IPC Get Interconnected.™ MIDWEST CONFERENCE & EXHIBITION

JCAA/JGPP Consortia Lead Free Solder Project: High Performance Use Environment Testing Program

Dave Hillman

Rockwell Collins

2007 IPC Fall Meeting

IPC ASSOCIATION CONNECTING ELECTRONICS INDUSTRIES®

IPC Get Interconnected.™ MIDWEST CONFERENCE & EXHIBITION

- **Agenda**
  - **<u>VERY</u> Short Consortia Background**
  - **Testing Program: Hybrids, CSPs and SMT R's & C's**
  - **The Next Phase: NASA DoD**

IPC Get Interconnected.™ MIDWEST CONFERENCE & EXHIBITION

Background

- **Consortia Goals:**
  - Generate reliability data for circuit cards manufactured and reworked with Pb-free solders and subjected to rigorous environmental exposure conditions.
  - Provide baseline data for aerospace and defense (high-performance) applications.

Key Question Being Addressed:

To what extent does Pb-free solder affect the solder joint reliability of high-performance electronics as compared to SnPb solder?

IPC Get Interconnected.™ MIDWEST CONFERENCE & EXHIBITION

Background

IPC
ASSOCIATION CONNECTING ELECTRONICS INDUSTRIES®

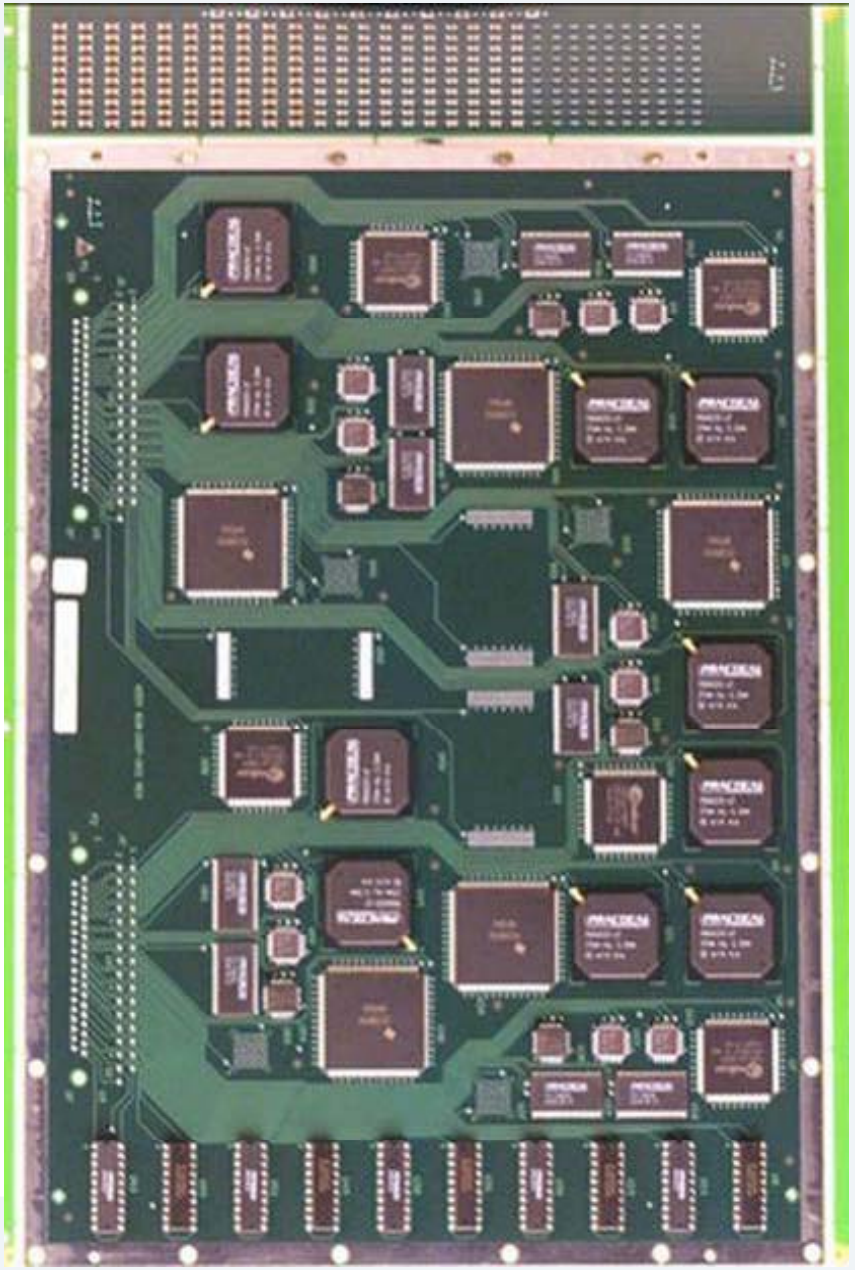
IPC Get Interconnected.™ MIDWEST CONFERENCE & EXHIBITION

Test Vehicle & Solder Alloys:

- **Sn3.9Ag0.6Cu (SAC) for reflow and wave soldering**
- **Sn3.4Ag1.0Cu3.3Bi (SACB) for reflow soldering**
- **Sn0.7Cu0.05Ni (SNIC) for wave soldering**
- **Sn37Pb (SnPb) for reflow and wave soldering**

- **Manufactured PWBs**
- **FR4 per IPC-4101/26 with a minimum Tg of 170°C with an immersion silver surface finish.**

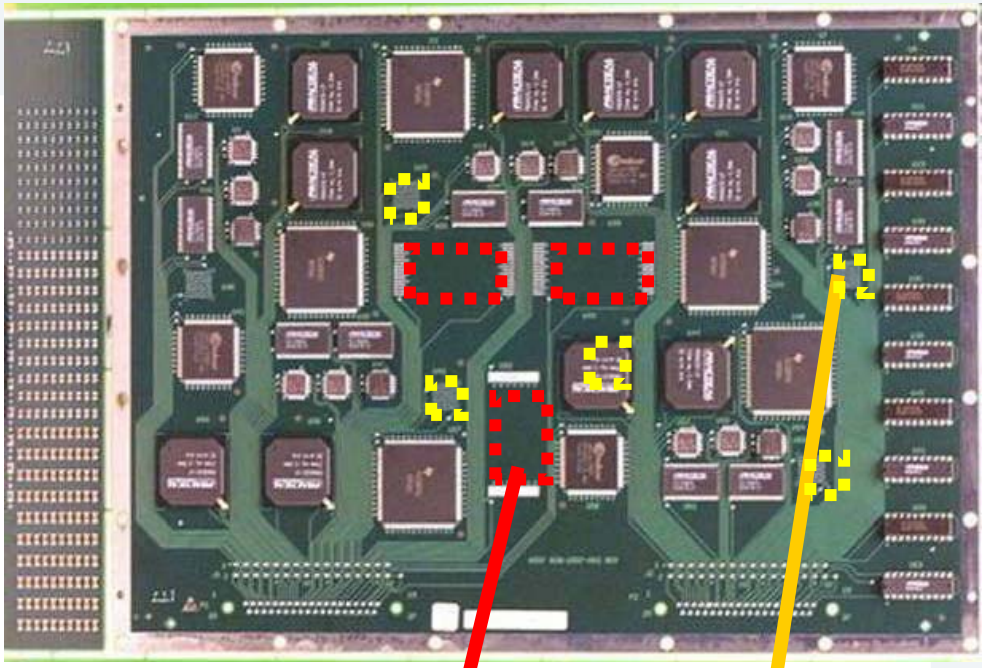
- **Reworked "Legacy" PWBs**
- **FR4 per IPC-4101/21 with a minimum Tg of 140°C with a hot air, solder leveled (HASL) surface finish**



IPC ASSOCIATION CONNECTING ELECTRONICS INDUSTRIES®

Test		Performed By
Thermal Cycle -20°C to +80°C	IPC-SM-785	Boeing-Seattle
Combined Environments Test	MIL-STD-810F, METHOD 520.2, PROCEDURE I	Raytheon
Thermal Cycle -55°C to +125°C	IPC-SM-785	Rockwell Collins
Vibration	MIL-STD-810F, METHOD 514.5, PROCEDURE I	Boeing-Seattle
Mechanical Shock Test Set I & II	MIL-STD-810F, METHOD 516.5, PROCEDURE I	ACI
Thermal Shock	MIL-STD-810F, METHOD 503.3, PROCEDURE I	Boeing-Seattle
Salt Fog	MIL-STD-810F, METHOD 509.4	ACI
Humidity	MIL-STD-810F, METHOD 507.4	ACI
SIR	IPC-TM-650, METHOD 2.6.3.3	Boeing-Anaheim
EMR	IPC-TM-650, METHOD 2.6.14.1	Boeing-Anaheim
Characterization		Rockwell Collins

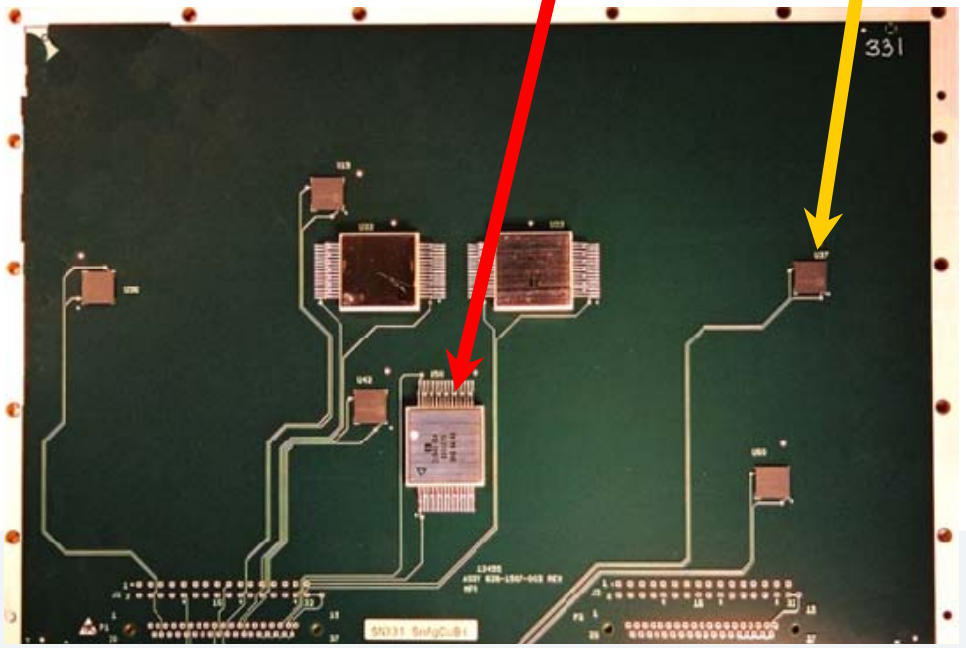
Primary test vehicle



Assemblies

- 119 Manufactured
- 89 Reworked (Legacy)
- 30 CSP and Hybrid

CSP & Hybrids test vehicle



Components

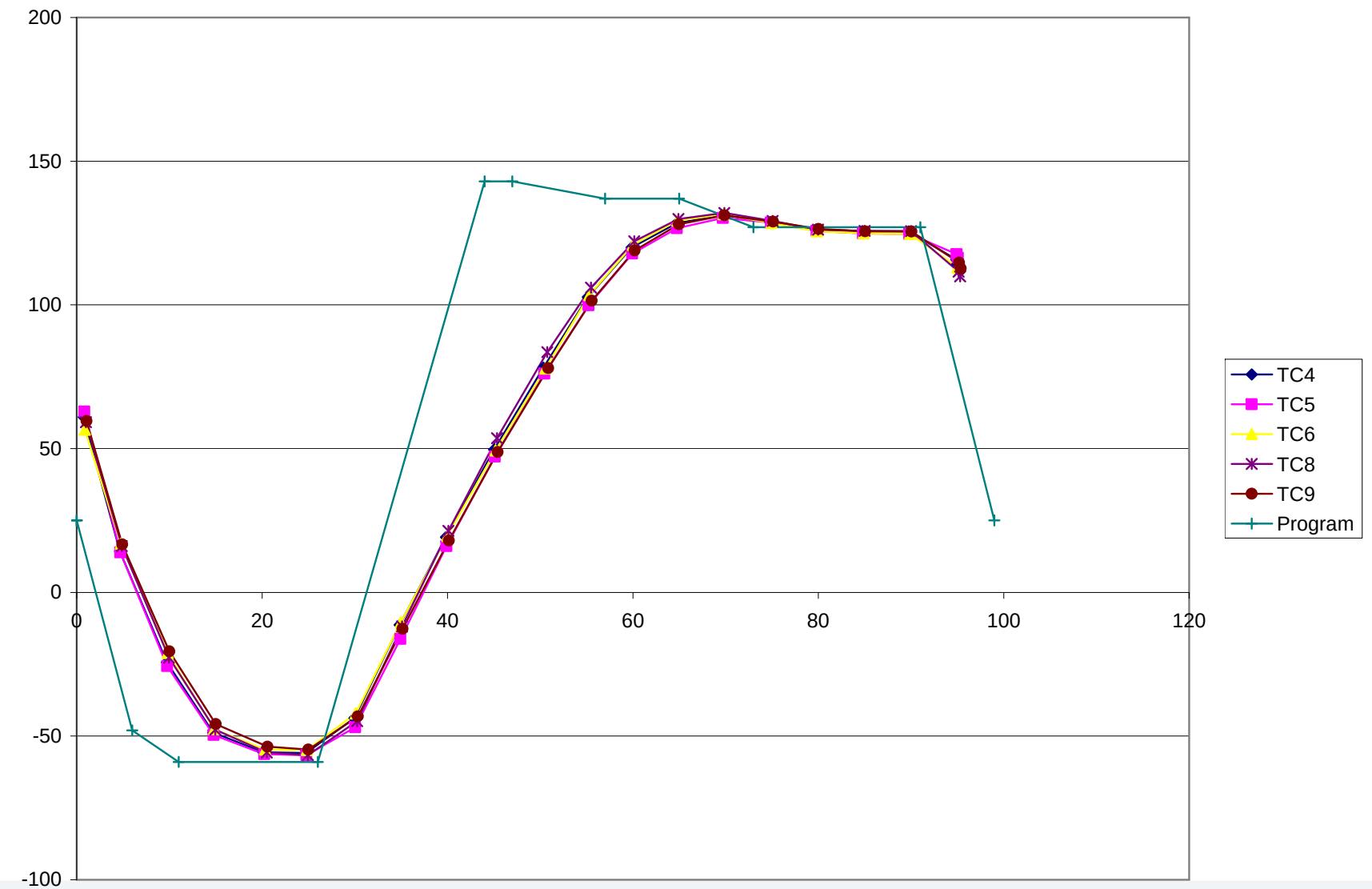
Component Type	Component Finish
Hybrid	SnPb
	SAC
	SACB
CSP	SnPb
	SnAgCu (SAC405)
0402 Capacitors	Sn
0805 Capacitors	Sn
1206 Capacitors	Sn
1206 Resistor	Sn

IPC Get Interconnected.™ MIDWEST CONFERENCE & EXHIBITION

Thermal Cycle Testing Methodology:

- In Accordance with IPC-9701
- Temperature Extremes: -55˚ C and +125˚ C
- Temperature Ramp: 5˚ C-10˚ C per minute maximum
- Temperature Dwells: 10 minutes @ -55˚ C & 30 minutes @ +125˚ C
- Continuous Monitoring with Event Detector:
  - An Event = channel resistance exceeded 300 Ω for longer than 0.2 μsec within a 30-second period
- A failure was defined when a component either:
  - 15 consecutive maximum resistance events,
  - 5 consecutive detection events within 10% of current life, or
  - Became electrically open

Testing Program



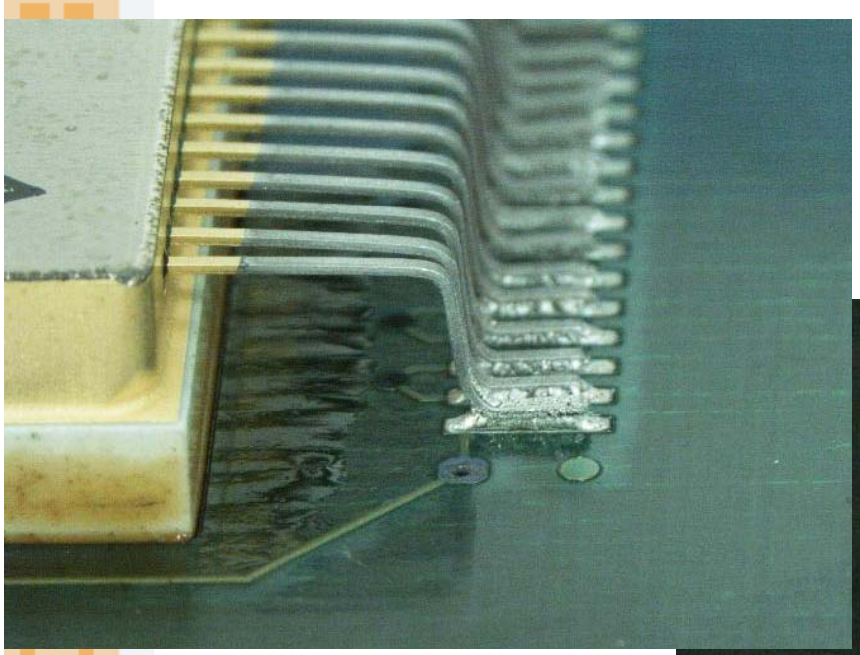
Thermal Cycle Results:

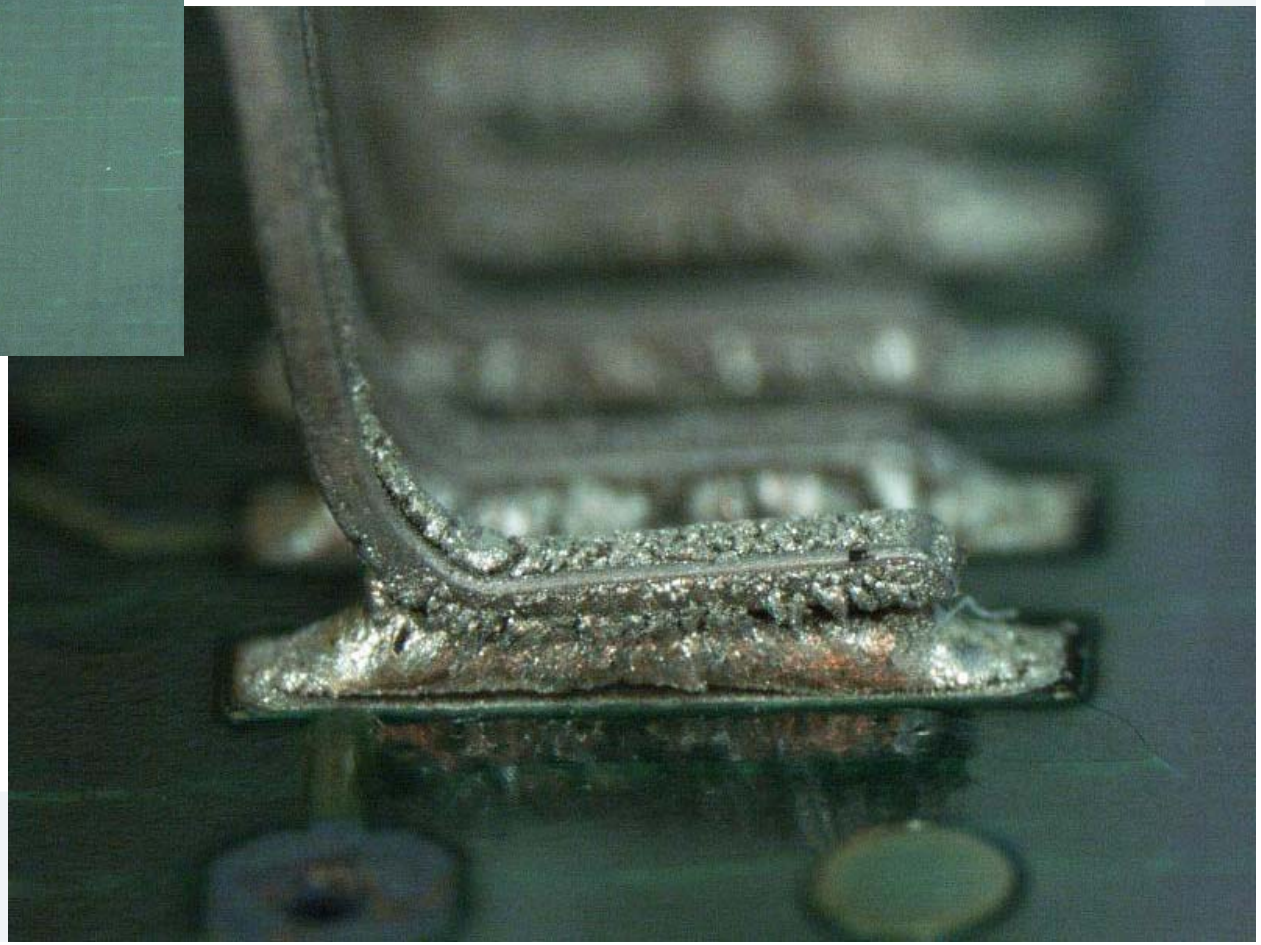
- **4698 Total Thermal Cycles Completed**
- **12 months of Testing !!!**

Component Type	Total Failures	Total Population	Percent Failed
Hybrid	4	45	8.8
CSP	74	74	100
SMT Resistor	107	170	63
SMT Capacitor	NA	NA	NA

IPC Get Interconnected.™ MIDWEST CONFERENCE & EXHIBITION

Failure Analysis Results: Hybrid Components

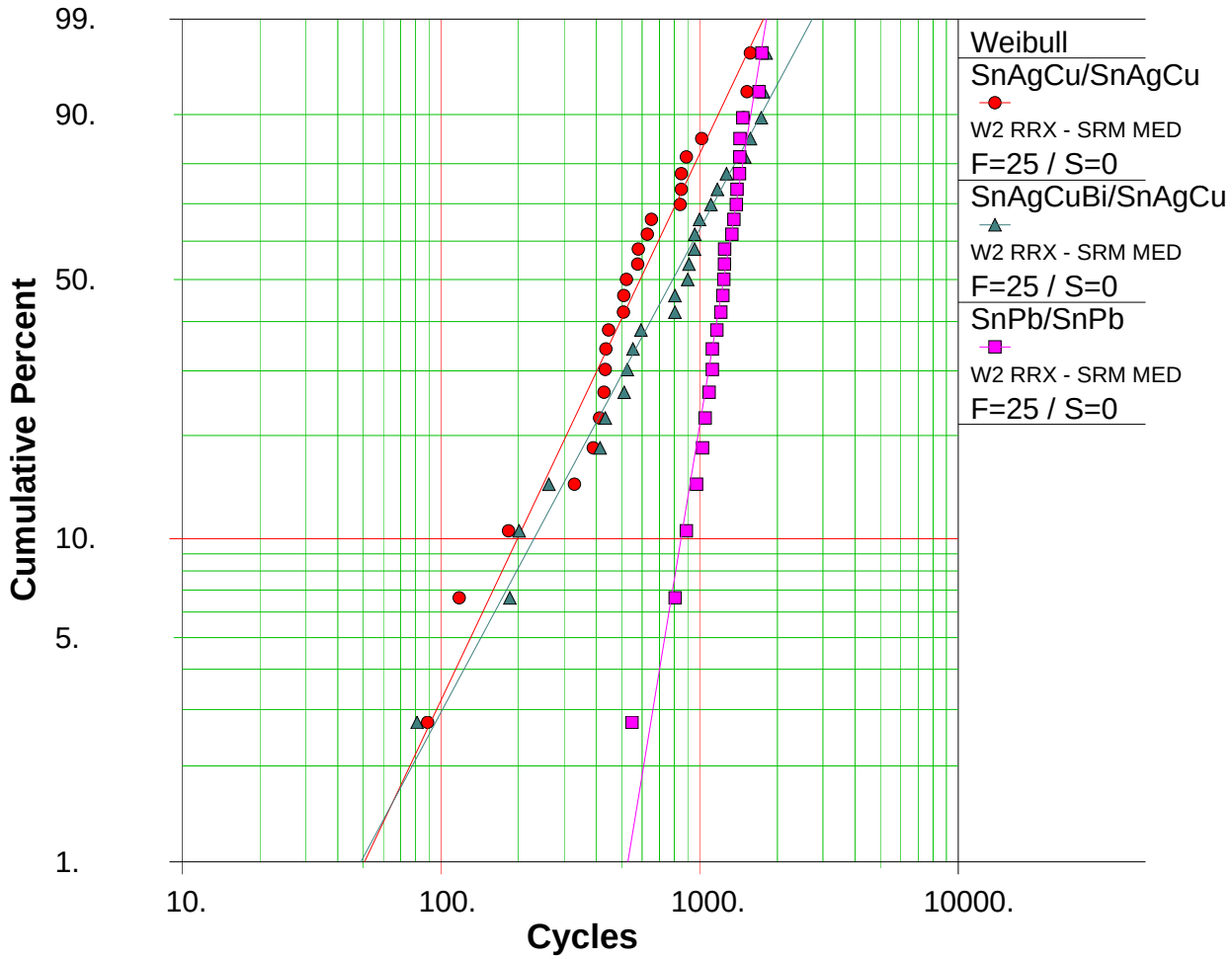




Test Vehicle 307
Hybrid U33, Tin/Lead Solder After 4478 Total Cycles

IPC ASSOCIATION CONNECTING ELECTRONICS INDUSTRIES®

Failure Analysis Results: CSP Components

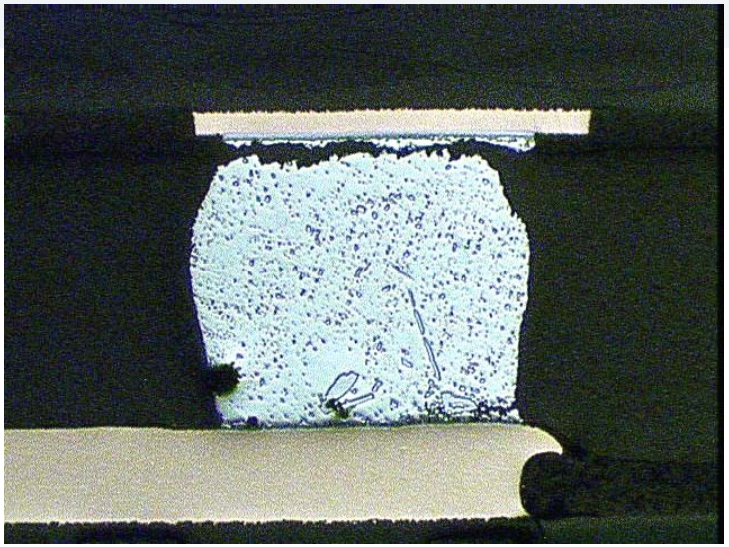


β1=1.7258, η1=730.5747, ρ=0.9778
β2=1.5258, η2=1003.0968, ρ=0.9911
β3=4.9621, η3=1335.8406, ρ=0.9806

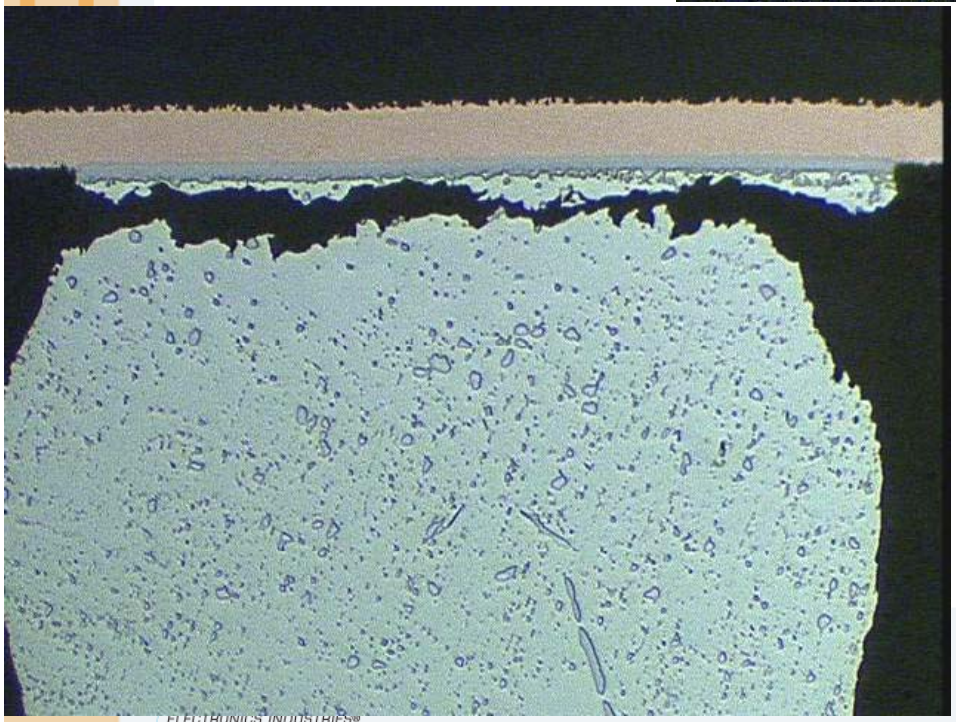
Key: Solder Alloy/Component Finish

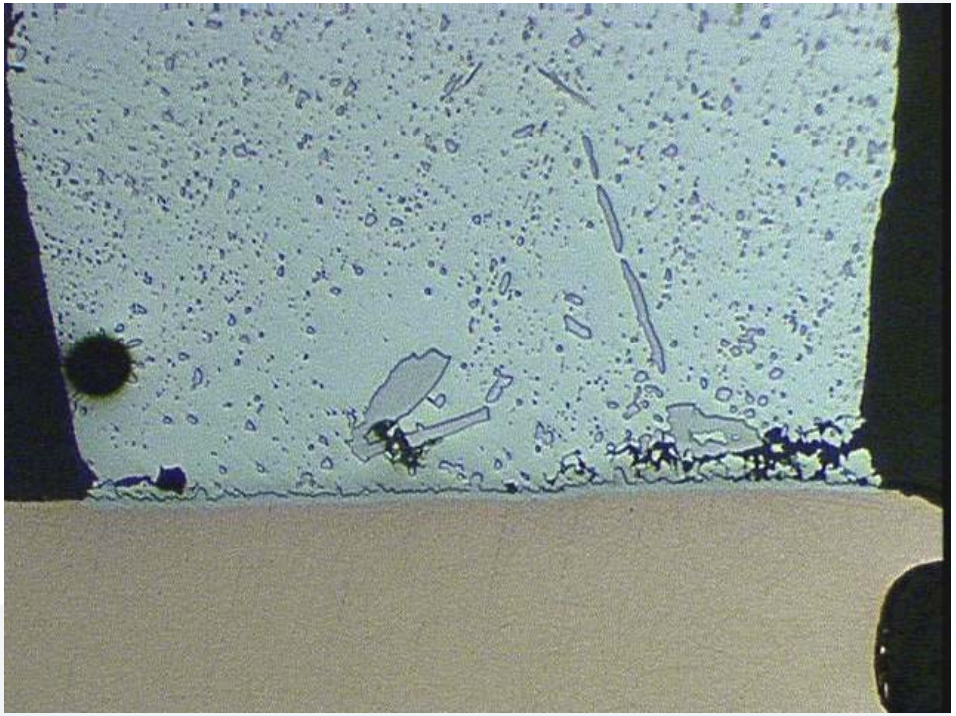
IPC Get Interconnected.™ MIDWEST CONFERENCE & EXHIBITION

Failure Analysis Results: CSP Components



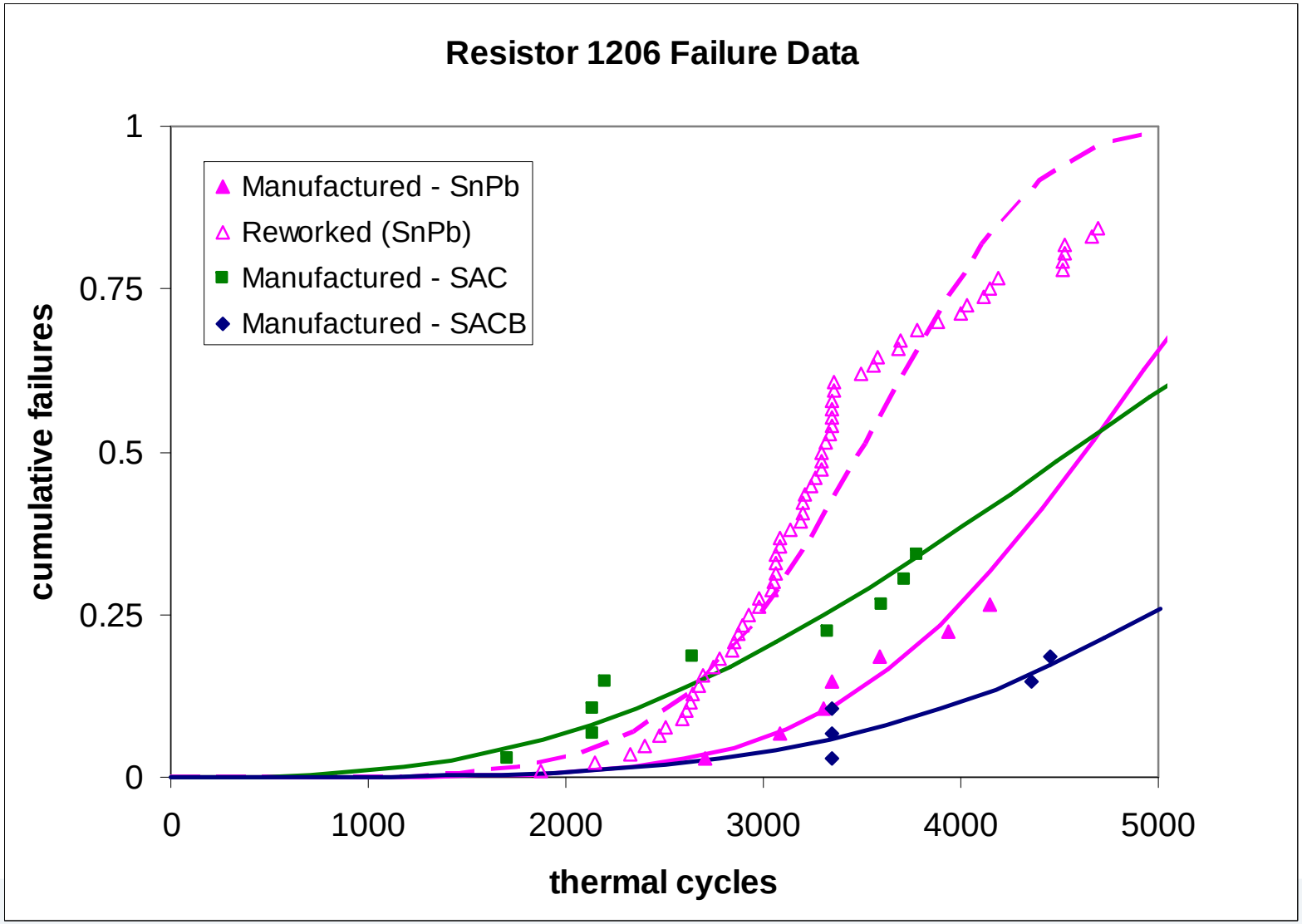
CSP Component U36, SAC Test Vehicle 317, 89 Total Thermal Cycles





IPC MIDWEST CONFERENCE & EXHIBITION

SMT Resistors



IPC ASSOCIATION CONNECTING ELECTRONICS INDUSTRIES®

SMT Resistors

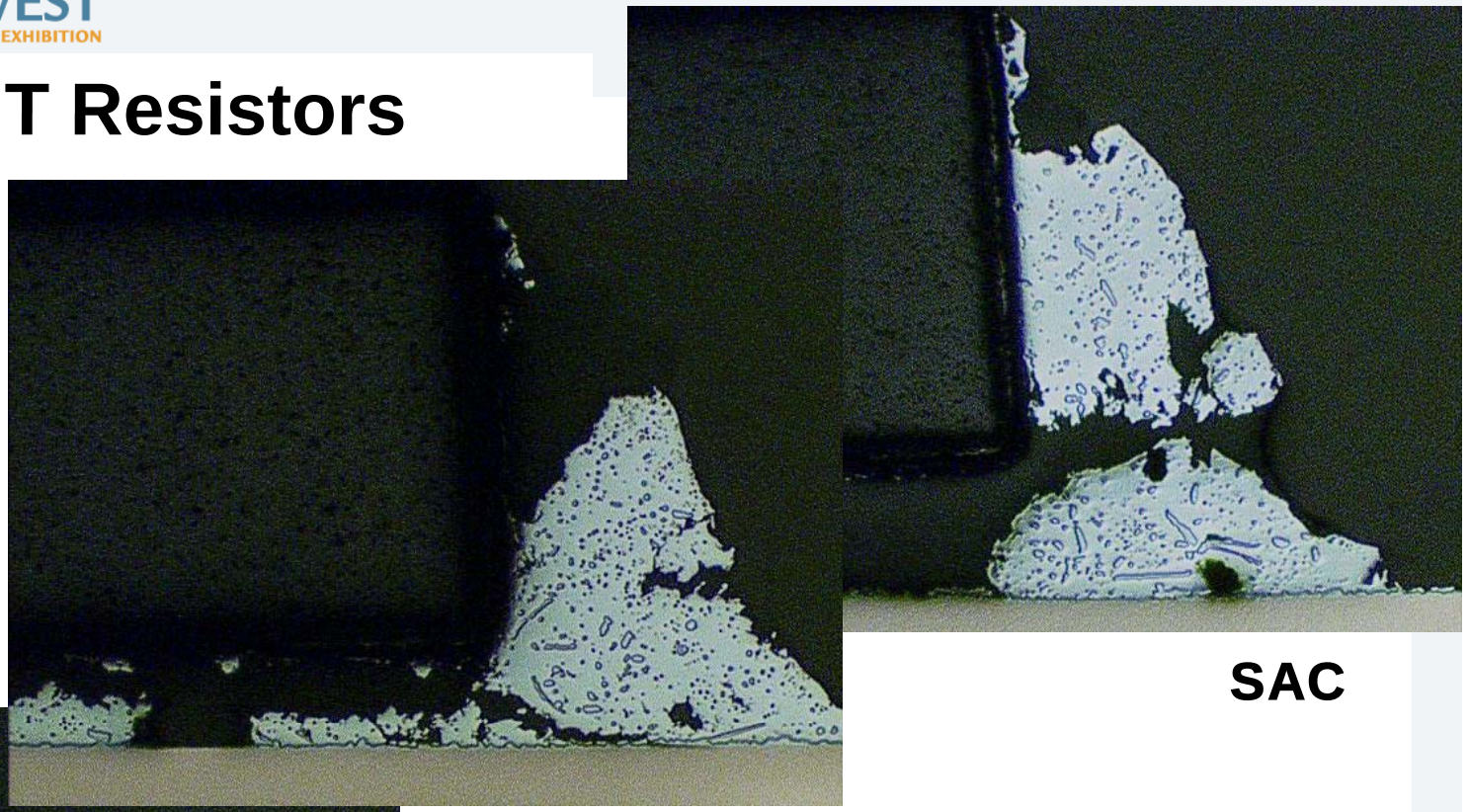
Solder Alloy	Manufactured		Reworked	
	slope	N_63	slope	N_63
SACB	3.98	6775	NA	NA
SnPb	5.56	4943	5.59	3734
SAC	2.76	5199	NA	NA

Two Parameter Weibull Values for SMT Resistors

Note: The Term "Rework" Means a Legacy laminate

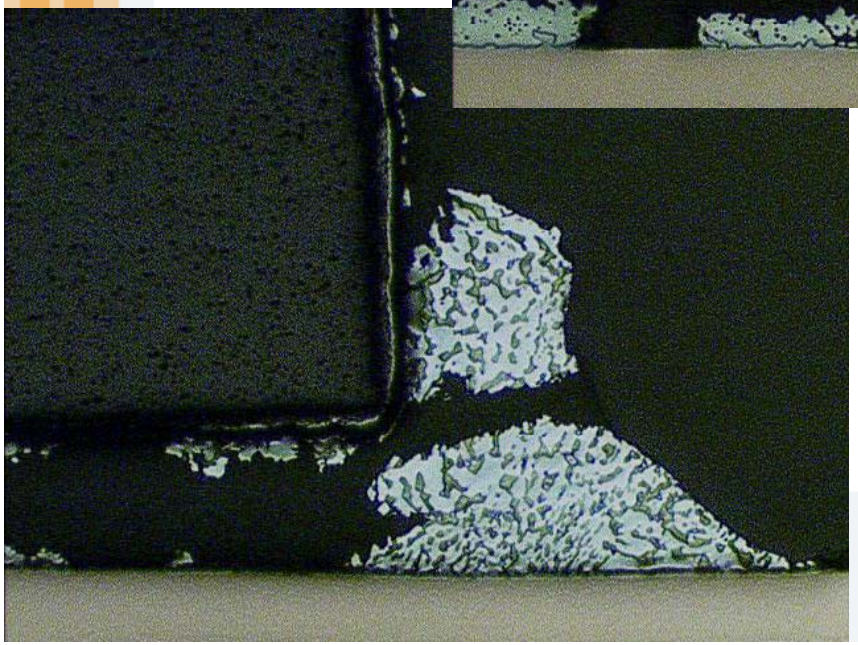
IPC Get Interconnected.™ MIDWEST CONFERENCE & EXHIBITION

SMT Resistors



SAC

SACB

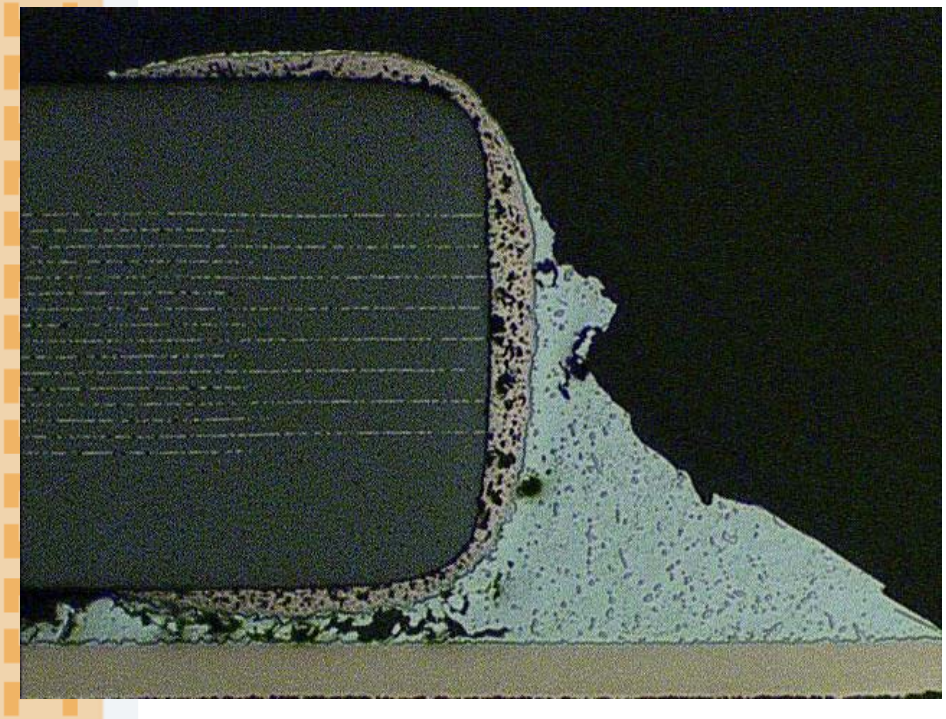


SnPb

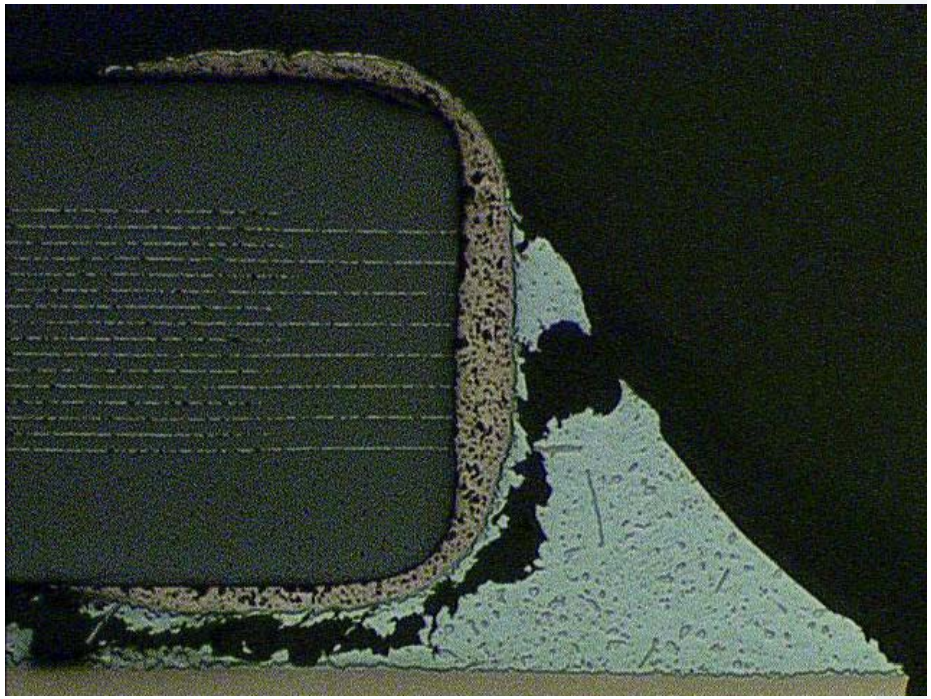
IPC Get Interconnected.™ MIDWEST CONFERENCE & EXHIBITION

SMT Capacitors

- **Capacitors began failing between 2203-3342 thermal cycles**



Size: 0805, Alloy: SAC, Cycles: 2203



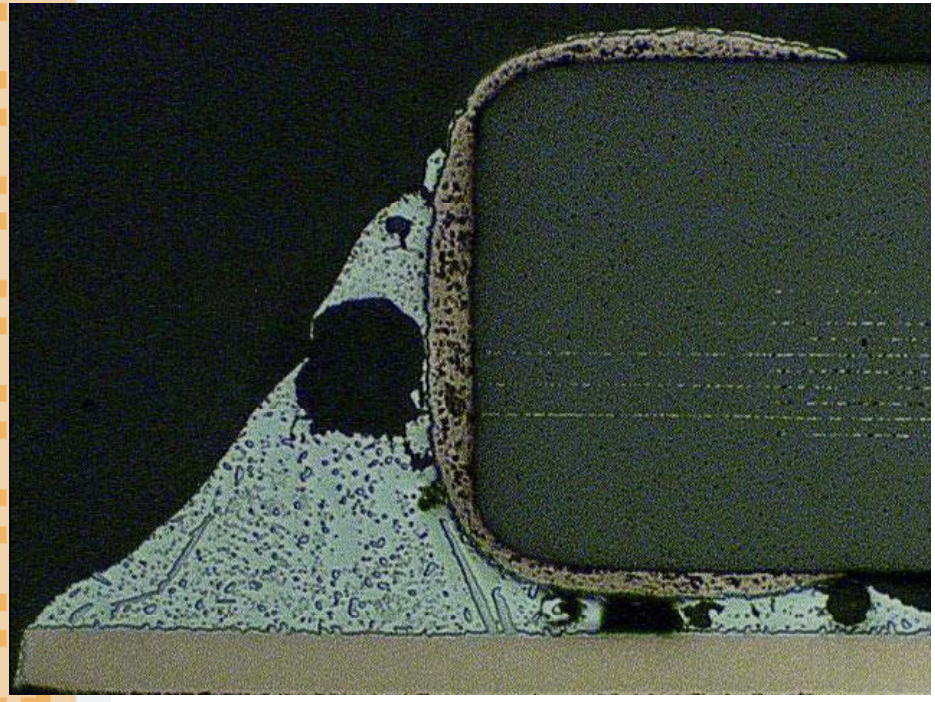
Size: 0805, Alloy: SAC, Cycles: 3342

IPC ASSOCIATION CONNECTING ELECTRONICS INDUSTRIES®

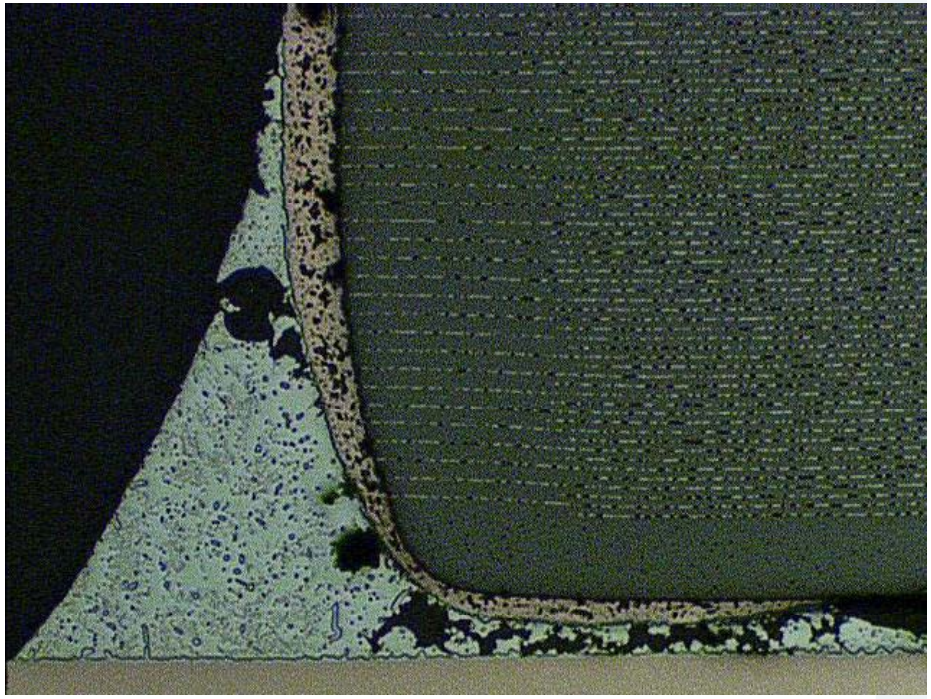
IPC Get Interconnected.™ MIDWEST CONFERENCE & EXHIBITION

SMT Capacitors

- **Capacitors began failing between 2203-3342 thermal cycles**



Size: 1206, Alloy: SACB, Cycles: 2203



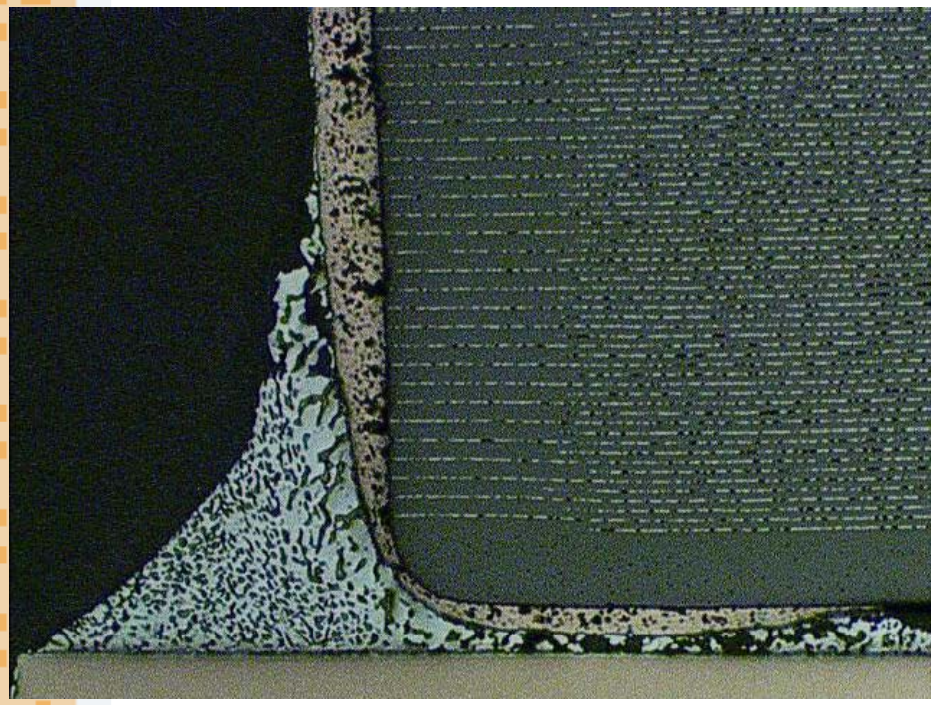
Size: 1206, Alloy: SACB, Cycles: 3342

IPC ASSOCIATION CONNECTING ELECTRONICS INDUSTRIES®

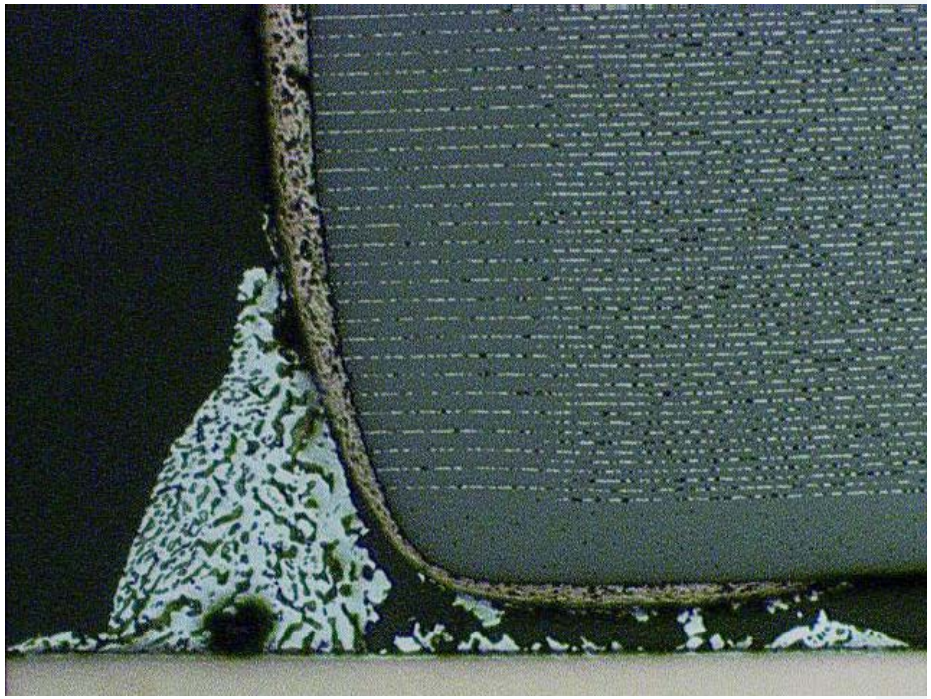
IPC Get Interconnected.™ MIDWEST CONFERENCE & EXHIBITION

SMT Capacitors

- **Capacitors began failing between 2203-3342 thermal cycles**



Size: 1206, Alloy: SnPb, Cycles: 2203



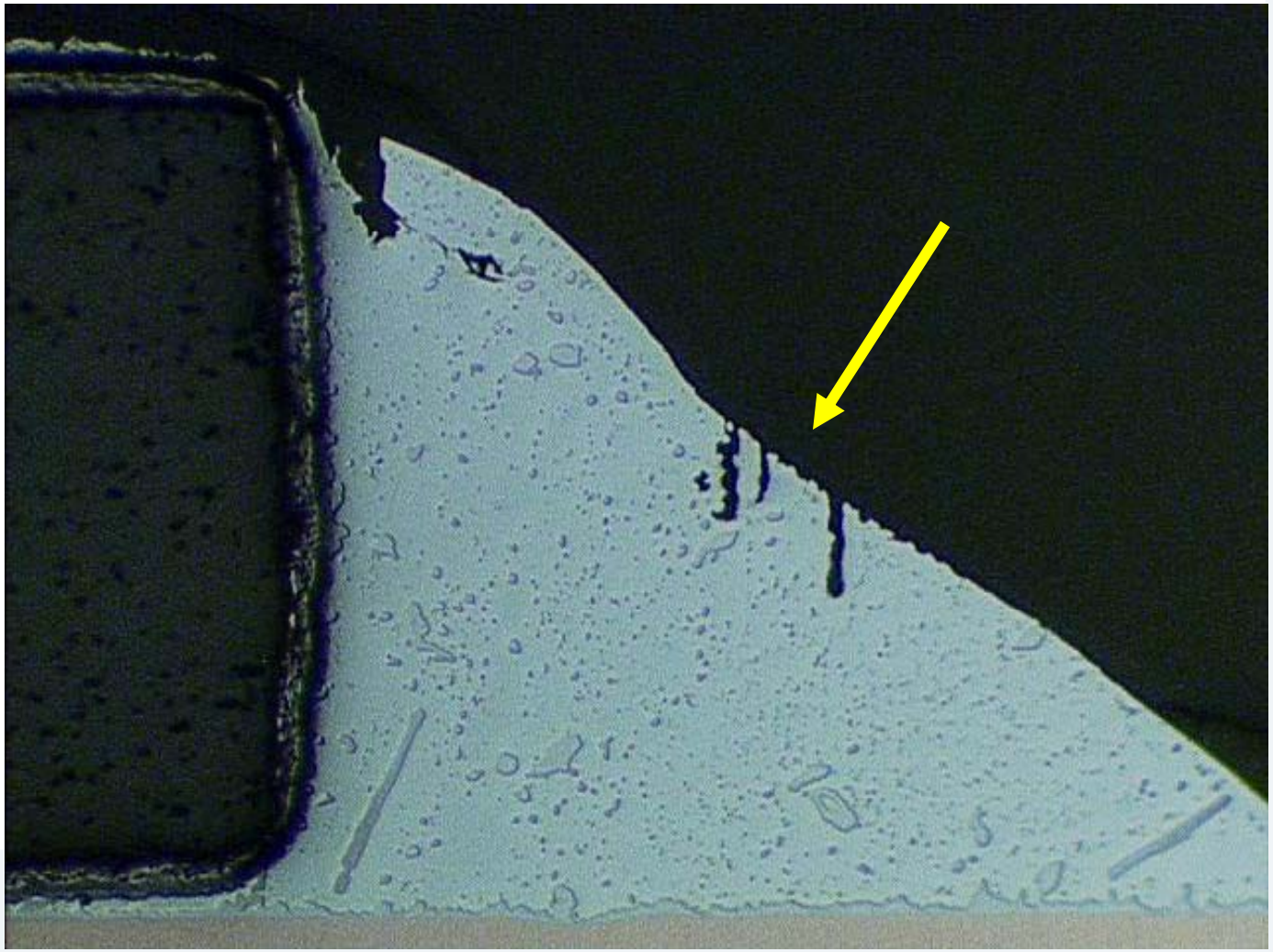
Size: 1206, Alloy: SnPb, Cycles: 3342

IPC ASSOCIATION CONNECTING ELECTRONICS INDUSTRIES®

IPC Get Interconnected.™ MIDWEST CONFERENCE & EXHIBITION

SMT Capacitors

- **SMT 0603 Capacitor, SAC Test Vehicle 88, 2203 Total Thermal Cycles: Shrinkage Voids in Solder Joint Not Acting As Crack Initiation Locations**



IPC ASSOCIATION CONNECTING ELECTRONICS INDUSTRIES®

Relative Solder Performance				
Component	**Solder/Component Finish**	**1st Failure**	**N10**	**N63**
CSP	SnPb/SnPb	0	0	0
	SAC/SAC	--	--	--
	SACB/SACB	--	--	--
Hybrid	SnPb/SnPb	0	0	0
	SAC/SAC	++	++	++
	SACB/SACB	++	++	++
SMT Resistors	SnPb/Sn (Tg – 170°C)	0	0	0
	SnPb/Sn (Tg – 140°C)	--	--	--
	SAC/ Sn	--	--	+
	SACB/ Sn	++	+	++
SMT Capacitors	SnPb/ Sn	NA	NA	NA
	SAC/ Sn	NA	NA	NA
	SACB/ Sn	NA	NA	NA

Legend:
0 = Same as control or <5% difference
+ = 5 to 20%
++ = >20%
- = -5 to -20%
-- = >-20% (red if much greater than -20%)
NA = Not Available (not enough failures)

IPC Get Interconnected.™ MIDWEST CONFERENCE & EXHIBITION

Weblink Information:

JCAA/JGPP Consortia Joint Test Report (JTP) Contains Final Report and Data

Weblink: http://acqp2.nasa.gov/LFS.htm

NASA DoD Phase II POC
Kurt Kessel
Phone: (321) 867-8480
Email: Kurt.Kessel-1@ksc.nasa.gov

IPC ASSOCIATION CONNECTING ELECTRONICS INDUSTRIES®

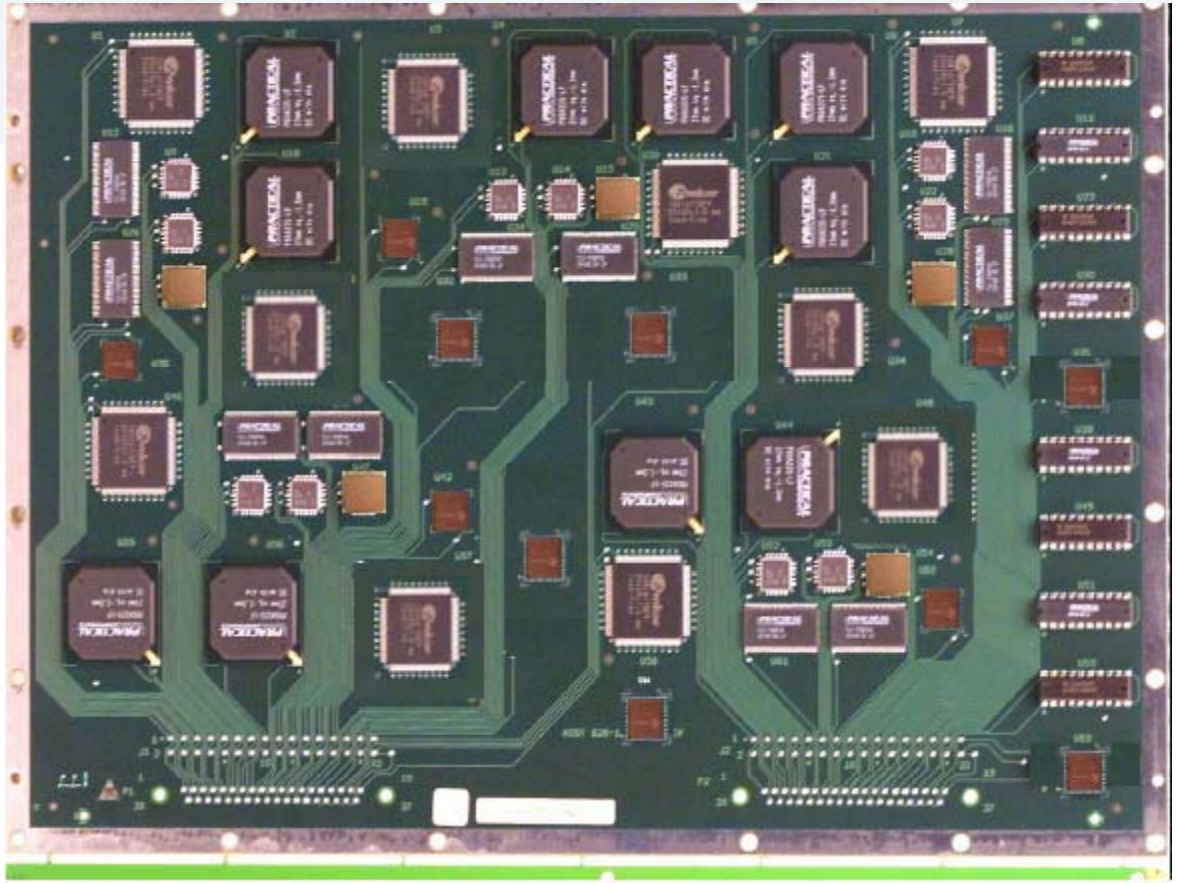
IPC MIDWEST CONFERENCE & EXHIBITION

Get Interconnected.™

NASA DoD Program:

Components:

- BGA (405,305,105)
- QFNs
- CSPs
- DIPs
- QFPs
- TSOPs



Solder Alloys:

- SnCu stabilized (SNIC)
- SAC305
- SnPb

Investigation Focus:

Mixed Metallurgy and Rework Topics

IPC
ASSOCIATION CONNECTING ELECTRONICS INDUSTRIES®

IPC Get Interconnected.™ MIDWEST CONFERENCE & EXHIBITION

Questions?

This is categorized as an issue!