Presented at the **Capital SMTA Chapter Pb-Free Tutorial Program**
May 9, 2006

Being "RoHS Exempt" in a Pb-free World

Michael Osterman, Ph. D.
osterman@calce.umd.edu

calce
Electronic Products and Systems Center
University of Maryland
College Park, MD 20742
(301) 405-5323
http://www.calce.umd.edu

Formed 1987

ISO 9001-2000 Certified, 1999

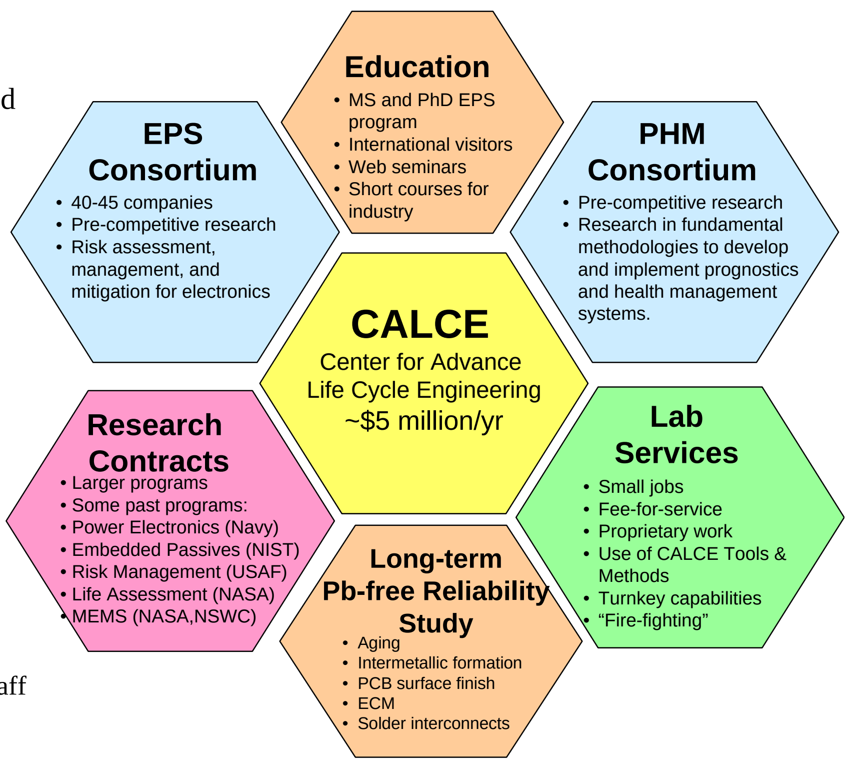
What is CALCE?

http://www.calce.umd.edu

Center for Advanced Life Cycle Engineering (founded 1987) is dedicated to providing a knowledge and resource base to support the development and sustainment of competitive electronic components, products and systems.

Areas of
- Physics of Failure
- Design of Reliability
- Accelerated Qualification
- Supply-chain Management
- Prognostics
- Obsolescence

~26 Faculty and Research Staff
~19 M.S. students
~66 Ph.D. students



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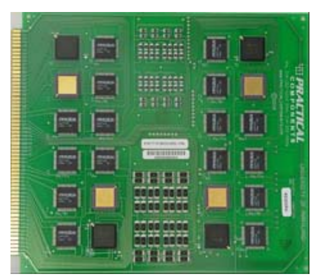
CALCE Long-term Pb-free Reliability Study



- **Participating Companies**: BAE Systems, Boeing, Emerson, General Dynamics, Goodrich Control Systems, Hamilton-Sundstrand, Honeywell, Lutron, NSWC, Raytheon Systems Company, Rockwell Collins, Rolls-Royce, Schlumberger
- **Goal:** to determine critical information related to the long-term (5-15 years) reliability of lead-free assemblies.
- **Expected Results:**
  - Examination of impact of Pb-free board finishes
  - Long-term low temperature storage effects on solder joints (tin pest)
  - Vibration fatigue reliability after long-term storage at high and low temperatures
  - Aged and unaged reliability of solder joints under combined temperature cycling and vibration
  - Electro-chemical migration in Pb-free assemblies after long-term exposure to temperature, humidity, and electrical bias
  - Reliability of single-sided through-hole assemblies under temperature cycling, vibration, and combined temperature cycling and vibration
- For more information contact: *pecht@calce.umd.edu* or *osterman@calce.umd.edu.*

Lead (Pb)-based vs. Lead (Pb)-free Soldering

Why lead(Pb)-based solders are used ?

- Low cost and abundant supply
- Forms a reliable metallurgical joint
- Good manufacturability
- Excellent history of reliable use.

Why migrate to lead(Pb)-free ?

- Government legislations
- Marketing advantage (“green product”)
- Inability to obtain lead-based parts
- Increased cost of maintaining lead-based assemblies
- Backward compatibility issues

Pb-free Legislation in Europe

- Waste Electrical and Electronic Equipment (WEEE) legislation aims to increase recycling and recovery of end-of-life electronics.
  - Producers (manufacturers, sellers, distributors) will be responsible for financing the collection, treatment, recovery, and disposal of WEEE from private households deposited at collection facilities by 13 August 2005.
- Restriction of Hazardous Substances (RoHS) legislation prohibits the use of lead and other harmful substances (i.e., mercury, cadmium, chromium, PBBs, PBDEs) in new electrical and electronic equipment put on the market after 1 July 2006 [1].
  - Pb-free is defined as <0.1% Pb by weight in a homogeneous materials
  - Self-certification, market surveillance
  - Provides exemptions (e.g. high lead solders for die attach)
  - Defense and aerospace not in scope
  - Batteries not in scope
- Both articles were issued by the European Union (EU) January 2003.

Pb-free Legislation in China

"Administrative Measure for the Control of Pollution Caused by Electronic Information Products" (Administrative Measure) formulated by the Ministry of Information Industry (MII), was issued February 28, 2006.

- Covers same materials as EU RoHS but State may added others.
- Defines what products are covered
  - Electronic Information Products refers to the following products and their accessories manufactured by using electronic information technology: electronic radar products, electronic communication products, broadcast television products, computer products, household electronic products, electronic measurement instrument products, electronic products for professional use, electronic component products, electronic application products, electronic material products, etc.
- There are no exemptions
- Labeling and marking is required
- Certification by a Chinese Lab is required
- Becomes effective March 2007

Pb-free Initiatives in U.S.

- The "Reid Bill" introduced in 1991 and the subsequent "Lead Exposure Reduction Act of 1993" were not adopted for electronic equipment due to strong opposition from the US electronic industry.
  - There were no known alternatives at that time to replace tin-lead solder.
- In 2001, the Environmental Protection Agency (EPA) lowered the Toxic Release Inventory (TRI) reporting threshold for sites releasing lead and lead compounds to the environment to 100 pounds per year.
- California Senate Bill (SB20 and amendment SB50), "Electronic Waste Recycling Act of 2003" was released in 2003.
- This regulations prohibits an electronic device from being sold or offered for sales in the State of California if the device is under the scope of RoHS directive on 1 January 2007 or the effective date of RoHS directive (whichever date is later).
  - California is the first state in U.S. which bans the usage of brominated flame retardants in electrical and electronic products. The ban will be effective on 1 January 2008.
- 52 bills have been introduced in 20 states

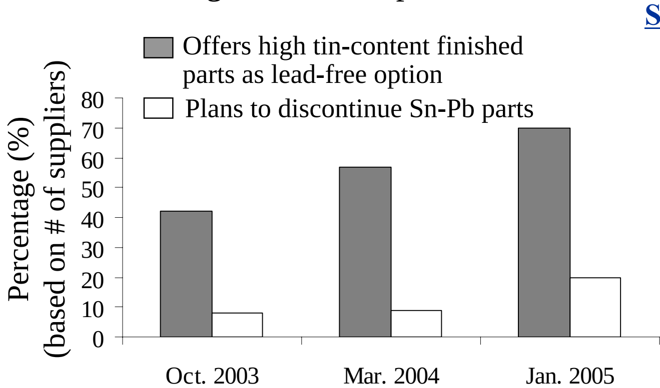
Pb-free Electronics Market Situation

Sector	Market share (2004 data)		Examples
Telecom	41 %	$ 36 billion	Ericsson, Infineon, Motorola
Computers	32 %	$ 28 billion	Dell, HP, IBM, NEC, Toshiba
Consumer	15 %	$ 13 billion	Fujitsu, Hitachi, Matsushita, NEC, Philips, Sony, Toshiba
Automotive	6 %	$ 5 billion	Delphi Automotive Systems, AB Automotive Electronics
Industrial	5 %	$ 4 billion	Emerson -Astec Power, Ericsson Power Modules
Avionics	1 %	$ 1 billion	Boeing, Airbus
Military/Space			Rockwell Collins

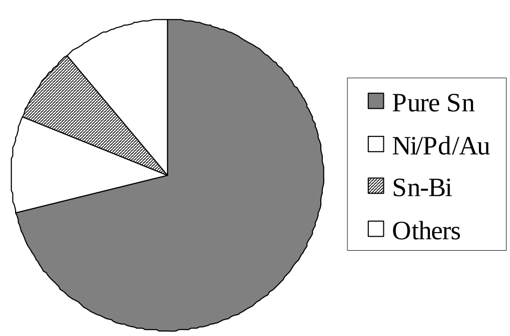
Exempted or not in scope industries

Electronic Part Suppliers Pb-free Reaction

- The electronics industry is in the process of eliminating lead (Pb) from the electrical and electronic products, driven by legislative mandate in EU (July 1, 2006) and a market differentiation.
- Part manufactures are also changing mold components to meet higher reflow requirements and to be RoHS compliant.
- The electronic part market trend implies a high likelihood of electronic products containing tin-rich component finishes.



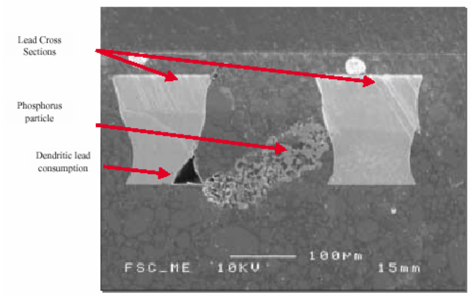
Selection of lead-free finishes (Jan. 2005)



(Based on survey of 121 suppliers)

Pb-free Supply Chain Issues

As a result of RoHS legislation and the move to higher temperature reflow temperatures, material changes by part manufacturers have already resulted in compromised product reliability.

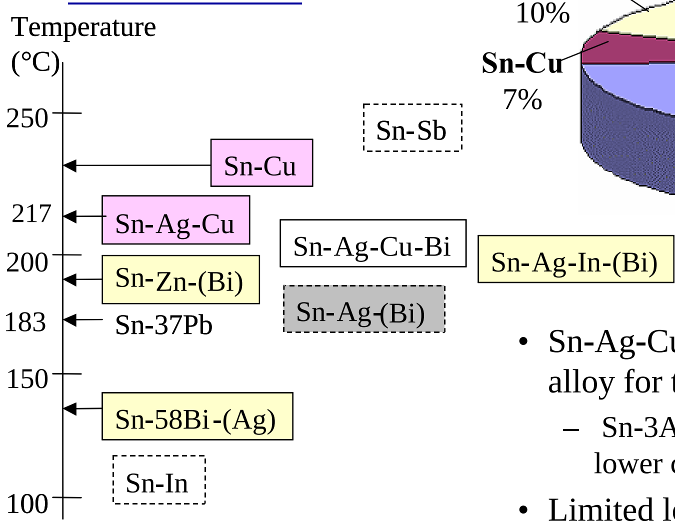


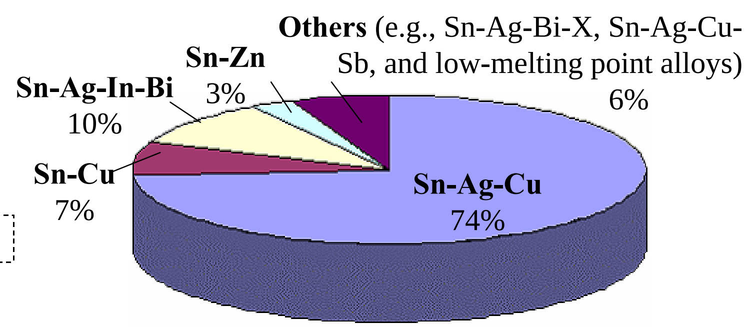
Changes in flame retardant in molding compound results in early failure due to internal corrosion and shorting.

Change of electrolyte in electrolytic capacitors produced excessive bulging and early failure

What is Available as Pb-free? - Solders -

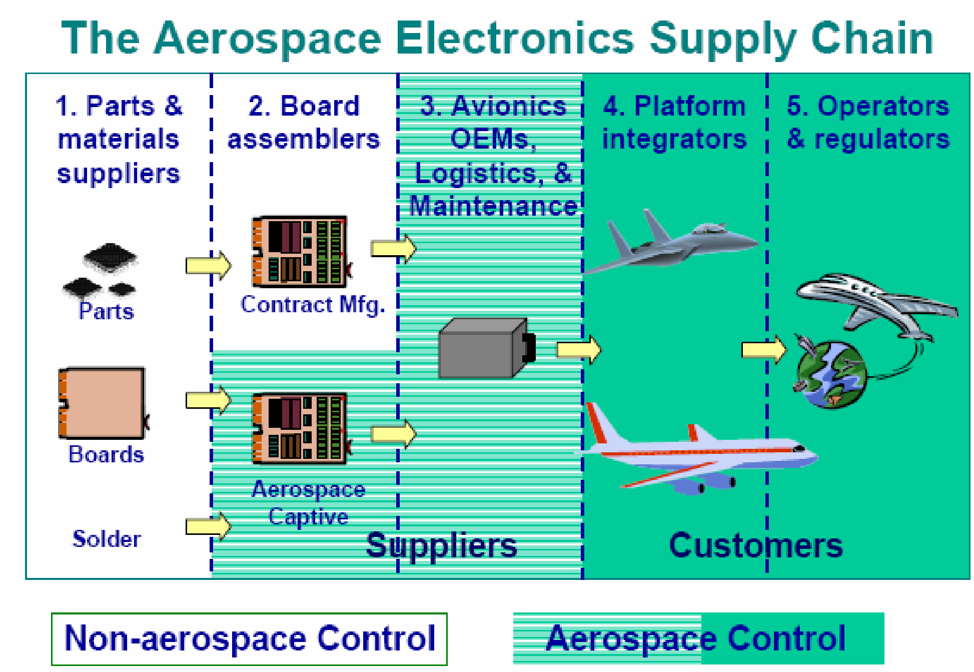
Melting temperature of Lead-free solders





[Japan Senju Metal, 2004]

- Sn-Ag-Cu (SAC) alloy is the most preferred alloy for the PCB assembly.
  - Sn-3Ag-0.5Cu is the preferred option, due to lower cost (lower Ag content)
- Limited long-term reliability data

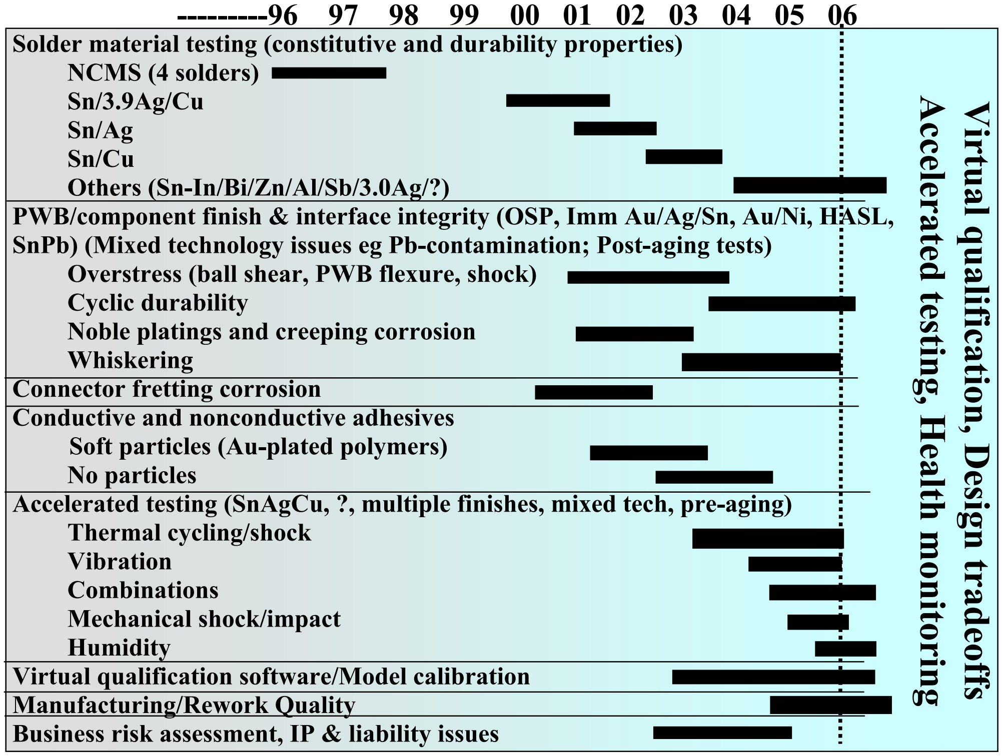


Lead-free Aerospace Electronics, William Procarione, Boeing
http://www.calce.umd.edu/lead-free/other/Procarione_ACI.pdf

Pb-free Transition Challenges

- **Technical:** potential new design, manufacturing, quality and reliability issues, as a result of different materials (e.g. solders, surface finishes) and higher process temperature relative to tin-lead soldering
- **Logistic:** supply chain, inventory management, adherence to reporting requirements (e.g., compliance certification), intellectual property, legacy products
- **Economic:** costs for materials (solder, board dielectric), parts (components withstanding 260°C reflow), research, development and manufacturing (equipment capital, process re-qualification, use of higher process temperature and/or nitrogen atmosphere), education/training
- **Customers/legal:** differences in regional legislations and public opinion

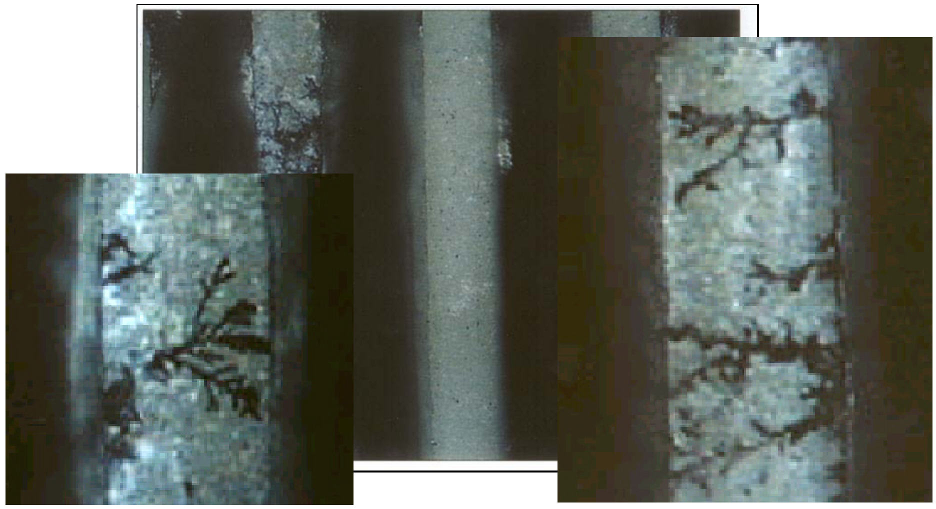
CALCE Pb-free Research



Pb-free PCB Assembly Reliability Concerns

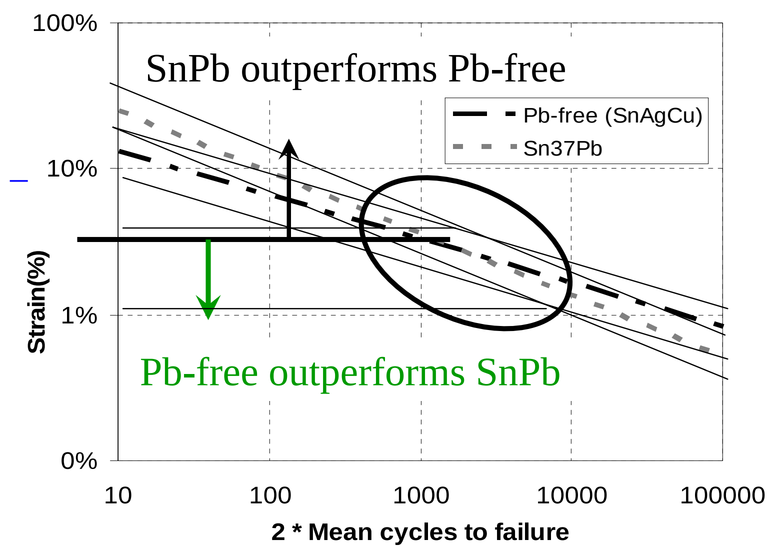
- PWB and Part Metallization
  - **Thermal fatigue of PTHs (barrel cracking, delamination)**
  - **Conductive filament formation (loss of insulation resistance)**
  - **Electrochemical migration (loss of insulation resistance)**
  - **Tin Whiskers**
  - **Tin Pest**
- Part Concerns
  - **Reflow Coplanarity**
  - **Multiple Layer Ceramic Capacitor Flex Cracking**
- Separable contacts (increase in contact resistance)
  - **Fretting corrosion**
- Permanent interconnects
  - **Fatigue (temperature cycling / mechanical vibrations)**
  - **Shock**
  - **Electromigration (high current density and temperature)**

Electrochemical Migration



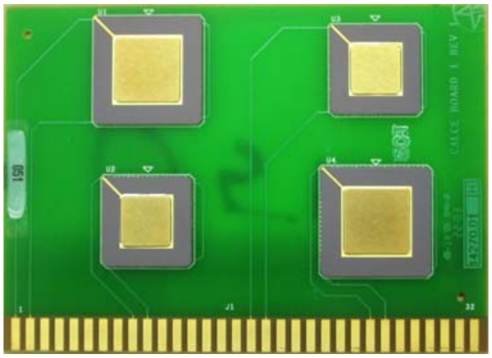
Silver in solder and in finish with polyimide boards appears to be a potential long term risk compared to high temperature FR4.

Durability of Solder under a Temperature Cycle



Crossing point likely to shift due to temperature cycle parameters (i.e. mean temperature, temperature range, dwell time, and ramp rate)

CALCE Pb-free Solder Temperature Cycling Reliability Testing



Packages Under Test

- 68-pin LCCC: 24mm × 24mm
- 84-pin LCCC: 30mm × 30mm
- PCB Board: 130 x 93 x 2.5 mm, FR4

- **Solders Completed**
  - Indium SMQ 230 Sn95.4/Ag3.9/Cu0.7
  - Indium SMQ 230 Sn96.5/Ag3.5
  - Indium SMQ 92J Sn63/Pb37
- **Solder Under Test**
  - Aim SN100C Sn/Cu/Ni(.5) w/254 flux
  - Aim SAC 305 w/254 flux
  - Indium SMQ92J Sn61.5/Pb 36.5/Ag2

Test details

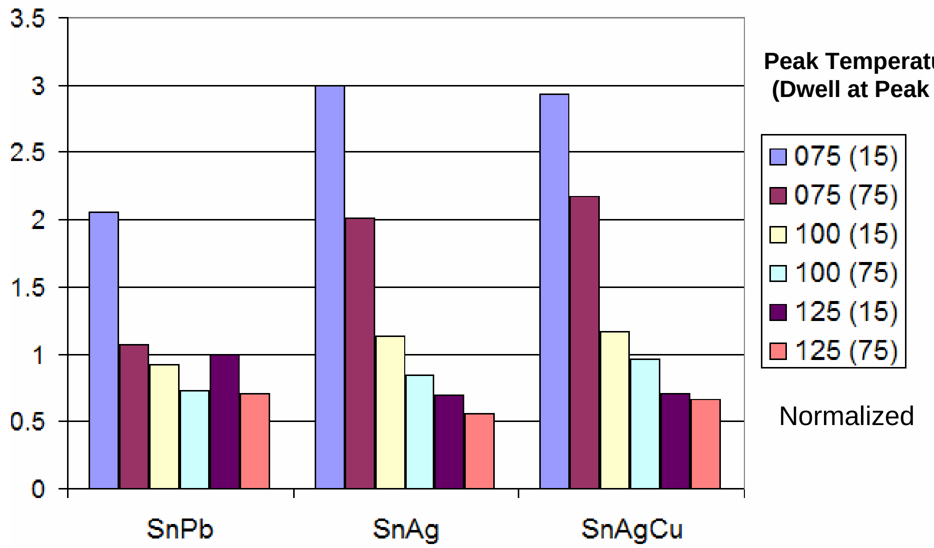
- 16 samples in each test condition
- Resistance of each chip is monitored by a data logger.
- Temperature is recorded at the center of each card.
- Test continues until 100 % failure occurs.
- Cross sectioning was performed on failed test specimens to verify a solder interconnect failure.

Experimental Test Matrix

Test	Min. Temp. (°C)	Max. Temp.(°C)	Temp. range (°C)	Dwell Time at Max temp* (min)	Status
1	0	100	100	15	Completed
2	-25	75	100	15	Completed
3	25	125	100	15	Completed
4	0	75	100	75	Completed
5	25	125	100	75	Completed
6	0	100	100	75	Completed
7	15	85	75	15	Completed
8	15	85	75	75	Completed

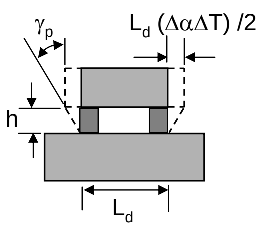
*Dwell at minimum temperature is set to be 15 minutes.

Comparison of Time to Failure (68 IO Package)



For the Pb-free solders, increasing the average cyclic temperature showed a decrease in time to failure. As can be seen in the above chart, the behavior of the SnPb solder at the 100 and 125°C peak temperature shows non-monotonically decreasing behavior.

Strain Fatigue Range Model

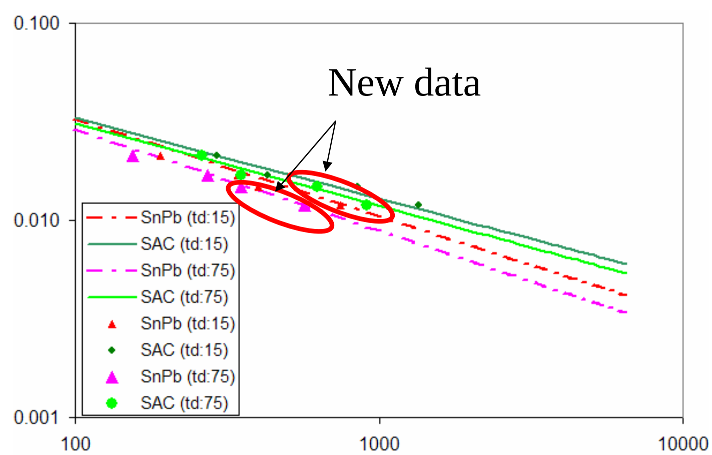


$$N_f = \frac{1}{2}\left(\frac{\Delta\gamma_p}{2\varepsilon_f}\right)^{\frac{1}{c}}$$

$$\Delta\gamma_p = L_d\left(\frac{k\Delta\alpha\Delta T}{2h}\right)$$

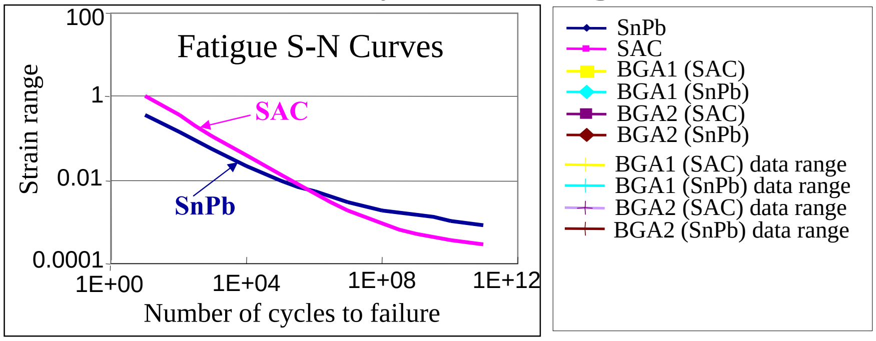
For eutectic solder,

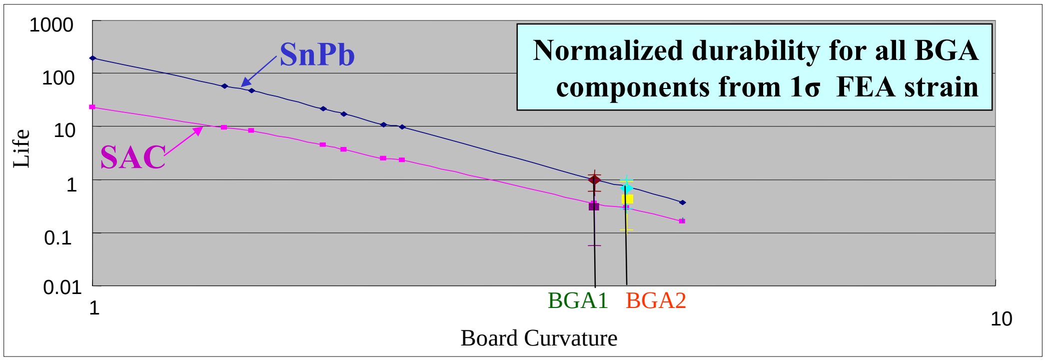
- ε_f = Constant
- $c = c_0 + c_1 T_{sj} + c_2 \ln\left(1 + \frac{360}{t_d}\right)$



Latest test results fit on the previously defined curves. Noted limitations for Sn37Pb no increase in life can occur at the high temperature end. However, a more immediate concern is that life will no reduce as the average solder joint temperature continues to decrease.

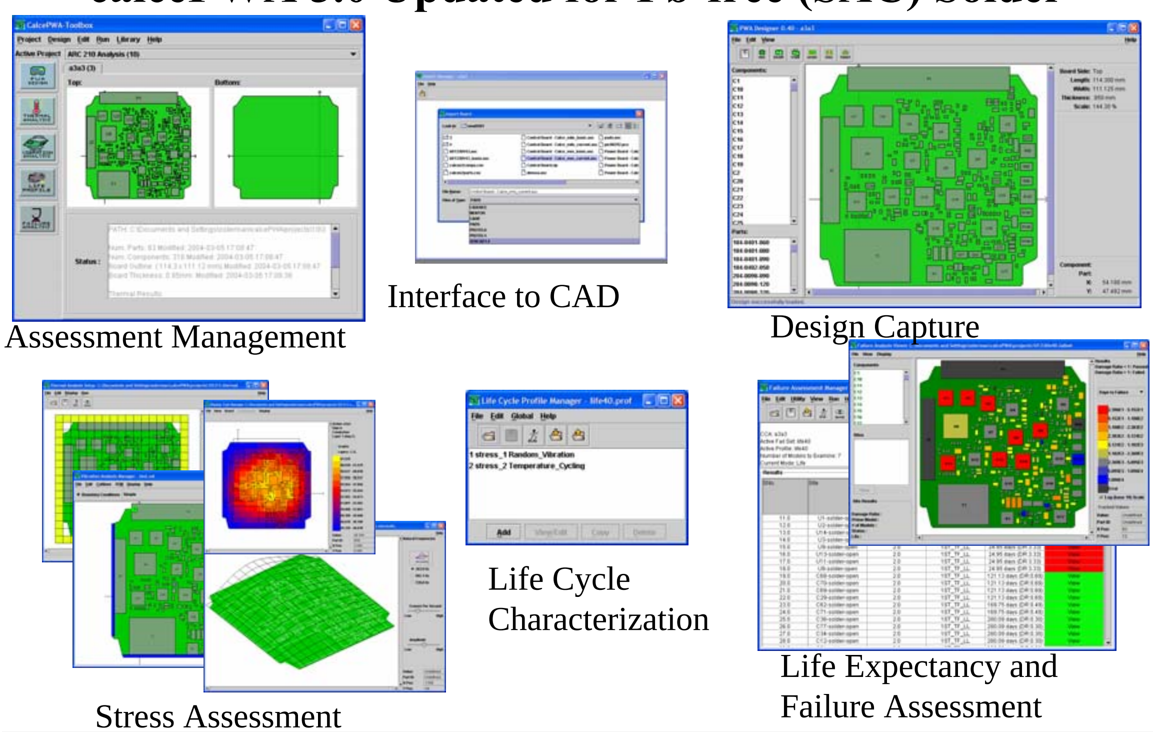
Vibration Durability Ranking: SnPb vs SAC





Durability of SnPb interconnect more sensitive to PWB curvature than SAC

PWA Simulation Assisted Reliability Assessment Software
calcePWA 5.0 Updated for Pb-free (SAC) Solder



Define a Clear Pb-free Policy

- **Maintain conventional Pb-based products**
  - Determine if you are exempt
  - Examine costs and availability of parts and processes
  - May need to consider life time buys
  - Define policy for handling Pb-free parts (e.g. tin whiskers)
    - Mitigation strategies
    - Quality and reliability assurance strategies
  - Communicate plan to suppliers and customers
- **Convert to a Pb-free products**
  - Define a plan of action which considers
    - Current and future products
    - Availability of parts
  - Implement a part management and selection process for Pb-free
  - Define timeline for transition
  - Update quality and reliability assurance plans
  - Communicate plan to suppliers and customers
- **Combination of the two**

Lead-based Part Supply Interruption

- Lead-based products may become unavailable as electronic suppliers transition to lead-free technology. Consequently, manufacturers of exempted applications (e.g., medical electronics) that develop non-RoHS compliant products may be exposed to the discontinuation of parts, making design, production and maintenance risky.
  - Potential solder joint reliability issues associated with assembling lead-free parts to a PCB using tin-lead solder and processes.
- Manufacturers relying on lead-based technologies should
  - Monitor product and process change notices (PCNs)
  - Identify whether their suppliers have any plans to discontinue the production of lead-based products. If so, the time line for the discontinuation should be obtained.
- Life time buy practices are a possible solution to resolve supply interruptions. Potential disadvantages include:
  - Significant one-time expenditure
  - Increased inventory on balance sheet
  - Requirement for proper storage space (with appropriate temperature, humidity, and handling conditions)
  - Potential for future unplanned requirements (e.g., significant changes in product technology or upgrades).

Increased Cost of Non-compliant Parts


Supply chain shortages on non-compliant parts - Lead-Free Zone Blog - Blog on Design News -...

File Edit View Favorites Tools Help

Address http://www.designnews.com/blog/710000071/post/290003029.html?nid=2739 Go

Careers

Polling Question

Which resource do you use most often when purchasing your components?

sponsored by MICROCHIP

A distributor web site

A manufacturer web site

A distributor catalog or 800-number

A manufacturer sales rep

Submit

Monday, April 10, 2006

Supply chain shortages on non-compliant parts

Apr 10 2006 6:40AM | Permalink | Email this | Comments (3) |
Blog This! using: Blogger.com | LiveJournal |

More than a year ago, distributors started to predict that non-compliant components would begin to dry up as component suppliers shifted to mostly lead-free production. This week may have seen the beginning of that trend. Some officials at Avnet Inc, a large components distributor, report the beginning of the tightening of the non-compliant parts supply.

The executives are reporting price increases for non-compliant inventory. Lead times are stretching out as well. The end-of-life notices for leaded parts have also increased, all indicating that component suppliers are cutting back on their production of non-compliant parts.

This trend was long predicted, since the exempt portion of the components market – mostly the defense, aerospace and medical industries – does not consume the large volume of parts purchased by the consumer electronics and business electronics markets. These recent changes may mark the beginning of the end for cheap off-the-shelf parts that were the preferred inventory for the exempt industries of defense and aerospace.

Internet

http://www.designnews.com/blog/710000071/post/290003029.html?nid=2739

Options with Inability to Obtain Pb-based Parts

- Add the lead back to the parts
  - For leaded parts, parts may be soldered dipped
    - Potential reliability issue due to handling and heating
    - Additional cost
  - Area array parts may be reballed
    - Part manufacturers will not warranty these parts
    - Potential reliability issue due to handling and heating
    - Additional cost
  - Discrete parts may be reprocessed (AEM Inc. provides such a service)
- Use as is
  - Mixed solder issues
  - Tin whiskers.
- Design out the part

Actions one and two have reliability risks are not very attractive and the third option may not be feasible.

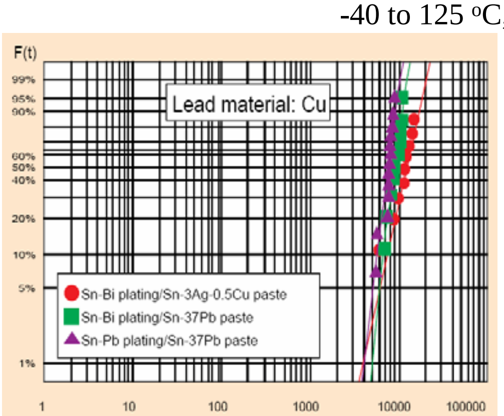
Issues with Using Pb-free Parts in a Pb-based Assembly

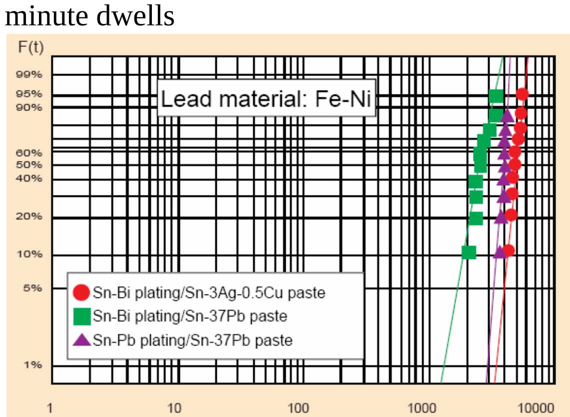
Backward incompatibility (component with lead-free termination soldered with tin-lead solder and a tin-lead temperature profile)

- Pb-free finished terminals containing high concentrations of Bismuth (Bi) >4% may produce poor joints.
- Ball grid arrays (BGA) packages with Sn-Ag-Cu solder balls may not be compatible with tin-lead solder, as combination of these materials can result in "cold" joint formation during assembly. Higher reflow temperatures may be needed to avoid this issue but this give rise to other issues.
- Tin Whiskers

Bismuth Bearing Finish Solder Reliability

208 IO PQFP
-40 to 125 ^{o}C, 10 minute dwells



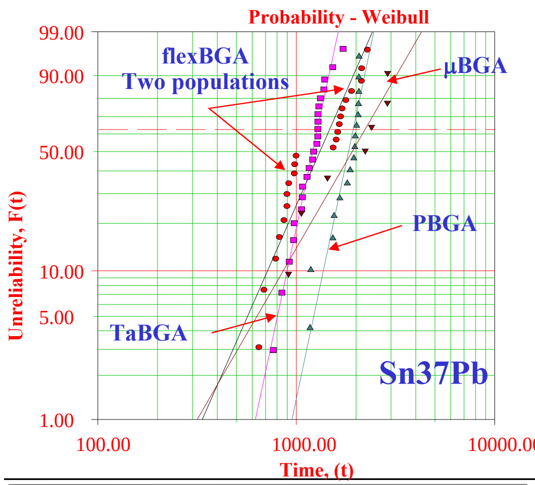


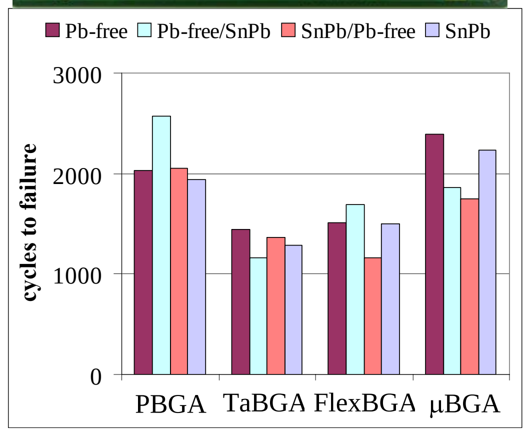
NEC Web Site, http://www.necel.com/pkg/en/pb_free/leadsmd.html

For copper leaded packages, Sn2Bi has not been reported be a reliability risk. However, NEC data indicates a potential issue with iron based lead frames. These results are supported by other reports.

Accelerated Life Testing

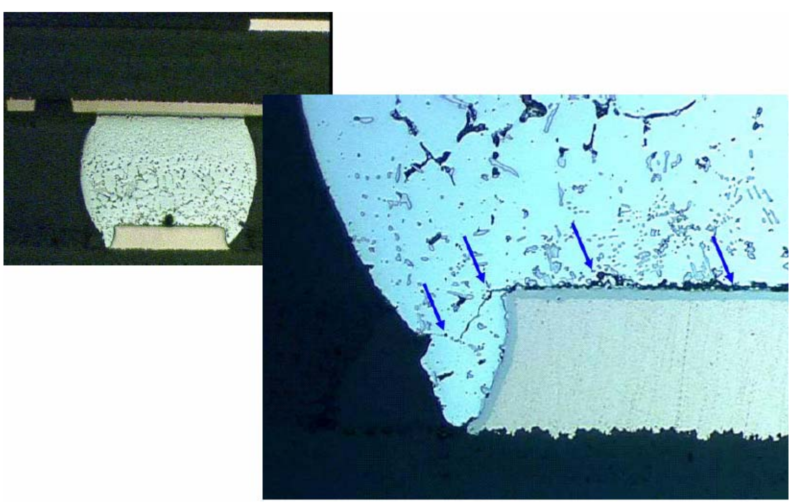
CALCE has conducted and participated in extensive accelerated life testing to understand the reliability of Pb-free assembled hardware.





The effect of Pb contamination in mixed technologies

SAC BGA in a Sn37Pb Assembly Process



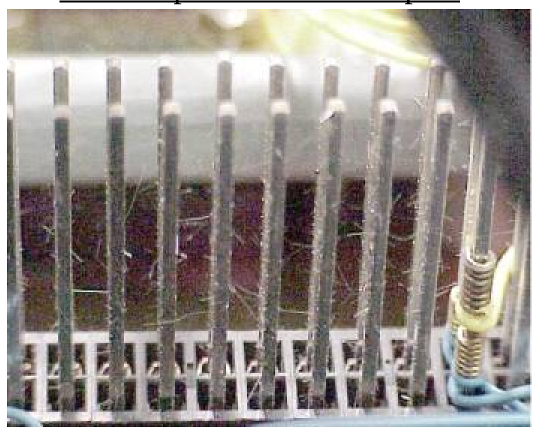
A SAC BGA was assembled under a conventional Sn37Pb solder process, failure under temperature cycling (-55 to 125°C) occurred in less than 150 cycles.

Hillman, D., Wells, M., and Cho, K., "The Impact of Reflowing a Pb-free Solder Alloy Using A Tin/Lead Solder Alloy Reflow Profile on Solder Joint Reliability" http://www.aciusa.org/lfpdf/lfjournal/CMAP_paper_Rev_A_(2).pdf Last Accessed 1/22/2006

Risks from Tin Whiskers

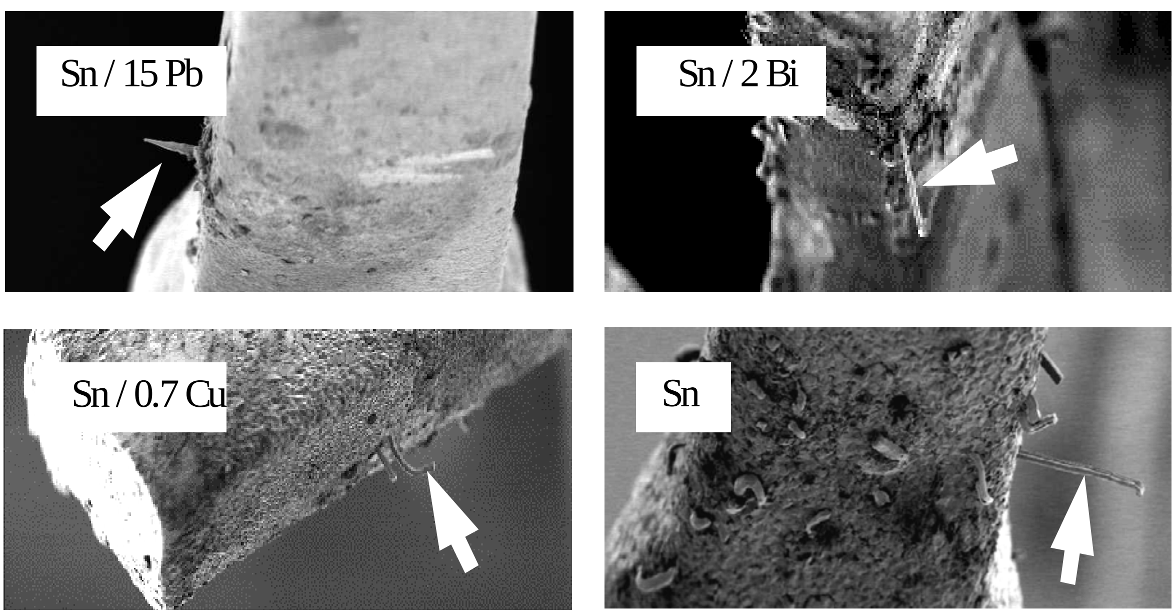
- Major failure modes and mechanism of tin whiskers are:
  - Electrical short: permanent (typically <10mA), intermittent (typically >10mA)
  - Metal vapor (plasma) arcing in vacuum and low pressure
  - Contamination
- Various sectors of the electronics industry, including military, medical, telecommunications and commercial applications, have experienced field failures induced by tin whiskers.

Pure tin plated connector pins



10 years in the field (reported in 2000)
[Courtesy of NASA Goddard]

Whiskers Grown from Various Plating Types



[Courtesy of Motorola]

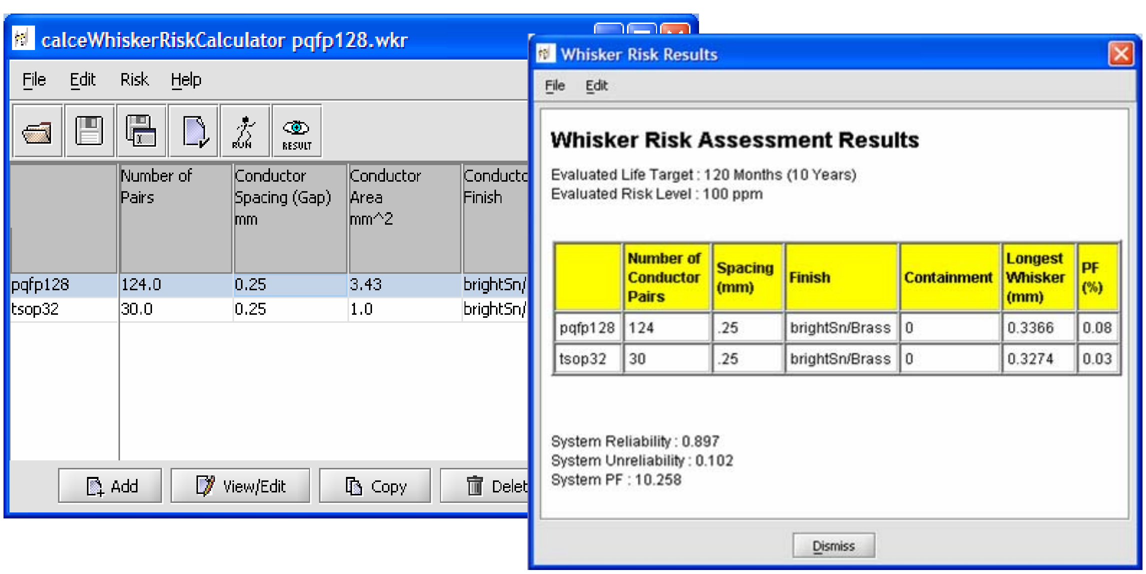
One reported observation based on 13-week period for the longest whiskers showed:
Sn-15Pb (40µm) < Sn-2Bi < Sn < Sn-Cu (170µm)

Factors the Influencing Tin Whisker Formation

- Base material
  - Formation of intermetallic compounds (e.g., Cu_6Sn_5), especially within the tin grain boundaries
  - Coefficient of thermal expansion (CTE) mismatch between the plating material and substrate
- Bath chemistry/plating process parameters seem to have a significant influence on whiskering.
  - NIST study on copper contamination shows that higher copper content reduces a grain size and increases a compressive stress level in the deposit, which may result in higher tin whisker growth propensity.
- Environment
  - Temperature cycling
  - Steady state temperature
  - Temperature/humidity
  - Compressive stresses, such as those introduced by torquing of a nut or a screw
  - Bending of the surface after plating
  - Scratches or nicks in the plating introduced by handling
- Generally agreed that compressive stress in the finish gives rise to whisker formation.

CALCE Tin Whisker Risk Assessment Software

A software package that calculates the probability of tin whisker failure for circuit card assemblies and products. Based on long-term test data.



Reprocessing Pb-free Parts

Converting a existing Pb-free part to a Pb-based part is possible, however there are reliability risks which have not been adequately assessed.

– Pb-free BGAs may be reballed. CALCE expects to introduce a industry project in FY07 to assess the yield, structural impact, and solder joint reliability of reballed Pb-free parts.
– Pb-free leaded parts may be dipped in SnPb solder or chemically reprocessed. CALCE has conducted whisker growth studies on reprocessed tin finished coupons and participated in an industry study on the impact of solder dipping on select parts.

CALCE EPSC FY07 Proposal P07-O2
Reliability of Pb-free and Reballed PBGAs in SnPb Assembly Process

This project will require at least of two critical sponsors.

This project will provide critical test data to assess the compatibility of Pb-free (SnAgCu (SAC) solder balls) and reballed PBGAS with the conventional SnPb solder assembly. Flip-chip and wirebond BGA package types will be identified and selected for this study.

Parts will be subjected to a commercial reballing process and physical degradation due to the reballing process will be examined using non-destructive and destructive physical analysis techniques.

Test assemblies will fabricated as defined below

	Part	Solder Paste	Reflow Profile
Cell 1	Reballed with SnPb	SnPb	SnPb
Cell 2	Virgin	SnPb	SnAgCu
Cell 3	Virgin	SnAgCu	SnAgCu

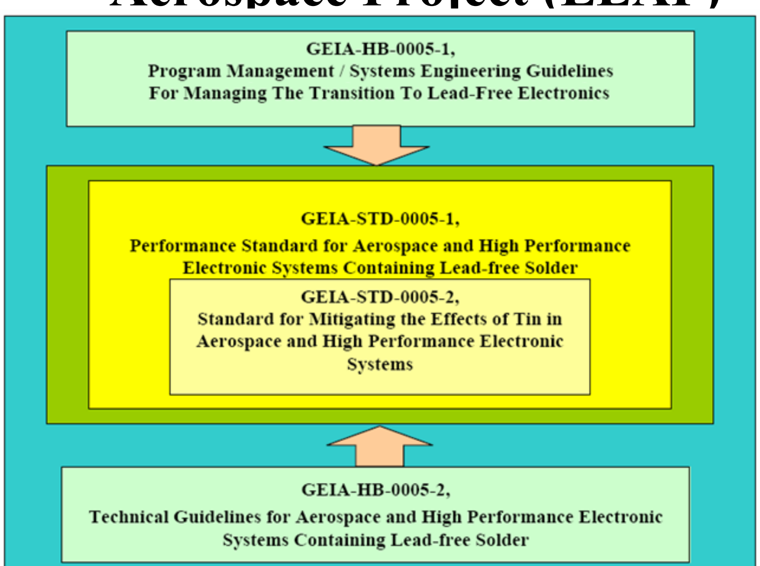
Solder interconnect reliability testing (i.e. temperature cycling) will be conducted on test assemblies.

Issues With Using SnPb Parts in a Pb-free Assembly

Forward incompatibility (component with lead-based termination soldered using lead-free solder and the appropriate lead-free temperature profile)

- Lead in lead-based component termination (leadframe or solder ball) can interact with **bismuth-containing lead-free solder** (e.g., Sn-Bi, Sn-Ag-Bi, Sn-Zn-Bi, Sn-Ag-Cu-Bi) during assembly, to form a low-melting point phase (Sn-51Bi-32Pb, melting point = 96ºC) which can cause cracking in solder joints.
- Lead-containing component termination (leadframe or solder ball) or PCB pad finish with **lead-free Sn-Ag-Cu or Sn-Ag solder** can result in poor solder joint mechanical reliability, due to the formation of a Sn-Pb-Ag eutectic (62Sn-36Pb-2Ag, melting point = 179ºC) during the cooling phase of the assembly process. Pockets of this alloy can act as voids in the solder joint.
- Temperature sensitivity of parts (popcorning)
- Tin Whiskers

AIA-AMC-GEIA Lead Free Electronics in Aerospace Project (LEAP)



CALCE is providing technical support for this effort.

Documents to be released by end of June 2006
Contact: Lloyd Condra (lloyd.w.condra@boeing.com)

JCAA/JG-PP Lead Solder Project

- International collaborative effort
  - Project begun under the auspices of the U.S. DoD's Joint Group on Pollution Prevention (JG-PP), then turned over to the DoD's Joint Council on Aging Aircraft (JCAA) (concerned about numerous lead-free solder logistical and repair issues)
  - DoD, NASA, U.S. and European defense and OEMs, and component & solder suppliers
- Key question being addressed: To what extent does lead-free solder affect the electrical reliability of military/space electronics as compared to tin-lead solder?
- Study basically complete
- CALCE is providing reliability modeling support for this project

Contact: Kurt Kessel (Kurt.Kessel-1@ksc.nasa.gov)
http://www.jgpp.com/projects/lead_free_soldering/lead_free_soldering.html

CALCE Lead Free Forum Web Site

- Current Issues
- Legislation
- Projects
- Services
- Training
- Publications
- Presentations
- Related Research Groups
- Contact Us

Lead Free and Green Electronics Forum

The CALCE Electronic Products and Systems Center's Lead Free Forum is dedicated to the collection, generation, organization, and dissemination of information related in the manufacture, assembly, and fielding of lead free and "green" electronic products and systems.

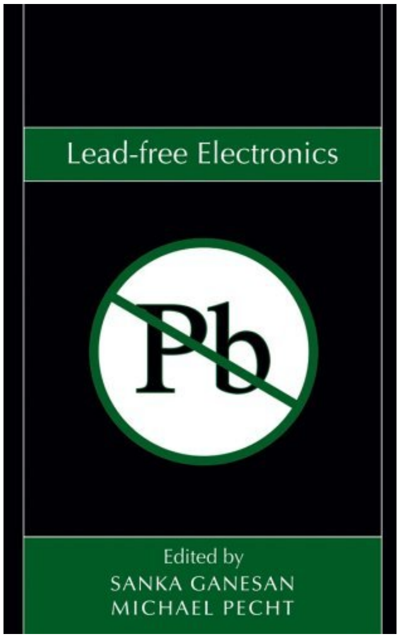
Current Issues and Events:

- CALCE Releases Tin Whisker Risk Assessment Software CALCE has released a new software for estimating the failure risk posed by tin whisker growth on electrical conductors in electronic hardware.
- CALCE Releases Pb-free Solder Fatigue Life Software CALCE has released a new software for estimating the life expectancy of solder joints in electronic hardware under temperature cycle loading. The new model is for SAC solder, the most widely adopted Pb-free solder.
- CALCE Long-Term Reliability Study for Pb-free Assemblies CALCE has initiated a reliability study of Pb-free assemblies to examine issues related to PWB surface and component terminal finish and durability of package to board interconnects under temperature cycling, vibration, and combined temperature cycling and vibration conditions.
- Part Suppliers Survey (Updated 3/14/05) (CALCE Consortium Member's Only) MS Excel Spreadsheet) A survey of electronic part suppliers. The survey represents information collected though review of public postings from part suppliers, as well as direct contact with representatives of the part supplier. The information gathering is an on-going activity. Individuals are encouraged to check with their part suppliers to obtain the latest information.
- Lead-free Electronics - 2004 Edition A new reference book for Pb-free electronics is now available from CALCE EPSC Press. (CALCE Consortium Members)
- CALCE Pb-Free Patent Finder Software (Members' Only) A software tool for examining existing international patents for Pb-Free Solders. This software was developed in part under C03-01. (Updated Version 1.0.1 posted 2/17/04)
- Tin Whisker Studies Information related to the tin whisker as a potential source of failure in electronic hardware.

http://www.calce.umd.edu/lead-free/

Lead-free Electronics Book

http://www.calce.umd.edu/general/published/books/books.html



- Chapter 1 Lead-free Electronics: Overview
- Chapter 2 Lead-Free legislations, Exemptions & Compliance
- Chapter 3 Lead-free Alloys: Overview
- Chapter 4 Lead-free Manufacturing
- Chapter 5 Review of Lead-free Solder Joint Reliability
- Chapter 6 Constitutive Properties and Durability of Selected Lead-free Solders
- Chapter 7 Interfacial Reactions and Performance of Lead-free Joints
- Chapter 8 Conductive Adhesives
- Chapter 9 Component-level Issues in Lead-free Electronics
- Chapter 10 Tin Whiskers in Electronics
- Chapter 11 Lead-free Separable Contacts and Connectors
- Chapter 12 Intellectual Property
- Chapter 13 Costs to Lead-free Migration
- Chapter 14 Lead-free Technologies in the Japanese Electronics Industry
- Chapter 15 Guidelines for implementing Lead-free Electronics

Final Summary

- Lead-free electronics are a reality.
- Companies with products that are exempt or not in scope will be impacted by the global transition to Pb-free and RoHS compliant electronics.
- All electronic equipment manufactures need to determine their course of action.
- Companies need to be educated through interaction with supply chain, consultants, and industry consortium.
- Not planning is not an option.

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Abbreviations

- ELV: End-of-Life Vehicle directive
- REACH: Registration, Evaluation, Authorization and Restriction of Chemicals
- IPP: Integrated Product Policy
- EuP: Energy-Using Products
- DTI: Department of Technology and Information
- JEIDA (currently JEITA): Japanese Electronics Industry Development Association (Japanese Electronics and Information Technology Industries Association)
- JIEP: Japan Institute of Electronics Packaging
- NCMS: National Center for Manufacturing Services
- IDEALS: Improved Design Life and Environmentally Aware Manufacture of Electronics Assemblies by Lead-free Soldering
- NEDO: New Energy and Industry Technology Development Organization
- NEMI (currently iNEMI): National (international) Electronics Manufacturing Initiatives
- IMS: Intelligence Manufacturing Systems