Capacitors

Damage Prevention When Soldering Ceramic Chip Capacitors
Survey Results of Failure Analysis

- Majority of failures were related to either:
  - Capacitors
  - Printed Circuit Boards
Types of Capacitor Failures

- Manufacturing Defects: 34%
- Flex Cracks: 25%
- Thermal Shock Cracks: 23%
- Placement Cracks: 5%
- Unknown: 13%
Induced Crack Defects

Two major causes of Capacitor cracking

• Mechanical
• Thermal
Flex Testing

Test Samples

Industry Standard Capacitor Bend Test
SnAgCu Flex Crack Examples

Figure 7: Optical micrograph of a 1812 capacitor attached with SnAgCu solder, flex cracks are identified with the red arrows
SnAgCu Flex Crack Examples

Figure 9: Optical micrograph of a 0805 capacitor attached with SnAgCu solder, flex cracks are identified with the red arrows.
SnAgCu & SnPb Comparison

Figure 2b: Optical micrograph of a cross-sectioned 1812 capacitor attached with SnAgCu solder. Rift cracks are identified with the red arrows.

Figure 11: Optical micrograph of a cross-sectioned 1812 capacitor attached with SnPb solder. Rift cracks are identified with the red arrows.
Flex Crack

- Fillet shape and height are similar
- Types of cracks exhibited are typical of flexure fractures in ceramic capacitors
Where Does It Happen?

- Flexing (Mechanical Stress) occurs in following areas:
  - Manufacturing
    - Soldering Handling
  - Board separation
  - Connector installation
  - Mechanical standoff installation
  - In-circuit testing
  - Customer usage
Flex Cracking

What do they look like?

- Flex induced cracks starts at the component solder termination and progresses up into the component, about half way up the component height.

Adapted from "AVX MLCC FlexiTerm Guarding Against Capacitor Crack Failures" by Mark Stewart, Technical Information
Flex Cracking Examples

Figure 1. Standard Termination MLCC exhibiting Typical Board Flex Crack
Flex Cracking Illustrations

Figure 9(a). Typical Board Warp Cracks

Adapted from AVX, Technical Information, “Assembly Induced Defects” by John Maxwell
Flex Mitigation

Try to avoid placing capacitors in:

• Close proximity to connectors and rigid fixtures
• Depanelization areas
• Box build as stresses from assembly process due to pcb distortion.
• Storage and handling

Adapted from Kemet, Flex Mitigation Technology 2009 Presentation
Crack Examples

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Crack Capacitor Example

Adapted from; Mechanical Cracking by Syfer Technology Limited

Yellow potting compound

Electrodes

Standard termination material (not polymer)

Mechanical crack (caused capacitor failure)

Black areas are damaged sections within the capacitor caused during the electrical failure

White lines are thermal cracks created during the electrical failure
Thermal Damage

As quoted by John Maxwell of AVX Corp.

“When processing temperatures exceed the glass transition temperature, Tg, of epoxy resins, the CTE can increase as much as an order of magnitude over room temperature values further increasing stress”
Thermal Crack

- Components terminations heat up quicker than the ceramic body, exerting forces which crack the ceramic when thermal shock is too quick.

AVX Technical Information, “Surface Mount Soldering Techniques and Thermal Shock in Multilayer Ceramic Capacitors” by John Maxwell
Thermal Crack Review

- Wave solder has the highest heat transfer rate and creates the most shock.
- Vapor phase uses latent heat of vaporization, less thermal shock.
- Surface Mount reflow, least amount of thermal shock.

AVX Technical Information, “Surface Mount Soldering Techniques and Thermal Shock in Multilayer Ceramic Capacitors” by John Maxwell
Thermal Defects

- Thermal cracks manifest themselves by micro cracks around the termination and ceramic body.
- Micro cracks have a tendency to propagate along isothermal lines, where there is maximum stress between both component and the board.
Thermal Defects

- Maximum shear occurs along these lines during the thermal excursion of the solder reflow or soldering process.

AVX Technical Information, "Surface Mount Soldering Techniques and Thermal Shock in Multilayer Ceramic Capacitors" by John Maxwell
Thermal Crack

- Micro cracks start at the ceramic / termination interface

AVX Technical Information, “Surface Mount Soldering Techniques and Thermal Shock in Multilayer Ceramic Capacitors” by John Maxwell
Thermal Testing

- **Heat Resistance:**
  - Subject caps to 125C \([257 \pm 35.6 \, \text{F}]\) for 2 hours and measure insulation resistance

- **Solderability**
  - 2 sec float test in 235C \([455 \pm 41 \, \text{F}]\), solder coverage will be greater than 75% when examined at 10x

- **Solder Heat Resistance**
  - Subject caps to 250C for 5 sec after preheating 10 to 30 sec at 80 to 120C \([176 \, \text{C} \, \text{to} \, 248 \, \text{F}]\). No visual damage

Adapted from Types MC and MCN Multilayer RF Capacitors
Reflow Profile

Soldering Profiles

Adapted from Types MC and MCN Multilayer RF Capacitors
Wave Solder Profile

Adapted from Types MC and MCN Multilayer RF Capacitors
Hand Soldering Method

- SnAgCu recommended solder
- Do not use strong acid type flux with RM or RMA
- Soldering iron tip temperature should be 250 °C to 280 °C ≤ 5 sec.
- 60 Watt iron or less
Hand Soldering Methods

Hand Soldering

• A pencil type soldering of 30 watts maximum and with a diameter of 3 mm maximum should be used.

• The soldering iron tip temperature should be less than 300\(^\circ\)C \([572\text{F}]\) and maximum contact time should be 5 seconds.

• The soldering iron tip should never come in contact with the component body.
Hand Soldering Methods

Component Removal:

- Soldering iron
- Hot tweezers
- Hot air

- All can be used to remove the component as the component is discarded.
Solder Irons

- When not in use keep the solder irons in the holding fixtures
- Keep the tip tinned
- When removing iron from holding fixtures, wipe off excess solder.
- Slightly tin the tip to create a solder bridge
- Make the solder connection.
- Wipe the iron and retin before replacing it into the holding fixtures.
Thank You
Any Questions?
Further Information

For questions regarding this webinar, please contact Leo Lambert at leo@eptac.com or call at 800-643-7822 ext 215

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