Lead-free Feasibility Program: Assembly and Testing of a Functional Military Avionics Unit

Authors: Dave Hillman and Matt Hamand – Rockwell Collins

EXECUTIVE SUMMARY

Although the official implementation of the EU Restriction of Hazardous Substances (RoHS) directive officially started on July 1, 2006, a significant portion of the avionics electronics supply chain began a wide variety of transition actions in the years prior to the implementation deadline in an effort to understand material issues and fabrication concerns. Original Electronic Manufacturers (OEMs) of avionics equipment were either exempt (military products) or excluded (commercial products) from the EU RoHS requirements due to the legislative directive being a single market initiative. However, due to the fact that components used in the avionics industry are largely common with those used in the affected consumer markets, Rockwell Collins had no choice but to begin proactively addressing these issues/concerns back in 2003. The objective of the investigation was to conduct a feasibility study using a functional avionics design to determine printed wiring board design and potential printed wiring assembly issues/concerns when using Pbfree soldering processes/procedures for military avionics products. Environmental Stress Screen (ESS) testing was completed demonstrating that the lead-free military avionics unit was equal to the typical tin/lead military avionics unit test results for the conditions used. This information will be incorporated into the Rockwell Collins Lead-free Control Plan (LFCP) knowledge database as customer information.

Rockwell Collins

Lead Free Assembly of Functional Military Avionics

Matthew Hamand
David Hillman

IPC MIDWEST CONFERENCE & EXHIBITION

Outline

- Objective
- Our History
- Unit
- Assembly
- Environmental Stress Test
- Results
- Failure analysis
- Discussion
- Conclusions

IPC MIDWEST CONFERENCE & EXHIBITION

Objective

- The objective of the investigation was to determine the impact of Pbfree materials and procedures on a legacy electronics system.

Our History

- **Lead free moving us somewhere**
  - **Widgets**
  - **Assemblies**
  - **Units (Commercial)**
  - **Units (Military)**

- **Answering the tough questions**
  - **Will lead-free hardware survive harsh conditions?**

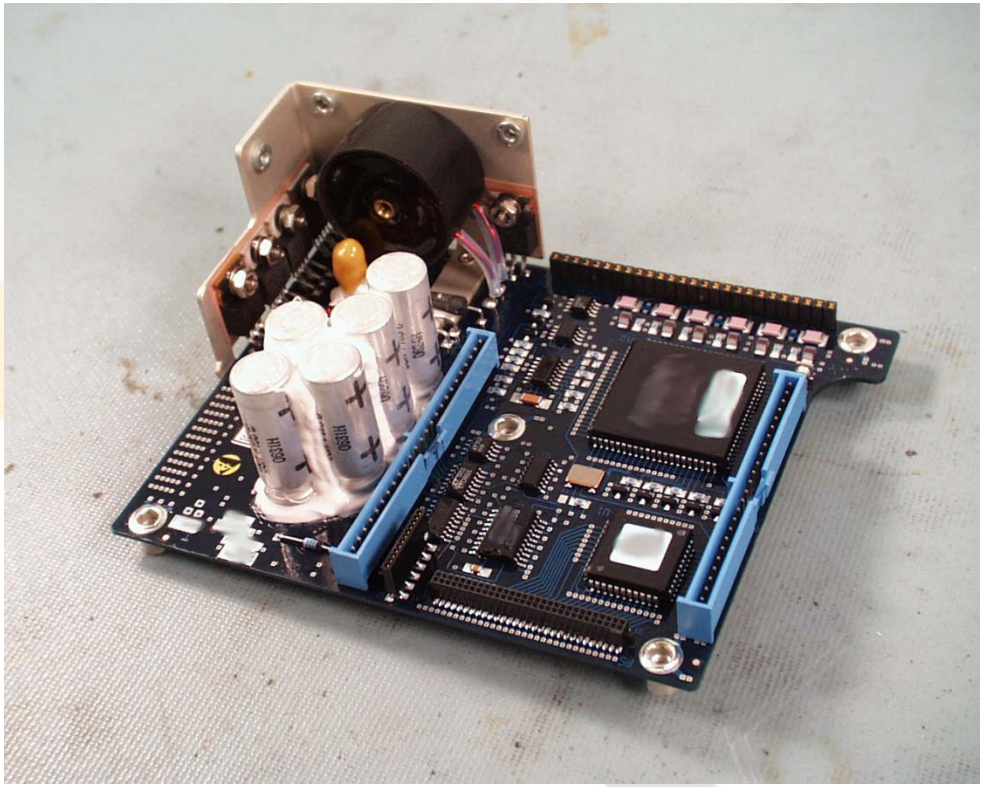
IPC MIDWEST CONFERENCE & EXHIBITION

CDU-220

- **Control Data Unit**
  - **Helicopter**
  - **Display**
  - **Designed in 1988**
- **Four Assemblies**
  - **Two assembled**
  - **Two COTS**

Assembly

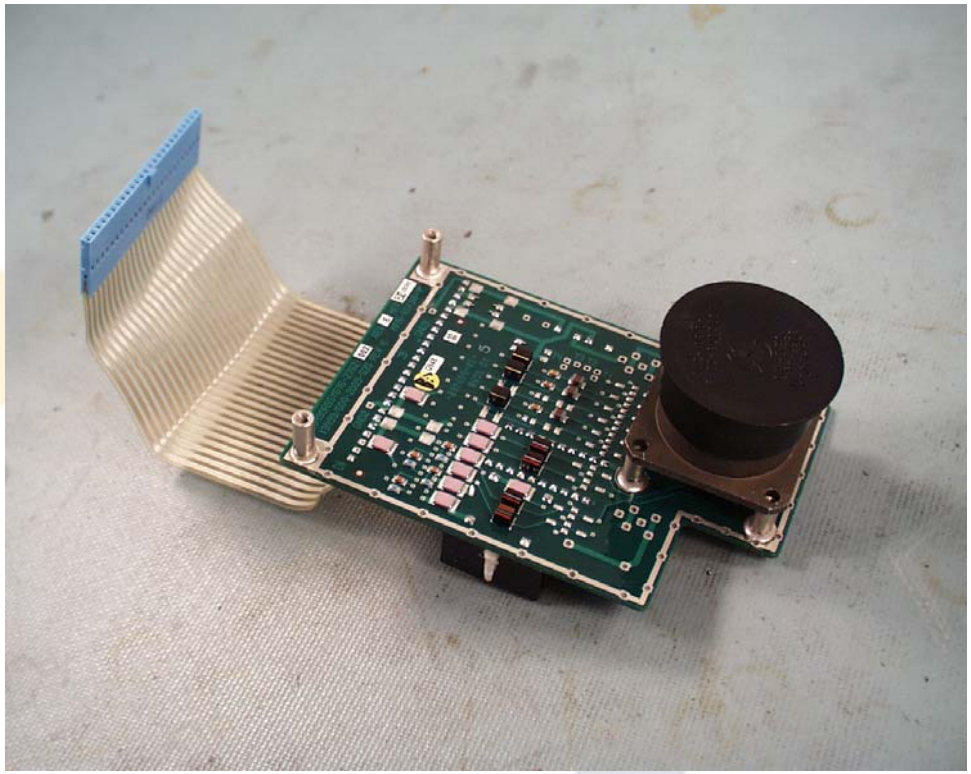
- **Board**
  - **FR4**
  - **135°C**
  - **Immersion tin**
  - **Blue soldermask**
- **Components**
  - **Surface mount**
  - **No area array**
  - **Thru hole connectors**



IPC MIDWEST CONFERENCE & EXHIBITION

Assembly

- **Board**
  - **FR4**
  - **135°C**
  - **Immersion tin**
- **Components**
  - **Surface mount**
  - **Circular PTH connector**



IPC MIDWEST CONFERENCE & EXHIBITION

Assembling the Assembly

- **Solder**
  - **Tin, Silver, Copper – SAC 305**
  - **Type IV Solder Paste**

- **Reflow**
  - **12 zone oven**
  - **Minimum temperature during peak reflow 235°C**
  - **Time Above Liquidus (TAL): 30-60 seconds**

IPC MIDWEST CONFERENCE & EXHIBITION

Assembling the Assembly

- **Manual Soldering**
  - **Double dip**
  - **Training**
- **Wash**
- **Inspection**
- **Conformal Coat**

IPC MIDWEST CONFERENCE & EXHIBITION

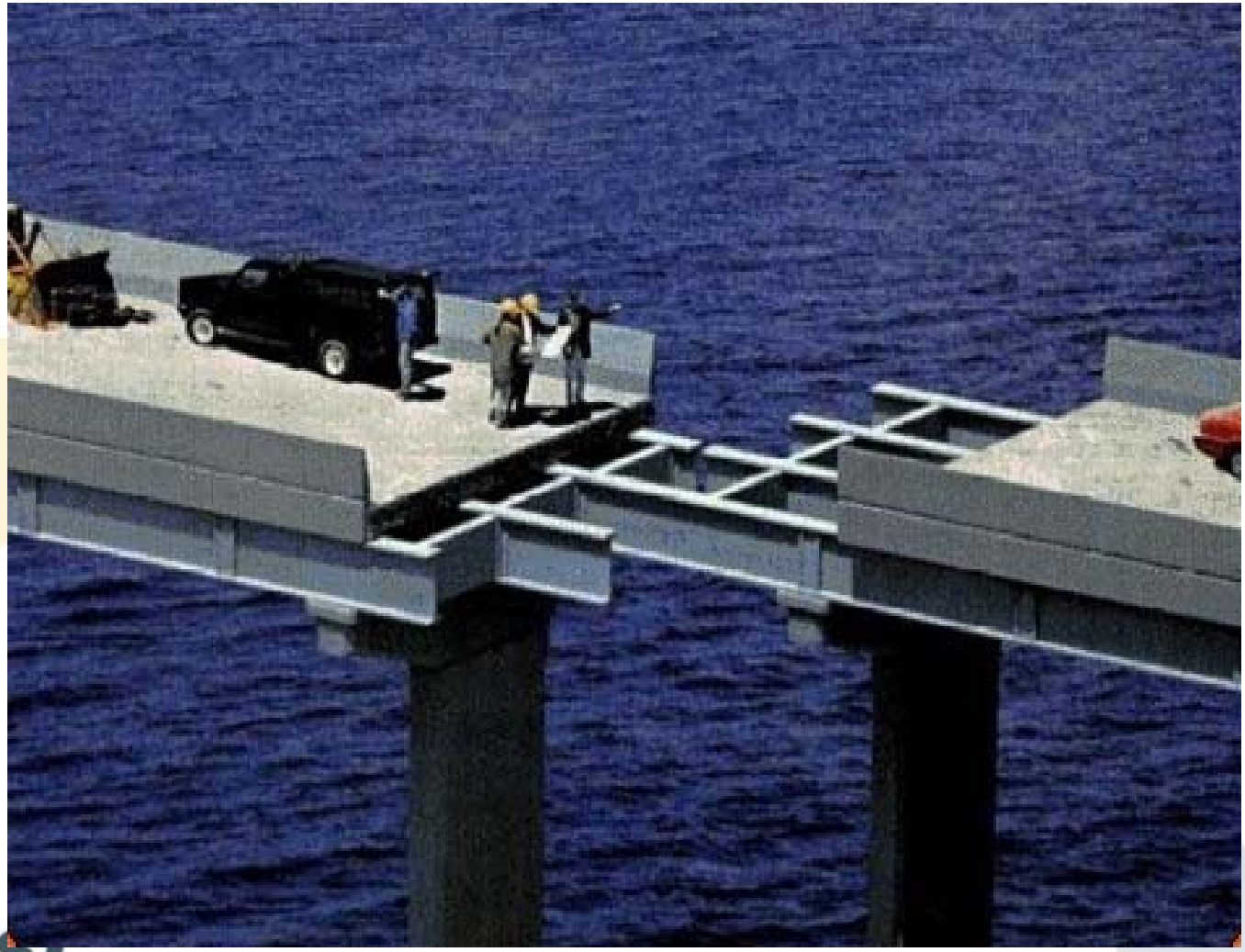
Environmental Stress Screen

- Vibration
  - 4 GMS for 10 minutes
  - Ran once per day for 14 days

- Thermal Excursions –
  - -40°C to 55°C
  - 1.5 hours at extremes
  - 15°C/minute maximum transition rate
  - Power on during Hot phase
    - Functional check, once/day
  - Ran continuously for 14 days
    - Break in testing of vibration

IPC MIDWEST CONFERENCE & EXHIBITION

Matt-to-Dave “Transition” Cell



IPC MIDWEST CONFERENCE & EXHIBITION

Results

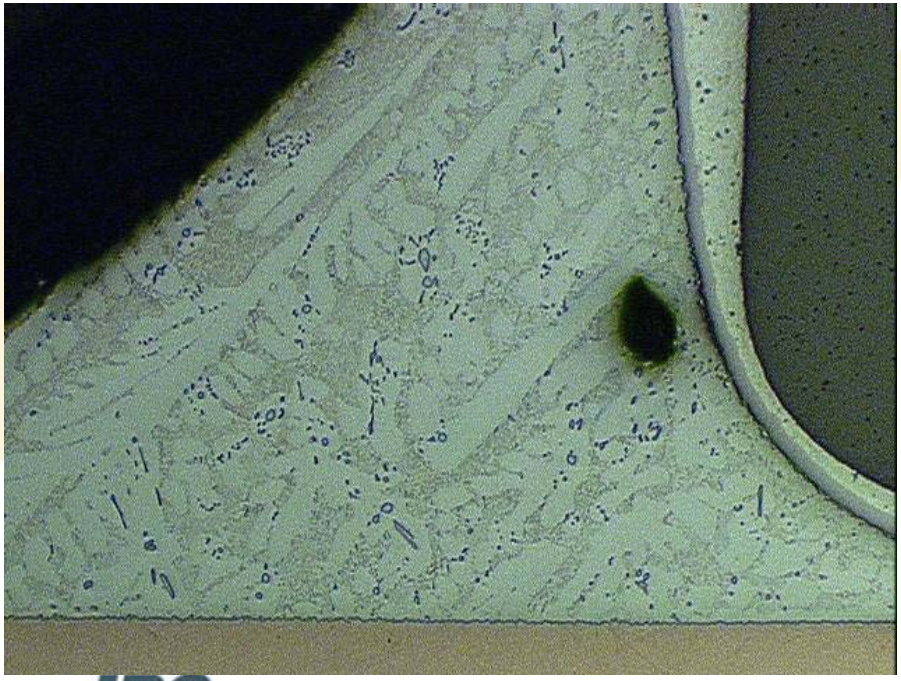
- **Comparison To Tin/Lead Baseline**

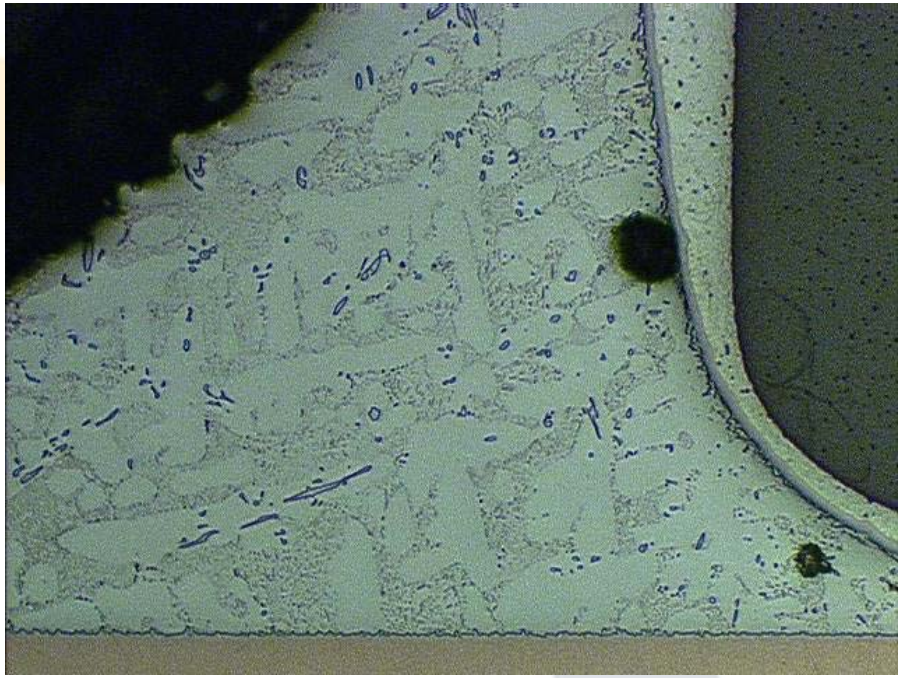
- **No “Road Blocks” (aka failures) During Endurance Trials**

IPC MIDWEST CONFERENCE & EXHIBITION

Failure Analysis

- **As Manufactured Versus ESS**
  - **Surface Mount Capacitor**

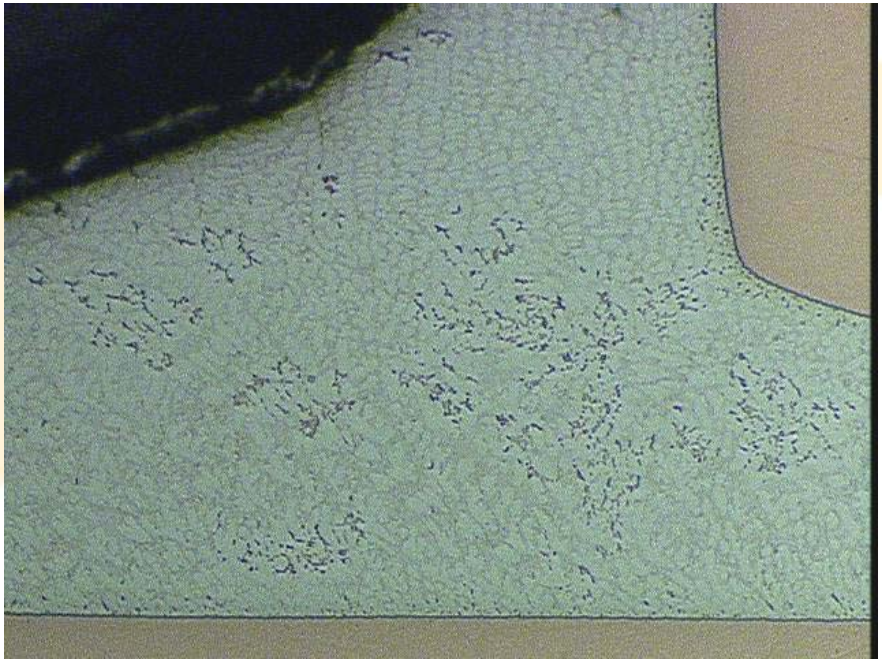


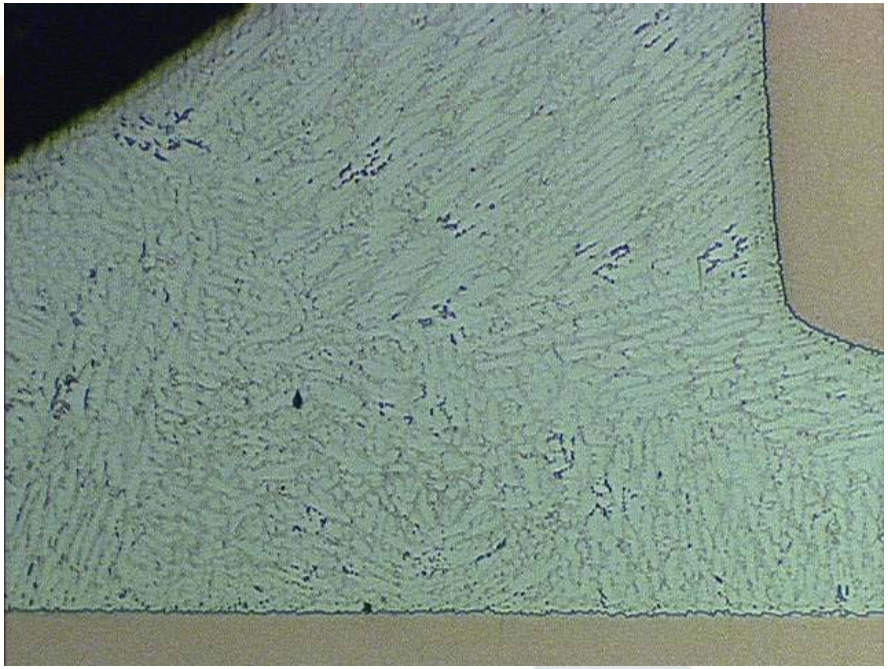


IPC MIDWEST CONFERENCE & EXHIBITION

Failure Analysis

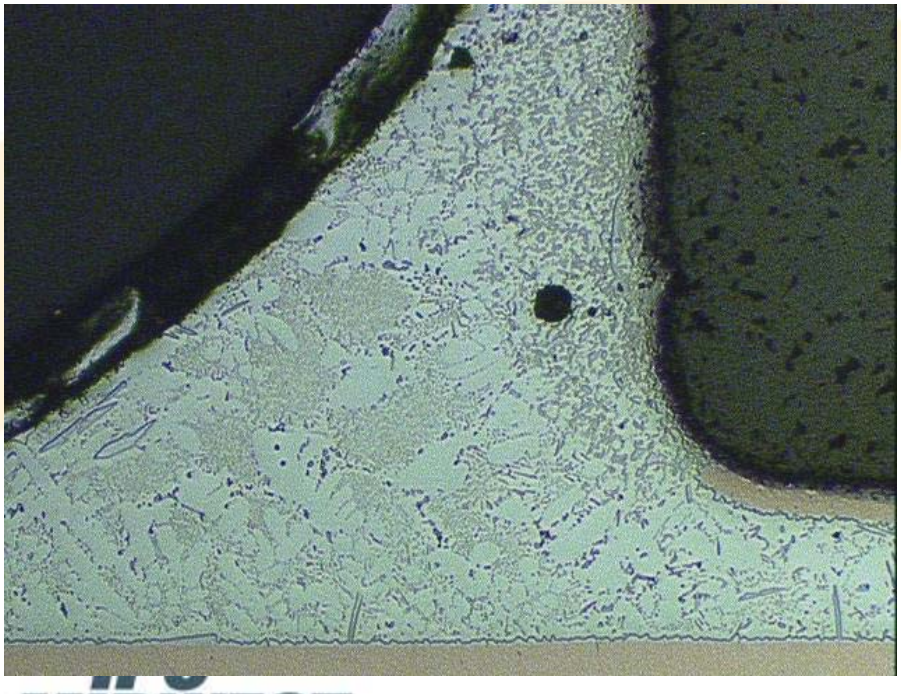
- **As Manufactured Versus ESS**
  - **Surface Mount Diode**

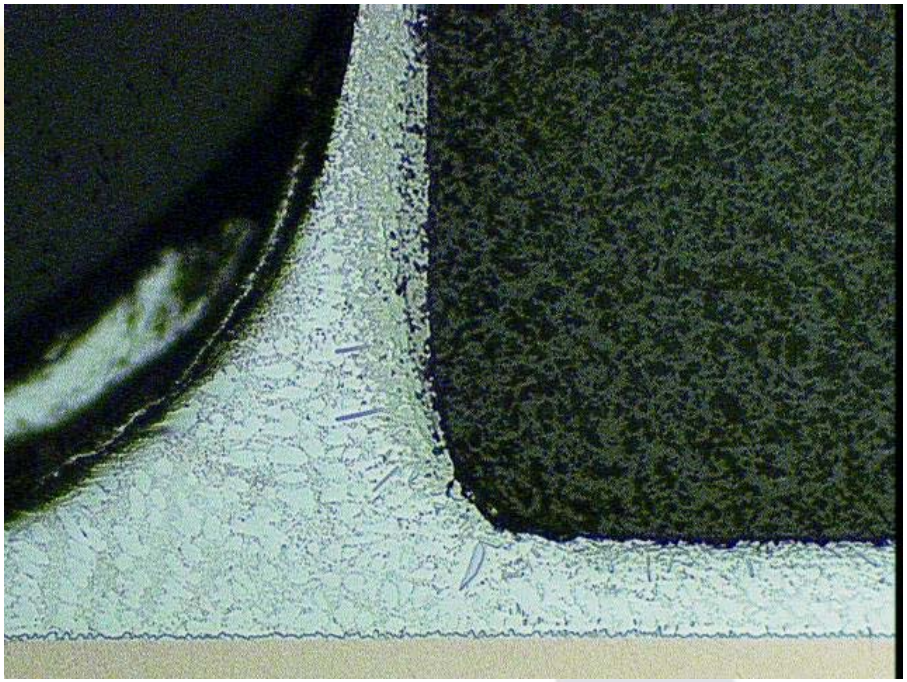




Failure Analysis

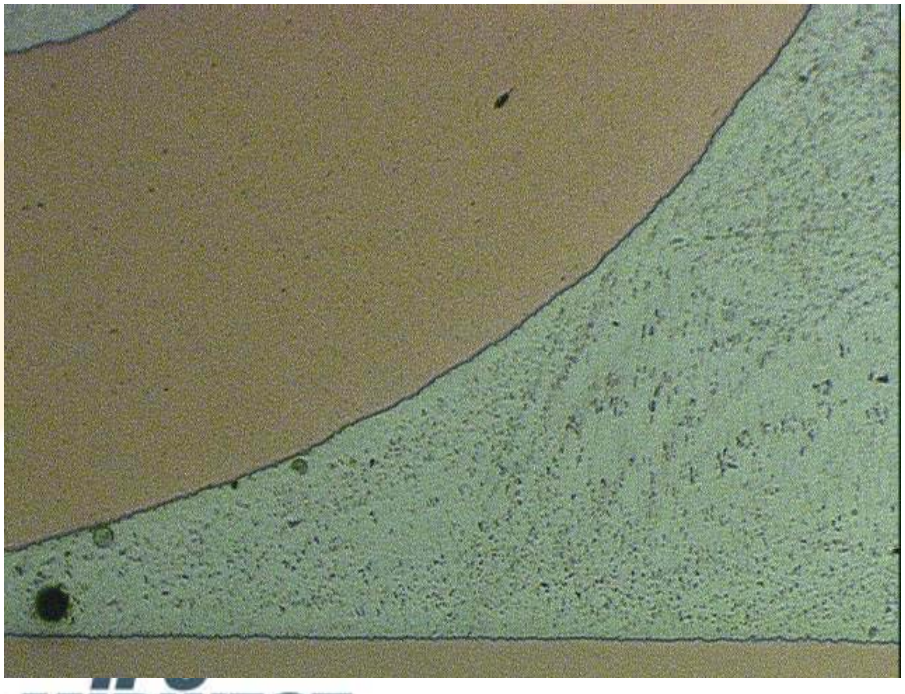
- **As Manufactured Versus ESS**
  - **Surface Mount Capacitor - Wire wound coil**

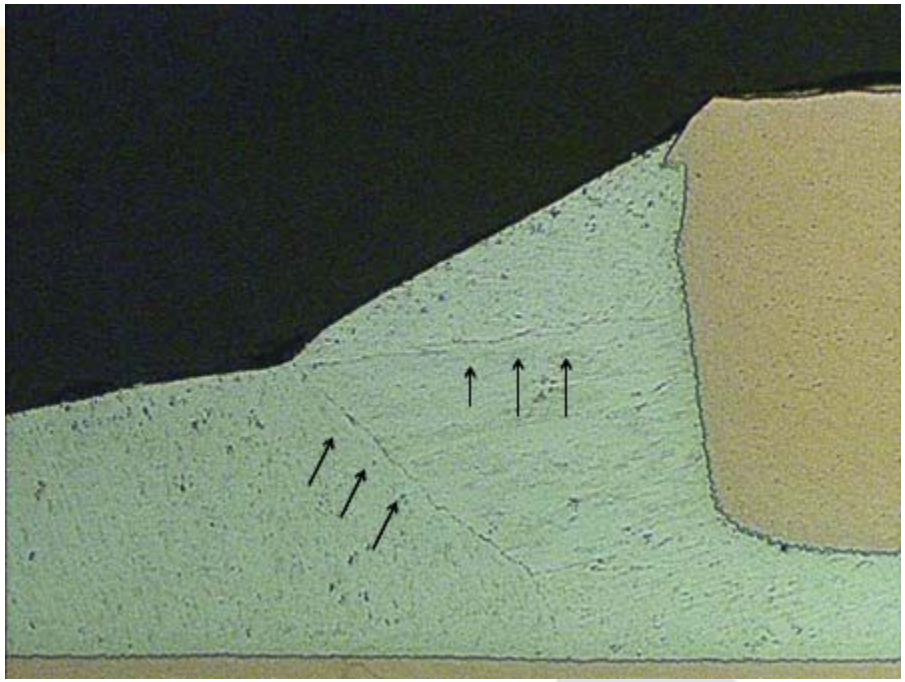




Failure Analysis

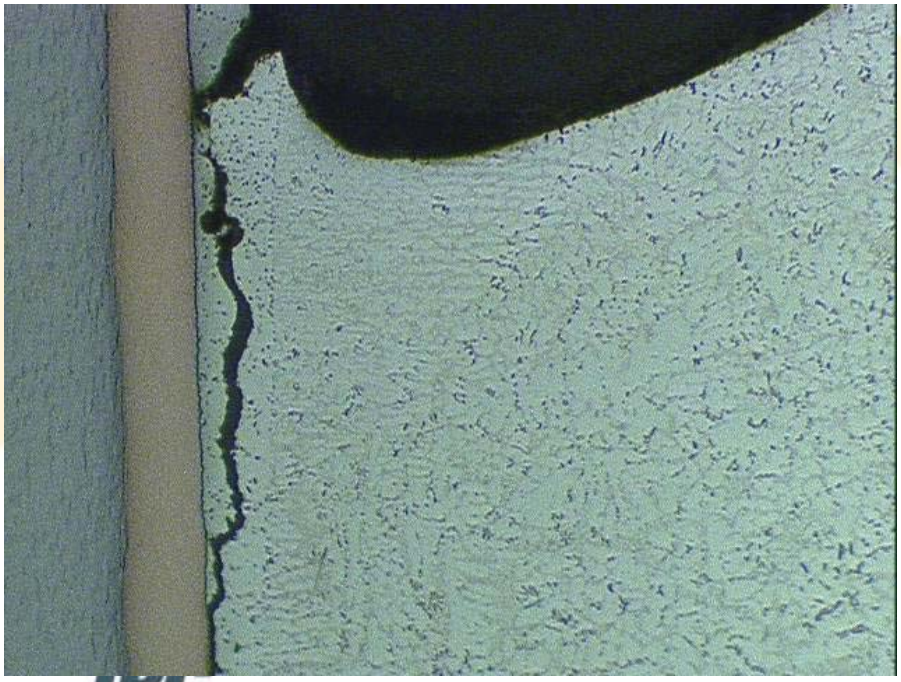
- **As Manufactured Versus ESS**
  - **Small Outline Package - Gull wing leads**

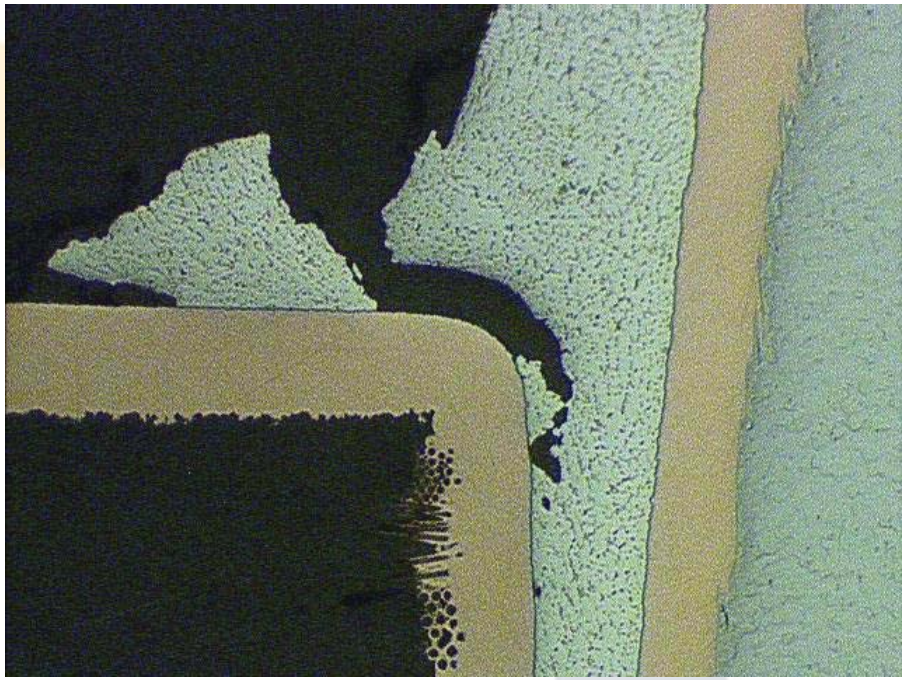




Failure Analysis

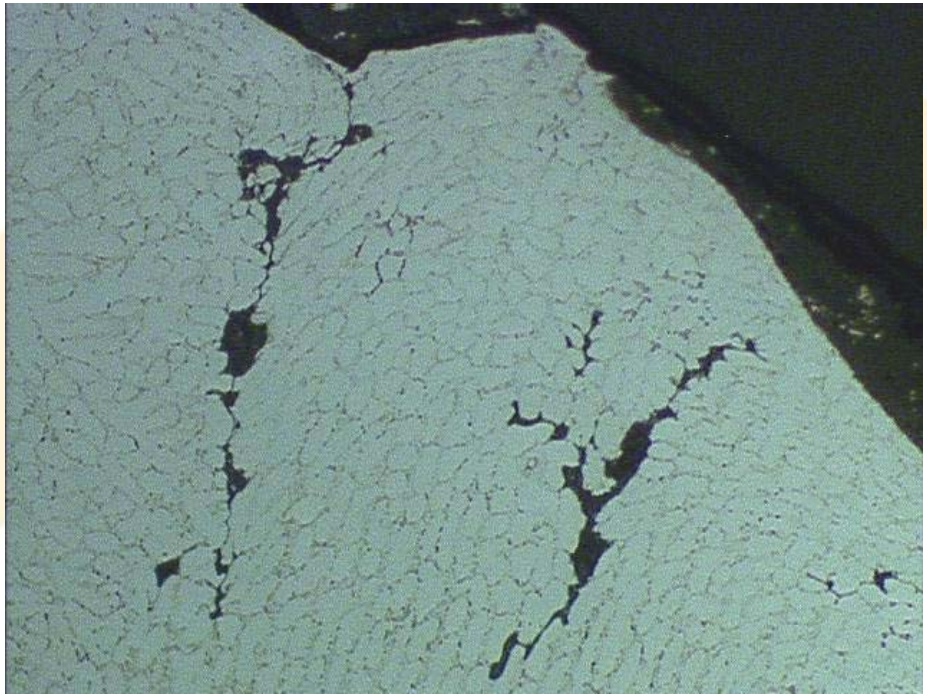
- **As Manufactured Versus ESS**
  - **PTH -Electrolytic Capacitor**

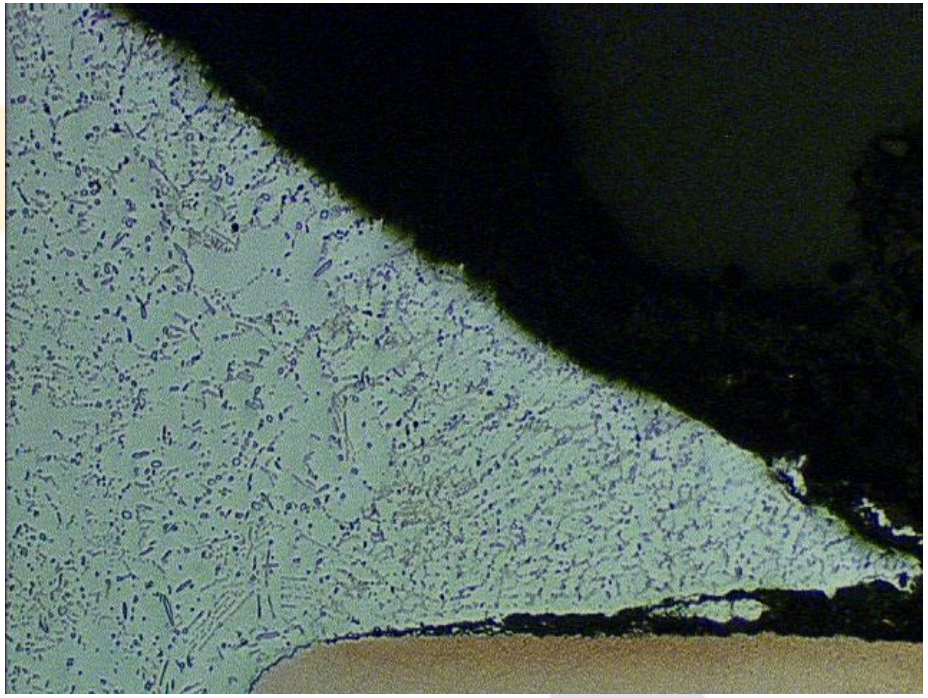




Failure Analysis

- **Shrinkage Voids**
- **Fillet Lifting**





Neither Phenomena Impacted ESS Results

Discussion

- Legacy Designs – So What Does Lead-free Mean For Older Products?
  - Why Should We Worry About Legacy Designs?
    - Matt was in first Grade
    - Dave was at his desk thinking how great Sn63/Pb37 solder works
  - Is The Conversion of A Legacy Design Necessary

IPC MIDWEST CONFERENCE & EXHIBITION

Conclusions

- The investigation results for the CDU-220 unit demonstrate that the impact of Lead-free materials and procedures on a legacy electronics design is minimal within the test conditions used

- An enterprise methodology/protocol needs to be implemented for determining if Legacy products should be subjected to a tin/lead-to-leadfree conversion activity

IPC MIDWEST CONFERENCE & EXHIBITION

Questions ???