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Capacitors

Damage Prevention When Soldering Ceramic Chip Capacitors

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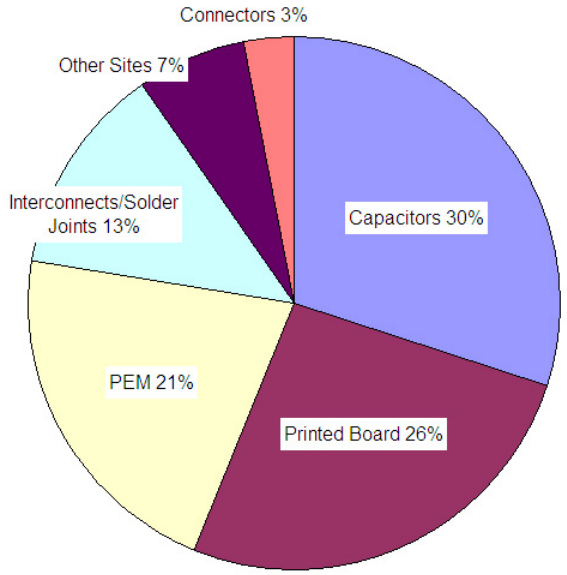
Survey Results of Failure Analysis

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



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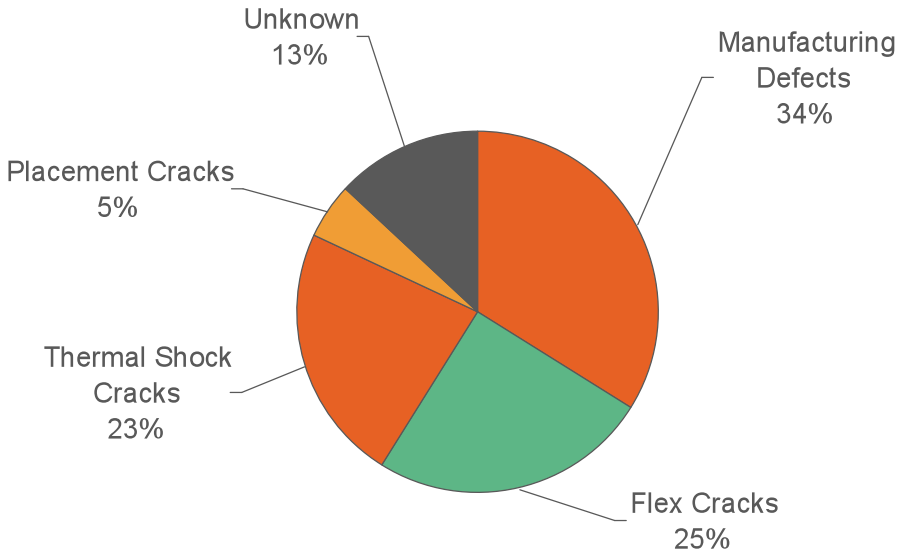
Types of Capacitor Failures



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Induced Crack Defects

Two major causes of Capacitor cracking

- Mechanical
- Thermal

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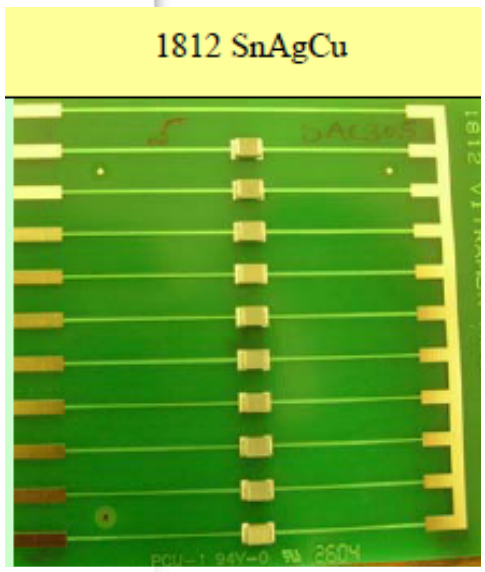
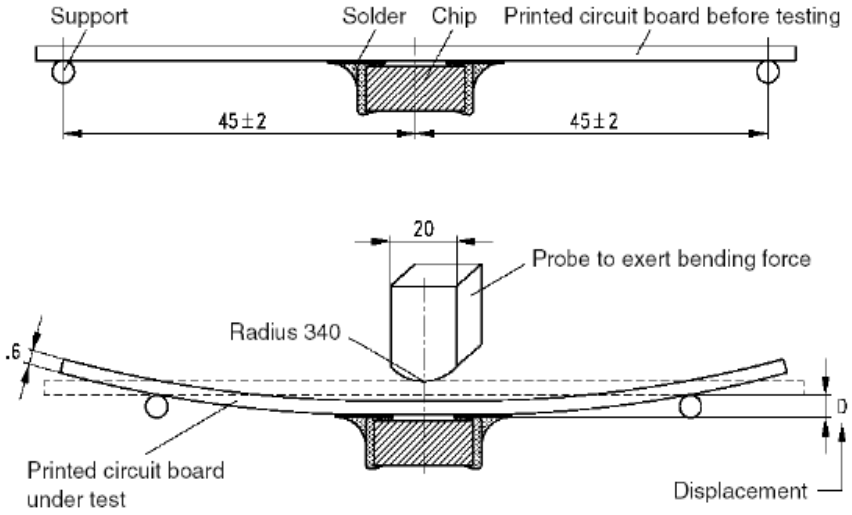
Flex Testing[1]



Test Samples



Industry Standard Capacitor Bend Test

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SnAgCu Flex Crack Examples

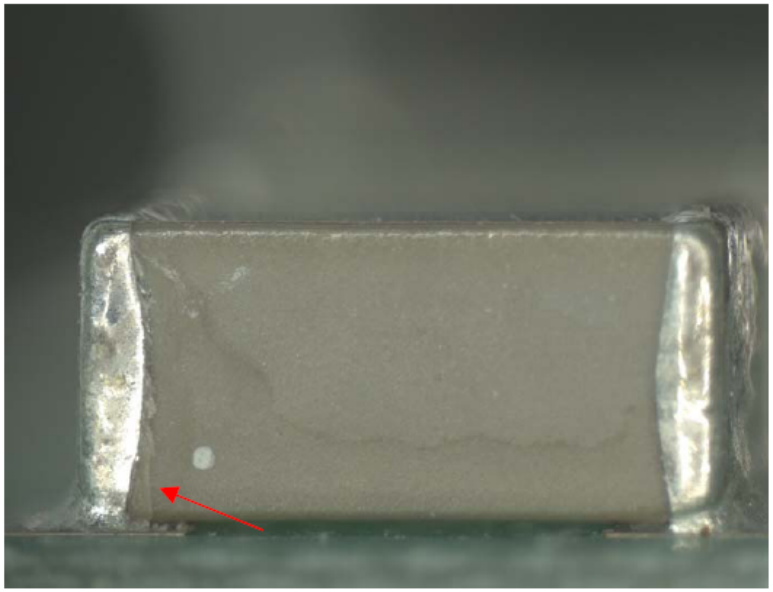

Figure 7: Optical micrograph of a 1812 capacitor attached with SnAgCu solder, flex cracks are identified with the red arrows

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SnAgCu Flex Crack Examples

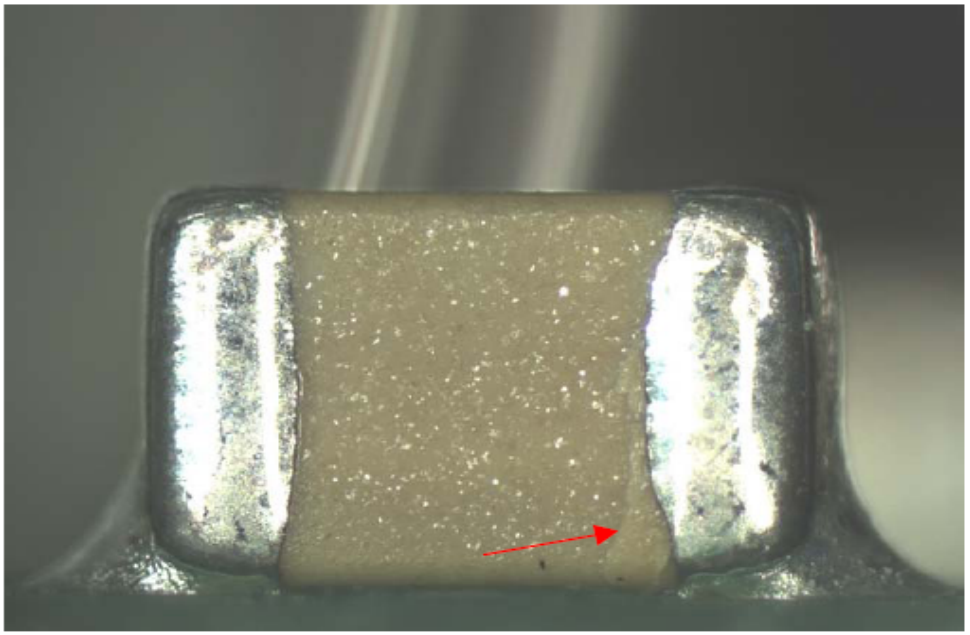

Figure 9: Optical micrograph of a 0805 capacitor attached with SnAgCu solder, flex cracks are identified with the red arrows

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SnAgCu & SnPb Comparison[1]

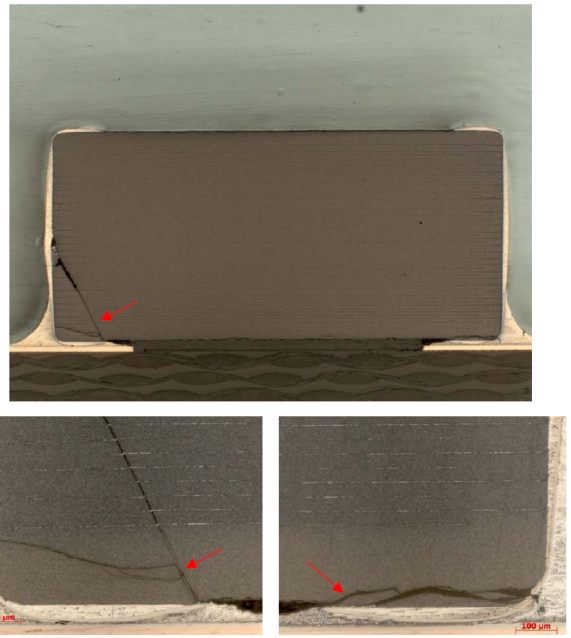

Figure 10: Optical micrograph of a cross-sectioned 1812 capacitor attached with SnAgCu solder, flex cracks are identified with the red arrows

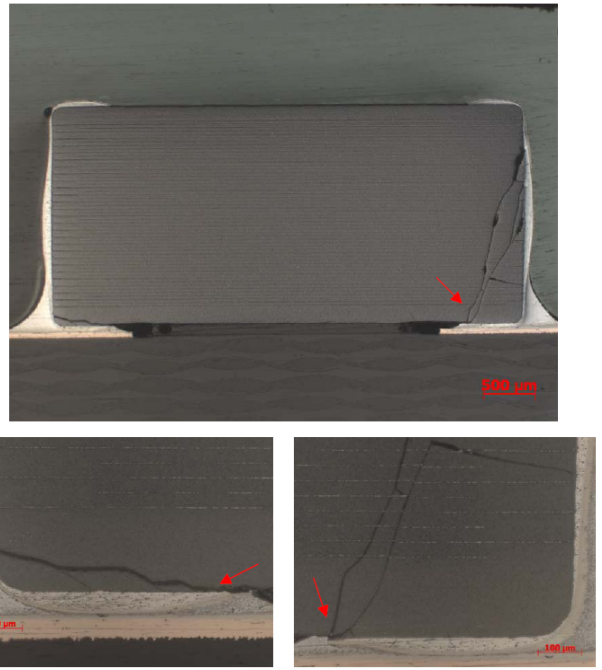

Figure 11: Optical micrograph of a cross-sectioned 1812 capacitor attached with SnPb solder, flex cracks are identified with the red arrows

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Flex Crack

- Fillet shape and height are similar
- Types of cracks exhibited are typical of flexure fractures in ceramic capacitors

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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

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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

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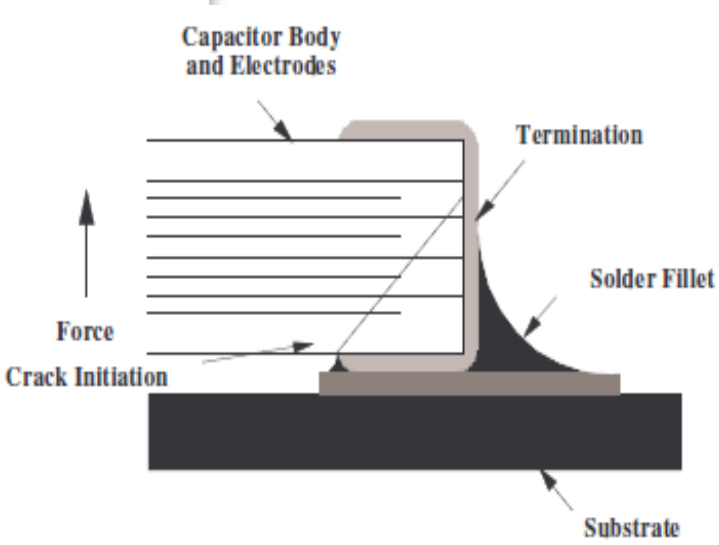
Flex Cracking Examples



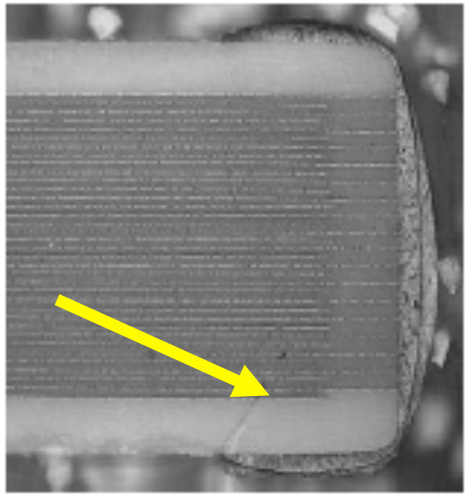


Figure 1. Standard Termination MLCC exhibiting Typical Board Flex Crack

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Flex Cracking Illustrations

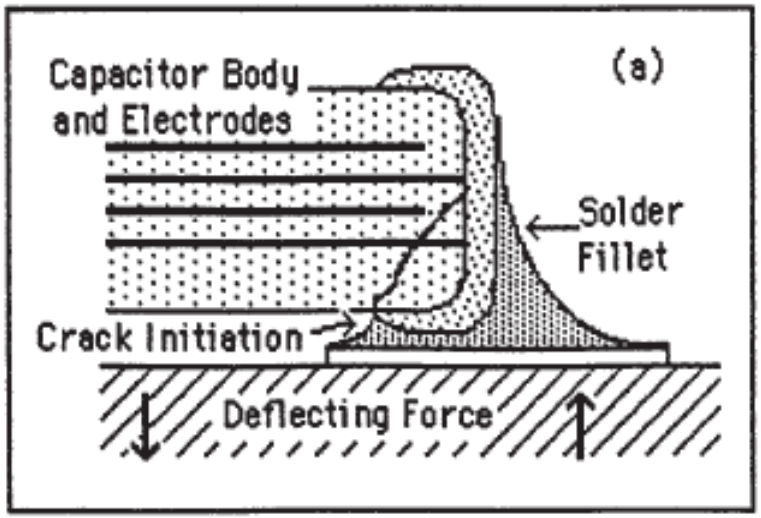

Figure 9(a). Typical Board Warp Cracks

Adapted from AVX, Technical Information, "Assembly Induced Defects" by John Maxwell

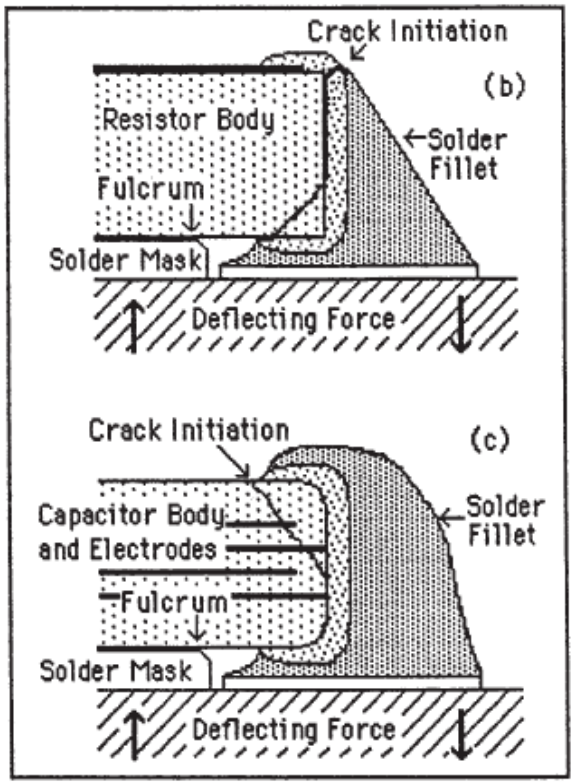

Figure 9(b, c) Typical Warp Cracks

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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

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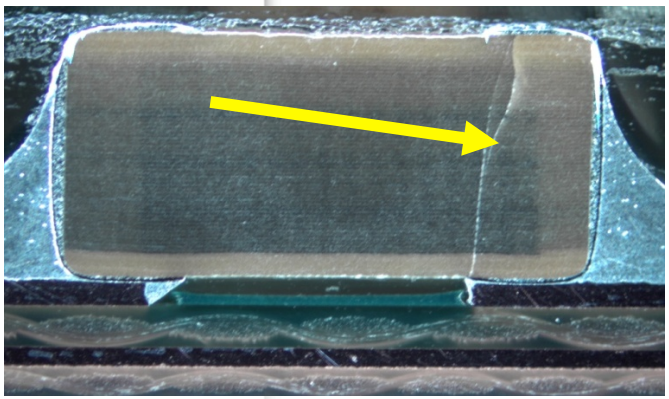
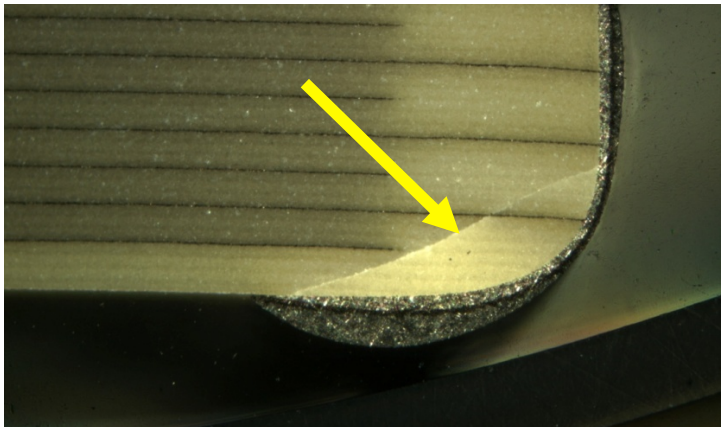
Crack Examples





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Crack Capacitor Example

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

Adapted from; Mechanical Cracking by Syfer Technology Limited

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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"

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Thermal Crack

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

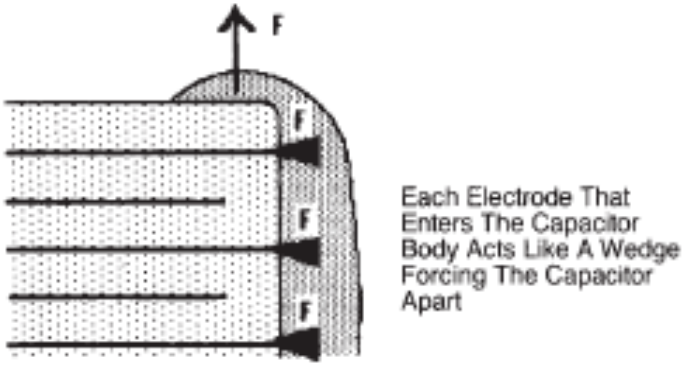

Figure 3. Temperature Forces that Stress an MLC's Structure

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

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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.

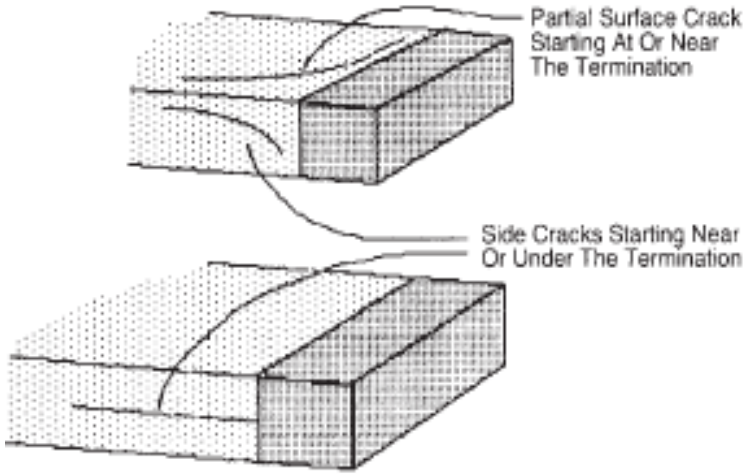

Figure 5. Extreme Thermal Shock Cracks in MLCs

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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.

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

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Thermal Defects

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

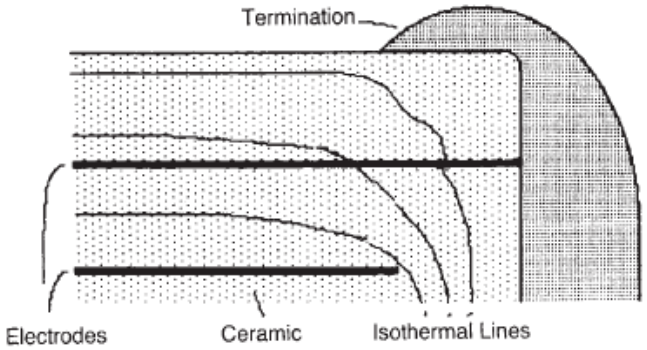

Figure 7. Isothermal Line Shortly After Exposure to Solder Temperatures

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Thermal Crack

- Micro cracks start at the ceramic / termination interface

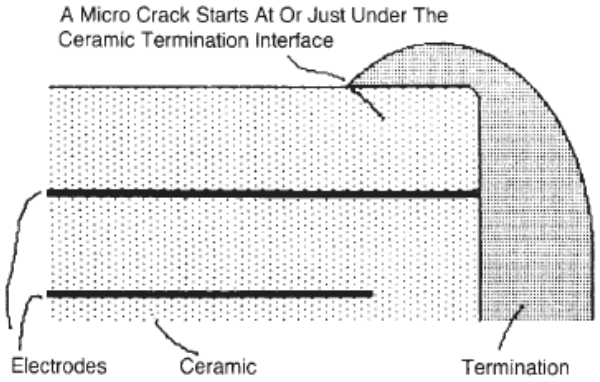

Figure 8. A Micro Crack at the Termination Ceramic Interface

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Thermal Testing

- Heat Resistance:
  - Subject caps to 125C [257 +/- 35.6 F] for 2 hours and measure insulation resistance
- Solderability
  - 2 sec float test in 235C [455 +/- 41F], solder coverage will be greater than75% 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 to 248F]. No visual damage

Adapted from Types MC and MCN Multilayer RF Capacitors

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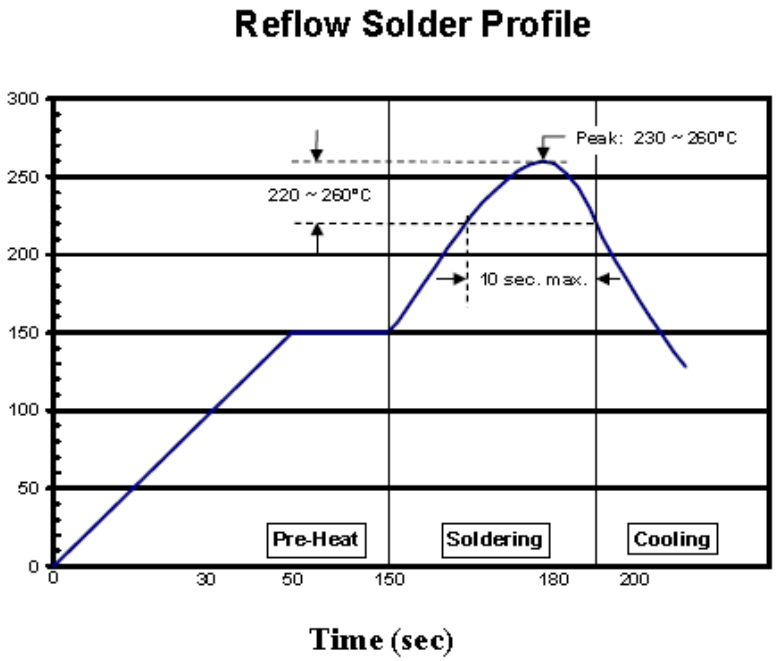
Reflow Profile

Soldering Profiles



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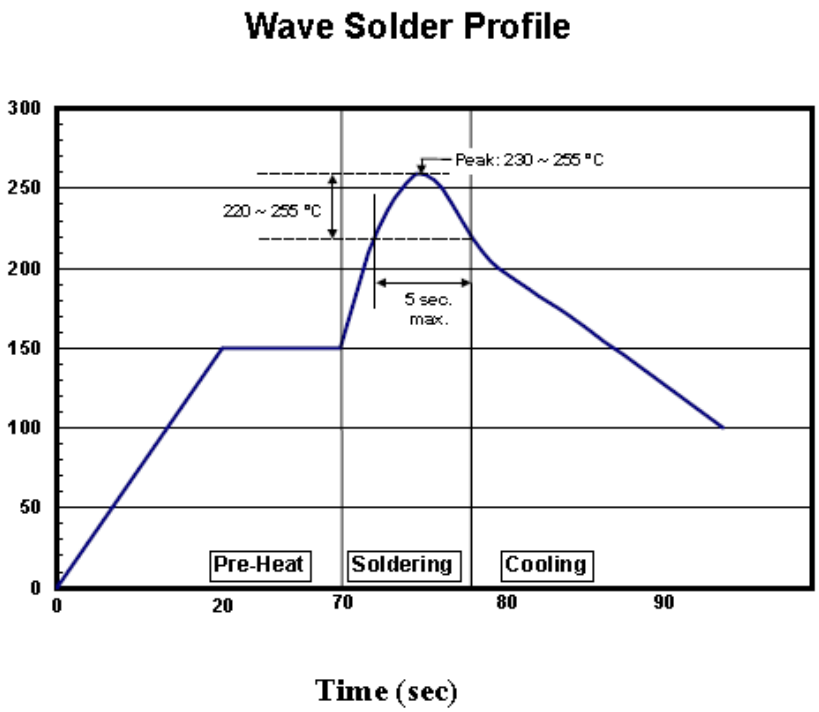
Wave Solder Profile



Adapted from Types MC and MCN Multilayer RF Capacitors

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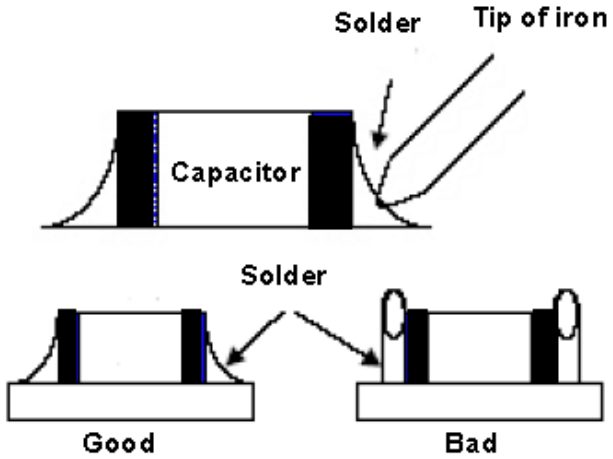
Hand Soldering Methods

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



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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°C [572F] and maximum contact time should be 5 seconds.
- The soldering iron tip should never come in contact with the component body.

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Hand Soldering Methods

Component Removal:

- Soldering iron
- Hot tweezers
- Hot air

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

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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.

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Thank You
Any Questions?

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Further Information

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