Overview of Risk Assessment, Mitigation, and Management Research for Pb-free Electronics

calce

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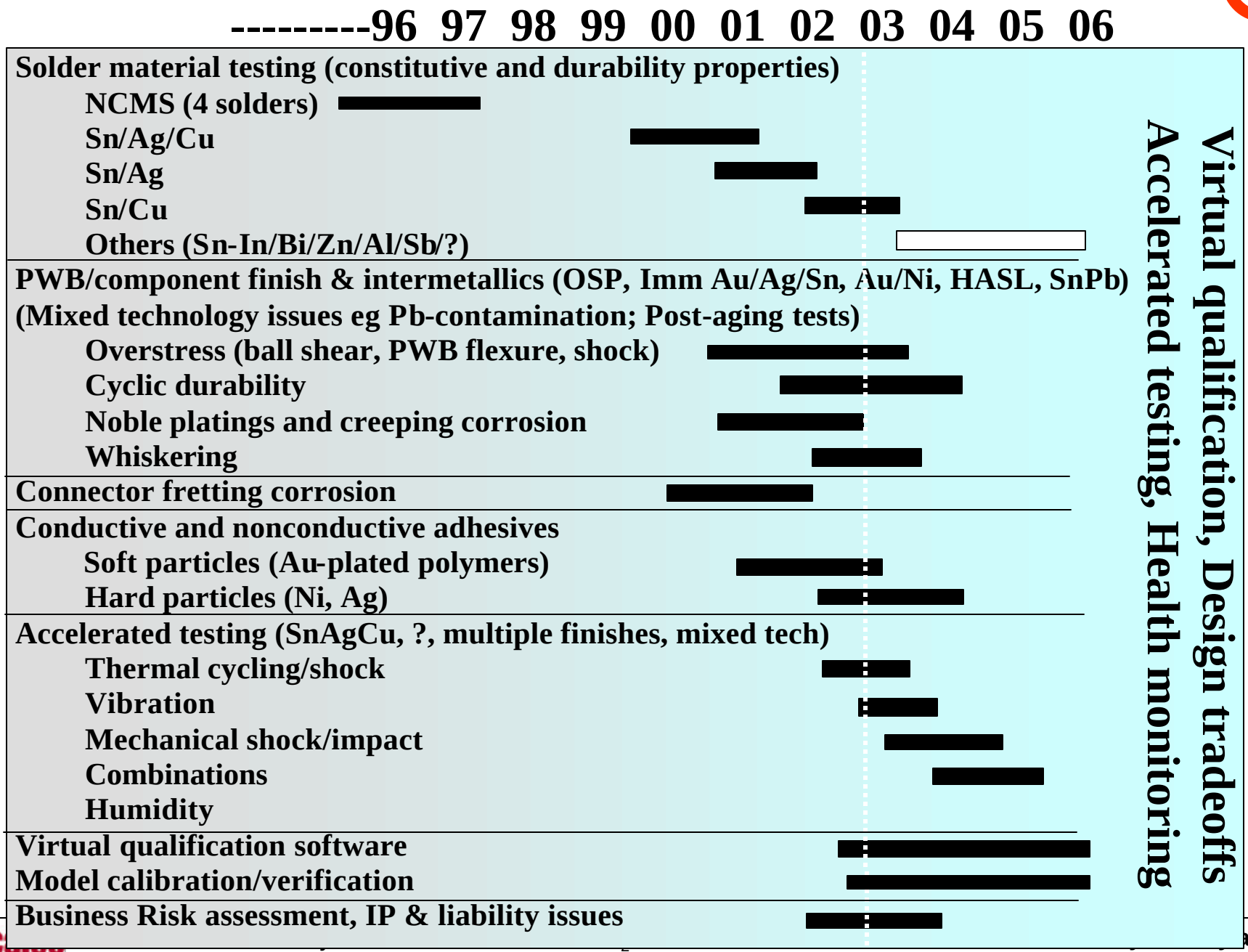
Formed 1987

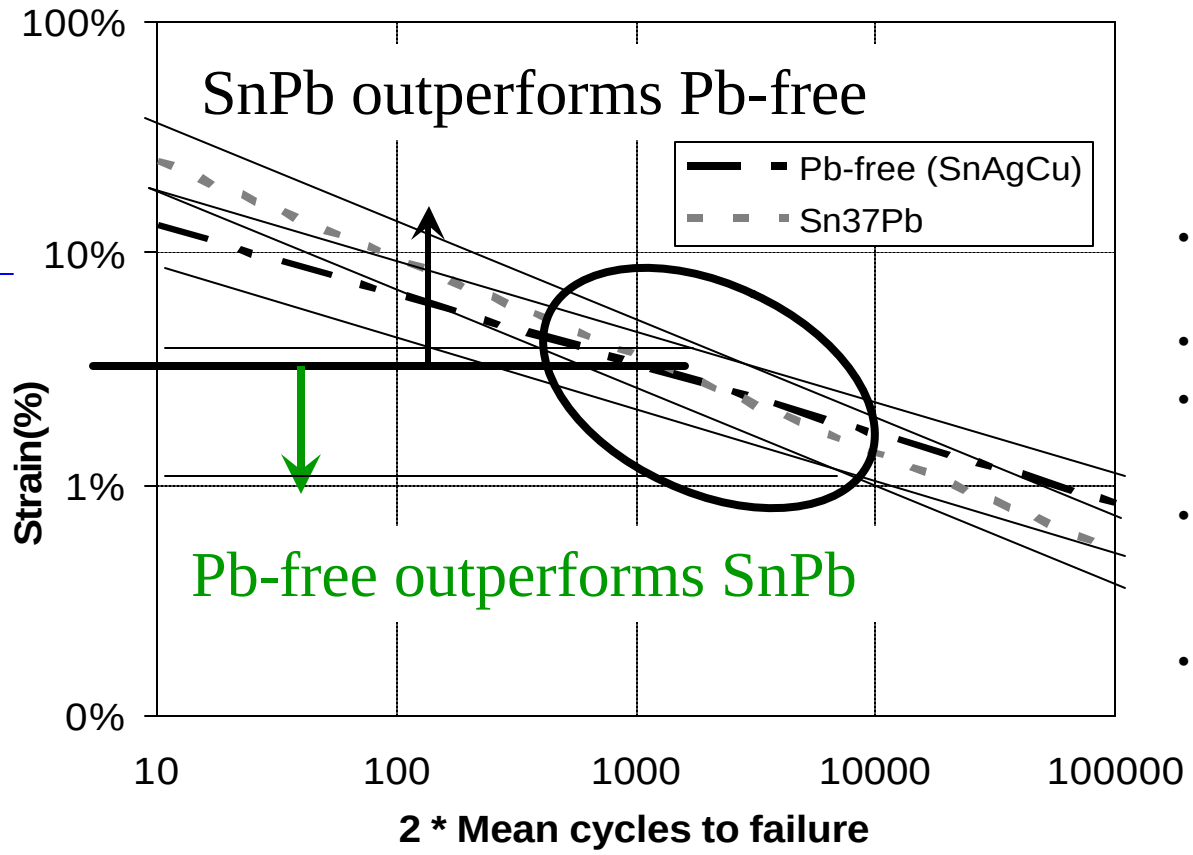
ISO 9001 Certified, 1999

CALCE Pb-free Tasks: Draft Roadmap



Durability of Solder under a Temperature Cycle

Collected experimental data has resulted in a preliminary rapid assessment model for Sn4.0-3.8Ag0.7Cu solder, released in the calcePWA software. Data consists mostly of standard test conditions (i.e. -40 to 125°C, -55 to 125°C, and 0 to 100°C) with little variation in dwell or mean temperature.



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

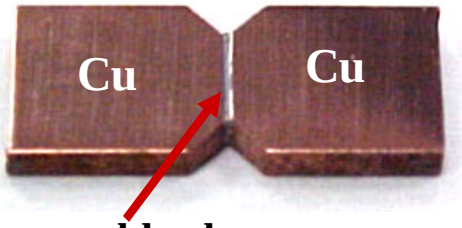
- N_f : mean number of cycles to failure
- $\Delta\gamma_p$: inelastic strain range
- ε_f, c : material constants

- Qualitative graph represents CalcePWA model predictions for SnPb and SnAgCu solders.
- Crossing point likely to shift due to temperature cycle parameters (i.e. mean temperature, temperature range, dwell time, and ramp rate)

Mechanical Cyclic Fatigue Durability Properties of Lead-free Solder

Objective: Determine cyclic fatigue durability properties of lead-free solder

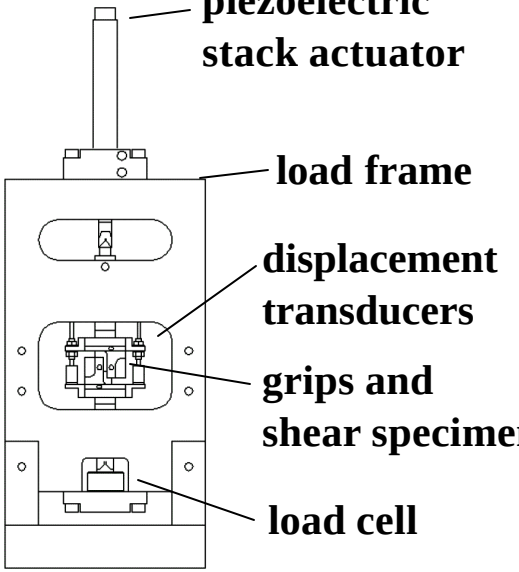
Miniature shear specimen

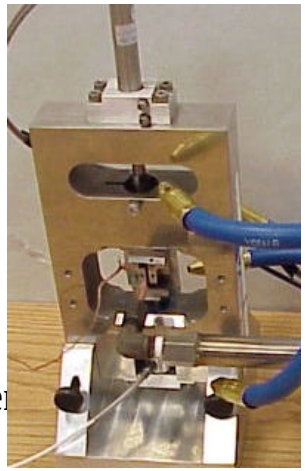


solder layer
(3mm x 1mm x 180 mm)

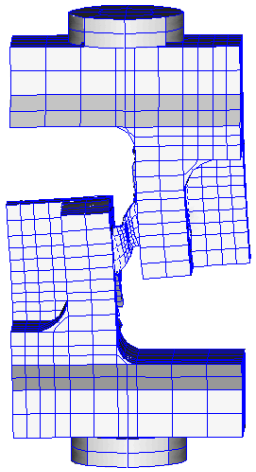
Test Setup

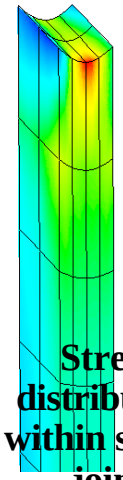
High-precision, custom testing frame provides control necessary for testing of miniature-scale specimens





Model of Test setup

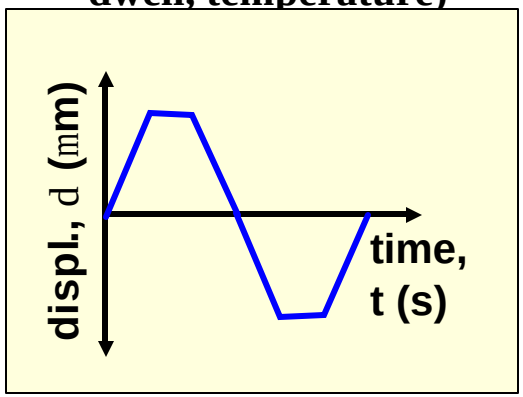




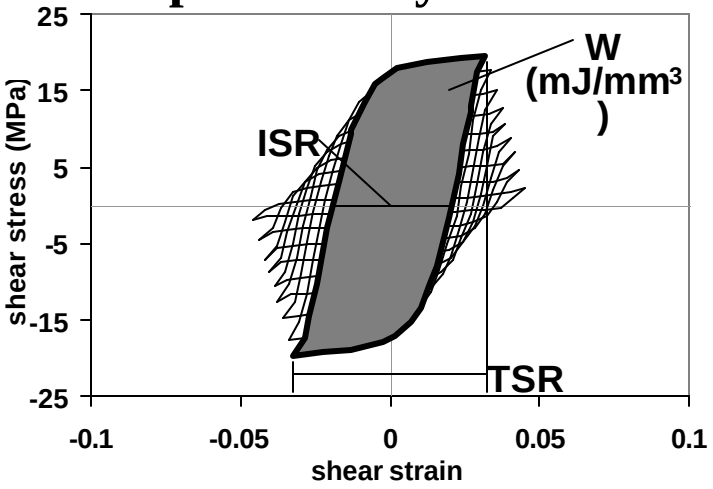
Stress distribution within solder joint

Cyclic durability Tests

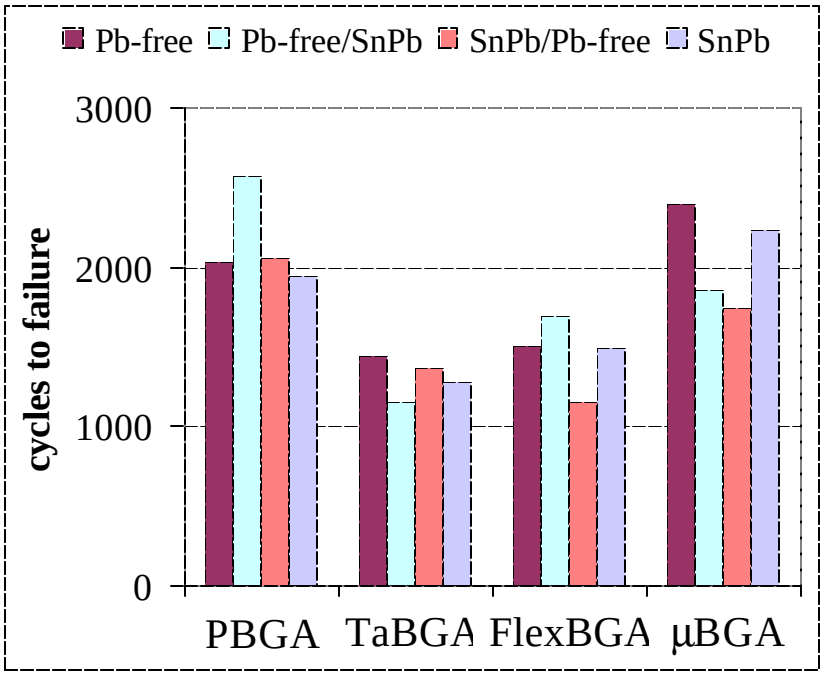
= *f*(amplitude, ramp rate, dwell, temperature)



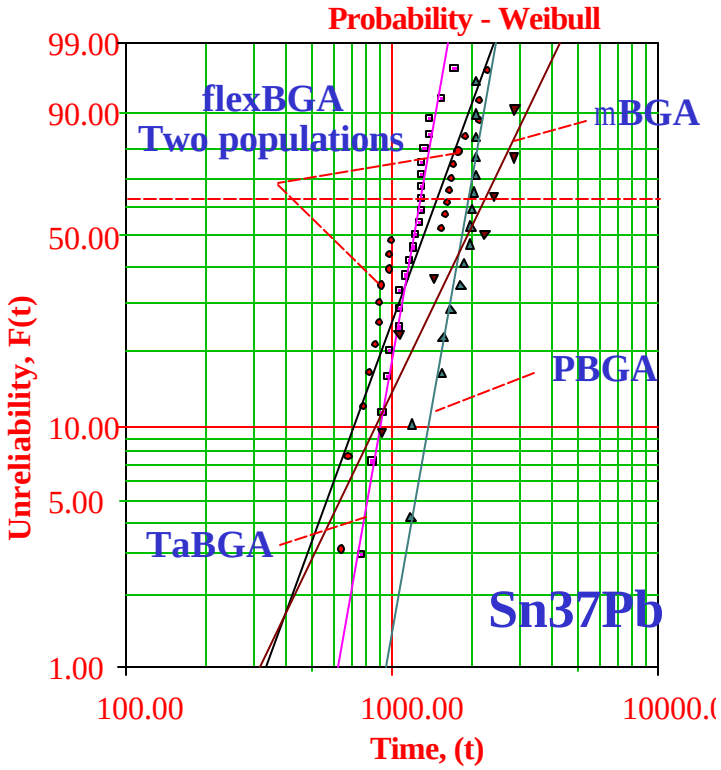
Specimen Hysteresis



Accelerated Thermal Cycling



The effect of Pb contamination in mixed technologies

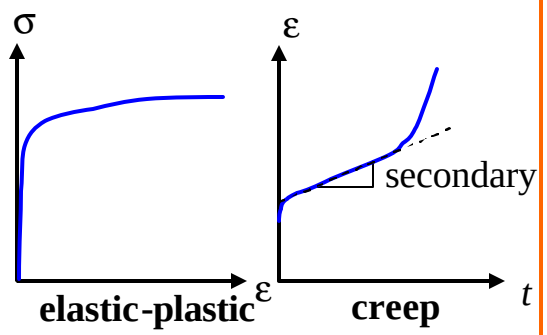


Detailed Modeling

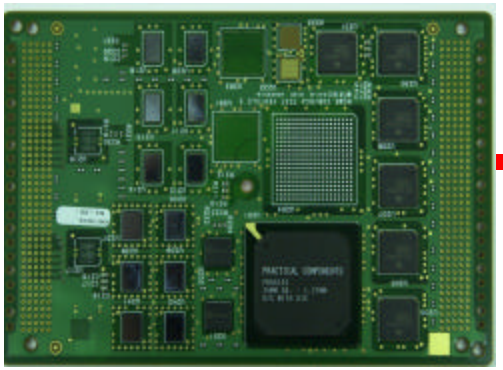
Energy-Partitioning Damage Approach

1

Constitutive Properties of Solders

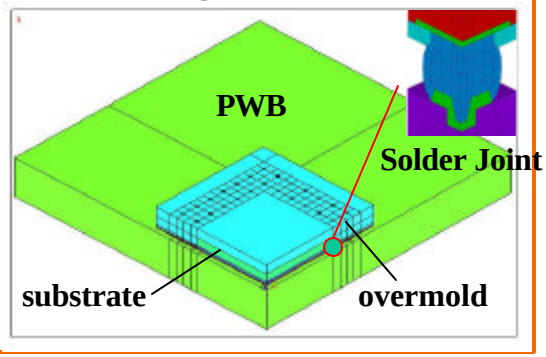


Test Vehicle



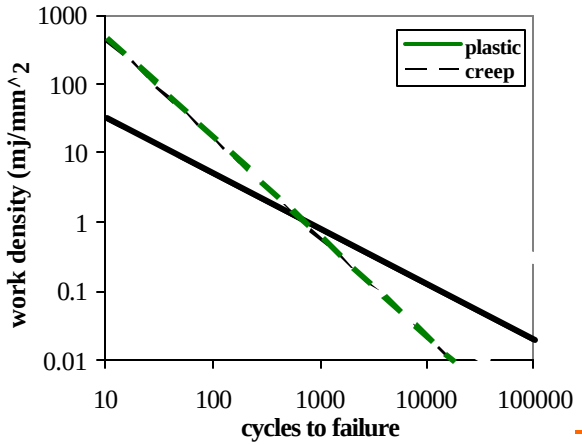
2

Package Architecture



4

E-P Model

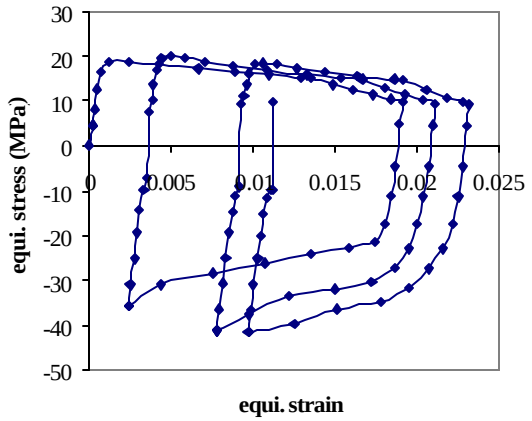


plastic work density
creep work density

plastic damage N_{fp}
creep damage N_{fc}

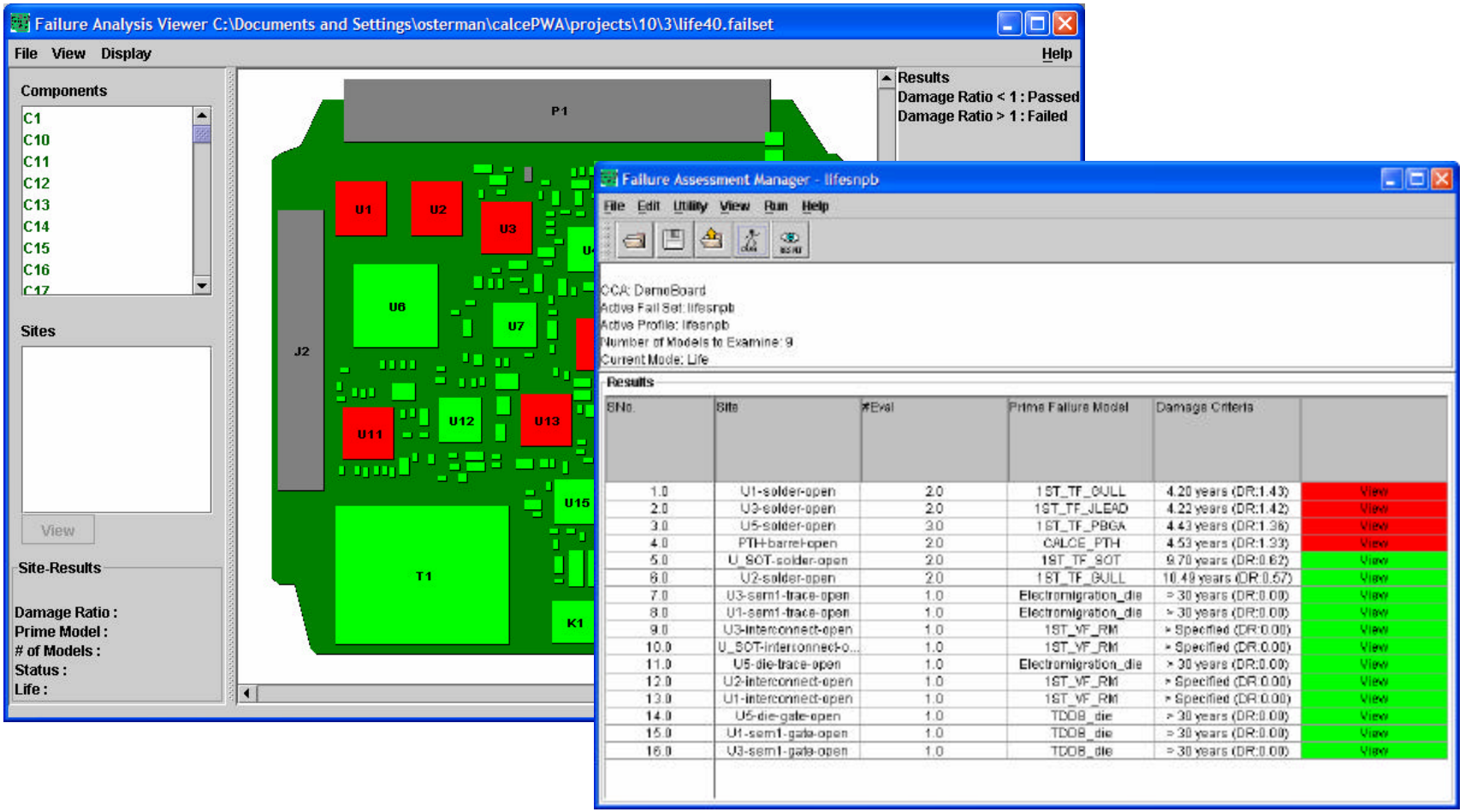
3

Stress-Strain Hysteresis



5 **Total cycles to failure:** $\frac{1}{N_{ft}} = \frac{1}{N_{fp}} + \frac{1}{N_{fc}}$

Rapid Failure Assessment Software for Pb-free



On-going efforts in rapid assessment of printed wiring assemblies has resulted in a preliminary model for assessing failure of Pb-free (SnAgCu) solder package to board interconnects.

PWB Plating Study

Five different platings from two manufacturers were reflow soldered with Sn3.8Ag0.7Cu to determine the intermetallic formation and shear strength.

Samples
$ENIG^{M}$, $ENIG^{T}$
$ImSn^{M}$, $ImSn^{T}$
$ImAg^{M}$, $ImAg^{T}$
OSP^{M}, OSP^{T}
$HASL^{T}$

Apply solder paste with stencil

Place solder balls

Reflow at peak T=244°C

Shear testing (25 balls)
Cross-sectioning (2 balls)

Thermal Aging

T_m(Sn3.8Ag0.7Cu)=217°C(490K)

$0.9T_m$ (168°C)

$0.85T_m$ (143.5°C)

$0.8T_m$ (119°C)

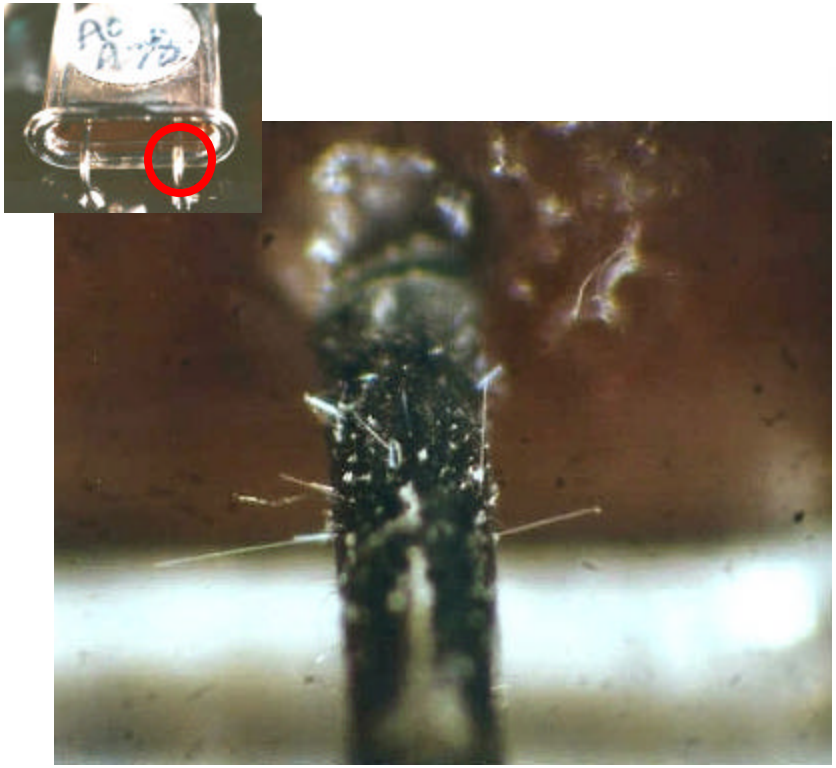
10 hours	100 hours	1000 hours

10 hours	100 hours	1000 hours

10 hours	100 hours	1000 hours

Shear testing (25 balls)
Cross-sectioning (2 balls)

CALCE Tin Whisker Study



Tin Whisker Information

Tin Whisker Alert (Whitepaper) A candid discussion of the concern over failures in electronics related to "tin-whiskers" and its potential re-emergence due to the move lead-free solders.

Tin Whisker Risks (Whitepaper) A technical discussion of the "tin-whiskers" phenomenon, current knowledge and remaining questions.

Tin Whisker Experiences (Whitepaper) A collection of experiences where "tin-whiskers" have been observed.

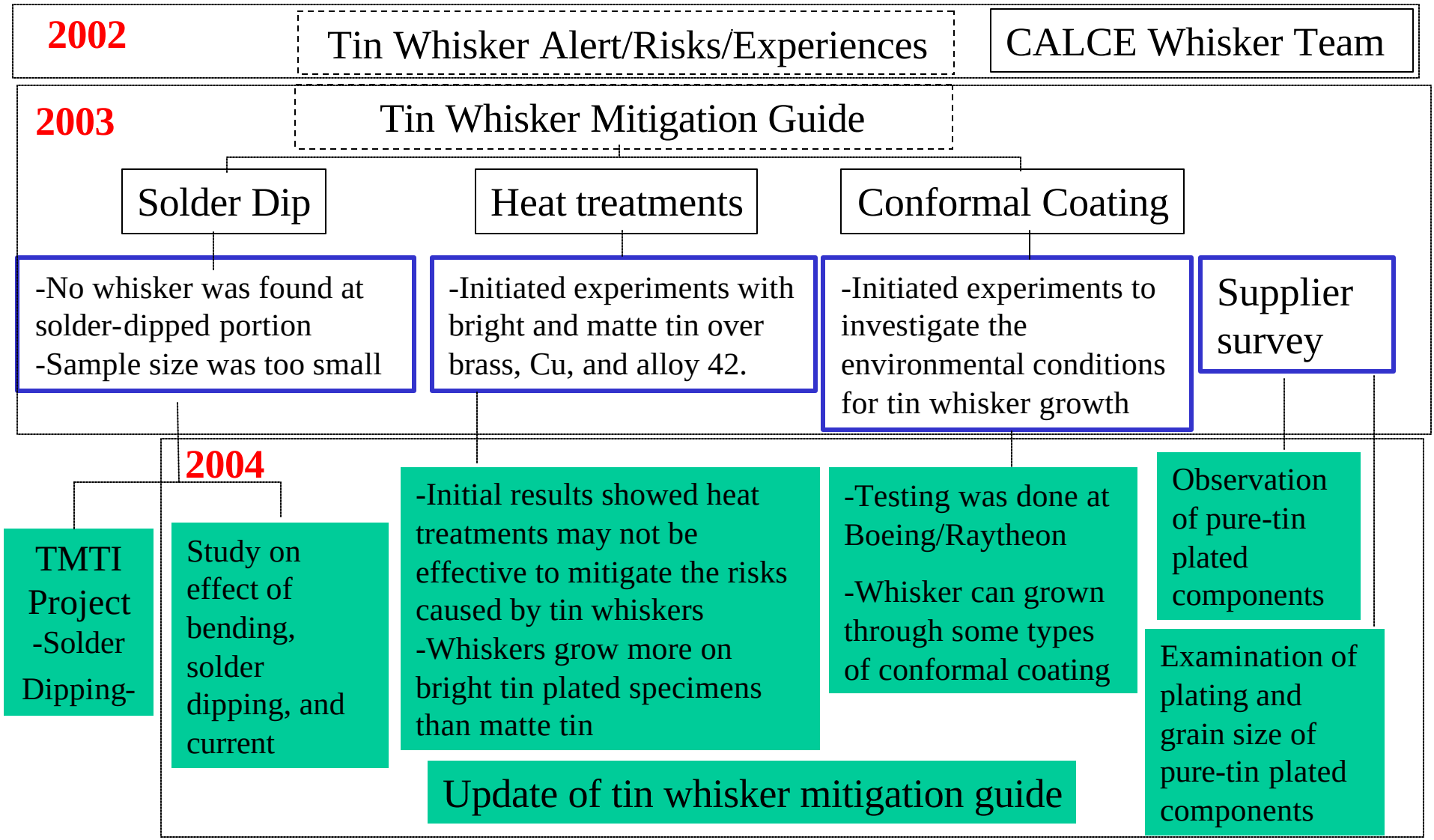
Tin Whisker Mitigation Guide (Whitepaper) A guide for mitigating the risk of tin-whiskers as a failure source in electronic hardware.

In addition to conducting multiple research projects on lead free solder issues this past year, CALCE joined with a number of companies to author an alert regarding the use of pure tin as a surface finish.

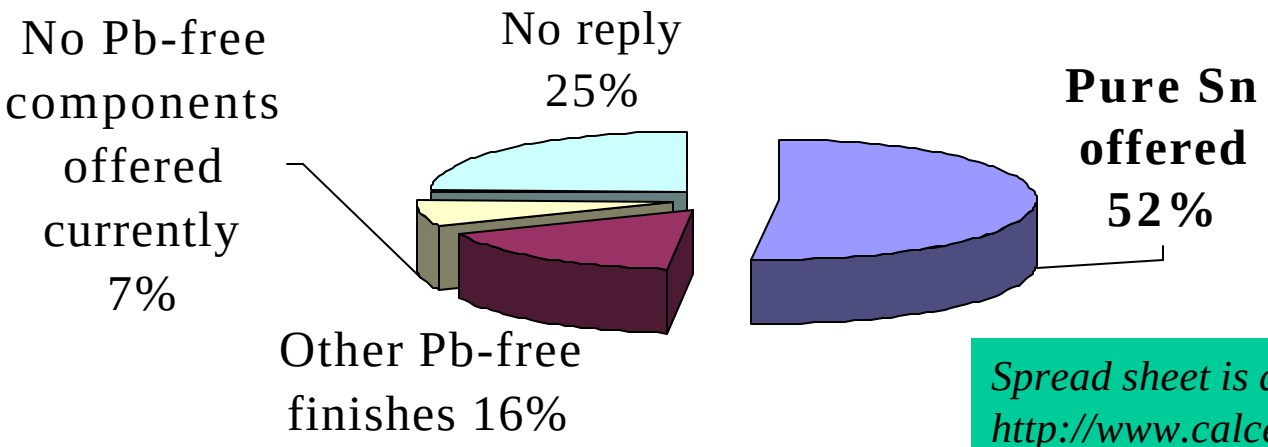
This alert was followed closely by a mitigation guide authored by CALCE with inputs from companies participating in the Tin Whisker Alert Working Group.

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

CALCE Tin Whisker Team Studies (Roadmap)



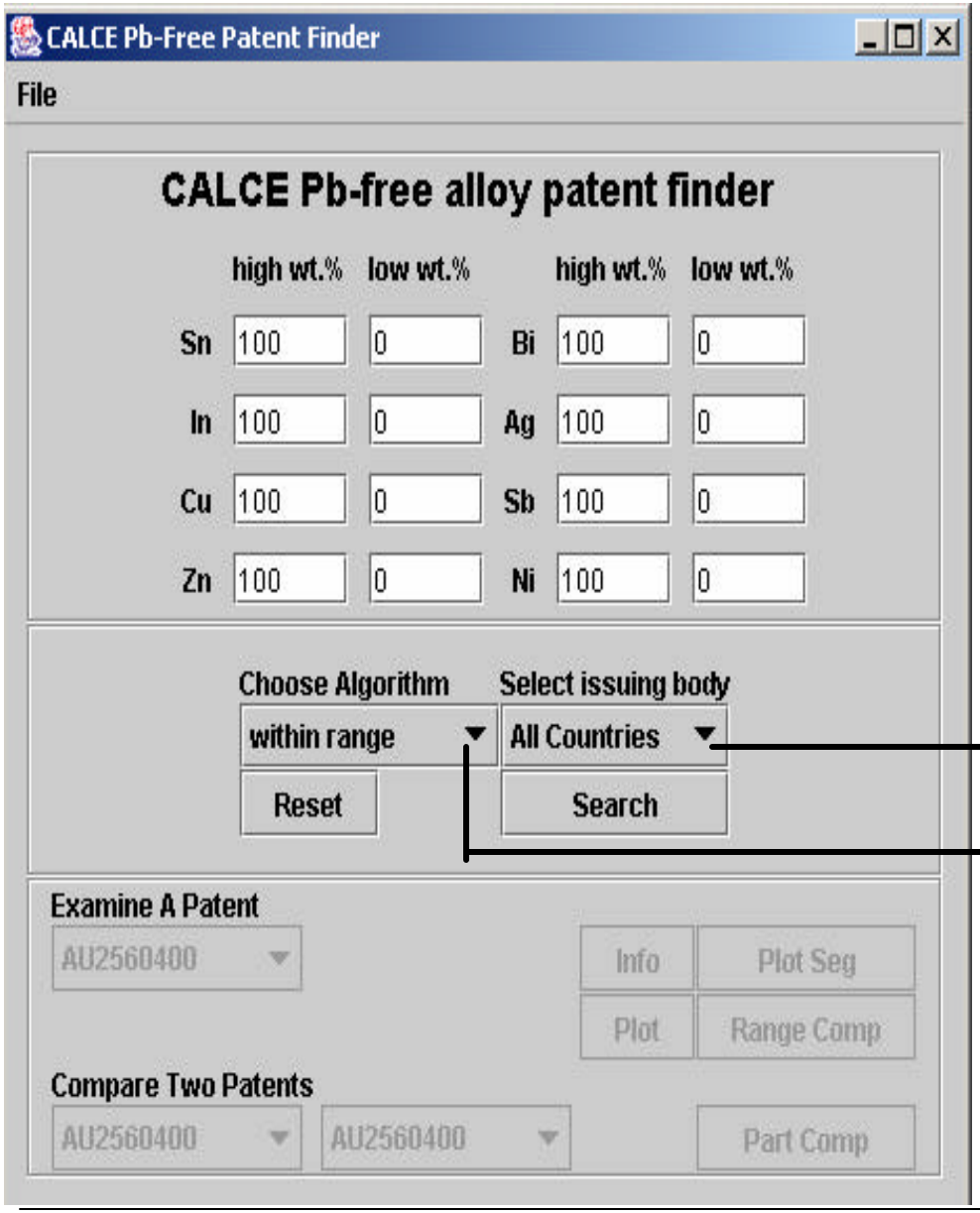
Component Manufacturers' Survey
- Pb-free Component Finishes -



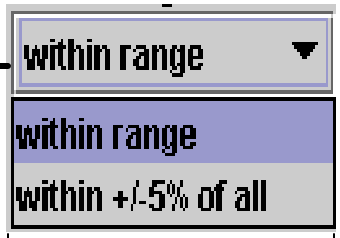
Spread sheet is available for review at http://www.calce.umd.edu/leadfree/members/partsuppliers.xls

- Since October 2003, an additional 10 % of companies selected pure tin (matte) as a Pb-free option. Survey was conducted among 104 leading component manufacturers.
- Even though a list of Pb-free components offerings is showed in the companies' websites (i.e., those components have been qualified and can be manufactured), availability of Pb-free component is still limited in the actual supply chain.
- Due to insufficient traceability of components, mistaken delivery of Sn-Pb components instead of Pb-free components has occurred.

CALCE Pb-free Alloy Patent Finder



- Check if and where an alloy is patented
- Compare patented alloys

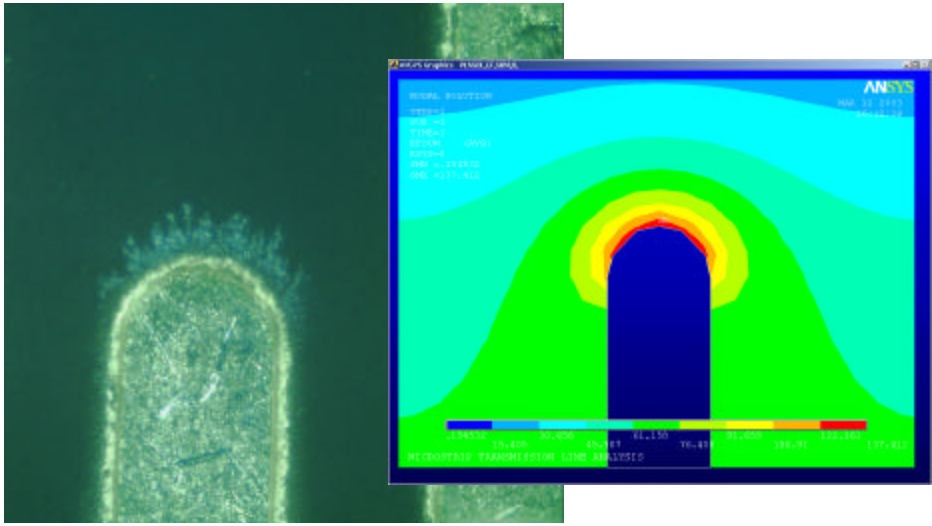


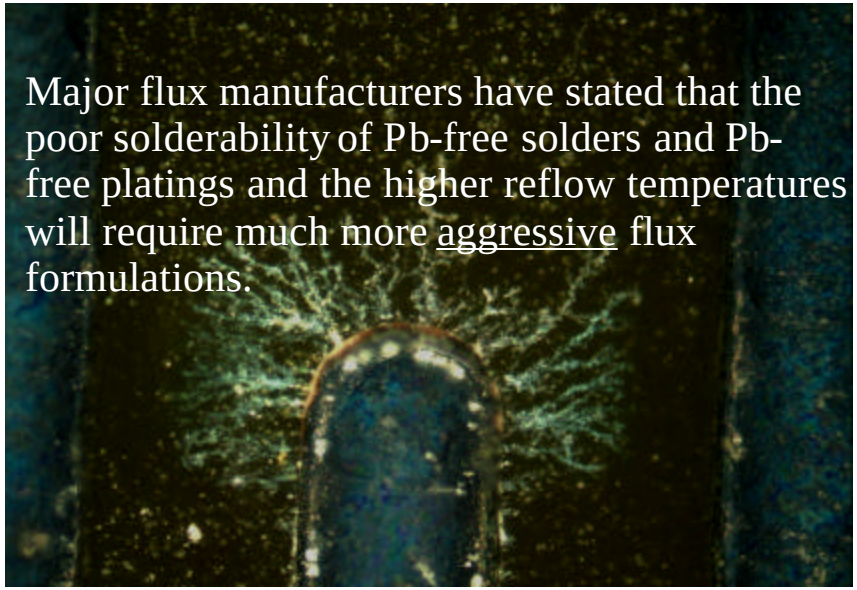
Choice of search methods

Restrict search by

Electrochemical Migration in the Age of Pb-Free

- What does Pb-Free mean to electrochemical migration (ECM)?
  - New plating materials
  - New interconnect materials
  - New flux chemistries
- ECM and alternative platings
  - ENIG and ImSn dependent upon plating quality
  - ImAg dependent upon electric field
- Sn-Based Alloys
  - Use environment likely to be acidic with the presence of oxygen and halides
  - Potential for order of magnitude increase in corrosion rate





2004 CALCE Consortium Research

http://www.calce.umd.edu/general/projects/current.htm

C04-01 Logistics and Cost Analysis for Lead-Free Implementation
C04-02 Risk Assessment & Accelerated Qualification of Pb-free Electronics
C04-03 Durability Characterization of Pb-free Solders
C04-04 Effect of Temperature Cycle on the Durability Pb-Free Inteconnects (Sn-Ag-Cu and Sn-Ag)
C04-05 Determination of Fatigue Constants of Lead-free Solder for calcePWA
C04-06 Intermetallic-Related Embrittlement of Lead-free Solder Die Attach
C04-07 Investigation of Issues on Lead-free Plating (Pure Sn)
C04-08 Reliability of Pb-free Interconnect Solutions
C04-09 Hermeticity of Wafer Level Packaging
C04-10 Qualification and Reliability Assessment of New Capacitor Technology
C04-11 Cracking of BME Ceramic Chip Capacitors in High Humidity
C04-12 Reliability Assessment of High Density IC sockets and Tests for the Causes of Failure
C04-13 Effects of Conformal Coating of Solder Spreading Phenomenon
C04-14 Dendritic Growth and the Effect of Conformal Coating
C04-15 Environmental Degradation of Polymer Waveguides
C04-16 Backplane Databuses for Modular Avionics
C04-17 Long-Term DMSMS Management and Planning
C04-18 Life Consumption Monitoring/Prognostic Application Space (ROI for Maintenance Planning)
C04-19 Integrated Health and Usage Monitoring System
C04-20 Methodology for Equipment Manufacturer Intervention in their Supply Chain
C04-21 Reliability Capability Assessment for Contractors and Vendors
C04-22 Advanced Micro-Structured Surfaces for Heat Sinks/Heat Spreaders
C04-23 Advanced Liquid Cooled Module for Cooling of High Flux Electronics
C04-24 Spot Cooling of High Flux Electronics with Thin Film Evaporation
C04-25 Thermal Characterization of Die Attach Adhesives
C04-26 Development of Hybrid-Level Screening Methodology
C04-27 Analysis of Intermittent Failures in Electronic Assemblies
C04-28 Failure Analysis of the Main Board in LCD Laptop Computer
C04-29 Dynamic Behavior of Plastics under Impact Loading
C04-30 Reliability Assessment of Electronic Assemblies Under High-G (Artillery Launch) Loads
C04-31 Improved Failure Simulation of Vibration Induced Failures - continued
C04-32 New Analysis and Modeling Capabilities for calcePWA
C04-33 Solder Joint Reliability with FBGA
C04-34 Reliability Assessment of Surface Mounted Chip Varistor Subjected to Thermal Shock
C04-35 Development of PoF Based Virtual Qualification Methodology for COF Packages (Phase II)
C04-37 PoF-Based Wire Lift-off Models for Aluminum Wedge Bonds
C04-38 Virtual Qualification of Subsystems at High Temperatures

CALCE Lead Free Forum Web Site

- Current Issues
- Projects
- Services
- Training
- Articles
- 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:

Lead-free Electronics - 2004 Edition A new reference book for Pb-free electronics is now available from CALCE EPSC Press.

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.

CALCE Lead Free Forum Workshop (CALCE Members Only) On October 10th 2002 CALCE hosted a Lead-Free Workshop.

Failures in Microeletronics Attributed to Phosphorus An update to the warning of a potential reliability risks attributed to molding compounds that use phosphorus as a flame-retardant.

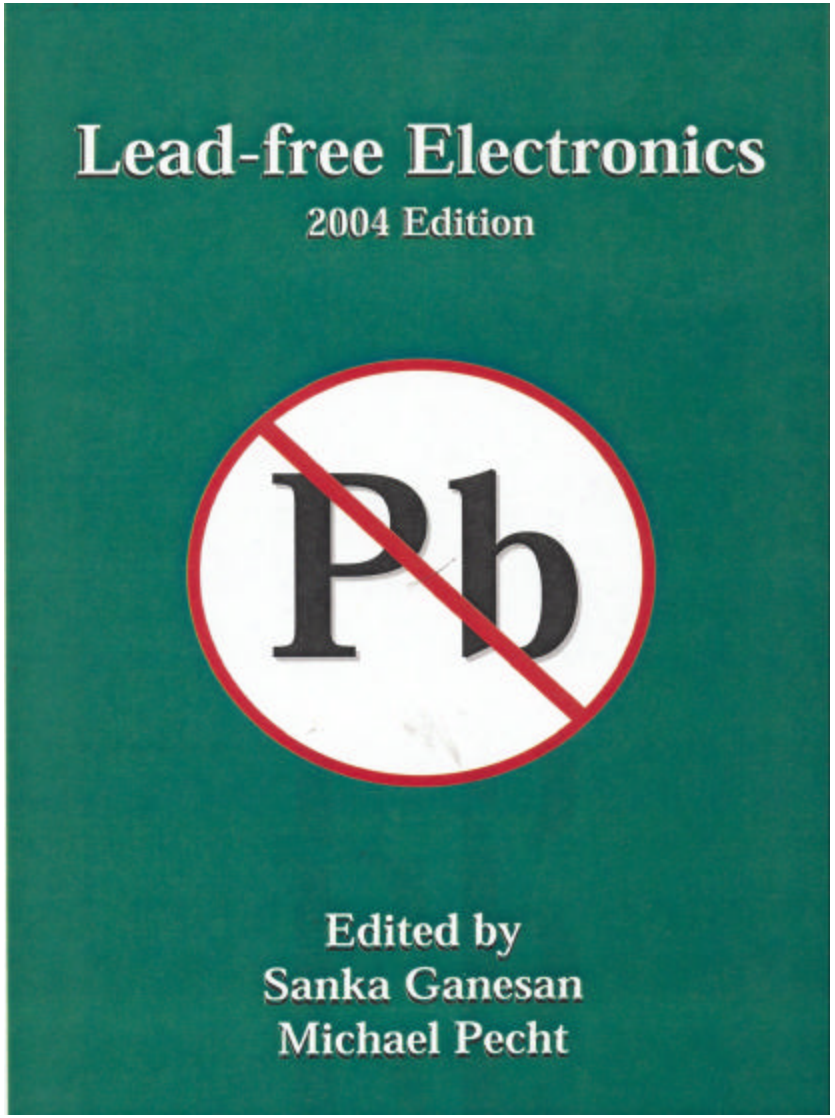
Lead Free Forum Point of Contact: M. Osterman

Please Mail Inquires to - leadfree@calce.umd.edu

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

Pb-Free Resources

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



Chapter 1 Lead-free Electronics: Overview

Chapter 2 Lead-free Alloys: Overview

Chapter 3 Constitutive Properties and Durability of Lead-free Solders

Chapter 4 Interfacial Reactions and Performance of Lead-free Joints

Chapter 5 Lead-free Manufacturing

Chapter 6 Component-level Issues in Lead-free Electronics

Chapter 7 Conductive Adhesives

Chapter 8 Lead-free Separable Contacts and Connectors

Chapter 9 Intellectual Property

Chapter 10 Costs to Lead-free Migration

Chapter 11 Lead-free Technologies in the Japanese Electronics Industry