



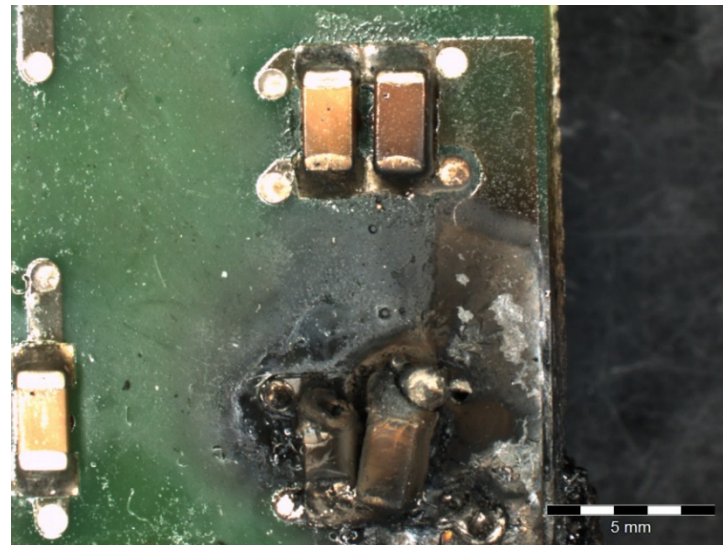
**Multi Layer Ceramic
Capacitors (MLCC)
one of the most
mechanical sensitive
component**

„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“

RoodMicrotec



What is a Multi Layer Ceramic Capacitor (MLCC)?

■ Structure

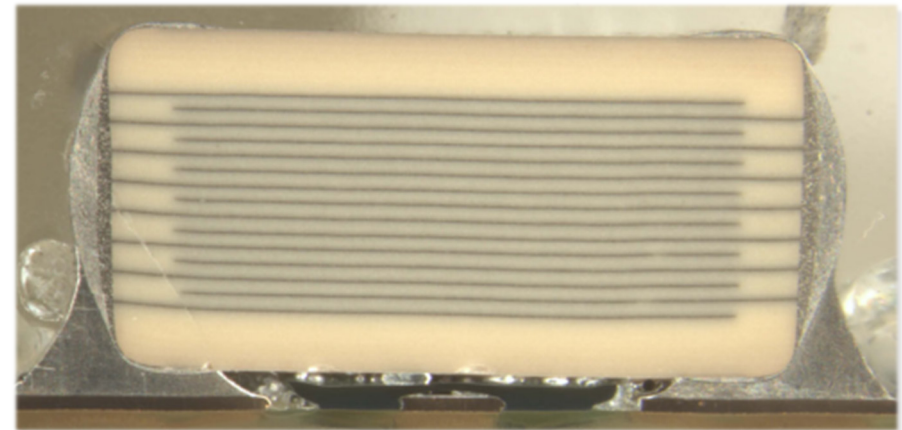
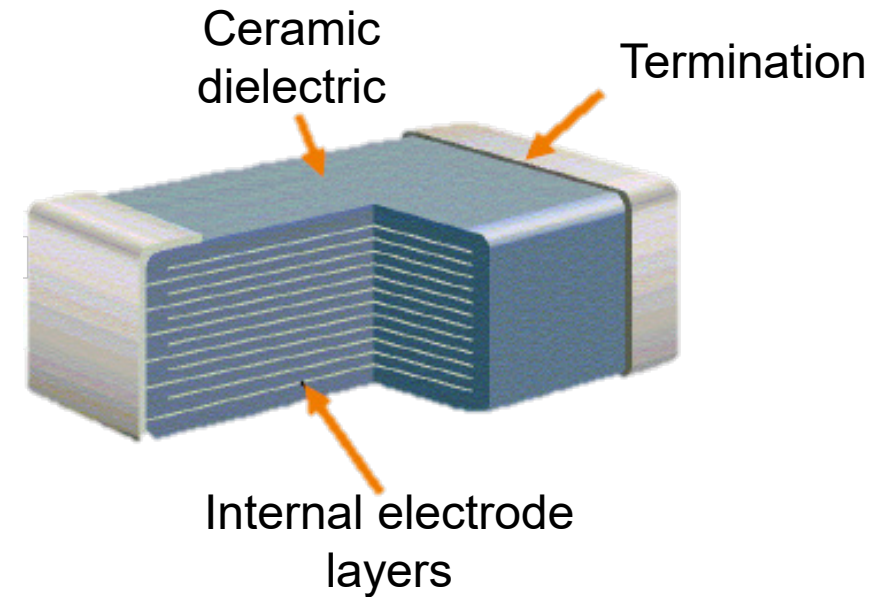
- Ceramic block
- Embedded metal layers
- Termination on both sides

■ Advantages

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

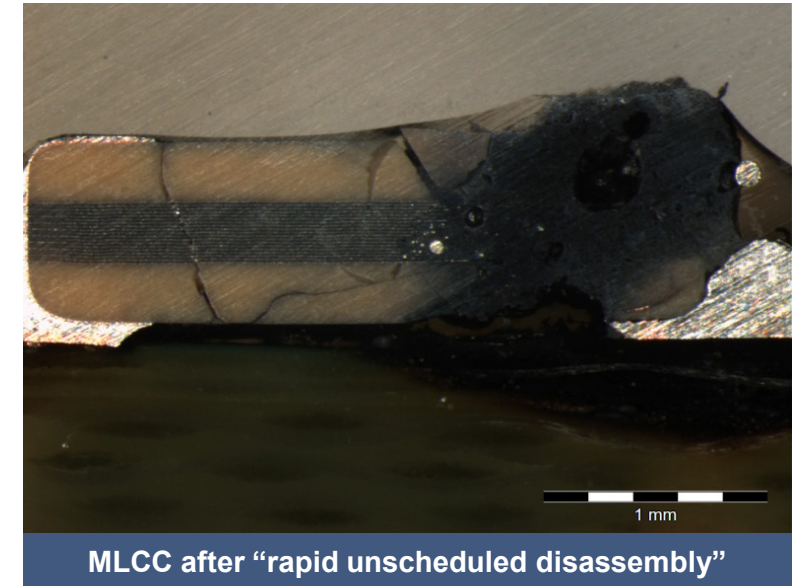
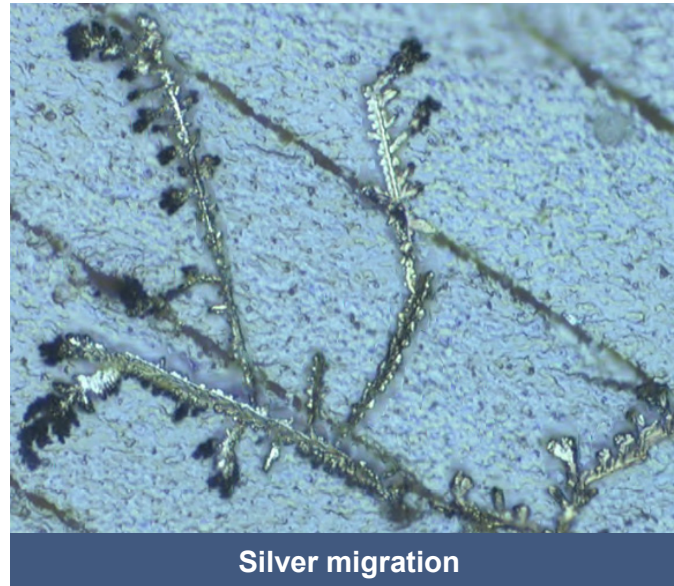
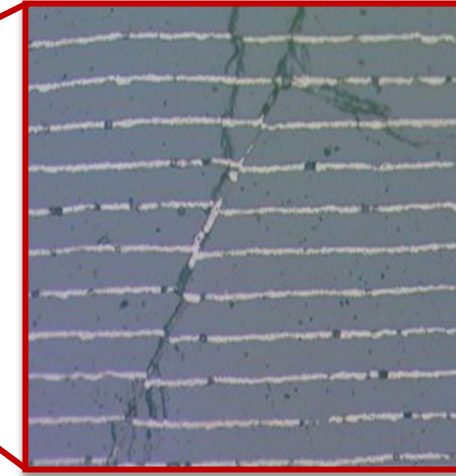
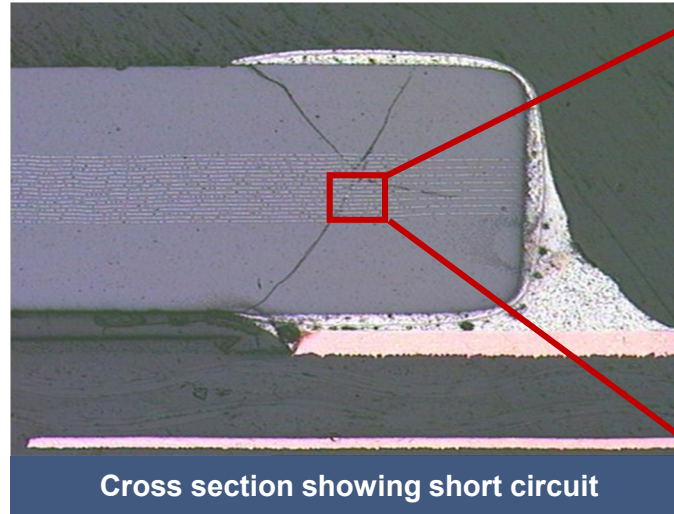
■ Disadvantages

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



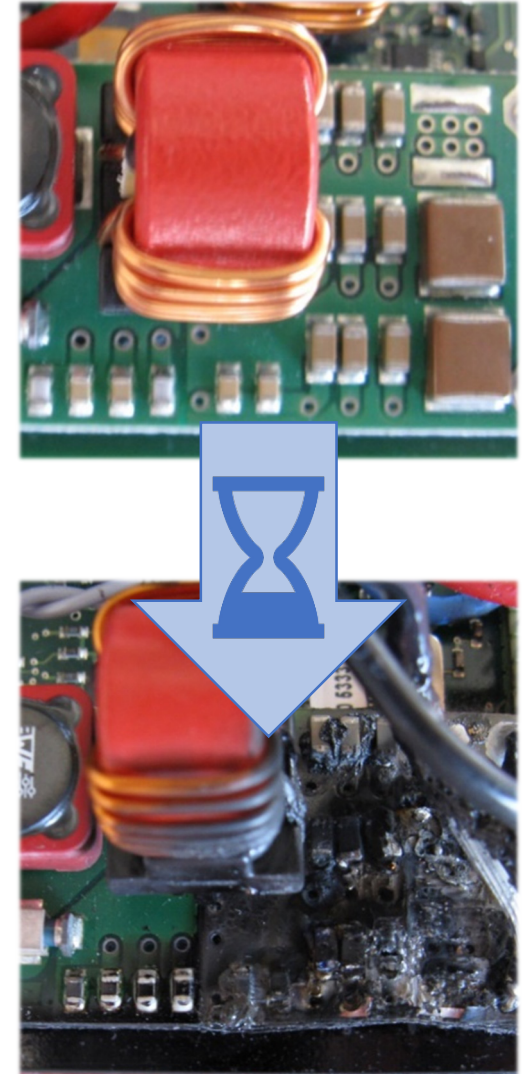
Migration and dendrite growth

- 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



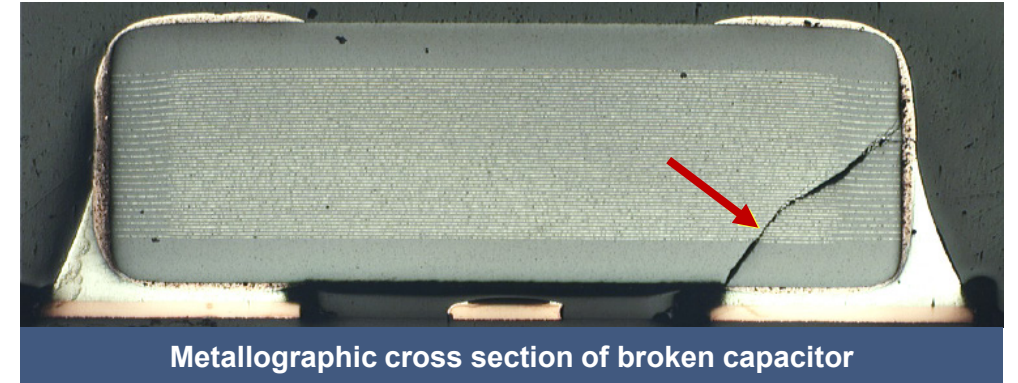
Typical Failures of MLCC

- ~ 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

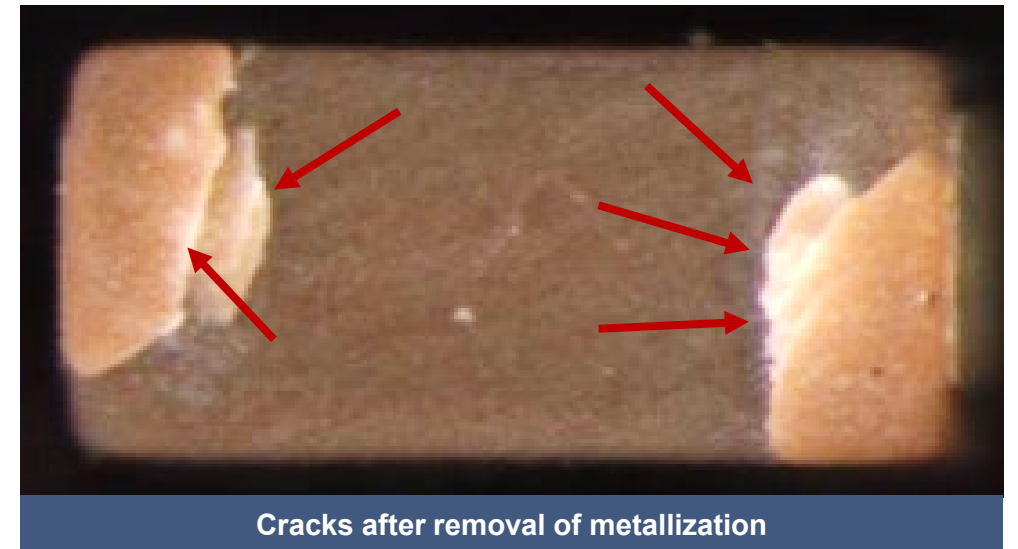


Analysis methods

- 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

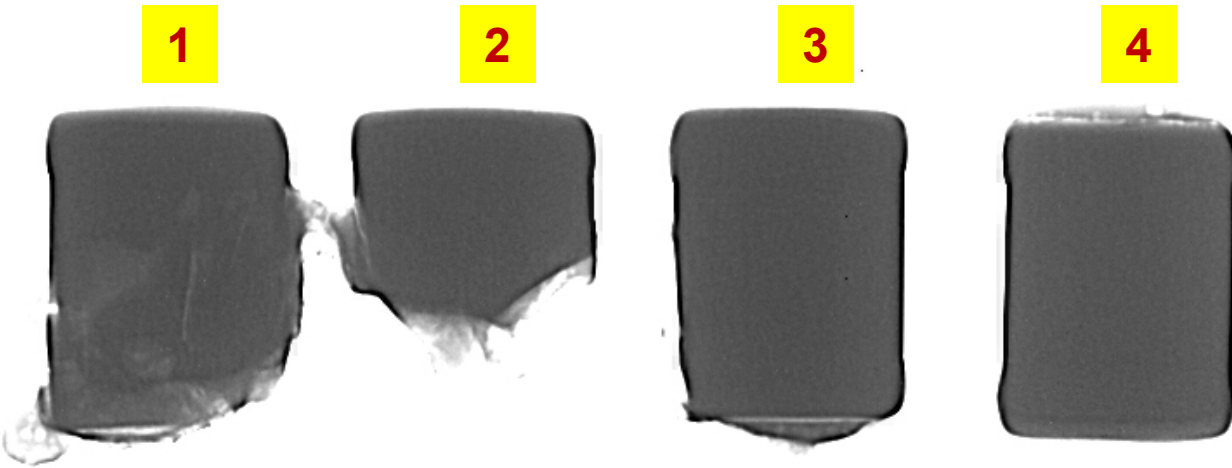


Metallographic cross section of broken capacitor

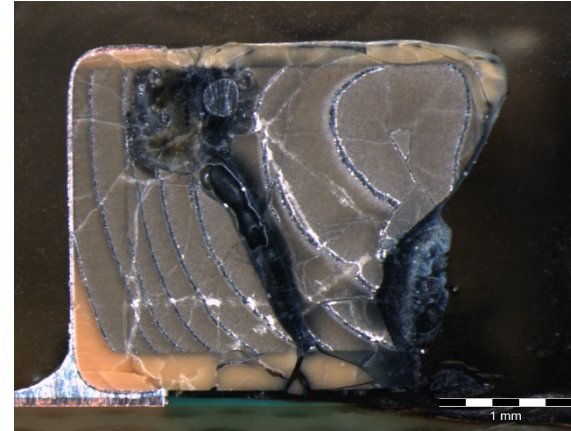


Cracks after removal of metallization

X-Ray Microscopy and why you should not trust it



X-Ray microscopy of ceramic capacitors

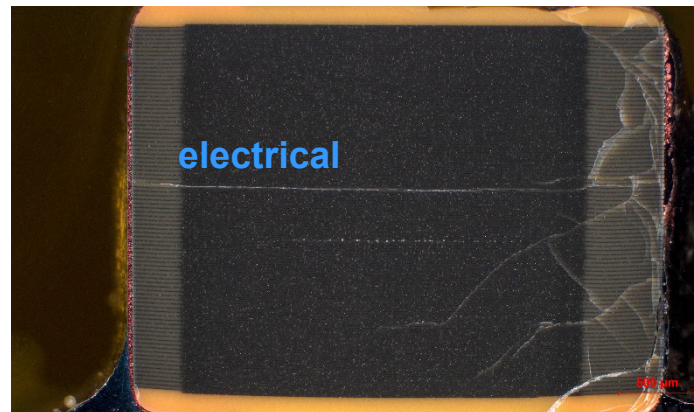


Cross section capacitor 1

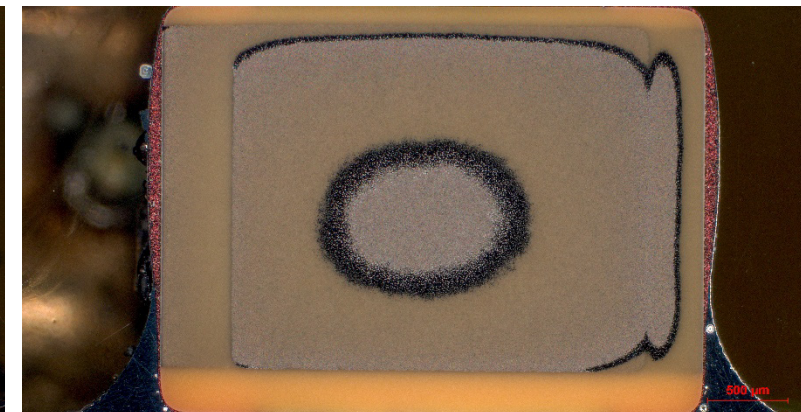


Cross section capacitor 2

- 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)



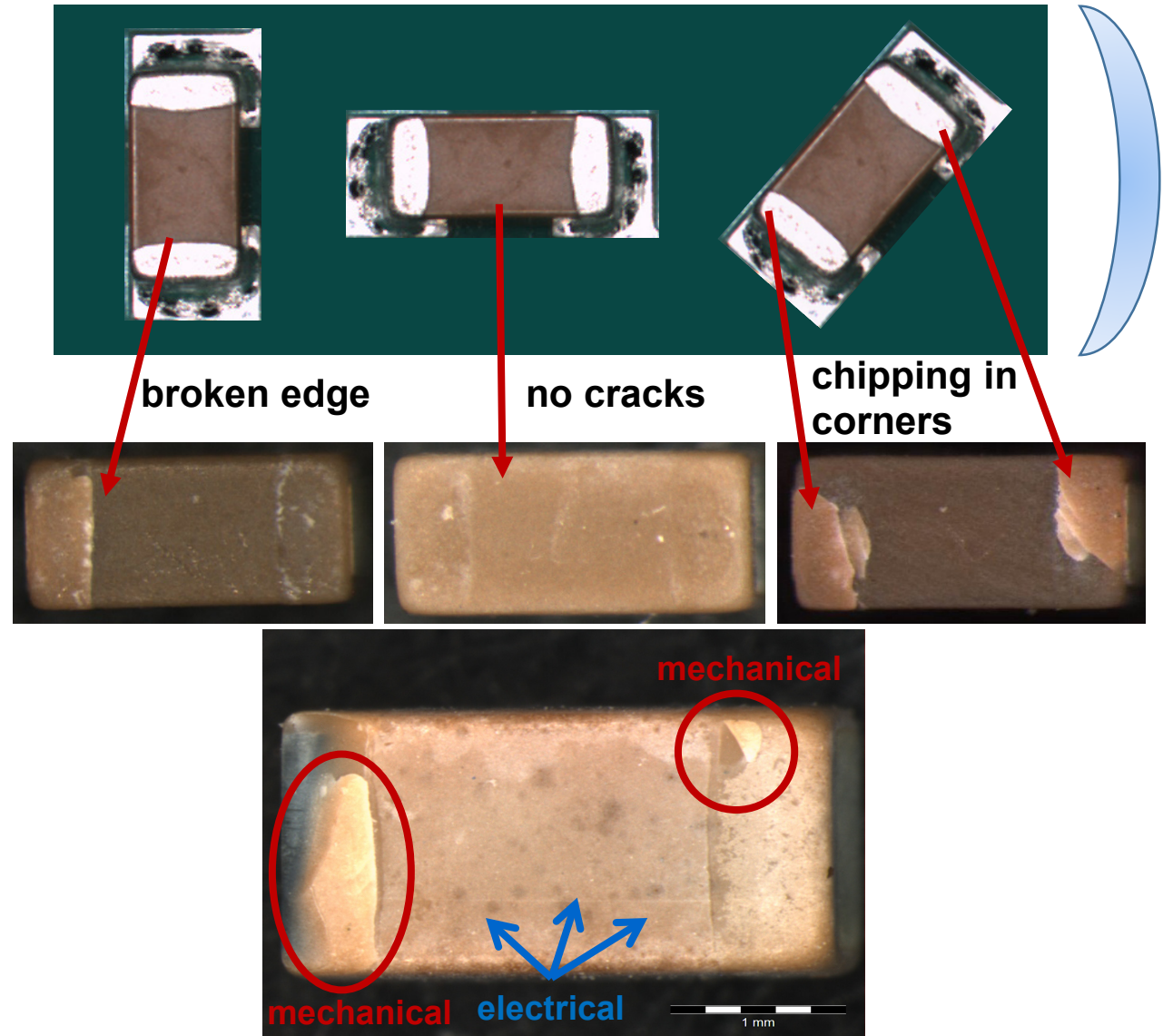
Cross section capacitor 3



Cross section capacitor 4

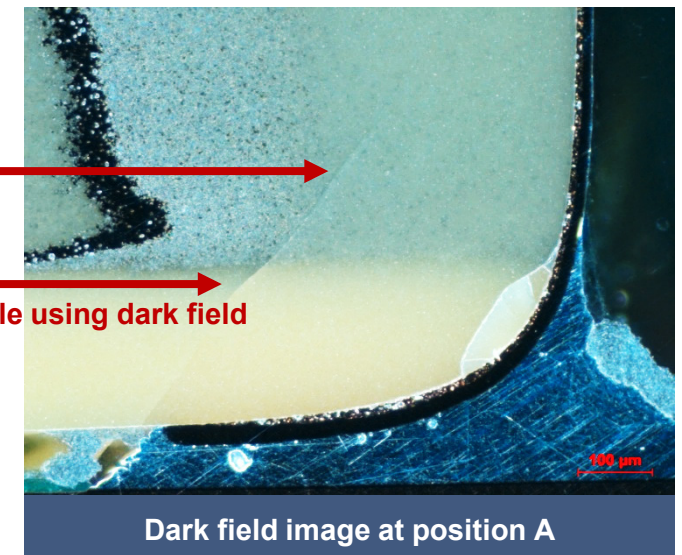
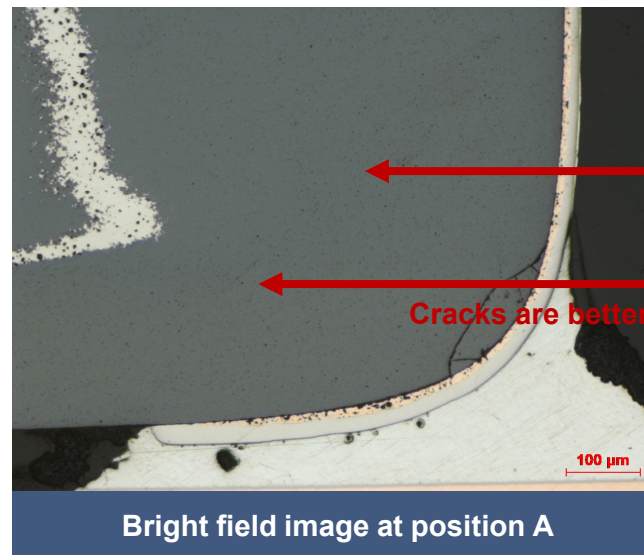
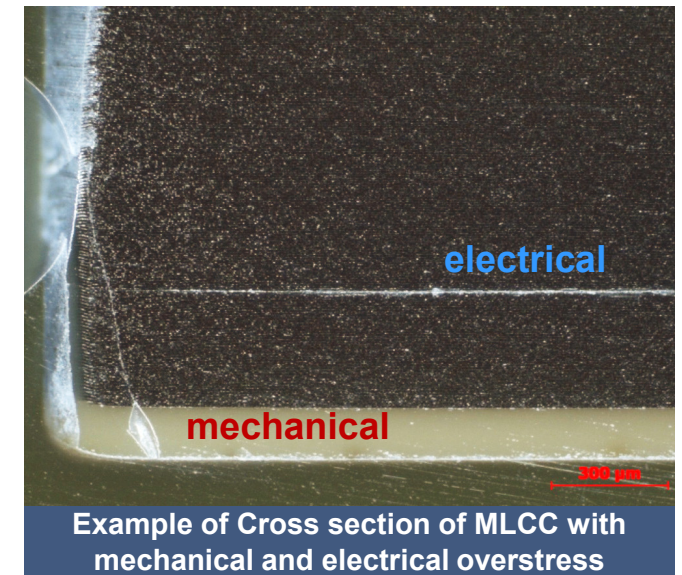
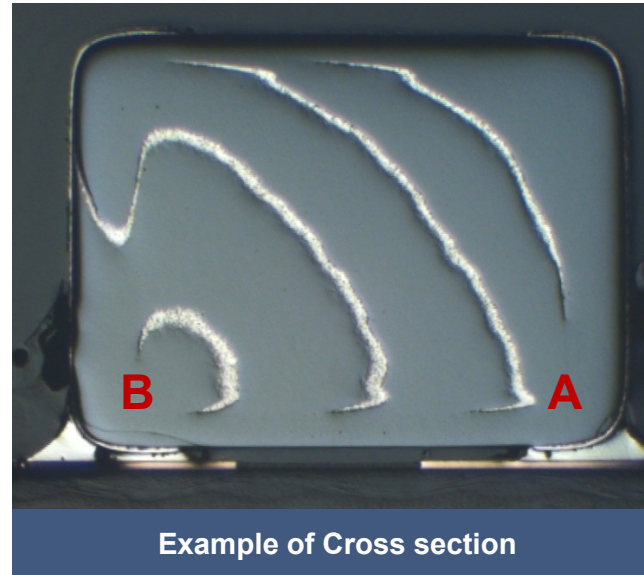
Optical inspection after removal of the terminal metallization

- 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

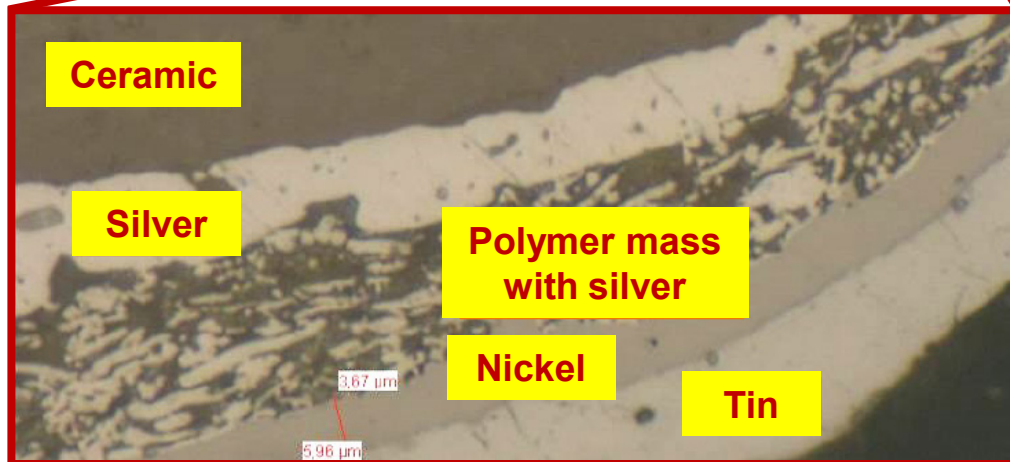
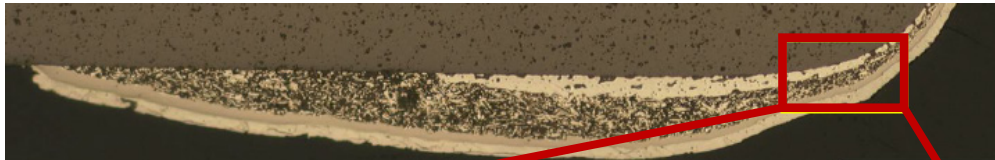
- Cracks within the capacitor visible
 - Starting at the edge of the solder joint
 - The crack path is always inclined towards cap
 - The crack always continues towards the terminal
- Electrical monitoring during grinding possible
- Electrical damage clearly visible (crack along plates)
- Manufacturing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



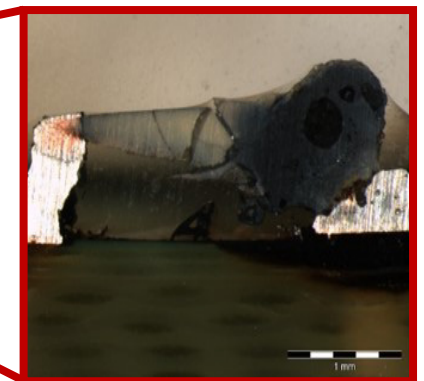
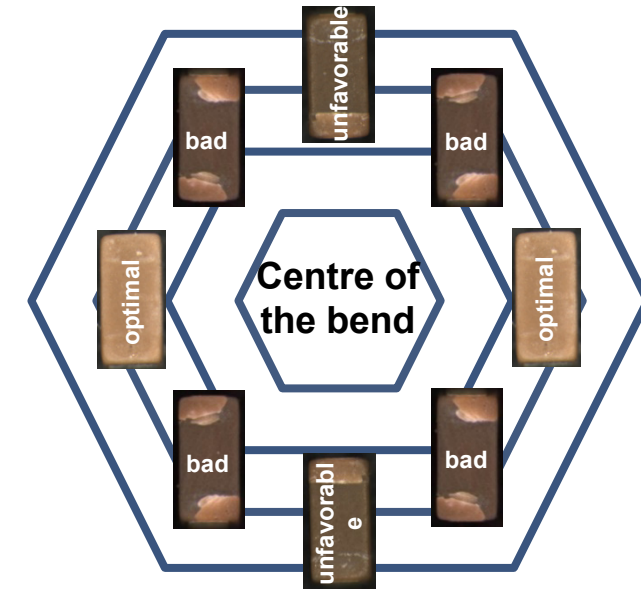
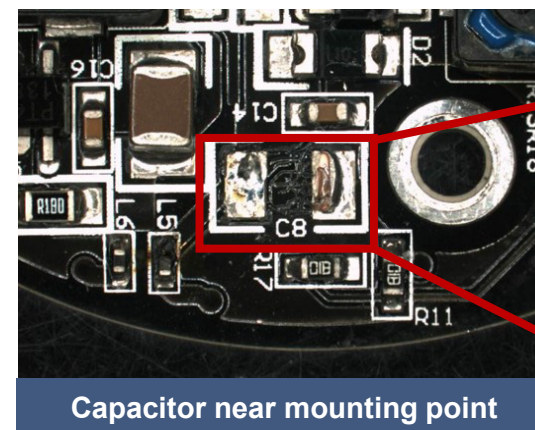
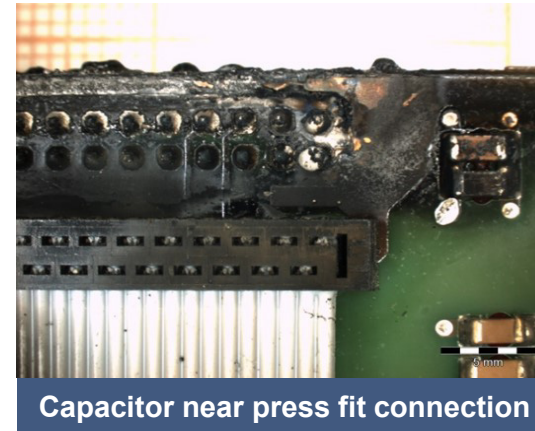
Cracks are better visible using dark field

Precaution – Contraceptives

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



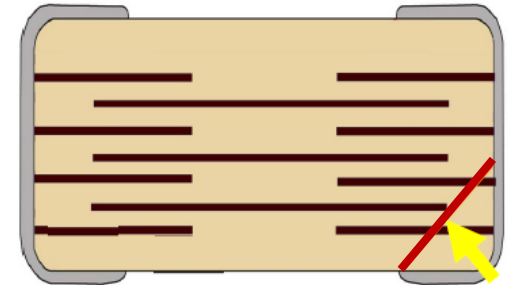
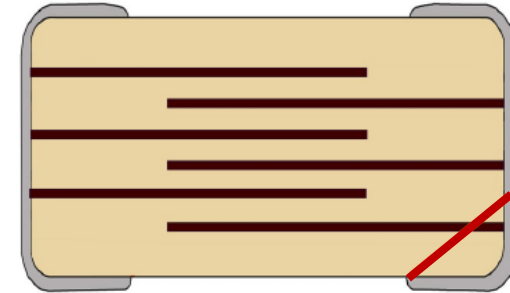
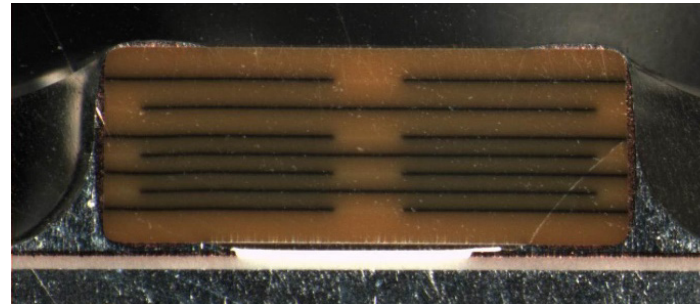
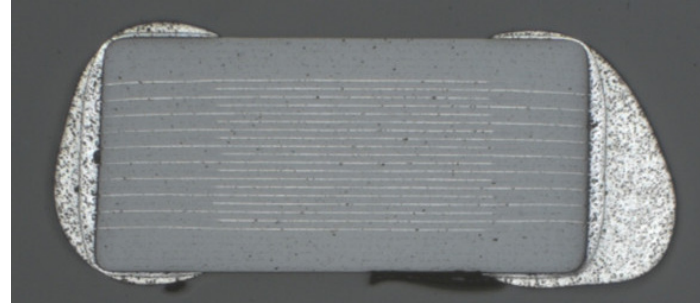
- PCBA design



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

Accredited and certified lab
according to



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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