Ceramic Capacitors
(MLCCs)
Design and Characteristics
All KEMET MLCCs are 100% Screened
- Cap / %DF / IR / DWV
- Vision
Ceramic Capacitors
Flex Cracking
Multilayer Ceramic Capacitor (MLCC)

Termination
(External Electrode, Cu for BME, Ag for PME)

Ceramic Dielectric

Plated Sn finish for Solderability

Internal Electrode (Ni for BME, Ag/Pd for PME)

Barrier Layer
(Plated Ni)
Typical Crack Signatures
MLCC Cross-Sections

The major sources MLCC of cracks are:

- Mechanical damage (impact)
  - Aggressive pick and place

- Thermal shock (parallel plate crack)
  - Extreme temperature cycling
  - Hand soldering
    - Do not touch electrodes while hand soldering!

- Flex or Bend stress
  - Occurs after mounted to board
  - Common for larger chips (>0805)

Failure is not always immediate!

Failure mode is not always deterministic!
Flex Cracks
Flex Mitigation Technology

FE-CAP
Floating Electrode

Open Mode

FT-CAP
Flexible Termination

FF-CAP
Floating Electrode + Flexible Termination

KPS
KEMET Power Solutions

Data Sheet:  http://bit.ly/y7G4V2
Ceramic Capacitors
AC Self-Heating
J-Lead compared to MLCC
Self Heating due to Dielectric Absorption

**Class 2 (X7R, X5R, etc) BaTiO₃**
Ferroelectric

Ferroelectric permanent dipoles in *domains* align with the AC Field

Domain wall heating & Signal distortion

**Class 1 (C0G, U2J) CaZrO₃**
Paraelectric

Paraelectric spontaneously created dipoles align with AC field

No domains, so
No Domain wall heating & Reduced signal distortion
Temperature Rise vs. Ripple Current - C2220C475K5R2C @ 25°C with 0 VDC Bias; RΘ=144 °C/W

- I = 3.125 A
- 1.00 kHz = OvrVlt
- 5.00 kHz = 66.77 °C
- 10.00 kHz = 47.18 °C
- 50.00 kHz = 18.27 °C
- 100.00 kHz = 12.35 °C
- 500.00 kHz = 6.68 °C
- 1.00 MHz = 5.89 °C
- 5.00 MHz = 5.19 °C
- 10.00 MHz = 5.21 °C
1. Under rated conditions, failure takes a long time.
2. Accelerated temp/voltage shows bathtub plot
3. Something is wearing out the dielectric
Over Stress: BME C0G
Calcium Zirconate

C0G BME takes incredible overstress before wearout.
What’s different?
Barium Titanate vs Calcium Zirconate
### Predicted Median Time to Failure

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Dielectric Family</th>
<th>Rated Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>0402 100nF</td>
<td>X7R</td>
<td>16</td>
</tr>
<tr>
<td>0603 100nF</td>
<td>X7R</td>
<td>50</td>
</tr>
<tr>
<td>1210 1µF</td>
<td>X7R</td>
<td>100</td>
</tr>
<tr>
<td>0402 1nF</td>
<td>C0G</td>
<td>25</td>
</tr>
<tr>
<td>1206 100nF</td>
<td>C0G</td>
<td>25</td>
</tr>
</tbody>
</table>
The Bathtub Curve
Hypothetical Failure Rate versus Time

Relative failure rate of an entire population over time
Ceramic Summary

Infant Mortality

*Manufacturing Defects*

100% Screening Reduces Them

*Flex Cracking*

Flex Mitigation

Not all flex cracked parts fail immediately

Wear-Out

*10s to 100s of years at rated conditions*

Derating helps, but is it necessary?

*Oxygen Vacancies become mobile*

More pronounced in X7R (Barium Titanate) than C0G (Calcium Zirconate)
Thank You