The Basics of SIR and ECM

Meagan Sloan
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Electronics Assembly Materials

Indium Corporation supplies:
• Solder pastes
• Solder preforms
• Metal thermal interface materials (mTIMs)
• Wave solder fluxes
• PoP fluxes and pastes
• Flux-cored wires
• Tacky fluxes
• Bar solder
• Underfill polymers
• And more…

www.indium.com/solders
What is SIR and ECM?

- **SIR (Surface Insulation Resistance)**
  - Tests resistivity and corrosiveness of a flux residue

- **ECM (ElectroChemical Migration)**
  - Tests propensity for surface electrochemical migration through a medium such as flux
Commonly Tested Materials

- Solder paste
- Wave flux
- Rework flux
  - Liquid
  - Tacky
- Cored wire flux
Flux Chemistry Impact on SIR

- **Activators**
  - “Cleans” metallic surfaces
    - Oxidation removal
  - Corrosive
  - “Activated”
    - Heat decomposition and consumption

- **Rosin (if applicable – e.g. rosin containing no-clean fluxes)**
  - Encapulates
    - Immobilizes corrosive ionic species
    - Humidity/moisture resistant
  - Electrically insulating
SIR

• J-STD-004A and J-STD-004B are the IPC Requirements for Soldering Fluxes
  – J-STD-004B is the latest version

• IPC-TM-650 Test Method Manual
  – Number 2.6.3.3
SIR Test Specimen

- The test vehicle is the same for both revisions:
  - IPC-B-24 coupon
  - 0.5mm spacing with 0.4mm lines
  - Bare copper finish
  - FR4
  - Cleaned to zero ionics
SIR Processing Conditions

• **Paste:**
  – 6 mil stencil
  – Reflow profile – vendor specific

• **Cored Wire:**
  – Iron temperature – vendor specific

• **Wave Flux:**
  – Preheat: 140°C and 30 – 45s or vendor specific
  – Wave temperature: 245 – 260°C
SIR Comparison: 004A Vs. 004B

<table>
<thead>
<tr>
<th>Parameter</th>
<th>J-STD-004A</th>
<th>J-STD-004B</th>
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<tbody>
<tr>
<td>Temperature and Humidity</td>
<td>85°C, 85% RH, 168 hours</td>
<td>40°C, 90% RH</td>
</tr>
<tr>
<td>Stress Bias</td>
<td>45 – 50 volts DC</td>
<td>25 volts/mm</td>
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<tr>
<td>Pre-Bias Stabilization Period</td>
<td>3 hours at T&amp;H</td>
<td>1 hour at T&amp;H</td>
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<tr>
<td>Measurement Bias</td>
<td>-100 volts DC</td>
<td>25 volts/mm (~5volts DC)</td>
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<tr>
<td>Time Readings</td>
<td>24, 96, 168 hours</td>
<td>At least once every 20 minutes</td>
</tr>
</tbody>
</table>
Passing Criteria for SIR

• Control Boards:
  – >1E9 Ohms, 96 hours to end (Both)

• SIR Data:
  – >1E8 Ohms @ 96, 168 hours (J-STD-004A)
  – >1E8 Ohms @ after 24 hours (J-STD-004B)

• Dendrites/Corrosion:
  – None >25% of spacing (J-STD-004A)
  – None >20% of spacing (J-STD-004B)
Pros and Cons: J-STD-004A vs. J-STD-004B

- 85°C
  - High chamber temp
    - Artificially improves SIR
    - Challenging for rosin-based fluxes

- Only 3 readings
  - May miss a dendrite

- Standing and test voltage too high
  - Not real world
  - “Fries” dendrites

- 40°C
  - Favors rosin based fluxes
  - Real world

- Voltage
  - Real world
  - Does not fry dendrites

- Continuous monitoring
  - Better dendrite detection
SIR Measurements of Flux Residue \( \geq 100\Omega \) or \( 1 \times 10^8\Omega \)
SIR Measurements of Controls
Dendrites
Minor Discoloration of One Pole of the Comb Pattern Conductors
Combo SIR Testing

• Determine “compatibility”
  – Solder paste
  – Wave soldering flux
  – Rework flux
    • Liquid
    • Tacky
  – Cored wire flux

• No industry method
  – Application of fluxes
  – Heating of fluxes

• OEM or CM specific method
ECM

- J-STD-004A and J-STD-004B are the IPC requirements for soldering fluxes
  - J-STD-004B is the latest version

- IPC-TM-650 test method manual
  - Number 2.6.14.1
Difference Between EM and ECM

• ECM and EM (Electromigration) are different, but go hand-in-hand:
  – Tests propensity for surface electrochemical migration through a medium such as flux
  – EM is the migration of metal ions due to the movement of electrons
ECM Test Specimen

• IPC-B-25A
• Spacing 0.0125” (0.318mm)
• Bare copper finish
• FR4
• Clean to 4E10 Ohms
ECM Processing Conditions

• Paste:
  – Stencil – negotiated
  – Reflow – production conditions

• Cored wire:
  – Production conditions

• Wave flux:
  – Preheat – production conditions
  – Solder wave – 250°C or compatible with alloy
ECM Temperature and Humidity

- Conditions:
  - 65°C
  - 85% RH
  - 500 hours
- Stress Bias – 10 volts
- Pre-Bias Stabilization Period – 24 hours at T&H
- Measurement Bias – 45-50 volts DC
- Time Readings – 96, 500 hours
Passing Criteria for ECM

• Control Boards:
  – $\text{IR}_{\text{initial}}/\text{IR}_{\text{final}} \leq 10$

• ECM Data:
  – $\text{IR}_{\text{initial}}/\text{IR}_{\text{final}} \leq 10$

• Dendrites/Corrosion:
  – None > 20% of spacing
Summary

• SIR and ECM are used to determine the reliability of flux residues

• There are pros and cons to 004A and 004B

• Dendrites are metal filaments that “grow” from trace to trace that can cause a short

• Combination testing can be done to determine the compatibility between multiple no-clean fluxes
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Sources

IPC (09/00). Electrochemical Migration Resistance Test. Northbrook, IL.

IPC (03/07). Surface Insulation Resistance. Bannockburn, IL.