IPC APEX 2012
San Diego, CA

PWB Stress Testing Correlation: Accelerated vs. Application – "The Round Robin Begins"

February 29, 2012

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PWB Stress Testing – Current Status?

12/10/10 Toronto – Reliability Meeting

The purpose of the meeting was to catalog as many issues as the attendees feel need to be addressed. This will include; end use environments, various constructions as well as different stress conditioning methods related to field exposure prediction. Once these issues were discussed an attempt would be made to organize them into a logical order which can be used to make recommendations or to identify technology gaps.

- **Reliability** is the ability to function as expected under the expected operating conditions for an expected time period without exceeding expected failure levels. Thus reliability is **Proof of Performance.**
- End item reliability can only be determined by the OEM.
- PWB Fabricators often have little or no visibility to end item requirements.

IPC BOX BUILD GUIDELINE BLOCKS

Testing Services (TM-650)

Box Build(IPC-630) & System

PCB(IPC-600)

PCBA(IPC610)

Components(?)

Cables & Harness (IPC-620)

Connectors(?)

Objective

PWB Stress Testing History

TR-579

1. Evaluate the performance of small diameter PTH under controlled environmental conditions
2. Evaluate the influence and thickness and the quality of the deposited copper on PTH performance
3. Determine the impact of varying PTH aspect ratios
4. Collect data on the influence of product design or manufacturing methods
5. Determine if test results from different military and industrial thermal shock procedures can be correlated.

Table 1 Conditions of Thermal Cycling Tests

Test	Temperature Range	Duration
MIL-T-CYCLE	-65°C to +125°C	400 cycles
COM-T-CYCLE	0°C to +100°C	1000 cycles
IEC OIL-T-SHOCK	+25°C to +260°C	10 & 30 cycles
APD OIL-T-SHOCK	-35°C to +125°C	400 cycles
FLUID SAND-T-SHOCK	+25°C to +260°C	30 cycles

Objective

PWB Stress Testing History

Worst-case use environment							
Use category	Tmin °C	Tmax °C	ΔT°C	t_D hrs	Cycles/ year	Typical years of service	Approx. accept. failure risk %
1) Consumer	0	+60	35	12	365	1-3	1
2) Computers	+15	+60	20	2	1 460	5	0.1
3) Telecom	-40	+85	35	12	365	7-20	0.01
4) Commercial aircraft	-55	+95	20	12	365	20	0,001
5) Industrial & automotive Passenger Compartment	-55	+95	20 &40 &60 &80	12 12 12 12	185 100 60 20	10	0.1
6)Military Ground & ship	-55	+95	40 &60	12 12	100 265	10	0.1
7) Space leo geo	-55	+95	3 to 100	1 12	8 760 365	5-30	0.001
8)Military avionics a b c	-55	+95	40 60 80 &20	2 2 2 1	365 365 365 365	10	0.01
9)Automotive under hood	-55	+125	60 &100 &140	1 1 2	1 000 300 40	5	0.1

Round Robin Reliability Evaluation “Revival” Proposal

1. TR-579
2. IST(IPC-9151/TM 2.6.26)
3. HATS (IPC-9151)
4. CITC(EIT)
5. TS(TM650-2.6.7.2B, MIL31032/1C)
6. Application(Odometer)

Objective

PWB Stress Testing History

Scope of work Beyond TR-579 ?

1. Correlation of accelerated tests with end use Application?
2. Designer considerations enhanced ?
3. Evaluate the performance of PWB under controlled environmental conditions?
4. Evaluate the influence PWB and/or Coupon characteristics on performance?
5. Collect data on the influence of product design or manufacturing methods?
6. Determine if accelerated test results (i.e., IST, HATS, CITC, and TS) can be correlated?

Objective

PWB Stress Testing History

Scope of work

The validation of IPC-TM-2.6.26 (IST), IPC-9151(HATS), EIT (CITC) , and Thermal Shock (IPC-TM650-2.6.7.2B, but 31032/1C [4.7.6.3]) via correlation to in service PCB field life testing as applied to high reliability applications(i.e., 100K+ miles) such as Locomotives , Automotive, Off Highway Vehicles , Buses, and Tractor Trailers.

Objective

PWB Stress Testing History

Location of the work volunteers?

Define who will provide the IST , HATS , CITC, and TS coupon testing.

- IST NWSC Crane
- HATS at CATS
- CITC EIT
- TS NWSC or DRTL
- DRTL will provide material analysis and reporting of the test coupons
- DRTL coordinate PCB test vehicle life testing.

Objective

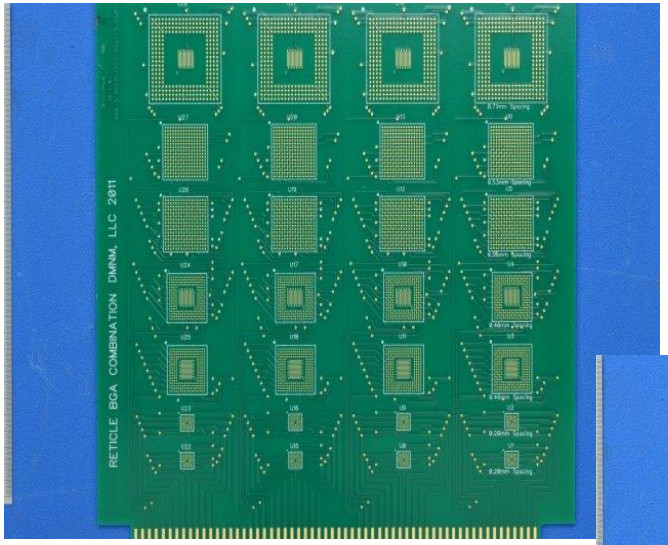
PWB Stress Testing History

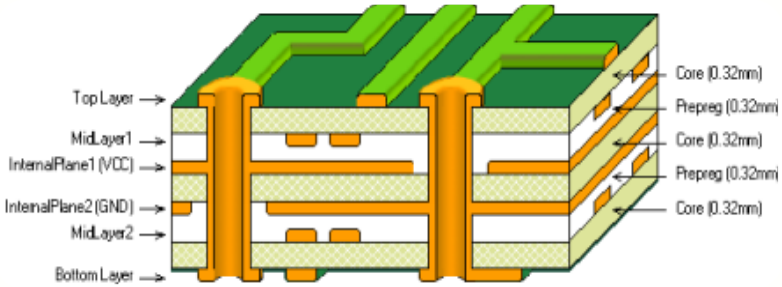
Revival Call for Participants & Support

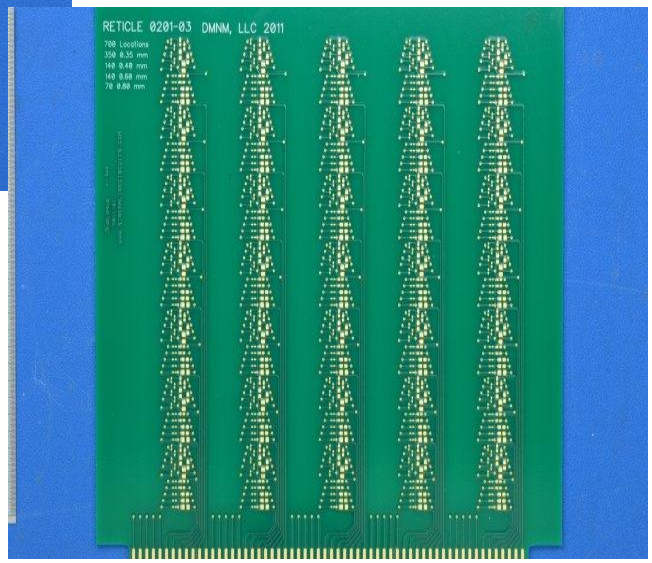
- IPC
- IEC Electronics
- Dynamic Research and Testing Laboratories(DRTL)
- PWB *Interconnect*
- NWSC
- Locomotive
- Caterpillar
- Automotive
- Long Haul Trailer
- Oil & Mining

Objective

PWB Stress Testing History







Coupon Deigns?

Objective

PWB Stress Testing History

Period of performance

The start and finish date for the project will require minimum of 6 months and maximum of 12 months for in service PCB test vehicle life testing.

Objective

PWB Stress Testing History

Deliverables schedule

One, six, and twelve months from the start date the following reporting deliverables will be issued.

- Preliminary IST, HATS, CITC and thermal shock baseline DRTL PCB analysis test coupon report will be published for reference.
- The baseline analysis test coupon report will reflect performance data from DOE utilizing a single PCB supplier, surface finish, laminate, 6X preconditioning utilizing define target temps(i.e., leaded or lead-free world), thickness, & Ionics.
- Coupons TBD (PTH , Buried, Blind vias to standardize)
- Laminate
- Copper and copper thickness
- Interconnect structures
- Stack-up combinations
- Assembly process exposures
- Field exposure

Objective

PWB Stress Testing History

Specialized Requirements

IST / CITC Test Parameters:
500 , 1000, 2000 cycles
6X Preconditioning @ 260C
Ambient to 190C

HATS Test Parameters:
500 cycles to 1000 cycles
Profile 260C
-40 to 145C
-60 to 160C
30s transition time

Product Application per end use					
End-use Environment	A-Interposer	B-Module	C-Portable	D-Product	E-Back Plane
1-Consumer	6X260°C	6X260°C	6X230°C	6X230°C	6X260°C
2-Computers and Peripherals	6X260°C	6X260°C	6X260°C	6X260°C	6X260°C
3-Telecomm	6X260°C	6X260°C	6X260°C	6X260°C	6X260°C
4-Commercial Aircraft	6X260°C	6X260°C	6X260°C	6X260°C	6X260°C
5-Industrial and Automotive Passenger Compartment	6X260°C	6X260°C	6X260°C	6X260°C	6X260°C
6-Military (ground and shipboard)	6X230°C	6X230°C	6X230°C	6X230°C	6X230°C
7-Space	6X230°C	6X230°C	6X230°C	6X230°C	6X230°C
8-Military Aircraft	6X230°C	6X230°C	6X230°C	6X230°C	6X230°C
9-Automotive (under hood)	6X260°C	6X260°C	6X260°C	6X260°C	6X260°C
10- Bio Medical & Life support	6X230°C	6X230°C	6X230°C	6X230°C	6X230°C

Thermal Shock Parameters:
Cycles 100
Temperature extremes -65˚ C and 125˚ C
Dwell time at temperature extremes 15 minutes
Failure threshold 10% resistance increase from first high temperature dwell
(method from TM650 2.6.7.2B, but 31032/1C [4.7.6.3] modified)

Solder Shock?

PWB Test Plan Defined

Analytical

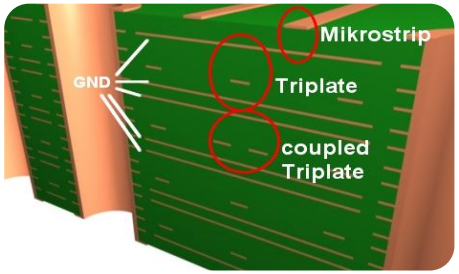
- External Visual
- Internal Visual
- X-ray
- XRF
- SEM
- EDX/EDS
- FTIR/TGA
- Ion Chromatography(2.3.28)
- Solderability
- Environmental Stress Test
- Thermal Shock

Evaluation – Techniques for Reporting
PWB Stress Testing

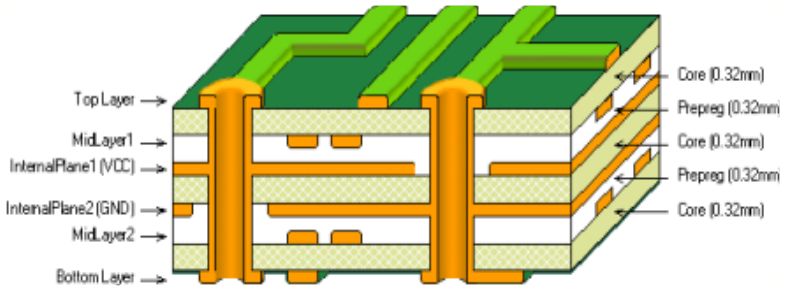
IEC Electronics Assembly(PCB, PCBA, and Components) Cleanliness Specification									
			PCBA	PCBA	PCBA	PCBA			
Ions	ID	PCB	Lead(Pb) -Free No Clean	Lead(Pb)-Free Clean	Lead(Pb) No Clean	Lead(Pb) Clean	Component	HW	Failed
Sodium	Na+	1	2	2	2	2	1	1	3
Potassium	K+	1	2	2	2	2	1	1	2
Calcium	Ca++	0	0	0	0	0	0	0	0
Lithium	Li+	0	0	0	0	0	0	0	0
Magnesium	Mg++	0	0	0	0	0	0	0	0
Ammonium	NH4+	<2.5	2	2	2	2	<2.5	<2.5	4
Acetate	CCOO-	0	3	3	3	3	3	3	4
Formate	COO-	0	1	1	1	1	1	1	4
Bromide	Br-	2	5	5	5	5	5	5	8
Chloride	Cl-	2	3	3	3	3	2	2	4
Fluoride	F-	<1	1	1	1	1	2	<1	1
Nitrate	NO3-	0	3	3	3	3	0	0	3
Nitrite	N02-	0	3	3	3	3	0	0	3
Sulfate	SO4-	0	3	3	3	3	<1	2	4
Phosphate	PO3-	0	3	3	3	3	0	0	4
Citrate	Citrate	0	2	2	2	2	0	0	2
WOA	SMT	25	25	25	25	25	25	0	25
WOA	Wave	0	150	25	150	25	0	0	150
MSA	MSA	<0.5	0	0	0	0	<0.5	<0.5	1
Totals		5	20	20	20	20	12	12	30

Note – Halogen Free ?

Evaluation – Techniques for Reporting
PWB Stress Testing

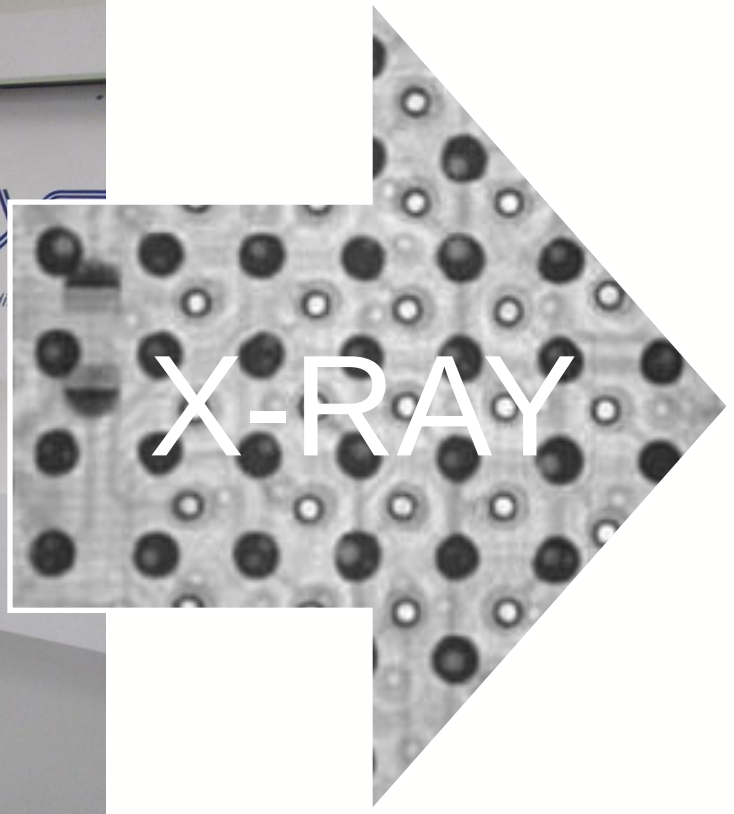


Optical Microscopy

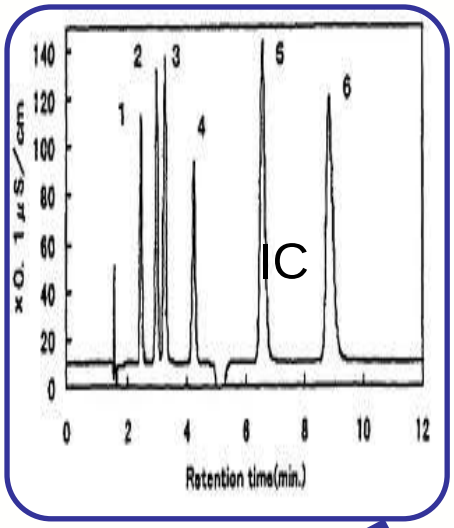


Evaluation – NDT Techniques for Reporting

PWB Stress Testing



Evaluation – Chromatography Techniques for Reporting *PWB Stress Testing*

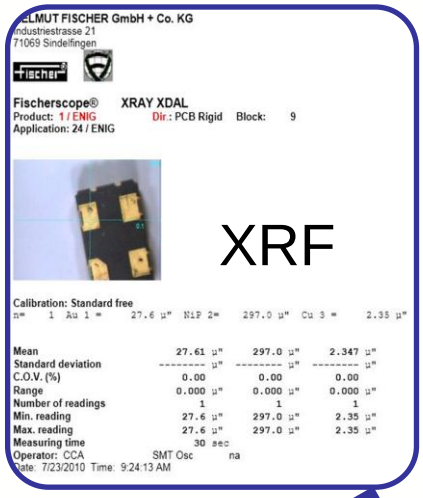


Anions

CATIONS

Evaluation – Elemental Techniques for Reporting

PWB Stress Testing

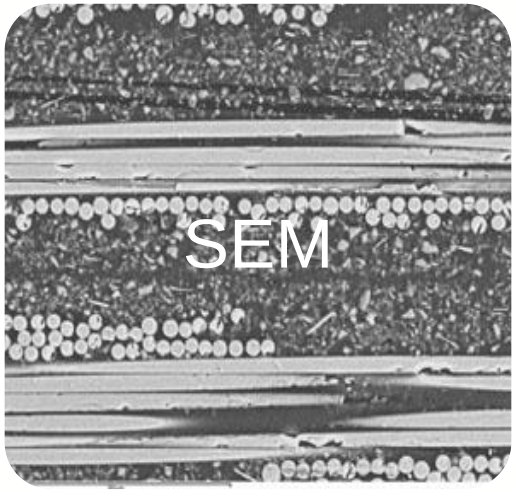


ENIG

ENEPIG

Evaluation – Elemental Techniques for Reporting

PWB Stress Testing

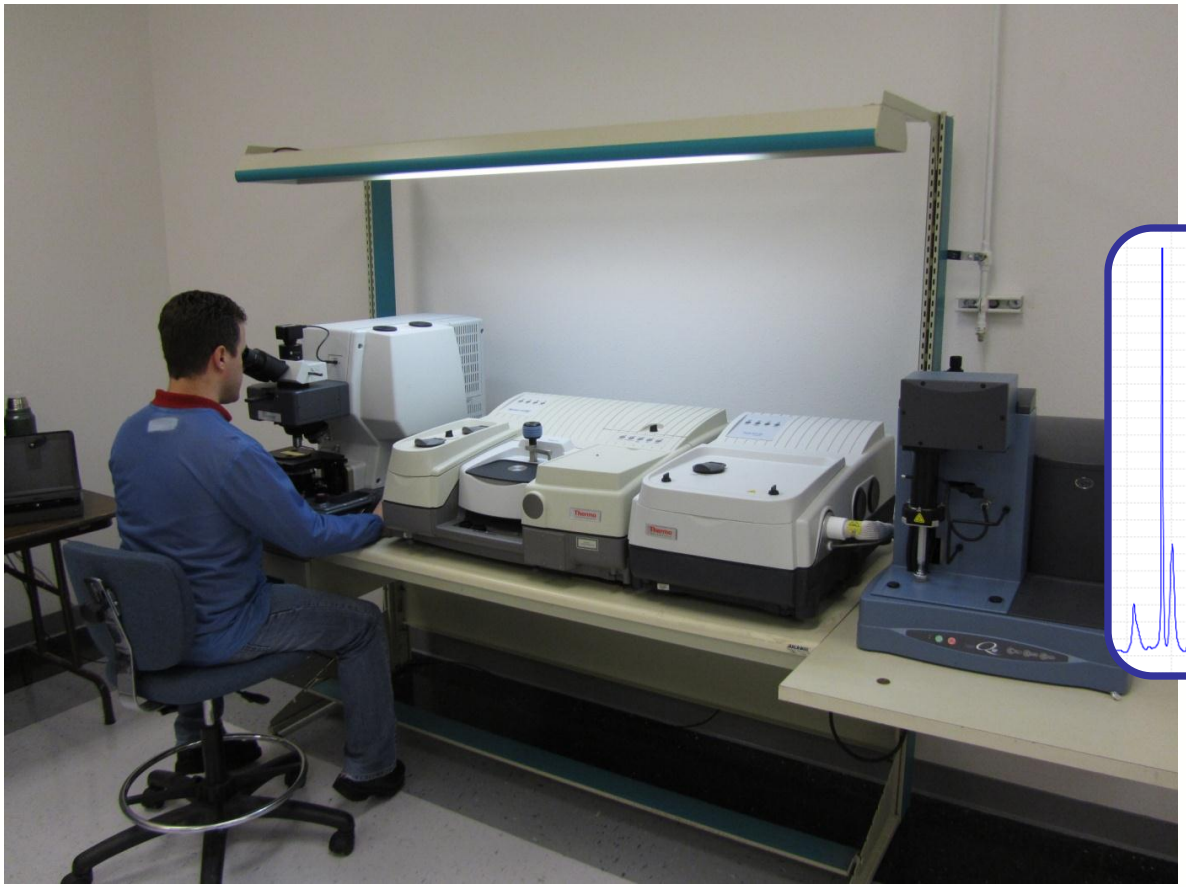


EDX

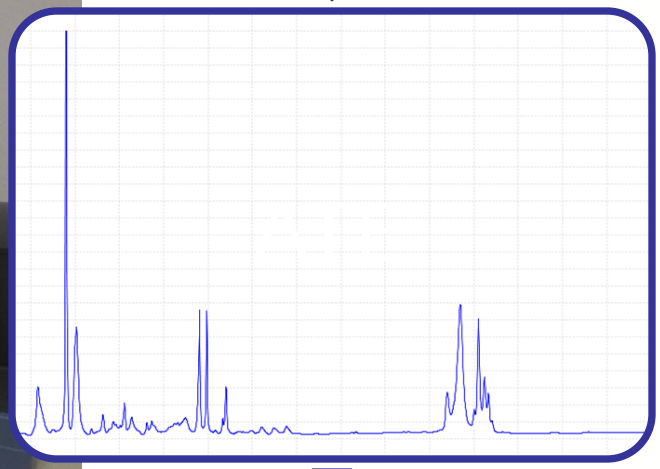
BSE

Evaluation – Organic Techniques for Reporting

PWB Stress Testing



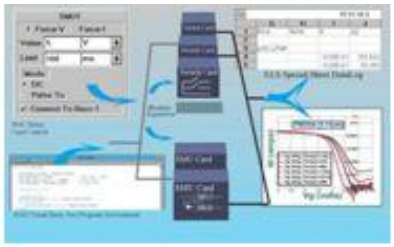
FTIR



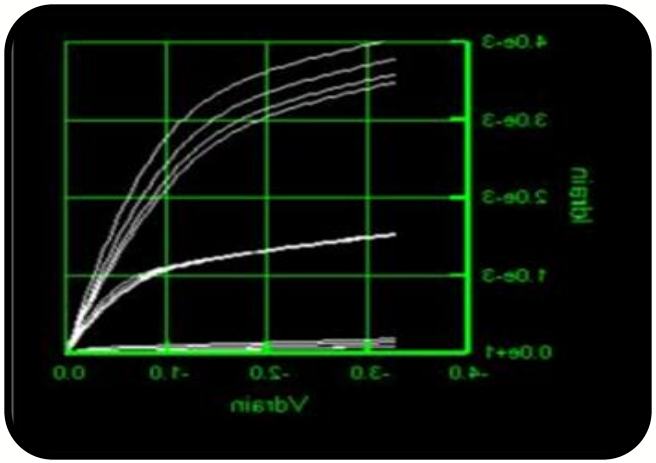
TGA

Evaluation – Electrical Techniques for Reporting

PWB Stress Testing



Analog

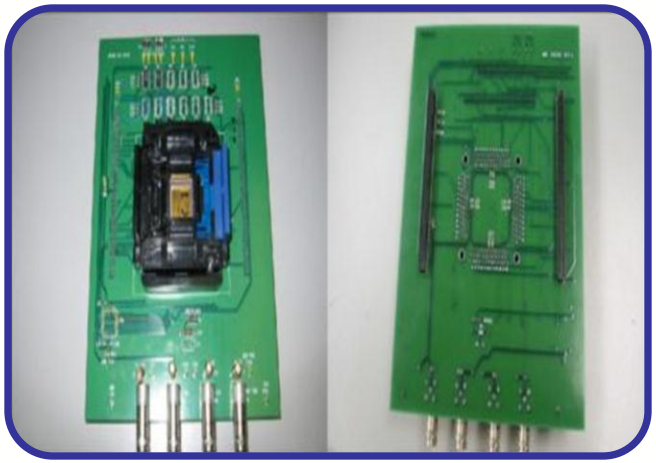


Digital

Evaluation – Techniques for Reporting

PWB Stress Testing

HAST

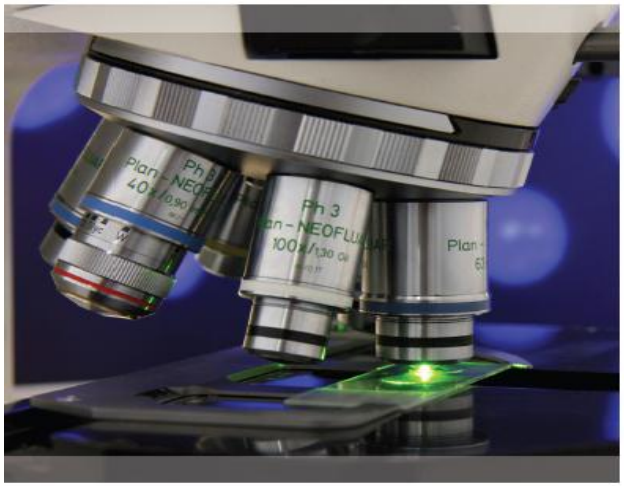


THERMAL CYCLE

Recommendations/Conclusions TBD

PWB Stress Testing

RESEARCH
AND TESTING
LABORATORIES, LLC



WWW.DRTLonline.com

PWB Stress Testing Actions

Deliverables Proposed:

1. Accelerated tests with end use application correlated or not
2. Designer considerations stated
3. The performance data of the PWB under controlled environmental conditions reported
4. PWB and/or Coupon characteristics influence performance stated relative to end use application
5. Product design or manufacturing methods recommendations
6. Accelerated test results (i.e., IST, HATS, CITC, and TS) correlated

PWB Stress Testing Update – Thank you !

Created By: Mark Northrup