



RoodMicrotec

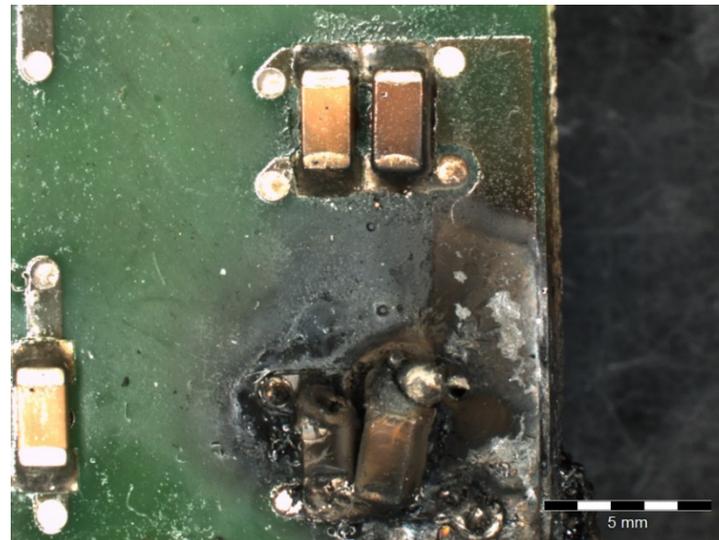
**Multi Layer Ceramic
Capacitors (MLCC)
one of the most
mechanical sensitive
component**

„It's Not the Fall That Kills You, It's The Sudden Stop At The End”

Douglas Adams

„It's Not the Crack That Kills Your Capacitor, It's The Electrical Short After Some Time“

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What is a Multi Layer Ceramic Capacitor (MLCC)?

■ Structure

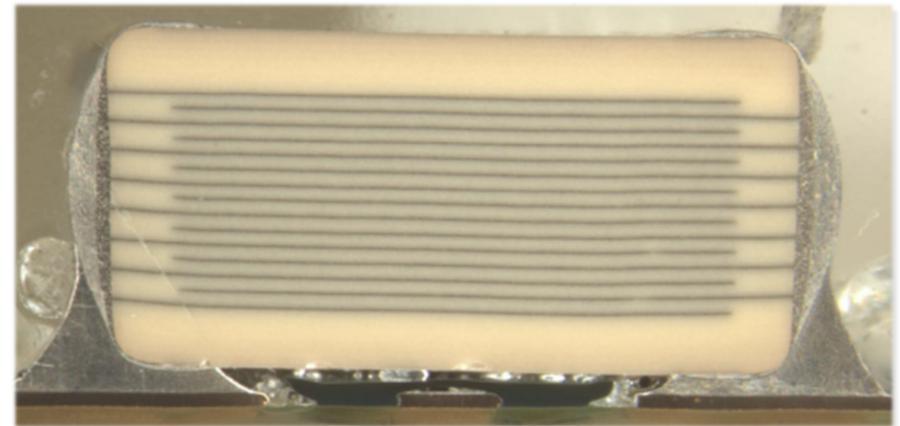
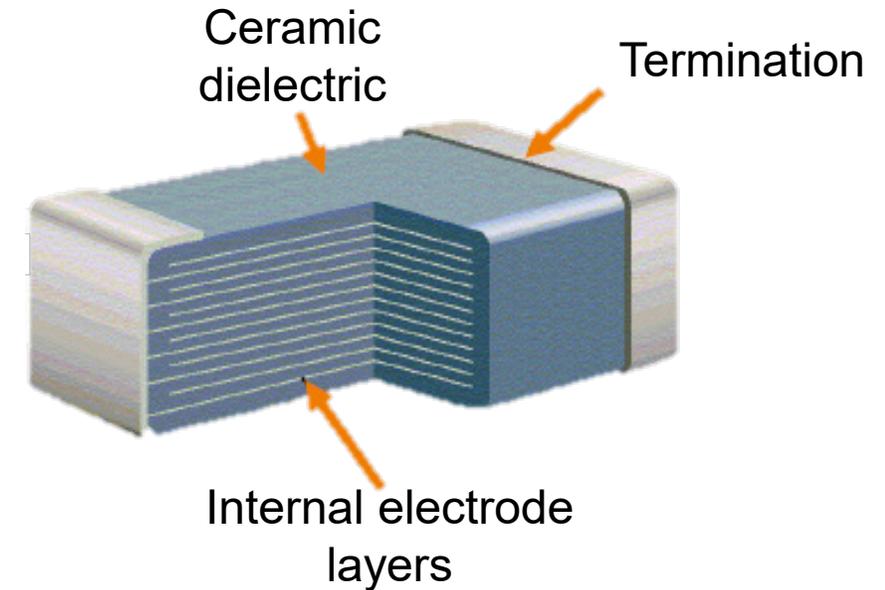
- Ceramic block
- Embedded metal layers
- Termination on both sides

■ Advantages

- Material admixtures enabling modifications in electrical behavior
- Stable over temperature and frequency
- Small package size
- Good HF behavior

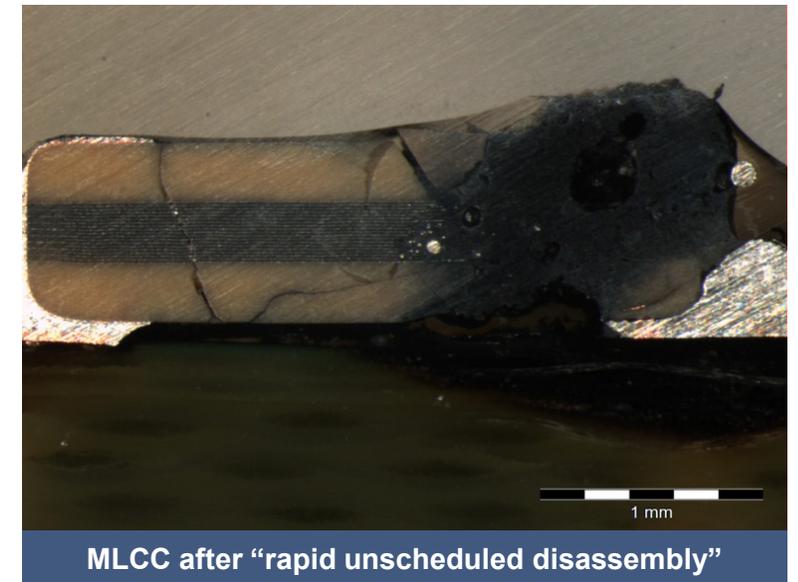
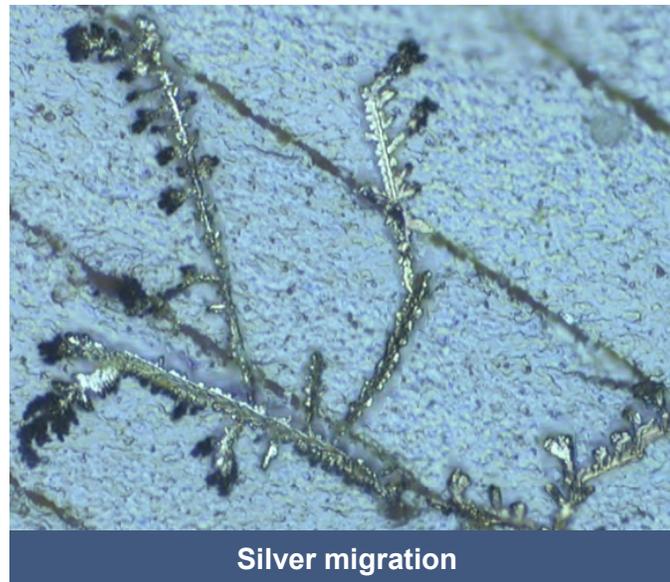
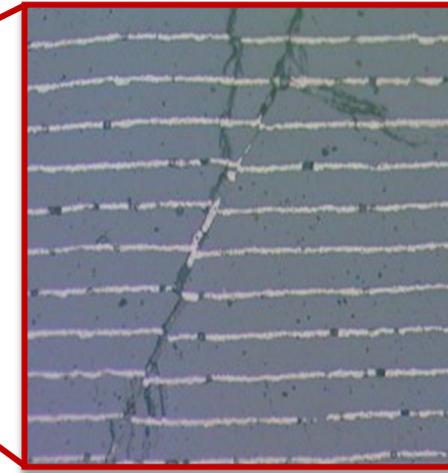
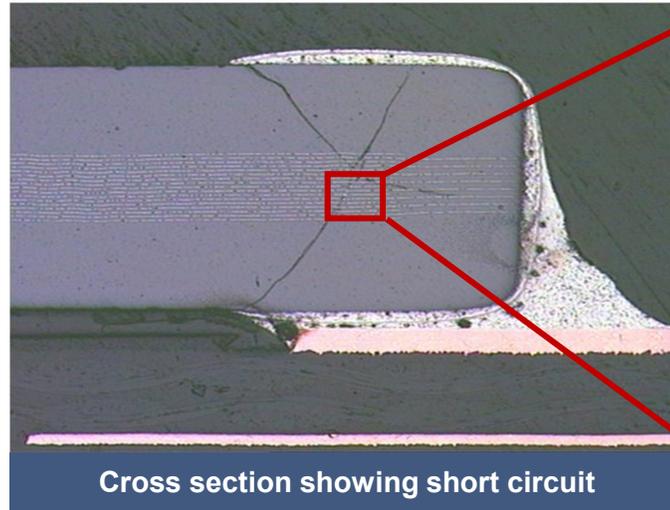
■ Disadvantages

- Susceptible against over voltage and voltage spikes
- High mechanical sensitivity



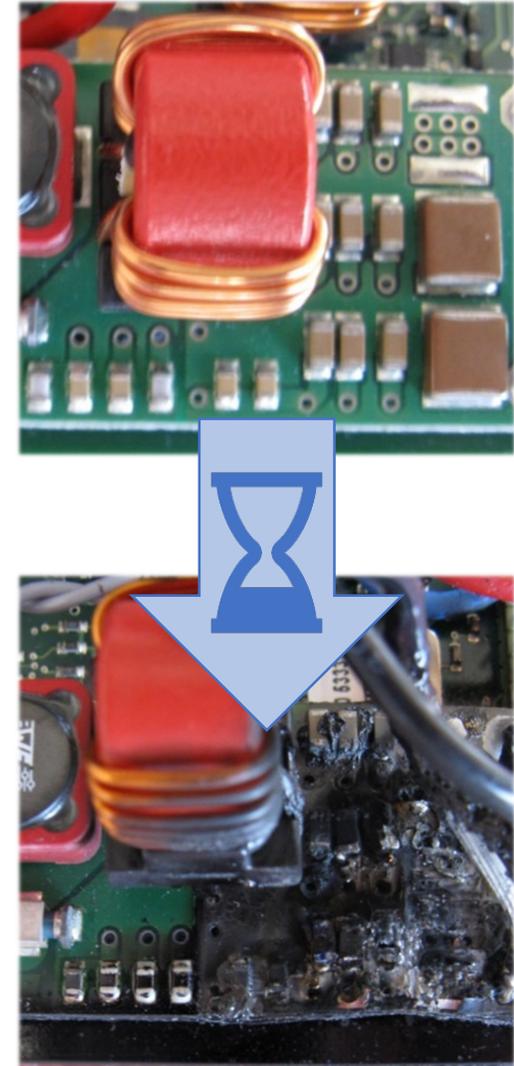
Migration and dendrite growth

- Cracked capacitors are hardly detectable within outgoing inspection
- Silver migration or dendrite formation through the crack resulting in an electrical short circuit
- Approximately after 6 to 24 months in the field the assemblies fail with burned capacitors due to electrical shorts between capacitor plates



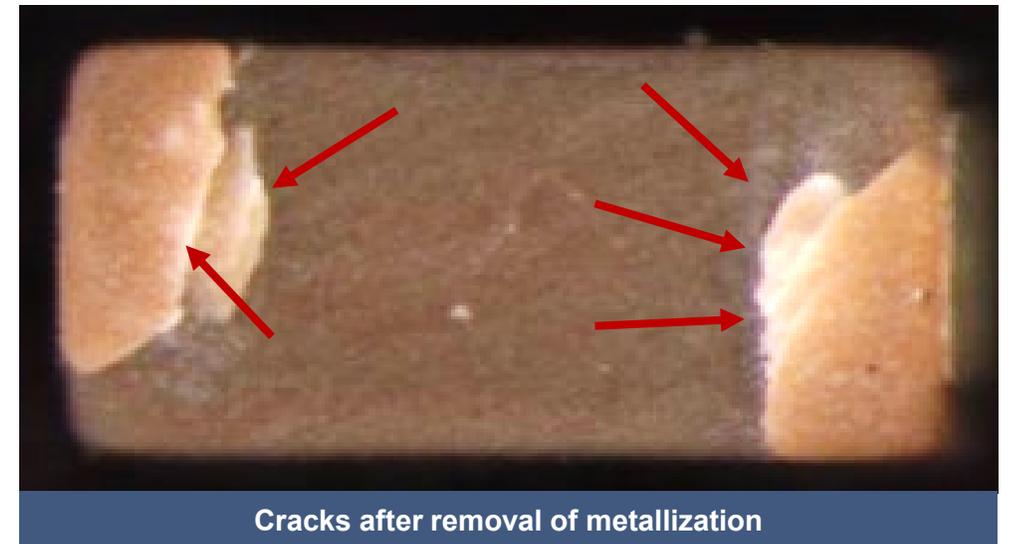
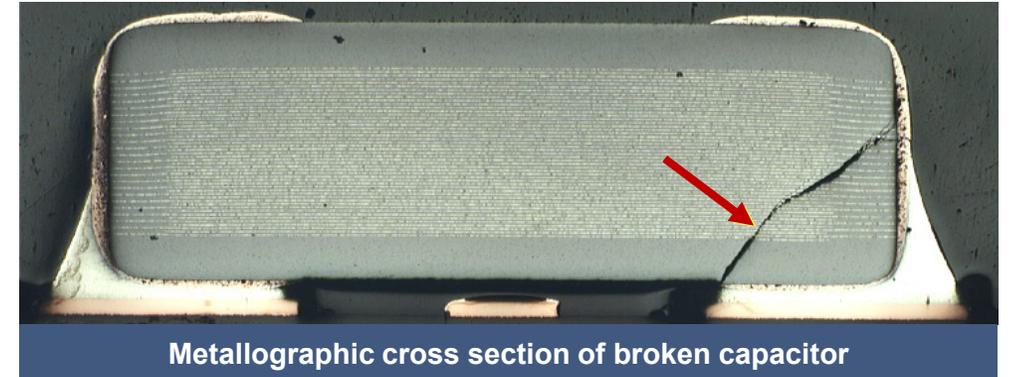
Typical Failures of MLCC

- ~ 90 % of MLCC field failures are caused by mechanical overstress, resulting in so called „Flex Cracks“
 - Critical processes are component assembly, assembly of press-fit components, singulation of multi panels and assembly in the system
 - High mechanical stresses occur at the edge of the printed circuit board (recommended distance greater than 5 mm), close to press-fit connectors, near large components and close to (screw) mounting points. These places are to be avoided.
 - **Electrical board tests detects roughly 1% of the cracked devices**
 - **Not visible by optical inspection**
- Electrical Damage
- Manufacturing defects



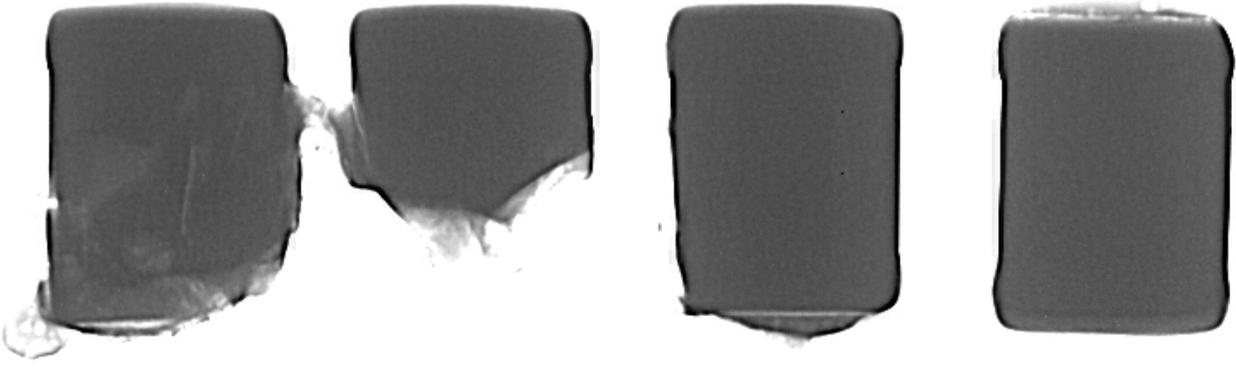
Analysis methods

- Metallographic cross sectioning
 - Inhomogeneity's within component visible
 - Electrical monitoring possible
 - Costly
 - Destructive
 - Only one plane at a time inspectable
 - **Mechanical stress due to sample preparation (sawing out)**
- Optical inspection after chemical removal of the terminal metallization
 - The preparation of many components can be done simultaneously
 - Non destructive to component body
 - Crack position allows conclusions about mechanical stress
 - **Thermal and mechanical stress due to sample preparation (desoldering)**
- X-ray Analysis
 - Non Destructive
 - Only large cracks parallel to the beam direction visible

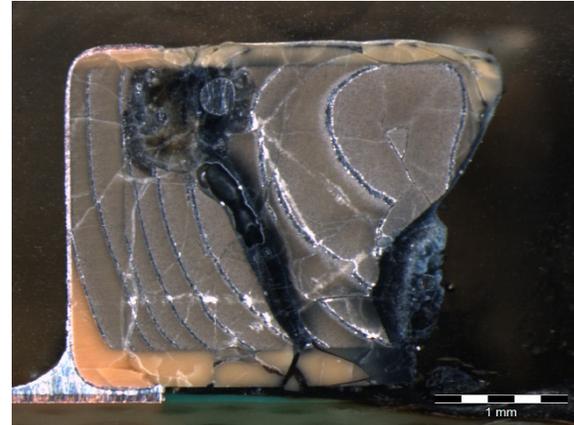


X-Ray Microscopy and why you should not trust it

1 2 3 4



X-Ray microscopy of ceramic capacitors

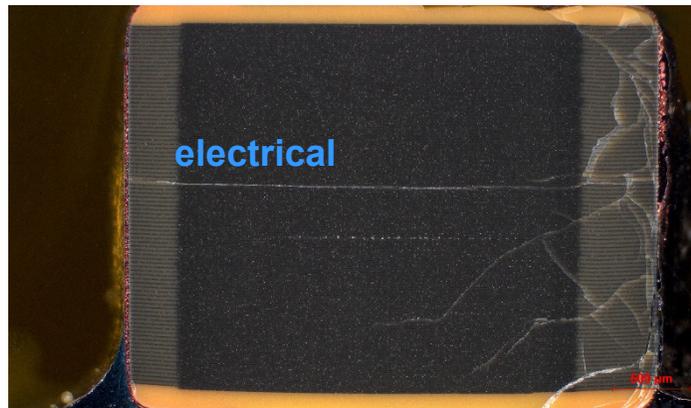


Cross section capacitor 1

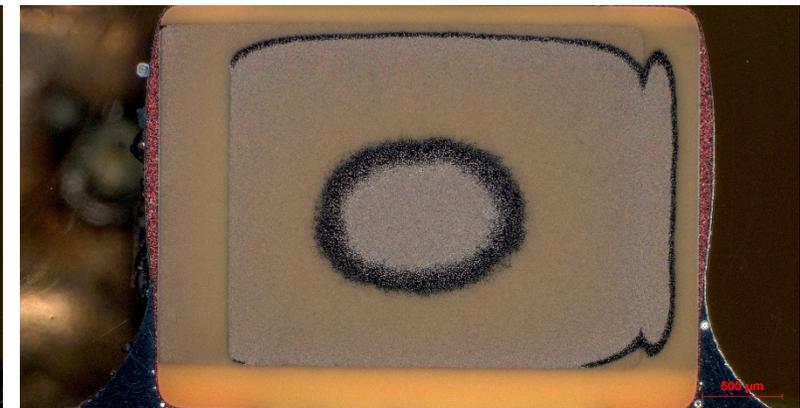


Cross section capacitor 2

- Capacitors 1 and 2 are more than obviously broken, but 3 and especially 4 look relatively inconspicuous on X-ray
- Cross sections revealed massive damage (electrical as well as mechanical) of capacitor 3
- Capacitor 4 has no visible damage (in this cross section plane)



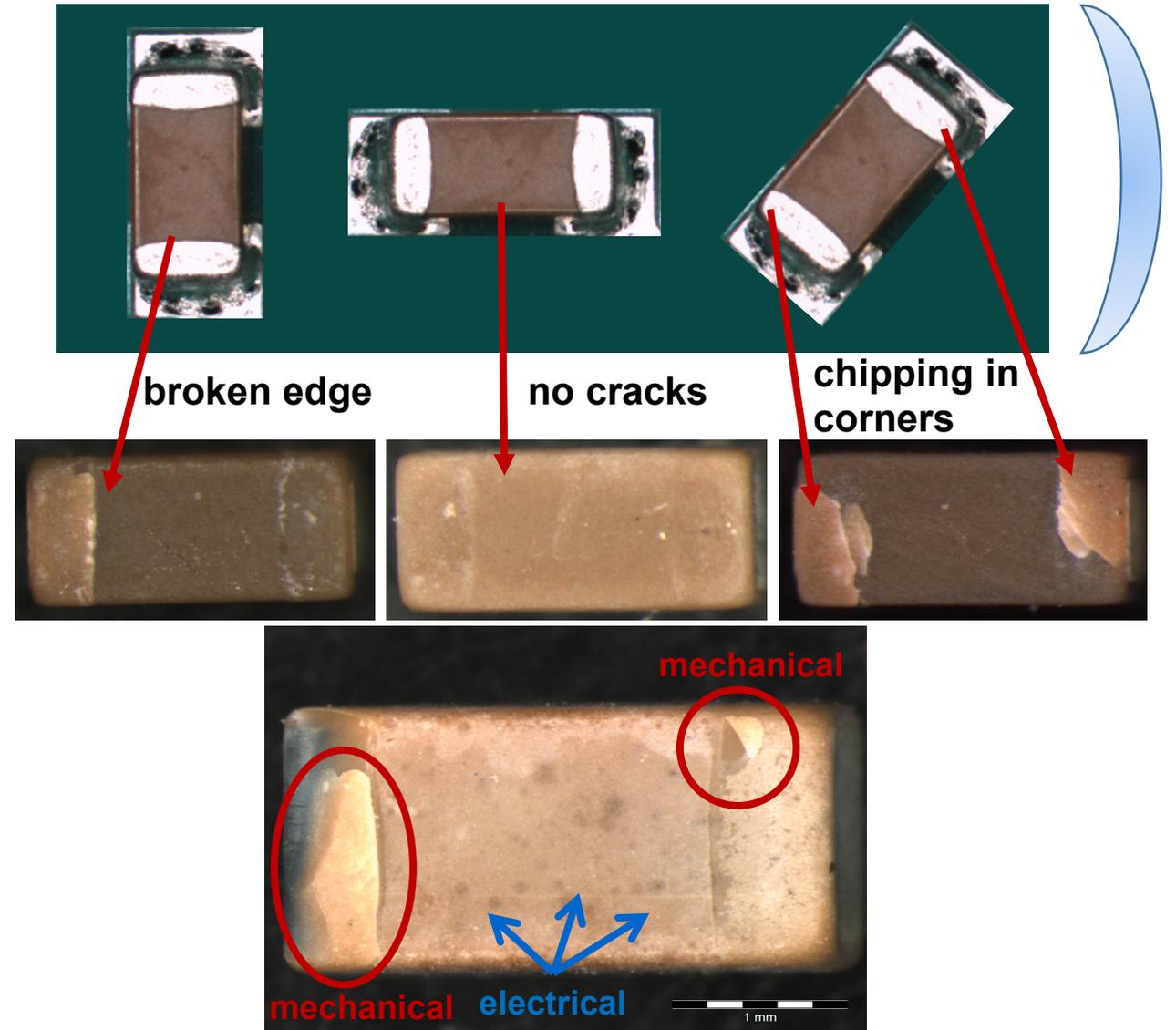
Cross section capacitor 3



Cross section capacitor 4

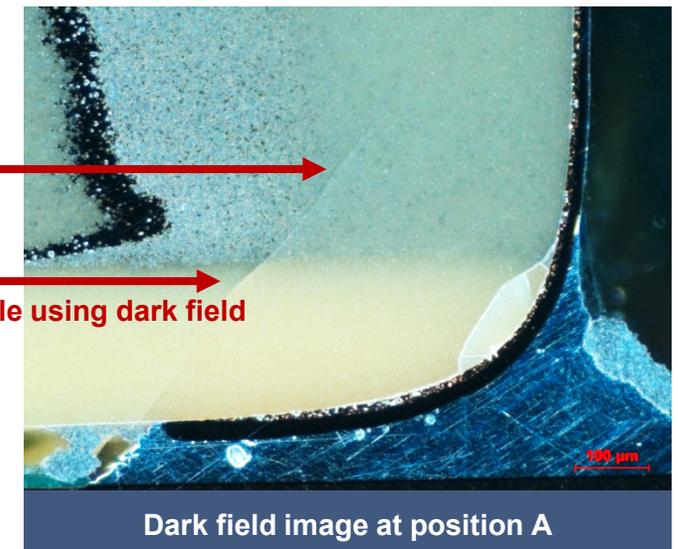
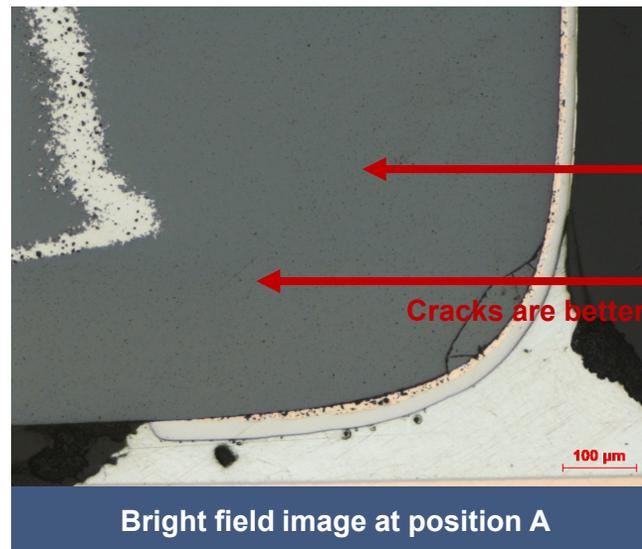
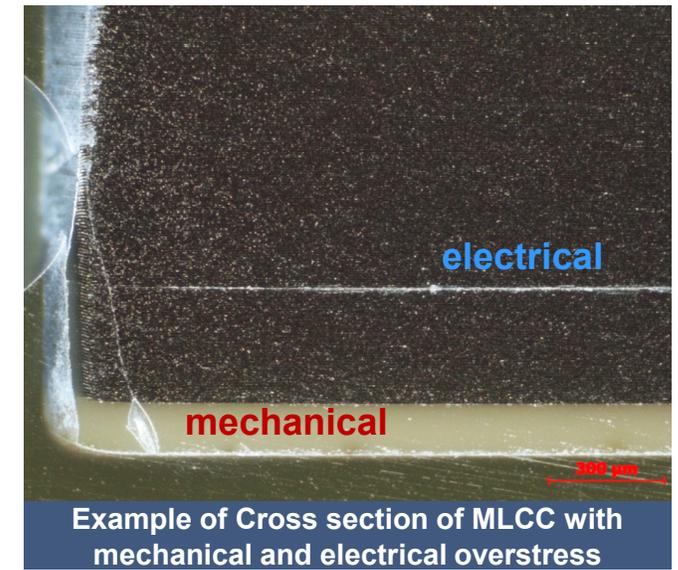
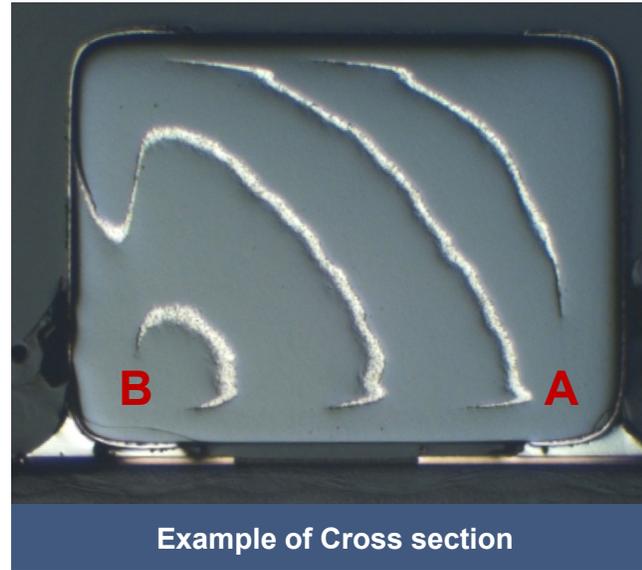
Optical inspection after removal of the terminal metallization

- Less time consuming compared to cross sectioning
- Position of crack(s) is visible
 - The fracture pattern is depending on the course of the bend relative to the orientation of the ceramic capacitor
 - Torsion?
 - Bending (-direction)?
- Electrical damage visible
- If the capacitor is mounted, thermal and mechanical stress can occur due to desoldering



Metallographic Cross Sectioning

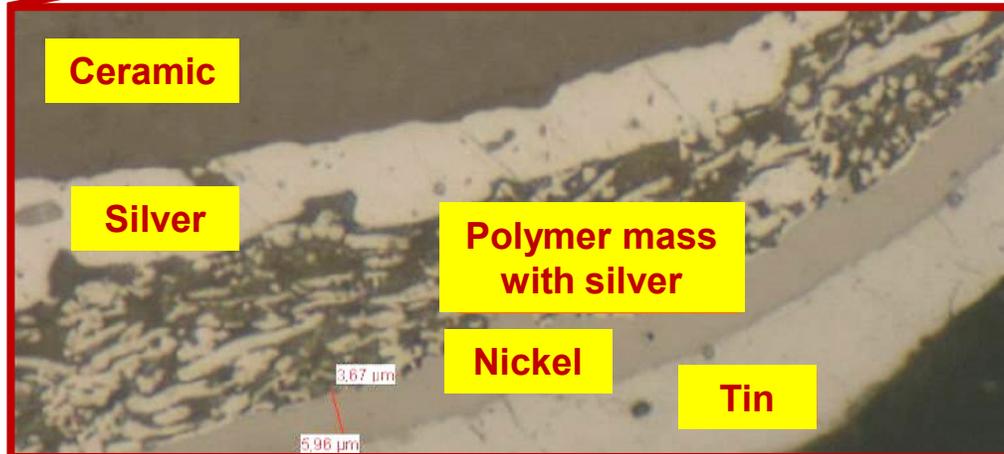
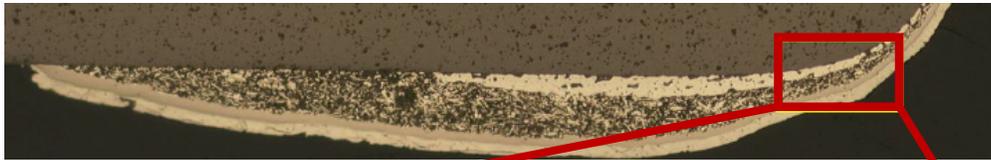
- Cracks within the capacitor visible
 - Starting at the edge of the solder joint
 - The crack path is always inclined towards cap
 - The crack always continues towards the terminal
- Electrical monitoring during grinding possible
- Electrical damage clearly visible (crack along plates)
- Manufacturing defects visible (e.g. missing plates)



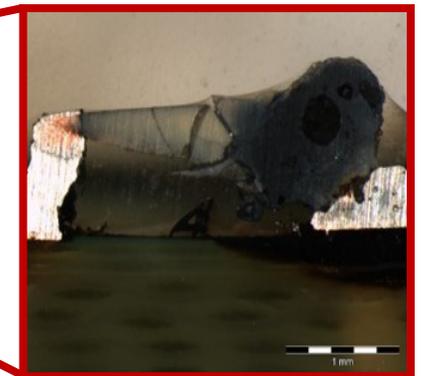
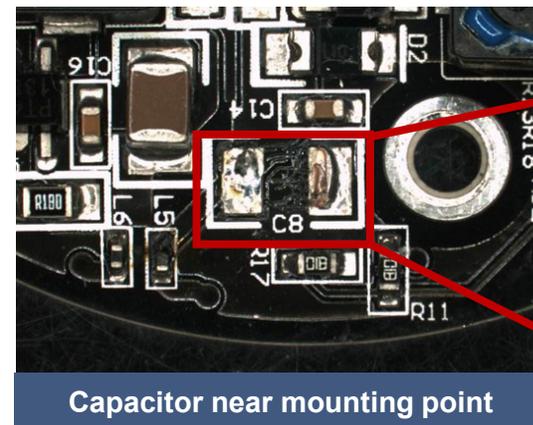
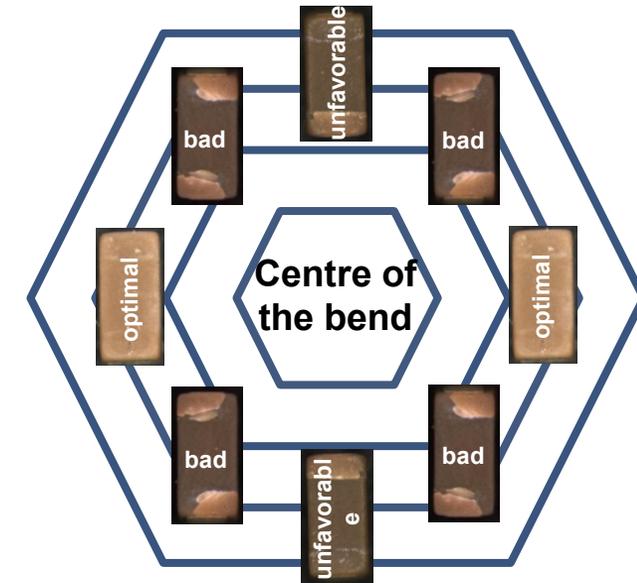
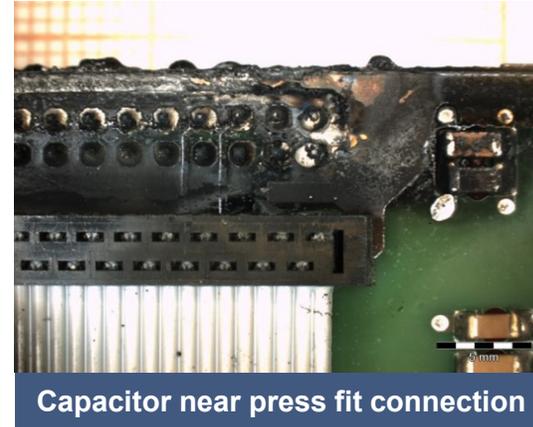
Cracks are better visible using dark field

Precaution – Contraceptives

- Flex cap – avoid the crack
 - Silver-filled polymer mass between silver terminal and nickel-tin layer compensates for mechanical forces



- PCBA design



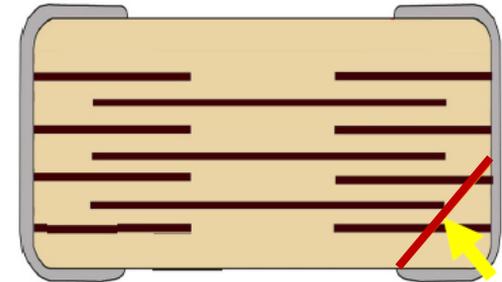
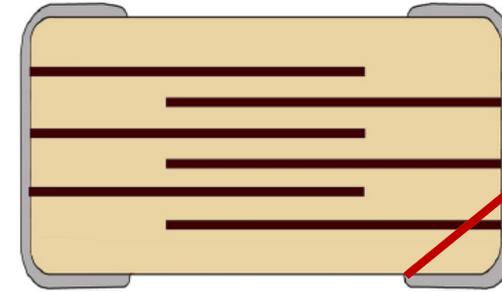
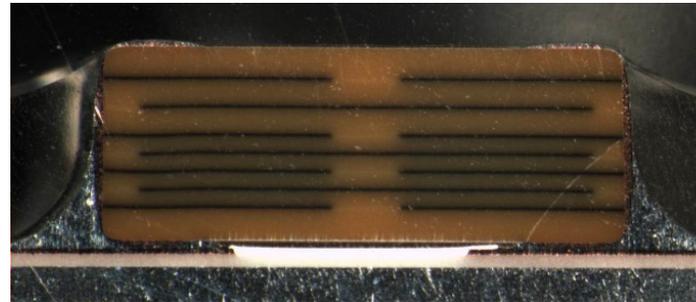
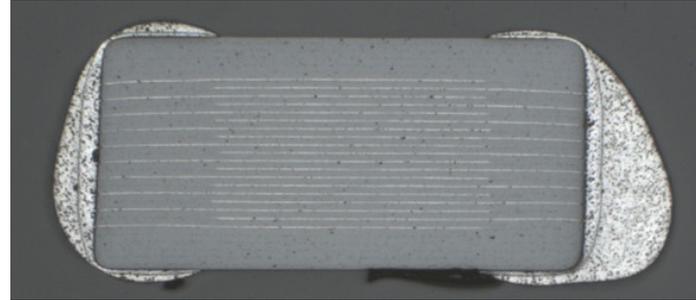
If it happened – *Emergency Contraception*

- Fail safe capacitors

- *Fail open type* - no overlap of the electrodes in the terminal area
- *Floating center plates* - no short circuit between the two component connections possible

- Serial connection of two capacitors

- No hard short circuit if one capacitor fails



Committed to Quality



The test laboratories are accredited according to DIN EN ISO/IEC 17025:2018 by the accreditation body DAkkS. The accreditation is valid only for the scope listed in the annex of the accreditation certificates D-PL-12120-01-02.

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Contact us

info@roodmicrotec.com

Tel: +49 9081 804-0

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