luminaires)*
6. *Electrical and Electronic Tools*
7. *Toys,Leisure & sports*
8. *Medical devices*
9. *(Monitoring & Control Instruments)*
10. *Automatic Dispensers*

Exemptions are in red and also includes 'Spare parts' used for the repair or reuse of equipment on the market before July 1st 2006

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Product Types NOT within RoHS

- *Automotive, Aerospace, Military*
  - *Exclusions have never been within the legislative scope but being evaluated for inclusion at a later date*
- *Intended to protect national security and/or for military*
- *Where electricity is not main power source*
  - *e.g. electronic control of gas heating*
- *Where electronic products are not needed to fulfil the primary function*
  - *e.g. musical birthday card*
- *That are part of another type of equipment*
  - *do not have a direct function outside that equipment*
  - *e.g. vehicle engine management*
- *Batteries*
  - *Covered under battery regulations*

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Product Types NOT within RoHS

- *Network Infrastructure (solder only)*
- *Servers and Storage Arrays (solder only) until 2010*
- *Equipment rated above 1000 VAC or 1500 VDC*

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Military Exemption??

MIL-PRF-31032

6.7 Environmentally preferable material. Environmentally preferable materials should be used to the maximum extent possible that the material meets or exceeds the operational and maintenance requirements, and promotes economically advantageous life cycle costs. Table I lists the Environmental Protection Agency (EPA) top seventeen hazardous materials targeted for major usage reduction. If any of these hazardous materials are required, it is recommended that it be used only when other materials cannot meet performance requirements.

Table I. EPA top seventeen hazardous materials.

Benzene	Dichloromethane	Tetrachloroethylene
Cadmium and Compounds	Lead and Compounds	Toluene
Carbon Tetrachloride	Mercury and Compounds	1,1,1 - Trichloroethane
Chloroform	Methyl Ethyle Ketone	Trichloroethylene
Chromium and Compounds	Methyl Isobutyl Ketone	Xylenes
Cyanide and Compounds	Nickel and Compounds	

Military Exemption??

MIL-PRF-55110 "*SUPERCEDED FOR FUTURE DESIGN"??*

6.6 Environmentally preferable material. Environmentally preferable materials should be used to the maximum extent possible that the material meets or exceeds the operational and maintenance requirements, and promotes economically advantageous life cycle costs. Table I lists the Environmental Protection Agency (EPA) top seventeen hazardous materials targeted for major usage reduction. If any of these hazardous materials are required, it is recommended that it be used only when other materials cannot meet performance requirements.

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Cyanide and Compounds	Nickel and Compounds	

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Established Levels

Current levels are as follows:

- *Lead (Pb), Mercury (Hg) and Hexavalent Chromium (Cr6+) <0.1% component weight = <1000 PPM*
- *Cadmium (Cd) <0.01%* component weight = <100PPM
- *PBB's and PBDE's <0.1% component weight = <1000PPM*

" By weight in homogeneous materials …… shall be tolerated"

What is the definition of 'homogeneous materials'?

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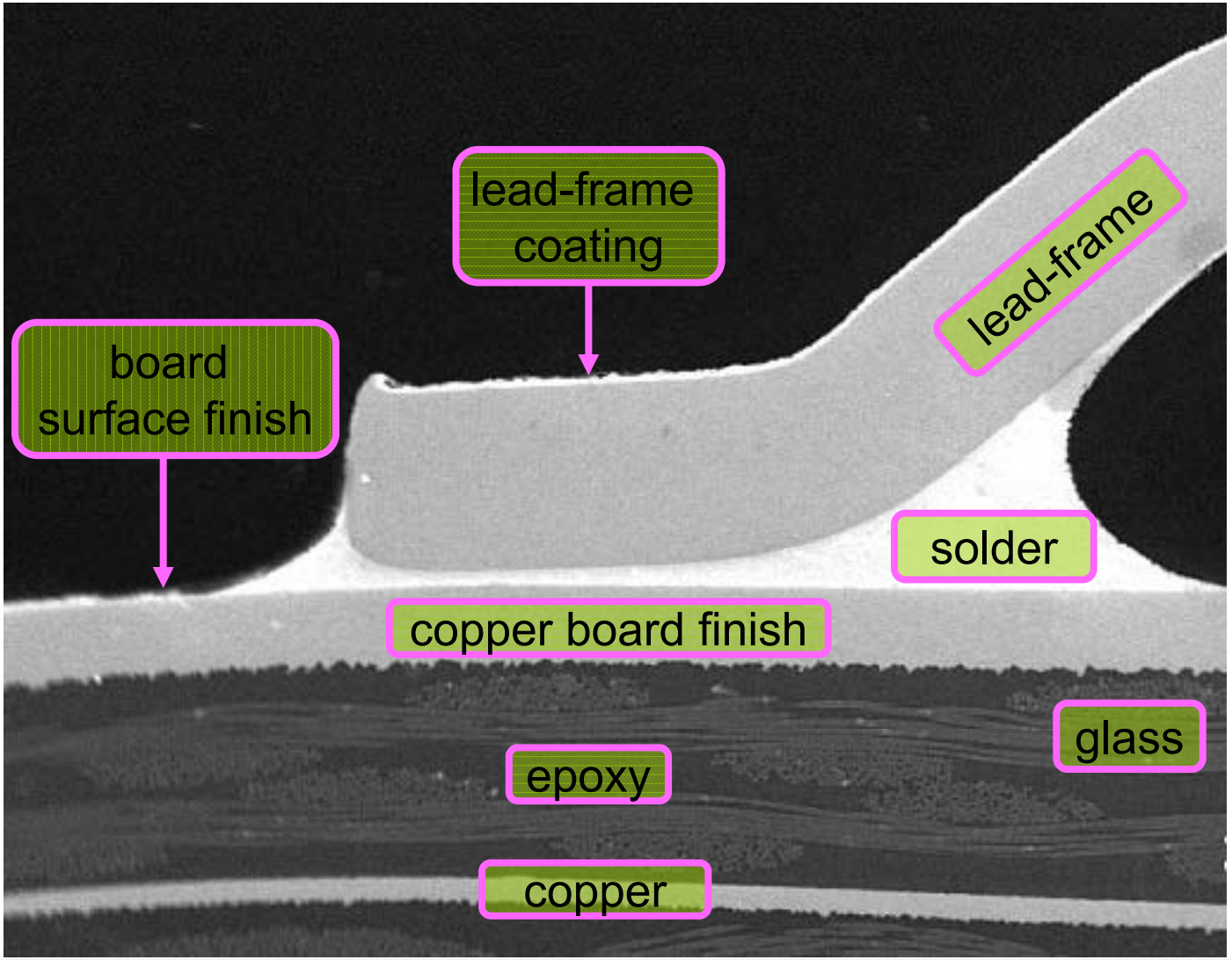
Homogeneous Material



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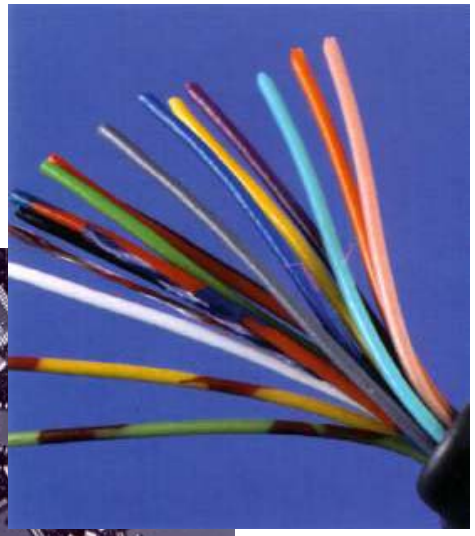
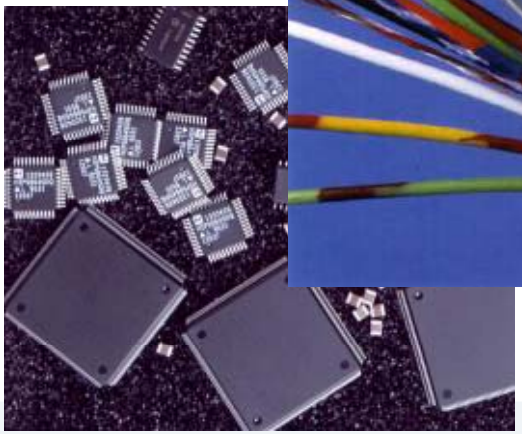
Hidden Banned Substances?

- *Mechanical fixings – may be Zn plated with hexavalent Cr used as a passivation layer*

- *Plastics – may contain Pb, Cd or PBDE*



- *Components – may have Pb on surface finish or as internal connections*



- *Etc !*

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Material Selection

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Material Selection

- *Resin Formula*
- *Flame Resistance*
- *Thermal Stability*
- *Mechanical Strength*
- *Electrical Properties*

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Material Selection Cont'd

- *Flexural Strength*
- *Reinforcing Sheet Material*
- *Maximum Operating Temperature*
- *CAF Resistant*
- *Halogen Free*

But, is this enough?

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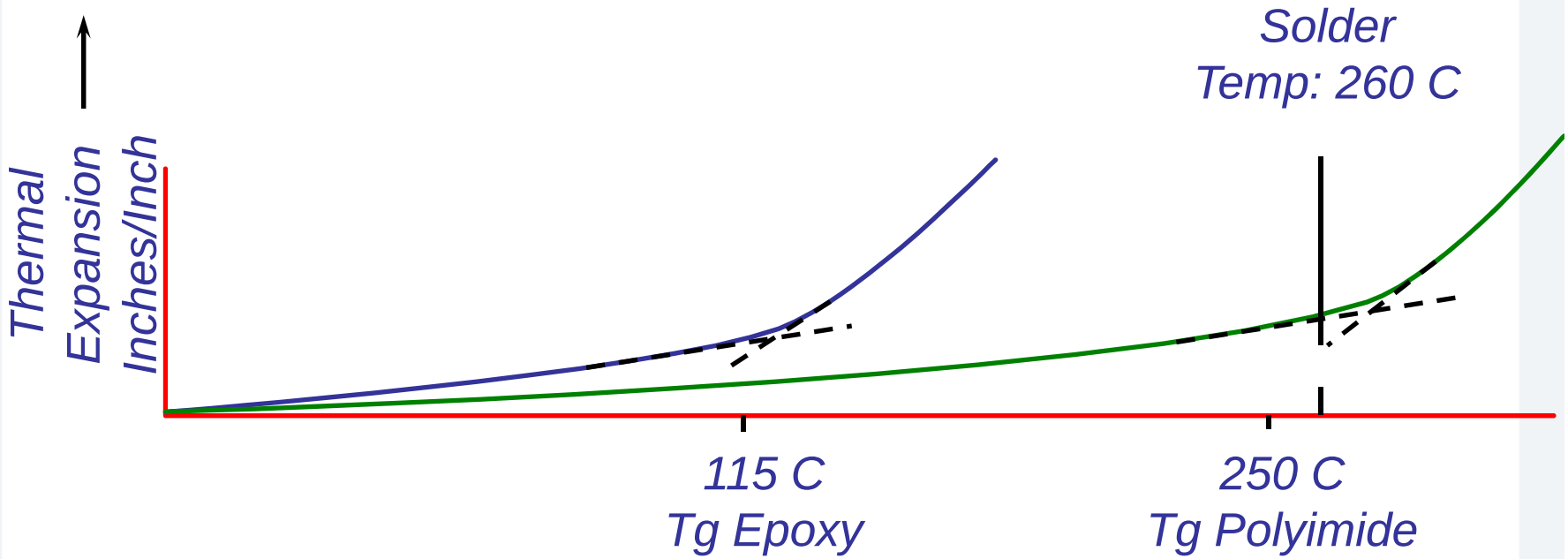
Glass Transition Temperature - Tg

Definition:

The temperature at which an amorphous polymer changes from being in a hard and relatively brittle condition to being in a viscous or rubbery condition.

Glass Transition Temperature - Tg



Increased layer count and thermal reliability have prompted specifying minimum Tg's

Is that enough??

Glass Transition Temperature - Tg

Test Methods

Dynamic Mechanical Analysis (DMA)
Measures modulus

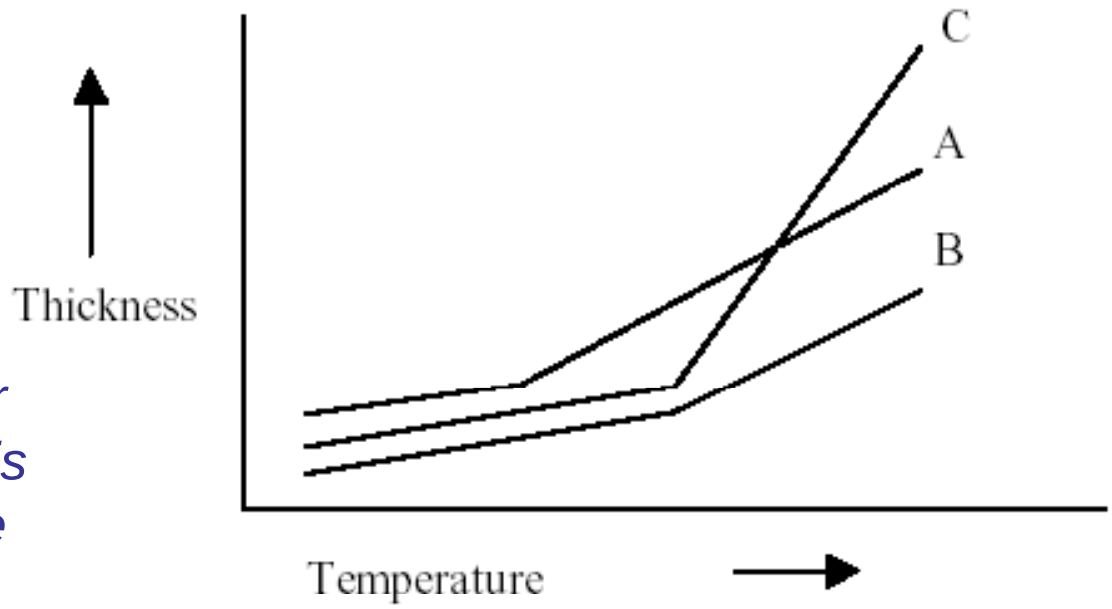
Differential Scanning Calorimetry (DSC)
Measures rate of heat absorption

Thermal Mechanical Analysis (TMA)
Measures expansion rate

Z-Axis Expansions

Post-Tg CTEs are higher than pre-Tg CTEs.

- *"A" exhibits more total Z axis expansion than "B" because of a lower-Tg.*
- *But "C", even with a higher Tg, exhibits more total Z-axis expansion than "A" because its post- Tg CTE is so high.*



Typical Supplier Data Sheets

Key Engineering Values

	N4000-13	N4000-13 SI
X/Y CTE (ppm/°C)[-40 to 125°C]	10 - 14	9 - 13
Z Axis Expansion (%) [50 to 260°C]	3.5	3.5
T_g by DSC (°C)	210	210
Dielectric Constant (50% resin content)		
@ 1 GHz (RF Impedance)	3.7	3.5
@ 2.05 GHz (Split Post)	3.9	TBD
@ 10 GHz (Stripline)	3.6	3.2
@ 10 GHz (Split Post)	3.7	3.3
Dissipation Factor (50% resin content)		
@ 2.05 GHz (Split Post)	0.008	TBD
@ 10 GHz (Stripline)	0.009-0.011	0.009
@ 10 GHz (Split Post)	0.009	0.006

Typical Supplier Data Sheets

Key Engineering Values

	N4000-13	N4000-13 SI
X/Y CTE (ppm/°C)[-40 to 125°C]	10 - 14	9 - 13
Z Axis Expansion (%) [50 to 260°C]	3.5	3.5
T_g by DSC (°C)	210	210
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@ 10 GHz (Split Post)	0.009	0.006

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Typical Supplier Data Sheets

POLYCLAD LAMINATE/PREPREG GRADE - PCL-FR-370HR/PCL-FRP-370HR (Provisional)
IPC-4101A SPECIFICATION SHEET(S) /98

LAMINATE

Property		Typical Values/IPC-4101/98 Specification				Units	Test Method
		Thickness <0.50 mm (< 0.0197 in)		Thickness ≥0.50 mm (≥ 0.0197 in)			
		Typical Value	Specification	Typical Value	Specification	Metric (English)	IPC-TM-650 (or as noted)
Glass Transition Temperature (Tg) by DSC, spec minimum		180	150-200	180	150-200	°C	2.4.25
Decomposition Temperature (Td)		350	—	350	—	°C	ASTM D3850
CTE, Z-axis	A. Pre-Tg B. Post-Tg	— —	AABUS —	45 220	AABUS —	ppm/°C	2.4.24
CTE, X-, Y-axes	A. Pre-Tg B. Post-Tg	— —	AABUS —	14 16	AABUS —	ppm/°C	2.4.24
Thermal Conductivity		—	—	TBD	—	W/mK	ASTM D5930
Thermal Stress 10 Sec @ 288°C (550.4°F), spec minimum	A. Unetched B. Etched	Pass Pass	Pass Visual Pass Visual	Pass Pass	Pass Visual Pass Visual	Rating	2.4.13.1
Permittivity, spec maximum (Laminate & prepreg as laminated)	A. @ 1 MHz B. @ 100 MHz C. @ 1 GHz	4.7 4.6 4.4	5.4 — —	4.8 4.6 4.5	5.4 — —	—	2.5.5.3 2.5.5.9 2.5.5.5
Loss Tangent, spec maximum (Laminate & prepreg as laminated)	A. @ 1 MHz B. @ 100 MHz C. @ 1 GHz	.015 .015 .015	0.035 — —	.015 .015 .015	0.035 — —	—	2.5.5.3 2.5.5.9 2.5.5.5
Volume Resistivity, spec minimum	A. 96/35/90 B. After moisture resistance C. At elevated temperature	$1.0x10^{8}$ — $7.5x10^{8}$	10^{6} — 10^{3}	— $9.5x10^{8}$ $9.6x10^{6}$	— 10^{4} 10^{3}	MΩ -cm	2.5.17.1
[illegible]	A. 96/35/90 B. [illegible]	$2.0x10^{8}$ [illegible]	10^{4} [illegible]	— [illegible]	— [illegible]	[illegible]	[illegible]

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IPC-4101 Slash Sheet

Proposed Specification Sheet

Specification Sheet # : IPC-4101/99
Reinforcement : Woven E-glass
Resin System : **Primary:** Epoxy
Secondary 1: Multifunctional Epoxy **Secondary 2:** Modified Epoxy or Non-epoxy (max. 5%)
Curing Agent : Non-Dicy
Flame Retardant Mechanism : Bromine / RoHS Compliant
Fillers : Contains inorganic fillers
ID Reference : **UL/ANSI:** FR-4/99

Glass Transition (T_g) : 150 – 200°C

UL Max Operating Temp : 130°C rating

Keywords (*For search only; not grade requirement - See Section 7*)
- Lead-free FR-4
- CAF resistance
- High decomposition temperature
- High reliability FR-4
- Low Z-axis CTE

LAMINATE REQUIREMENTS

Laminate Requirement	Specification <0.50 mm [0.0197 in]	Specification ≥0.50 mm [0.0197 in]	Units	Test Method	Ref. Para.
1. Peel Strength, minimum					
A. Low profile copper foil and very low profile copper foil - all copper weights > 17µm [0.669 mil]	AABUS	AABUS	N/mm (lb/inch)	2.4.8 2.4.8.2 2.4.8.3	3.9.1.1 3.9.1.1.1 3.9.1.1.2 3.9.1.1.3
B. Standard profile copper foil					
1. After Thermal Stress	0.80 (4.57)	1.05 (6.00)			
2. At 125°C [257 F]	0.70 (4.00)	0.70 (4.00)			
3. After Process Solutions	0.55 (3.14)	0.80 (4.57)			
C. All other foil – composite	AABUS	AABUS			
2. Volume Resistivity, minimum					
A. C-96/35/90	10^6	---	MΩ-cm	2.5.17.1	3.11.1.3
B. After moisture resistance	—	10^4			
C. At elevated temperature E-24/125	10^3	10^3			

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IPC-4101 Slash Sheet

3. Surface Resistivity, minimum A. C-96/35/90 B. After moisture resistance C. At elevated temperature E-24/125	10^4 — 10^3	--- 10^4 10^3	MΩ	2.5.17.1	3.11.1.4
4. Moisture Absorption, maximum	-	0.5	%	2.6.2.1	3.12.1.1
5. Dielectric Breakdown, minimum	-	40	kV	2.5.6	3.11.1.6
6. Permittivity at 1 MHz, maximum (Laminate & Prepreg as laminated)	5.4	5.4	—	2.5.5.3 2.5.5.5 2.5.5.6	3.11.1.1 3.11.2.1
7. Loss Tangent at 1 MHz, maximum (Laminate & Prepreg as laminated)	0.035	0.035	—	2.5.5.3 2.5.5.3 2.5.5.9	3.11.1.2 3.11.2.2
8. Flexural Strength, minimum A. Length direction B. Cross direction	— —	415 (60,190) 345 (50,140)	N/mm^2 (lb/in^2)	2.4.4	3.9.1.3
9. Flexural Strength at Elevated Temperature, length direction, minimum	–	–	N/mm^2 ($lb/inch^2$)	2.4.4.1	3.9.1.4
10. Arc Resistance, minimum	60	60	S	2.5.1	3.11.1.5
11. Thermal Stress 10 s at 288°C [550.4F],minimum A. Unetched B. Etched	Pass Visual Pass Visual	Pass Visual Pass Visual	Rating	2.4.13.1	3.10.1.2
12.Electric Strength, minimum (Laminate & Prepreg as laminated)	30	—	kV/mm	2.5.6.2	3.11.1.7 3.11.2.3
13. Flammability, (Laminate & Prepreg as laminated)	V-0 minimum	V-0 minimum	Rating	UL94	3.10.2.1 3.10.1.1
14. Glass Transition Temperature	--	150 - 200 minimum	°C	2.4.24 2.4.25	3.10.1.6
15. Decomposition Temperature	--	330 minimum	°C	TBD (5% wt loss)	3.10.1.10
16. Z-Axis CTE A. Alpha 1 B. Alpha 2 C. 50 to 260 Degrees C	-- -- --	60 maximum 300 maximum 3.5	PPM/°C PPM/°C %	2.4.24	3.10.1.11

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IPC-4101 Slash Sheet

17. Thermal Resistance A. T260 B. T288 C. T300	 -- -- --	 30 minimum 5 minimum ABBUS	 Minutes Minutes Minutes	2.4.24.1	3.10.1.12
18. CAF Resistance	--	AABUS	Pass/Fail[∓]	ABBUS	3.12.1.4

[∓] Pass or Fail are determined by Fail being ≥ 1 decade drop in the sample's initial insulation resistance value.

PREPREG REQUIREMENTS

Prepreg Requirement	Specification	Units	Test Method	Ref. Para.
1. Shelf Life, minimum (Condition 1/Condition 2)	180/90	Days	AABUS	3.17
2. Reinforcement	As per IPC-4412 or AABUS.			
3. Volatile content maximum	1.5	%	2.3.19	3.9.2.2.8
4. Prepreg Parameters	–	AABUS	AABUS	1.1.7
5. Flammability (as laminated)	V-1 minimum	rating	UL94	3.10.2.1
6. Other	–			

*AABUS = As agreed upon between user and supplier. **See Slash Sheet 2 in IPC-4121.

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Lead Free Impact on Board Fabrication

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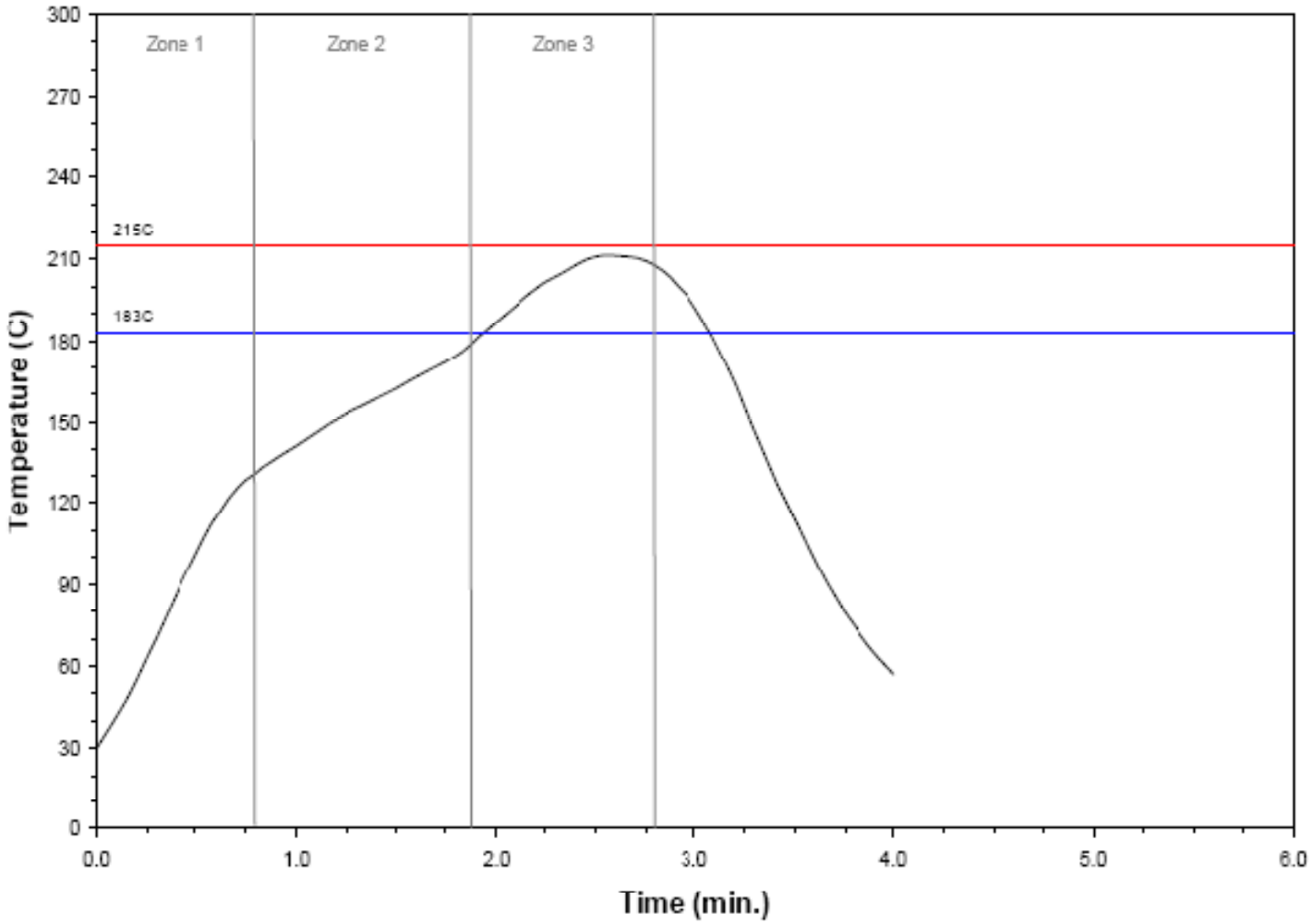
SnPb – Eutectic Profile



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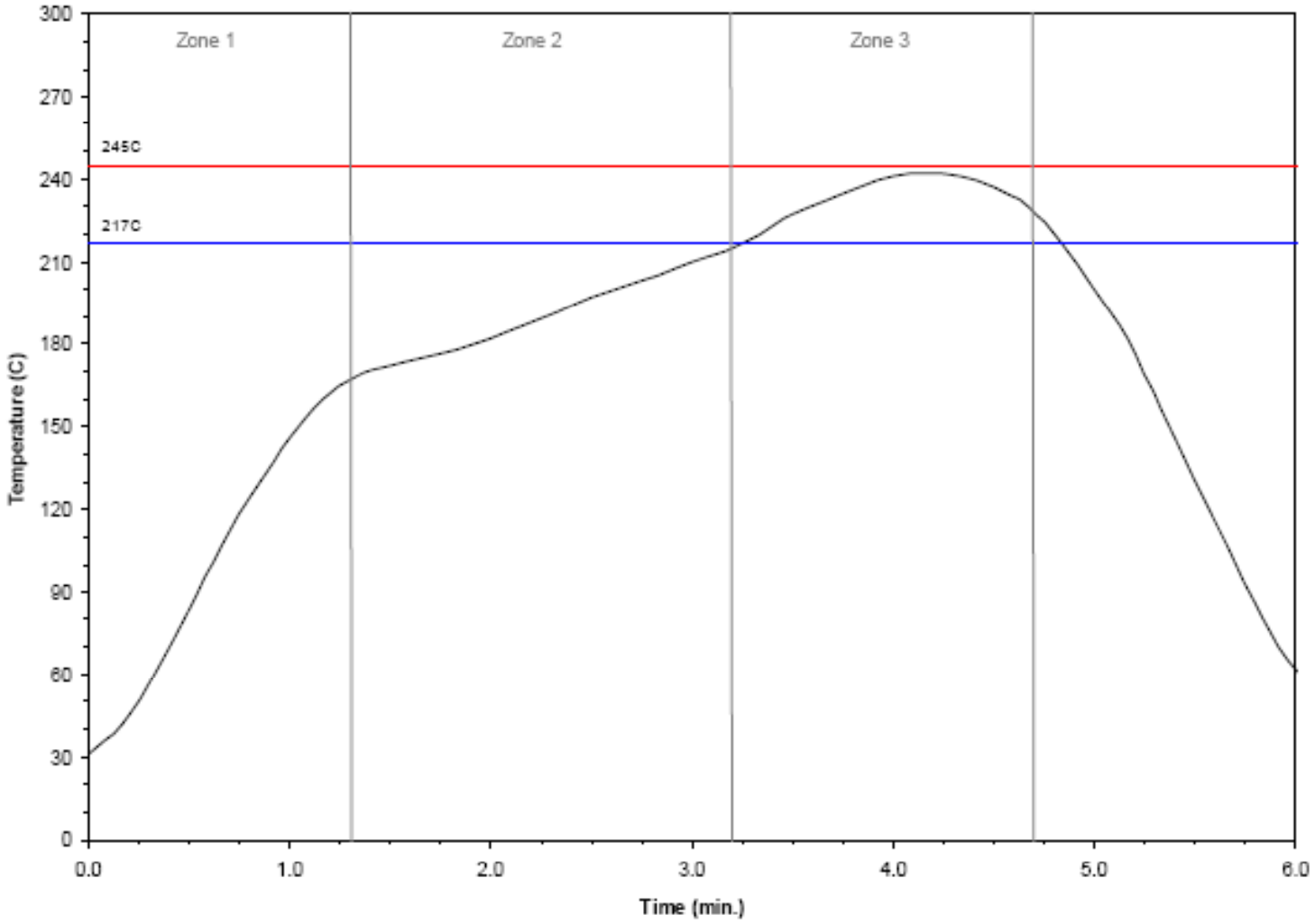
SnAgCu - Profile



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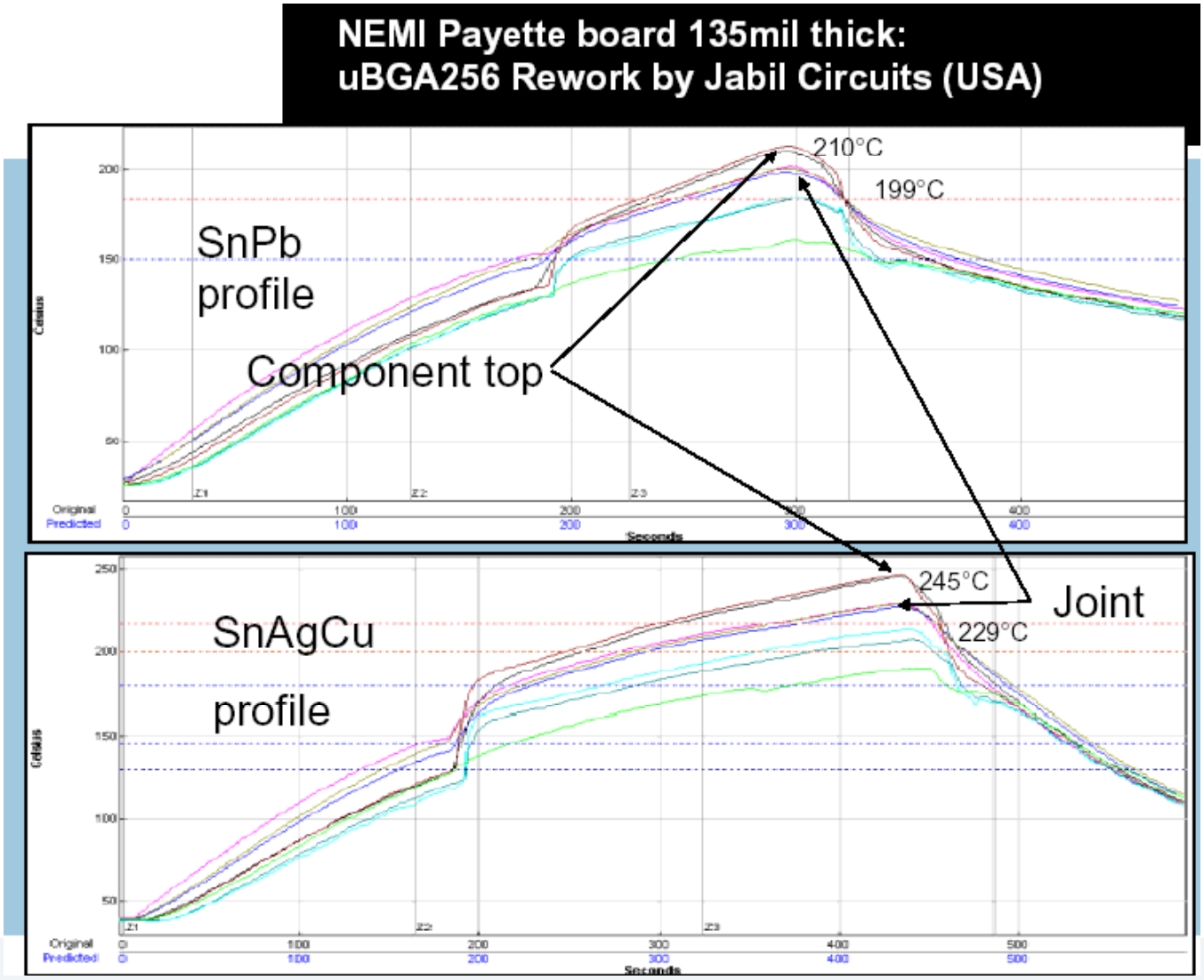
Lead Free Impact on Board Fab

NEMI Payette board 135mil thick:
uBGA256 Rework by Jabil Circuits (USA)



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Lead Free Impact on Board Fab

Mis-conceptions

- *"Lead free assembly will have only a minor effect on laminates."*
- *"Just switch to existing high-Tg materials."*
- *"Most existing materials can be used in Lead free assembly without a significant problem."*

Lead Free Impact on Board Fab

Challenges as a result of Higher Temperature Processing

Problems	• Through hole reliability • Delamination • Measle • Blister resistance
Mechanisms	• Z Axis expansion • Thermal stability
Key Base Material Properties	• Degradation temp/Tg • Time at temperature performance

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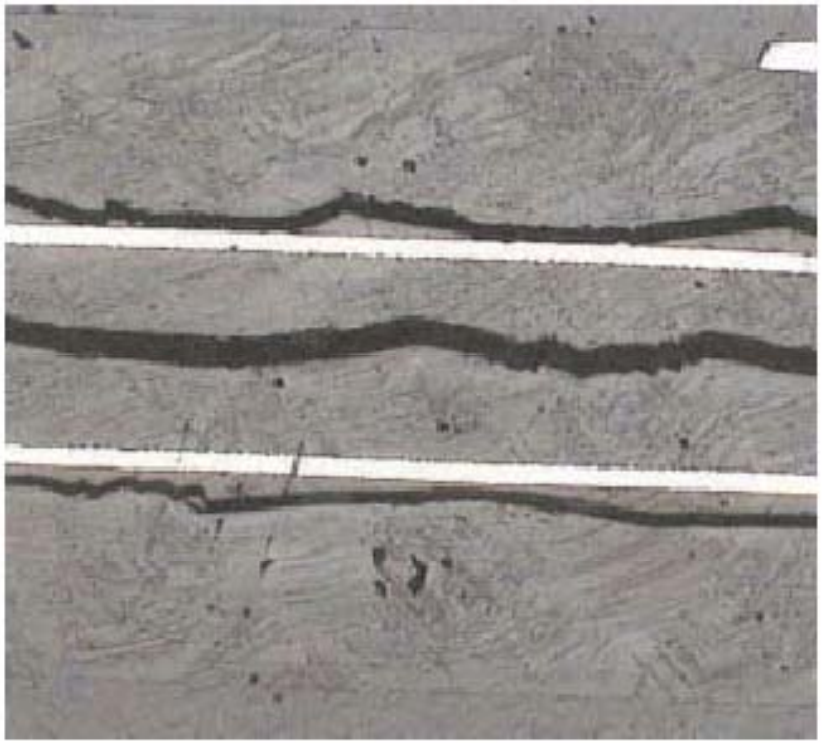
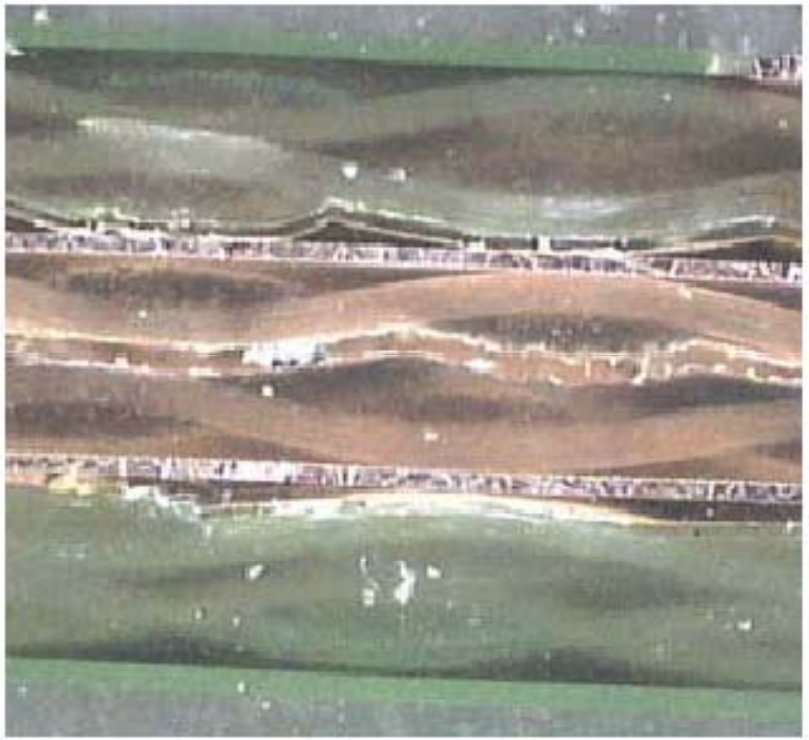
Lead Free Impact on Board Fab Worse Case Results

A Common High Tg FR-4 After Lead Free Assembly





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Lead Free Impact on Board Fab Decomposition Temperature - Td

Definition:

The Temperature at which a 5% weight loss occurs by thermal gravimetric analysis (TGA) using Test Method ASTMD3850

Lead Free Impact on Board Fab Decomposition Temperature - Td

What happens as the decomposition temperature is exceeded?

Irreversible degradation and damage of material due to breakage of chemical bonds

Even 2-3% loss, especially when exposed to multiple thermal cycles, can significantly degrade reliability

- *The point at which this level of decomposition occurs is critical.*

Lead Free Impact on Board Fab Time at Temperature Performance

Definition:

A number of ways to evaluate -

T260/T288 measures time to delamination at specific temperature (i.e. 260° C/288° C)

Test Method: IPC-TM-650

- *T260 = 30 minutes minimum*
- *T288 = 10 minutes minimum*
- *T300 = 1 minute minimum*

Lead Free Impact on Board Fabrication Time at Temperature Performance

What happens and what does it mean?

- *At the test temperature after some period of time the sample will delaminate*
- *Longer T260/T288 times indicate better delamination/measle/blister resistance*
- *Results are dependent on decomposition temperature, Tg and other factors*

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Lead Free Impact on Board Fab Supplier Material Studies

Material Type/Property	Material A	Material B	Material C	Material D
Resin System	High Tg Epoxy	Enhanced High Tg	High Tg Epoxy	Mid Tg Epoxy
Primary Cure Chemistry	Non-Dicy	Non-Dicy	Dicy	Dicy
Tg (DSC)	175°C	210° C	175°C.	155°C.
CAF Resistant	Yes	Yes	No	Yes
Contains Bromine	Yes	Yes	Yes	Yes
Dielectric Constant (1 MHz)	4.3	3.9	4.3	4.5
Dissipation Factor (1MHz)	0.020	0.009	0.023	0.018
X/Y axis CTE (-40 to +125°C)	12-14 ppm/°C	10-14 ppm/°C	12-16 ppm/°C	12-15 ppm/°C
Low Z-CTE Resin Chemistry	Yes	Yes	No	Yes

Table 1 – PWB Substrate Material Properties

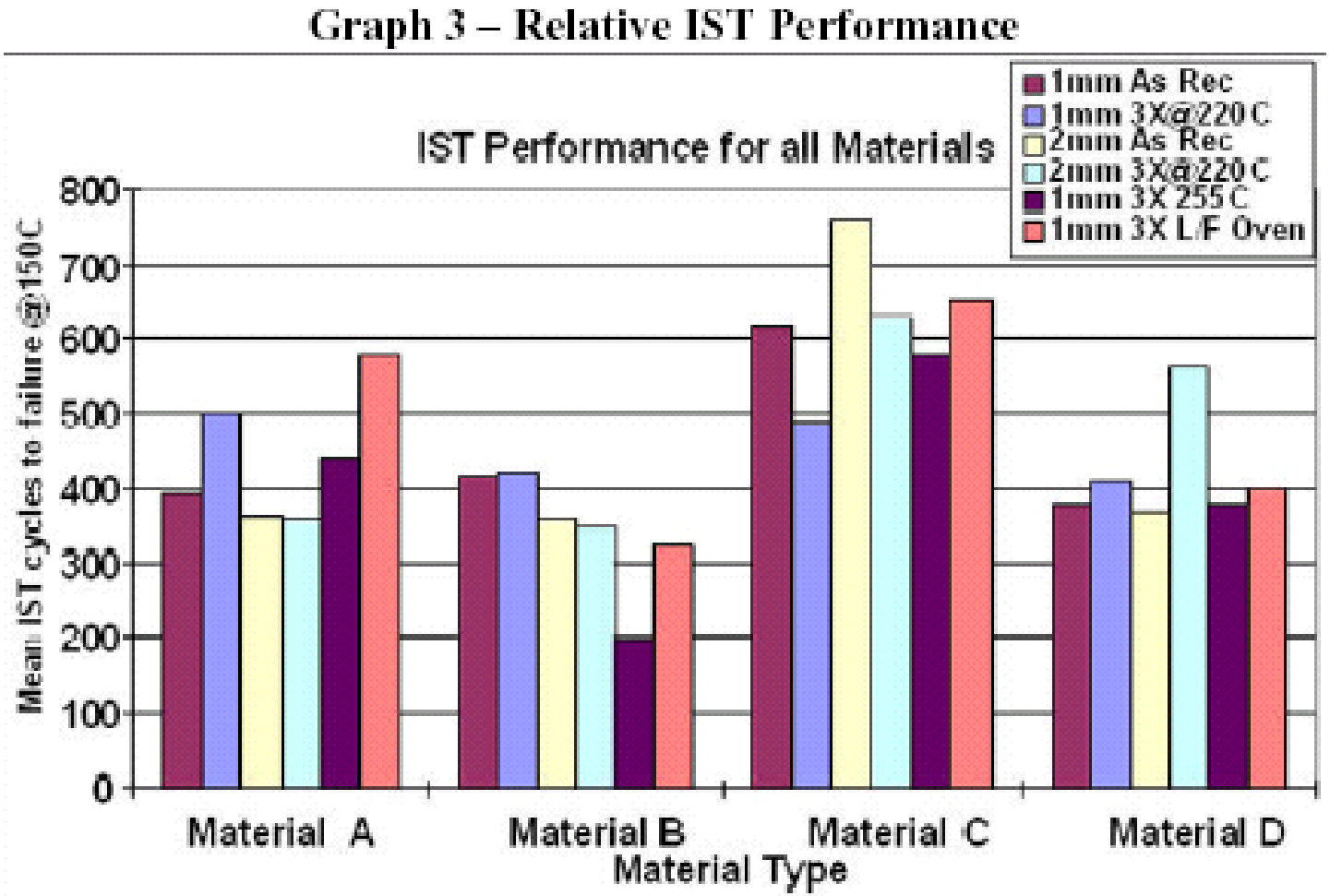
Park Electrochemical Corp.

Lead Free Impact on Board Fab Supplier Material Studies

Property/Condition	Material A	Material B	Material C	Material D
Resin System	High Tg Epoxy	High Tg Enhanced	High Tg Epoxy	Mid Tg Epoxy
Tg (DSC)	175°C	210° C	175°C.	155°C.
Tg (TMA)	165°C	200° C	170°C.	150°C.
Tg (DMA)	195°C	240°C	180°C	160°C.
Degradation Temperature (TGA - 5% weight loss)	362°C	357°C	325°C	330°C.
Z axis expansion* (50 to 260°C in %)	3.20%	3.50%	3.70%	3.80%
Z axis expansion (50 to 288°C)	4.20%	4.10%	5.90%	4.60%
Moisture Resistance (24 hr. immersion)	0.15%	0.10%	0.15%	0.07%
T260	30 min.	> 30 min.	7 min.	16 min.
T288	6 min.	9 min.	N/A	1.4 min.
Solder Float (4"x4" Cu Clad) (288°C. - time to failure)	550 sec.	>600 sec.	230 sec.	263 sec.

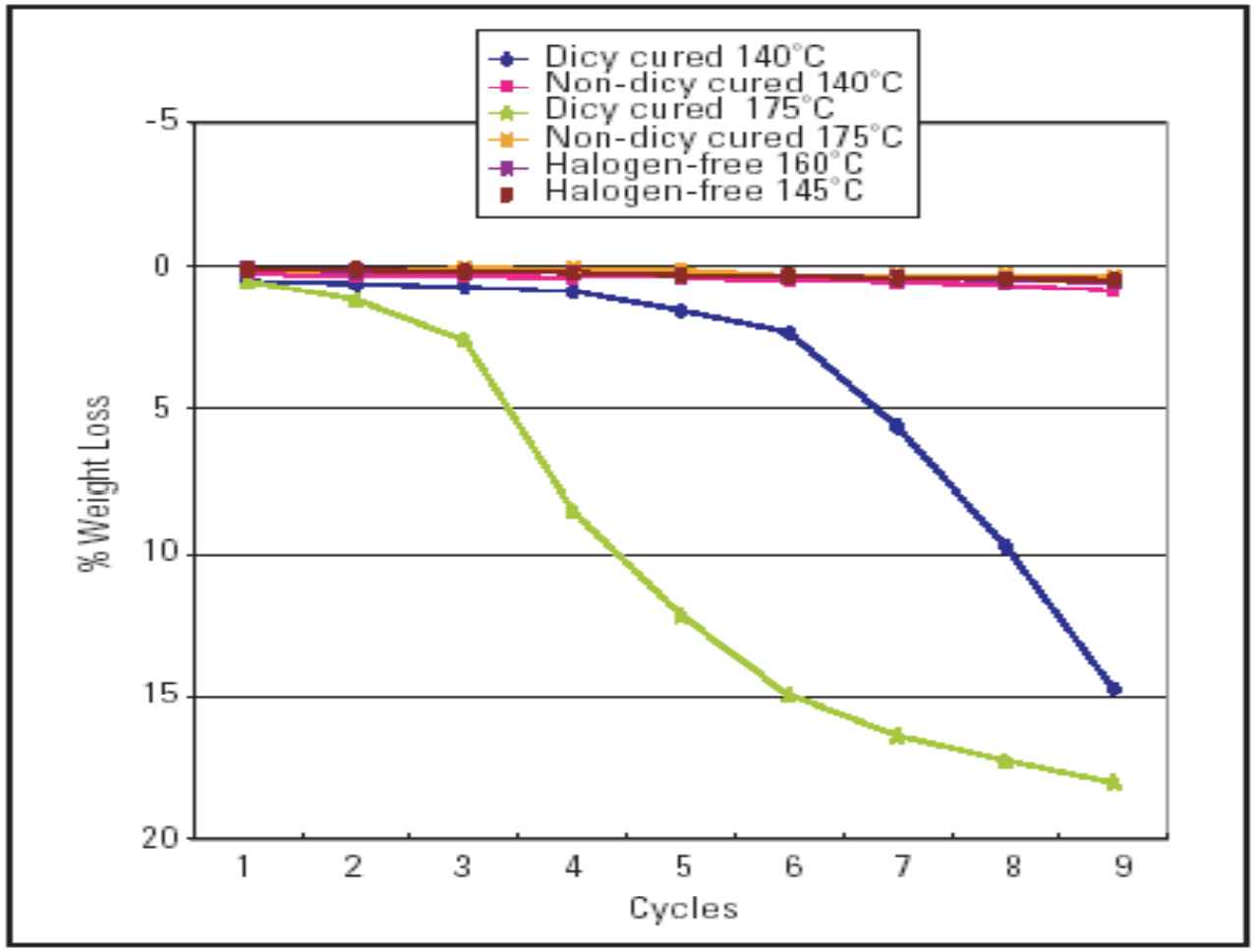
Table 3 – Thermal Test Data of Substrate Materials

Lead Free Impact on Board Fab Supplier Material Studies



Lead Free Impact on Board Fab Supplier Material Studies

Thermal cycles @ 235ºC



Isola Laminates

Lead Free Impact on Board Fab

Tg and Td are not the only issues to consider CTE must considered as well

The following formula takes all three into consideration. A minimum index of 215 is recommended for the lead free environment:

Soldering Temperature Impact Index (STII)

$$STII = (Tg + Td)/2 - (\%\ \text{thermal expansion from 50} - 260^{o}C)X10$$

Lead Free Impact on Board Fab

Material Selection Summary:

- *Specifying Tg may be necessary, but it is insufficient. Higher Tg is not always better.*
- *Decomposition temperature is a critical property to understand when specifying materials for Pb free assembly.*
- *CTE values should be considered also. Calculate STII !*
- *Time to delamination tests are increasingly relevant, but multilayer PCBs can be affected by other variables than just materials.*
- *If switching materials, verify other performance characteristics also, e.g. Dk and Df values. Don't forget the electricals!*

Lead Free Impact on Board Fab

Stress Testing:

- *Typical fabricator thermal testing is in the range of 1 – 3 thermal cycles (solder floats)*
- *Revised requirement for Lead Free; 5-6 thermal cycles @ 260°C*
- *Hats or IST testing*

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Land Characteristics

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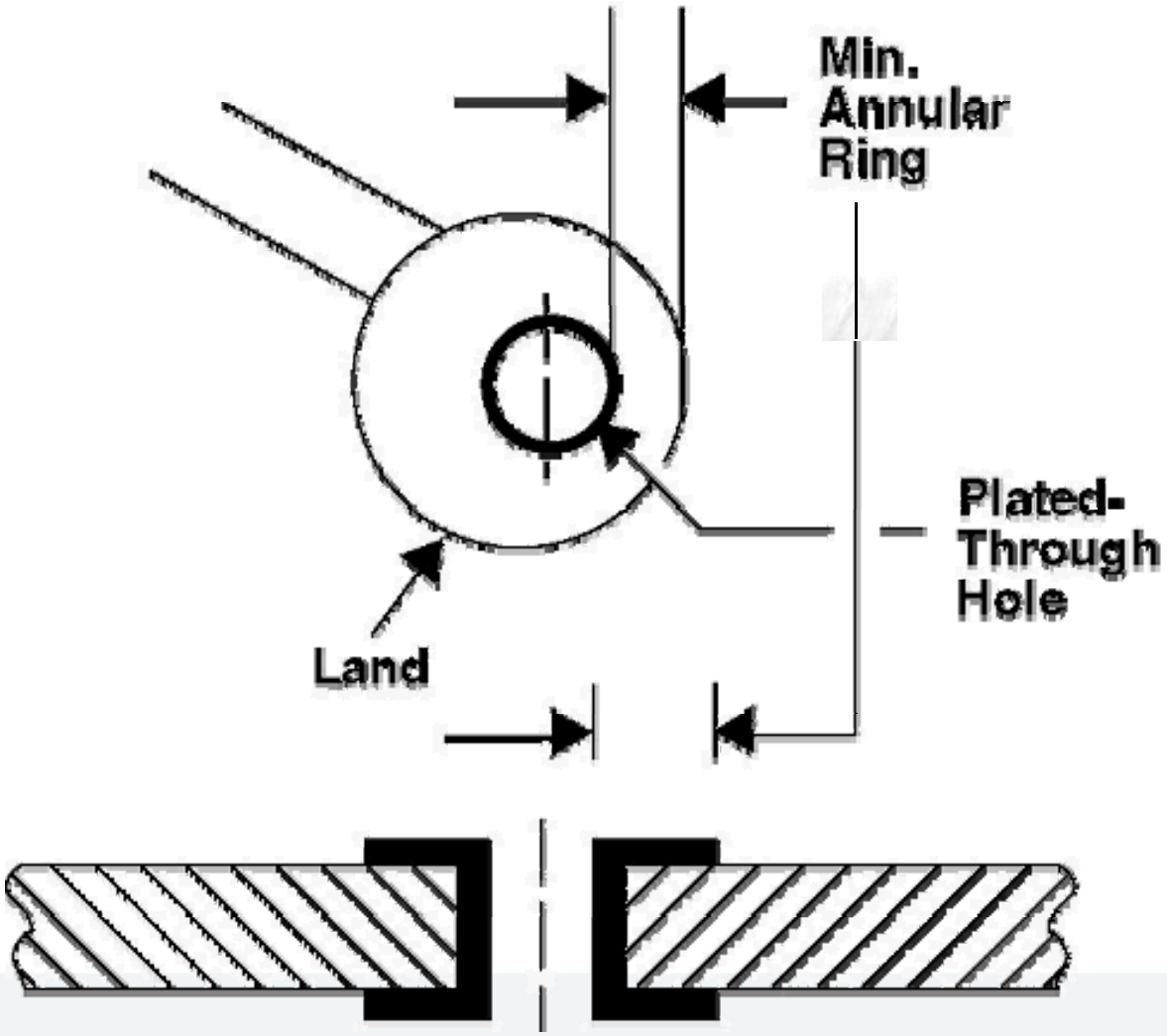
9.1.2 Annular Ring Requirements

The minimum annular ring for unsupported and supported holes **shall** be in accordance with Table 9-2 and Figures 9-2 and 9-3.

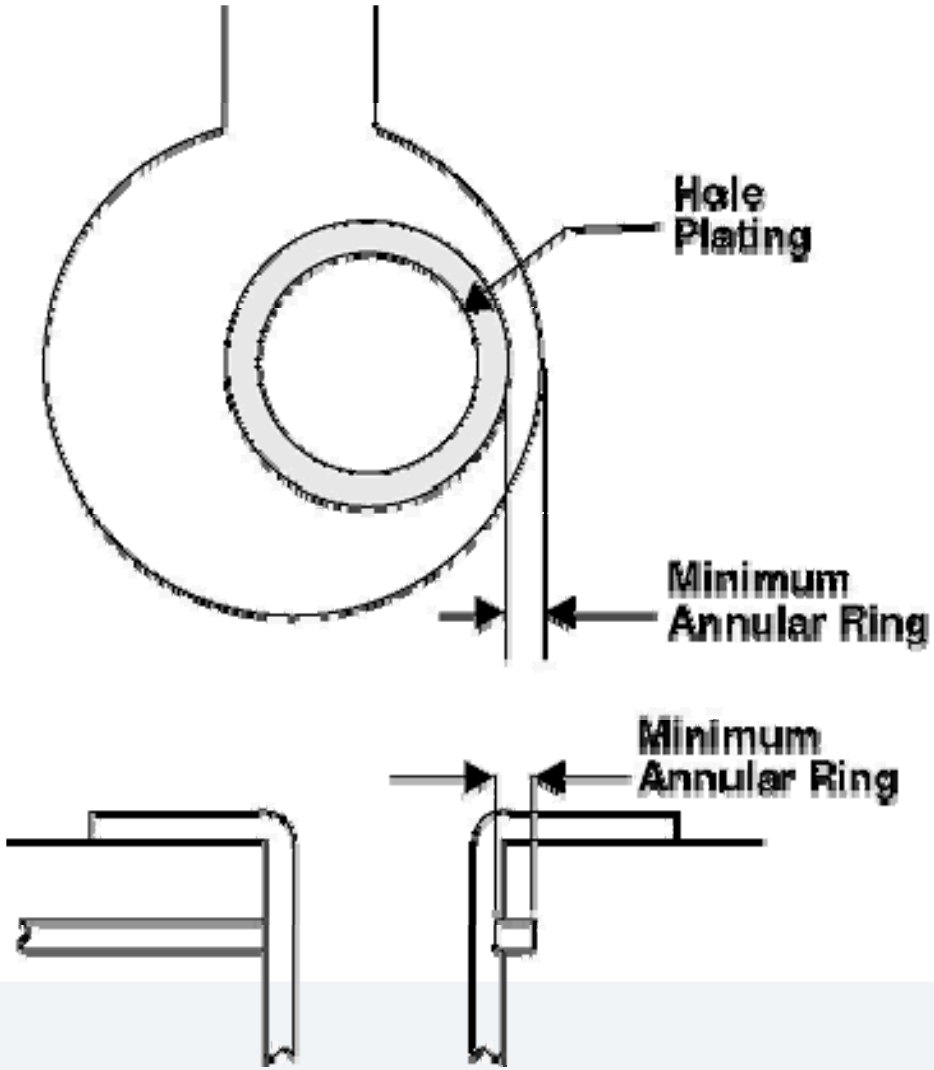
Table 9-2 Annular rings (Minimum)

Annual Ring	Class 1,2,3
Internal Supported	0.03 mm
External Supported	0.05 mm
External Unsupported	0.15 mm

IPC-2221 Figure 9-2
External Annular Ring



IPC-2221
Figure 9-3 Internal Annular Ring



Minimum Standard Fabrication Allowance For Interconnection Lands

Level A	Level B	Level C
0.4 mm [0.016]	0.25 mm [0.010]	0.2 mm [0.008]

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Land Size Calculation

Maximum Hole Size = 0.041

Annular Ring (0.005) X 2 = 0.010

Fabrication Allowance = 0.010

Minimum Land Size 0.041 + 0.010 + 0.010 = 0.061 Diameter

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What About Lead Free Impact?

- *Surface Adhesion*
  - *increased annular rings?*
- *Plated Barrel Thickness*
  - *ductility of the copper*

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SURFACE FINISHES

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Surface Finishes

The "Ideal" PCB surface finish would have these characteristics:

- *No-clean and water soluble paste & flux compatibility*
- *Strong intermetallic joint - BGA - tensile stress*
- *Three reflow sequences spread over 1 week*
- *Storage for 1 year*
- *Press fit connector Compatibility*
- *Visually inspection - quality assurance*
- *Lead free - environmental initiatives*
- *Minimize total cost*

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Surface Finishes

Popular Lead Free Surface Finishes:

- *PCB Surface Finishes*
- *OSP*
- *Tin (Sn)*
- *ENIG (NiAu)*
- *Silver (Ag)*
- *Palladium / Gold (PdAu)*
- *Lead Free HASL*
- *Gold (Au) on copper*

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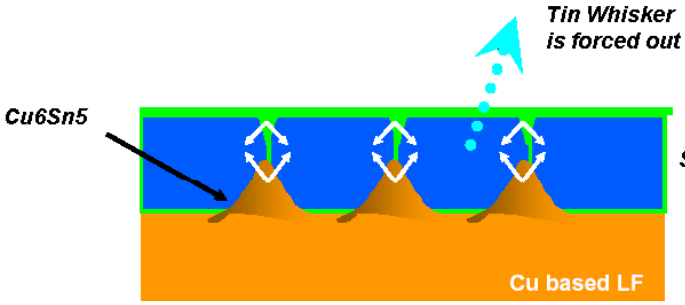
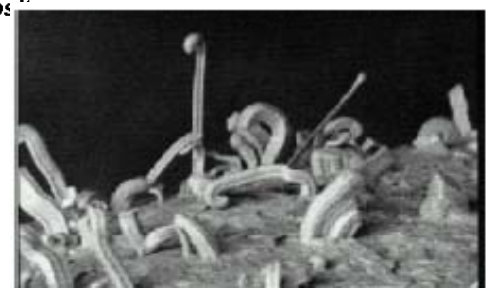
Surface Finishes

Tin Whiskers

Whiskers grow because of compressive stress in the plating which is caused by irregular growth of intermetallics



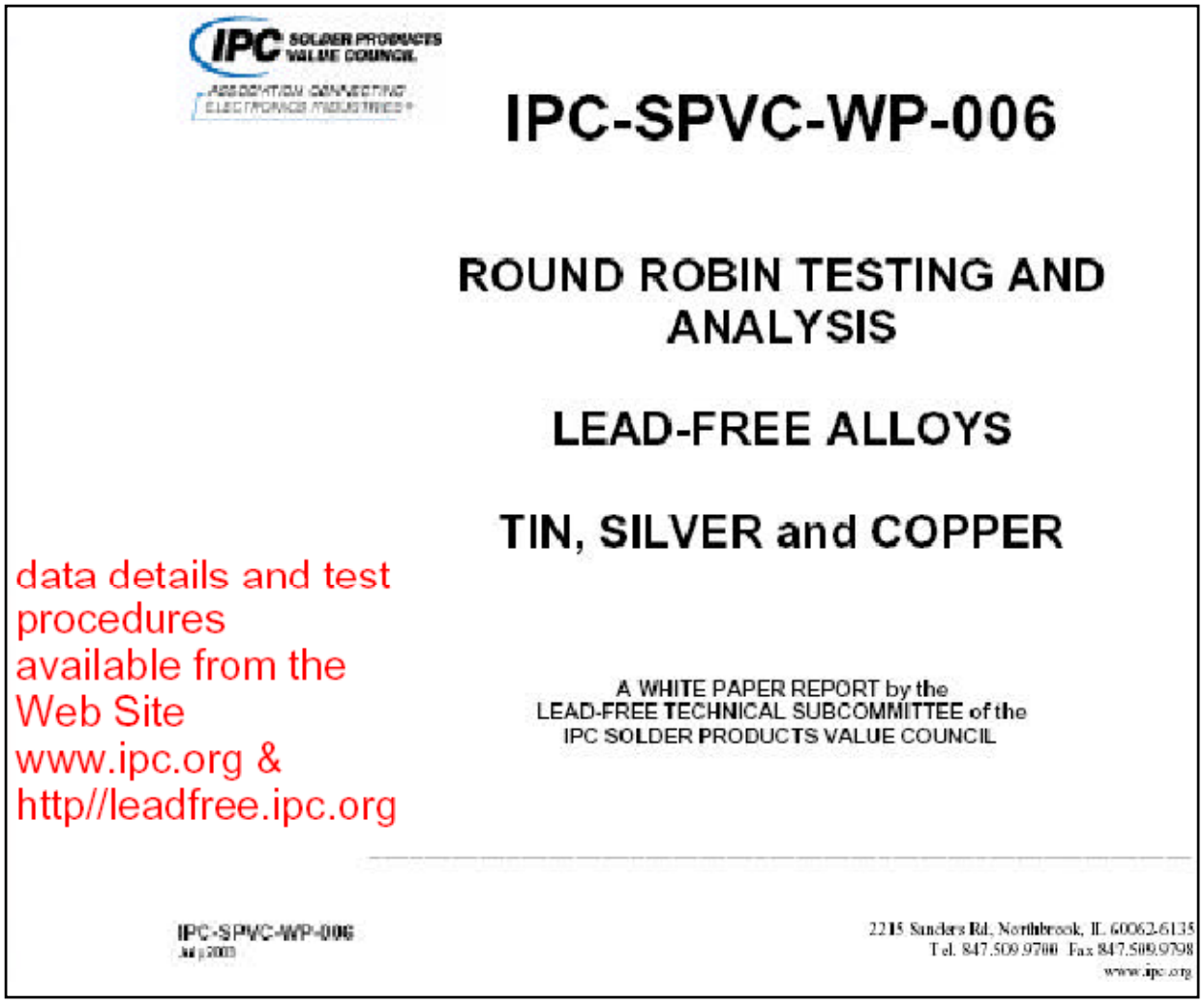


Problems with Tin Whiskers

A number of government and industry alerts have been issued relating to whiskers for aerospace, defense and medical industries. Tin Whiskers can contribute to a number of potential
problems in electronic hardware.
These problems include:

- *Permanent short circuits*
- *Transient short circuits*
- *Metal vapor (plasma arc in a vacuum)*
- *Debris / contamination*

IPC Lead-Free Alloy Testing



data details and test procedures available from the Web Site www.ipc.org & http//leadfree.ipc.org

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Quality Assurance

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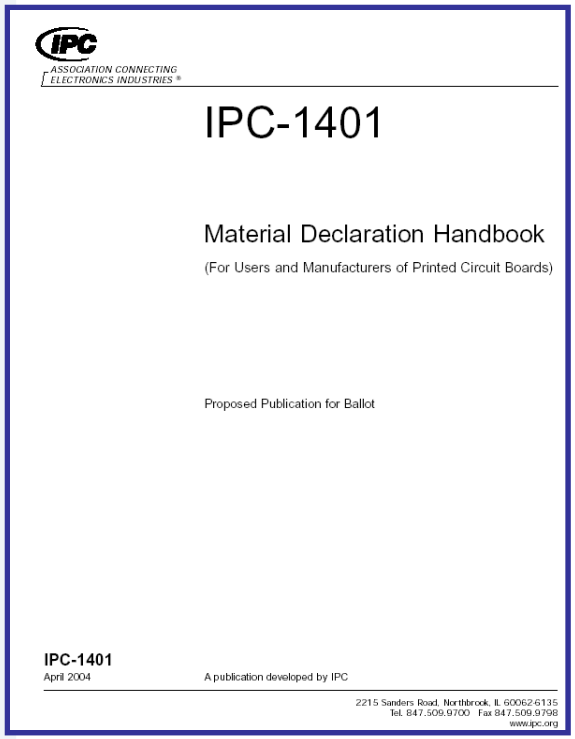
Raw PWB Materials Declaration (Sample)



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IPC-1401

Material Declaration Handbook

(For Users and Manufacturers of Printed Circuit Boards)

Proposed Publication for Ballot

IPC-1401
April 2004

A publication developed by IPC

2215 Sanders Road, Northbrook, IL 60062-6135
Tel. 847.509.9700 Fax 847.509.9798
www.ipc.org

APPENDIX A3 – SPECIFIC MATERIAL DATA

Customer: _____
Customer Part Number: _____
Your Part Number: _____

Where Used	Substance	Substance Wt. (grams)	Substance %	Substance (ppm)
Metal Conductors	Arsenic	0.15	0.012	118
	Chromium VI	0.00	0.000	0
	Copper	304.20	23.930	239,296
	Copper Phosphide	0.03	0.002	24
	Zinc	0.00	0.000	0
Reinforcement	SiO_2	284.86	22.408	224,082
	CaO	105.50	8.299	82,990
	Al_2O_3	73.85	5.809	58,093
	B_2O_3	39.56	3.112	31,119
	MgO	13.19	1.038	10,376
	Na_2O/K_2O	2.64	0.208	2,077
	Remainder	7.92	0.623	6,230
Resin	Bromine	72.71	5.720	57,197
	Chlorine	0.10	0.008	79
	Epoxy	355.02	27.927	279,273
Soldermask	Epoxy	6.26	0.492	4,924
	SiO_2	4.53	0.356	3,563
Surface Finish	Tin	0.71	0.056	559
Totals		1271.23	100.000	1,000,000

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Stress Testing

Used to evaluate the effects of high temperature soldering PCB structure

Types:

- *Air–to-Air*
- *Interconnect Stress Test (IST)*
- *Highly Accelerated Thermal Shock (HATS)*
- *Reflow Oven*

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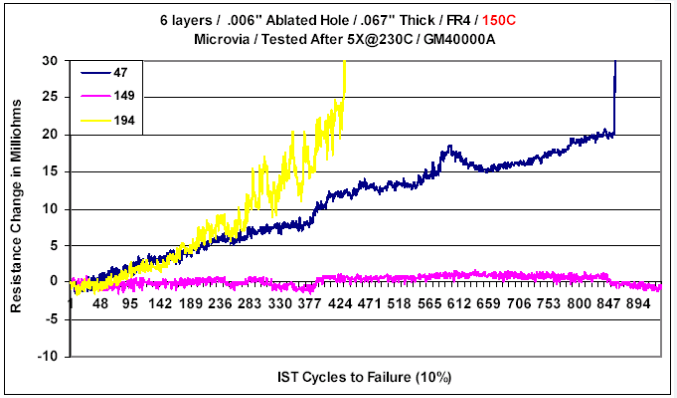
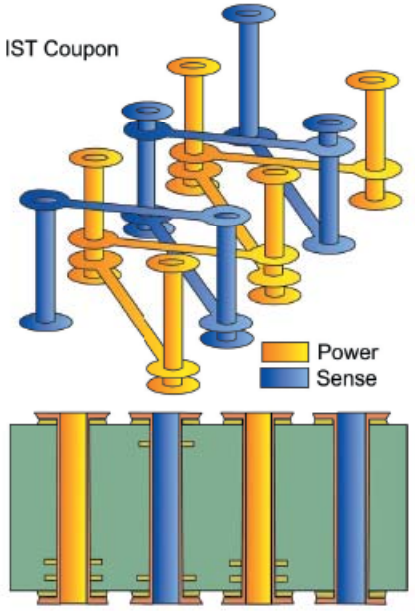
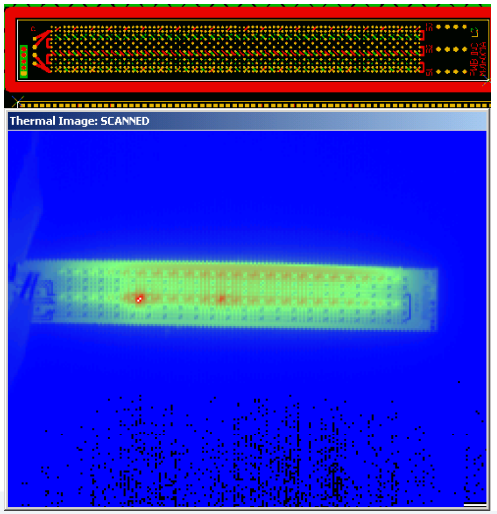
Interconnect Stress Test (IST)

The method uses the copper circuits (both traces and vias) integrated into the DUT as direct-current heating elements, and is cooled to ambient temperature with circulated air.







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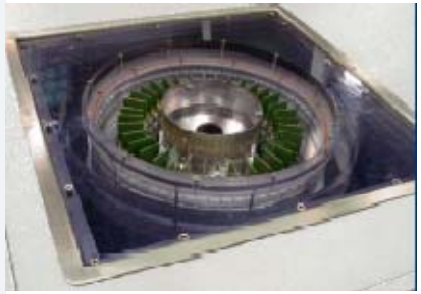
Highly Accelerated Thermal Shock (HATS)

The test uses a single chamber in which high volume hot and cold air pass stationary samples.



Chamber

Wired Modules

Stress Testing

HATS	IST
Range: -60 to 160°C	Range: 25°C minimum
Heating Method: air	Heating Method: DC current
36 coupons	6 coupons
4 nets each	2 nets each
144 nets total	12 nets total
Coupon emulates PCB design	Coupons with special heating nets
Typical cycle time: 3.5 min. from 25 to 150°C 6 min. from -45 to 150°C	Typical cycle time: 3 min. from 25 to 150°C

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Stress Testing

Preconditioning using reflow oven is the most accurate assessment of survivability!

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Assembly Issues

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Marking Standardization

Suggested marking per IPC-1066

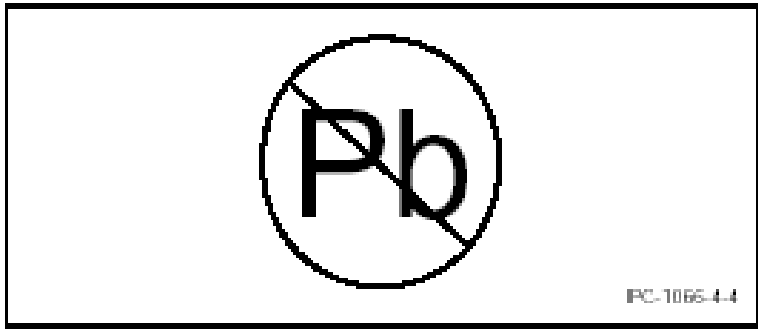

Figure 4-4 Pb-Free Symbol

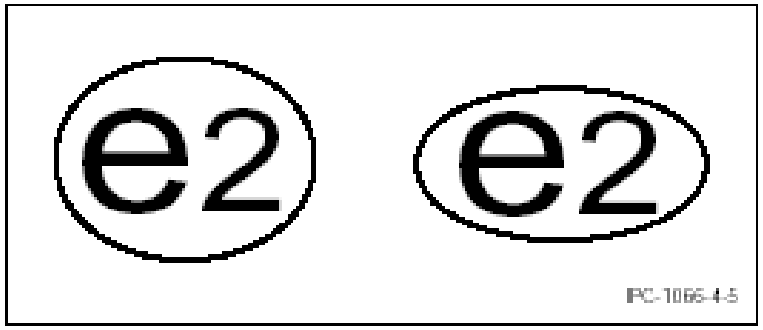

Figure 4-5 Example of Mark Showing Category 2 and Option of Circle or Ellipse

5 LABELING CATEGORIES

5.1 Solder Finish Categories The following categories are meant to describe the Pb-free 2nd level interconnect (see Figure 4-5) terminal finish/material of components and/or the solder paste/solder used in assembly.

e1 – SnAgCu
e2 – Other Sn alloys (ie. SnCu, SnAg, SnAgCuX, etc.) (No Bi or Zn)
e3 – Sn
e4 – Precious metals (ie. Ag, Au, NiPd, NiPdAu, but no Sn)
e5 – SnZn, SnZnX (no Bi)
e6 – Contains Bi
e7 – Low temperature solder (<150°C) containing indium but no bismuth

e8, e9 symbols are unassigned categories at this time.

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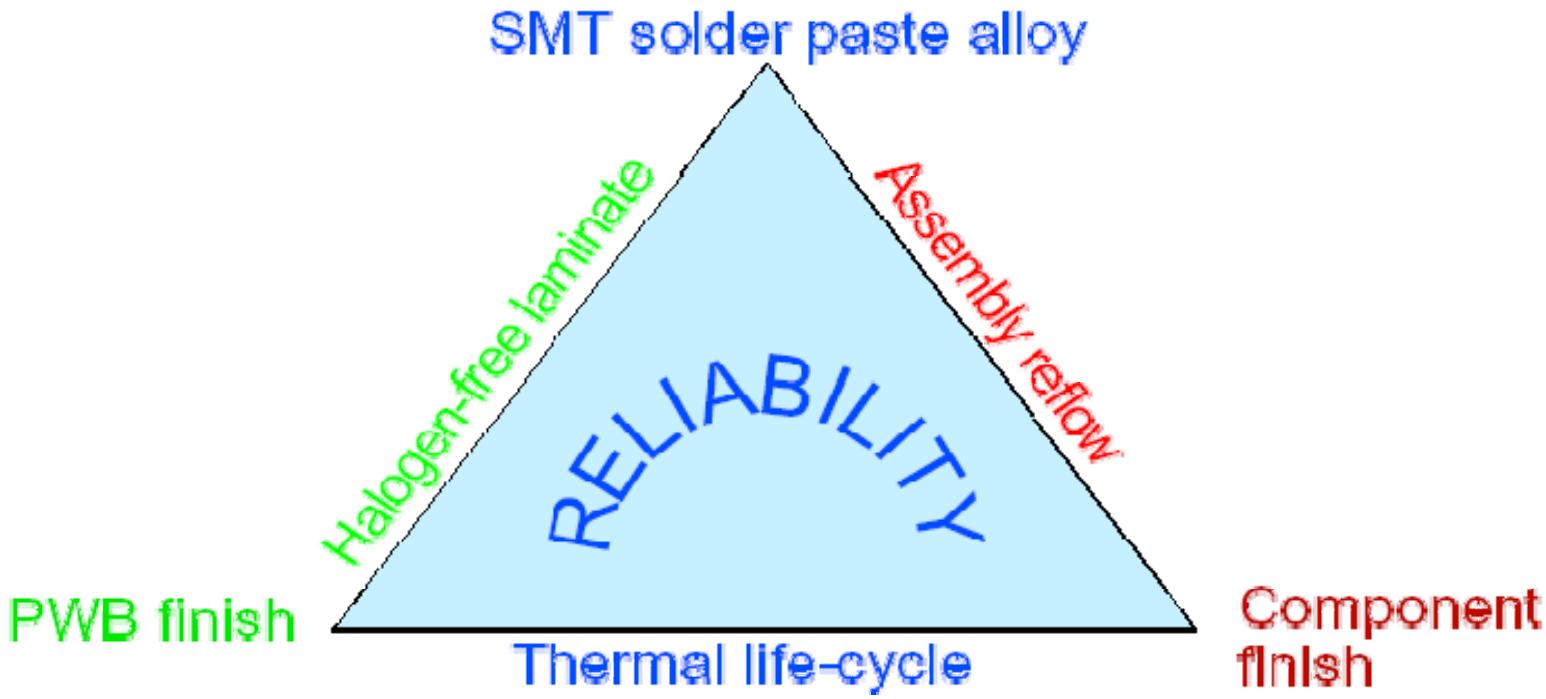
Lead Free Assembly Issues



The final solder joint alloy could be very unpredictable.
Who pays for the failures could end up with a lot of finger pointing

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Lead Free Assembly Issues

Reflow Process Window

With Tin-Lead: melting point = 183C
lower temp limit for reflow = 200C
upper temp limit for reflow = 235C
process window = over 30C

With 95.6Sn-3.7Ag-0.7Cu: melting point = 217C
lower temp limit for reflow = 235C
upper temp limit for reflow = 260C
process window = 25C

High temperatures can lead to many new problems: component cracking and "popcorning", laminate measling & delamination, stress on thru-holes, second-side oxidation and non-wetting and intermetallic growths. The lower the temperature, the better!

source: Assembly, Dec.2003

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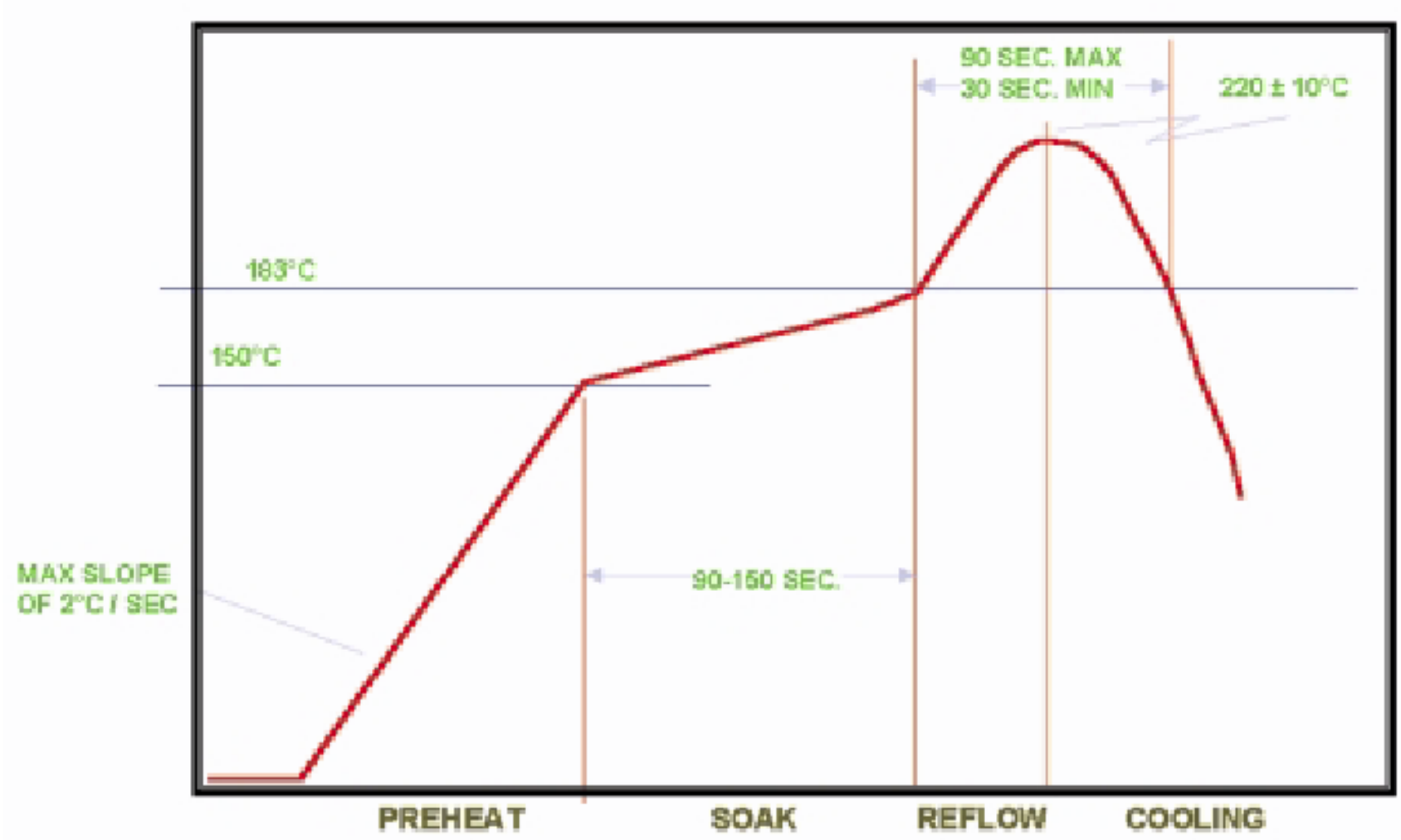
Typical Soldering Profile



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Lead Free Assembly Issues

- *Wetability*
- *Joint appearance*

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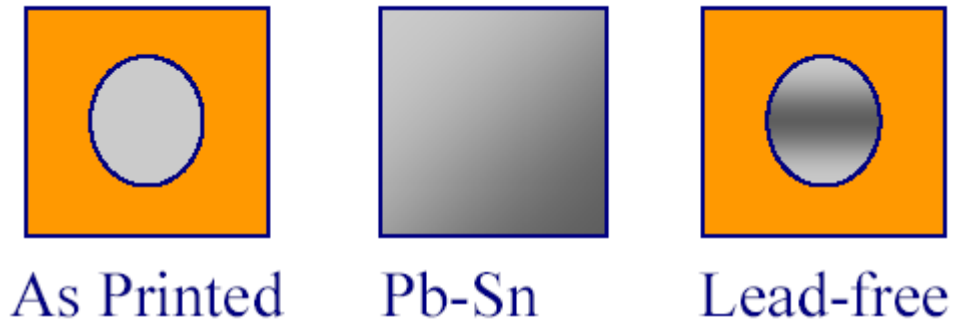
Lead Free Assembly Issues

Wetability

- *Lead-free solders do not spread during reflow*
- *Dependant upon Surface Finish*



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Placement Issues

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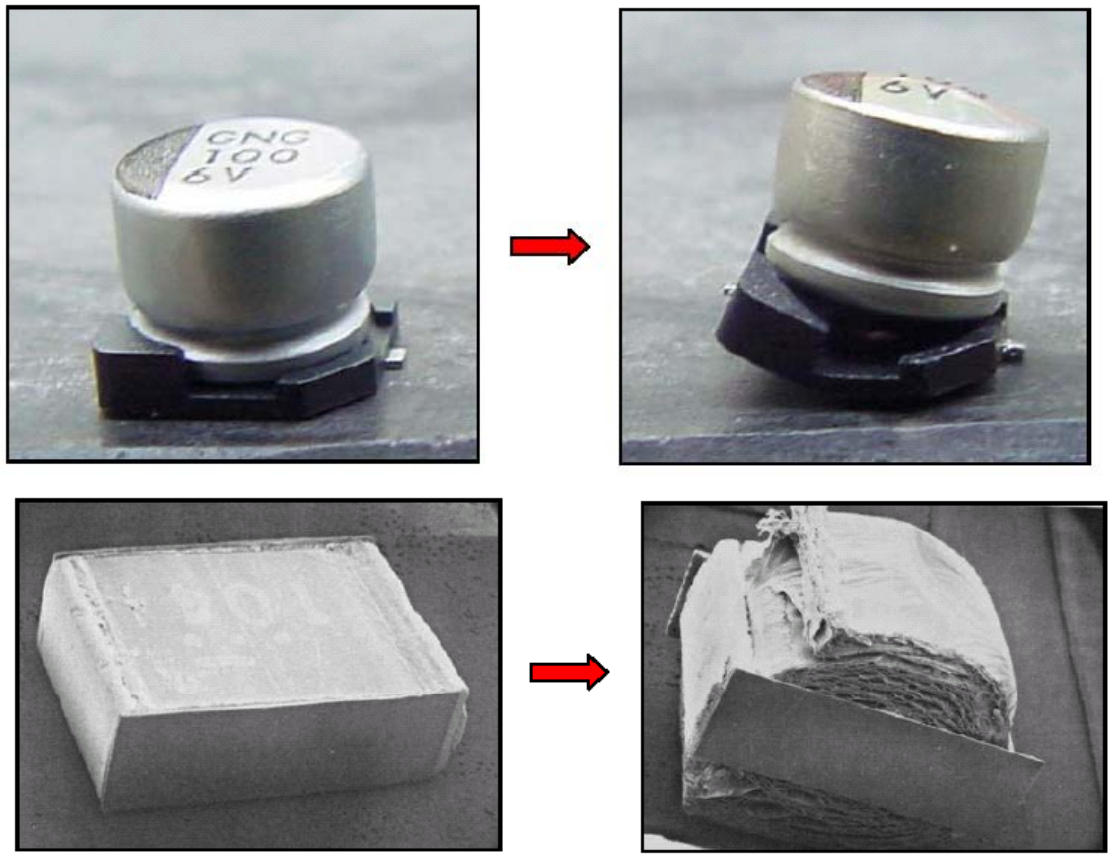
Placement Issues

- *Decoupling caps placed next to large thermal masses, such as BGAs with SAC alloy balls and heat sinks, are subject to much greater heat profiles !*
- *Becomes a major decoupling issue for high speed applications*

Lead Free Assembly Issues

Component Damage



Pictures: Philips

225° C

250° C

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Component Selection

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Component Selection

- *Typical Component Lead Free finishes:*
  - *Tin (Sn)*
    - *8 – 12 microns typical thickness*
    - *Some manufacturers anneal right after plating*
  - *Tin/Bismuth (SnBi)*
  - *Nickel/Palladium/Gold (NiPdAu)*
- *Tested to Proposed NEMI and JEDEC Standards*
  - *JESD22A121*
- *Tin Whiskers*
  - *Some growth allowed under certain conditions*

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Component Selection

Each component would need the following information:

- *MSL testing for non-hermetic sealed plastic parts (J-STD-020C)*
- *Testing Data is needed to 260^{0}C peak*
- *High temperature Storage data (JEDEC 22-A103-B)*
- *Tin whisker testing*
- *Maximum reflow temperature rating*
- *Solderability Test with tin-lead and lead free solder (J-STD-002B)*

ROHS compliant:

- *Lead, Mercury, Hexavalent Chromium, PBB, PBDE < 0.1 wt%,*
- *Cadmium < 0.01wt%*

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Component Selection

- *Mechanical Hardware*
  - *Screws, nuts, washers*
  - *Mounting brackets*
  - *Card extractors*
  - *Roll pins*
  - *Etc.*

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Lead Free Assembly Issues - Summary

For a robust lead free process consider the following

- *solder used*
- *board surface finishes*
- *components and lead finishes*
- *printing process (stencil)*
- *reflow soldering*
- *wave soldering*
- *cleaning*
- *rework and repair*

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Master Drawing Notes

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MATERIAL:

LAMINATE GLASS FIBER EPOXY FLAME RETARDANT PER IPC-4101/126, 170^{O}C Tg MINIMUM, AS TESTED TO IPC-TM-650, 2.4.24C (TMA). DECOMPOSITION TEMPERATURE 340^{O}C MINIMUM, AS TESTED TO IPC-TM-650, 2.4.24.6. A T288 DELAMINATION TIME OF 35 MINUTES MINIMUM, AS TESTED TO IPC-TM-650, 2.4.24.1C. A MAXIMUM THICKNESS EXPANSION OF 3% FROM 50 - 260^{O}C. PREPREG MATERIALS PER IPC-4101/126 SHALL MEET THE SAME REQUIREMENTS AS BASE MATERIAL. CONSTRUCTION IN ACCORDANCE WITH FIGURE 1.