Extension of the space qualified MLCC’s ranges
SPCD, Noordwijk
11/10/2018
Introduction
Introduction

• Presentation will aim at:
  ✓ Describe qualification status of Exxelia’s ceramic products and how it has been achieved
  ✓ Present an overview of the development work (roadmap)

• Results presented correspond to about 10 years development

• Work conducted with the help of CNES. Many thanks.
Introduction

• Driving need: smaller / lighter / cheaper equipments
  ✓ Miniaturization of the components
  ✓ Surface Mounted Devices

• What does it imply?
  ✓ Manufacturing process modifications
  ✓ Materials evolution

• What are the possible ways?
  ✓ To design smaller capacitors with lower rated voltages
  ✓ To design alternative components with reduced lossed in order to minimize heating
Smaller capacitors with lower rated voltages
Smaller capacitors with lower rated voltages

• Goal: to extend chips qualification down to 0402 size and 10V what implies:
   Reduction of dielectric thickness
   Reduction of size margins
   Both actions to increase maximum available capacitance

• Constraint: to maintain a good reliability level

• Implications:
   New dielectrics or better desagglomerated
   New manufacturing equipments
   New (cleaner) manufacturing environment
Smaller capacitors with lower rated voltages

• Dielectric:
  ✔ No change until now, planned for future (see roadmap)
  ✔ Slurry preparation optimization
  ✔ New milling equipment (more powerful and parameters better tunable)
Smaller capacitors with lower rated voltages

- New manufacturing equipment:
  - Dedicated casting equipment in a clean area
  - Stacking equipment using tape on plastic in order to be able to handle very thin layers
  - New metallization equipment

![Ceramic sheet on plastic tape](image1)

![Casting equipment](image2)
Smaller capacitors with lower rated voltages

• New manufacturing equipment:

Stacking equipment

Metallization machine
Smaller capacitors with lower rated voltages

- Parts evaluated / qualified:
  - CEC (NPO) and CNC (BX / X7R)
  - Sizes 0402 to 2220
  - Rated voltage from 10V to 100V
    - Ag/Pd/Pt termination
    - Ag + nickel barrier + Sn/Pb 60/40 (or gold)
    - Ag + Ag filled polymer + nickel barrier + Sn/Pb 60/40 (or gold)

- Tests done according to ESCC 2 263 000 and 3001 + some additionnal tests such as:
  - 500 thermal shocks -55°C / +125°C
  - 100 thermal shocks -55°C / 125°C + 85/85 damp heat 1000h
Smaller capacitors with lower rated voltages

- Qualification results:

<table>
<thead>
<tr>
<th>Voltage</th>
<th>0402</th>
<th>0603...</th>
<th>1210...</th>
<th>2220</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 V</td>
<td>NEW</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>16 V</td>
<td></td>
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<tr>
<td>25 V</td>
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<tr>
<td>50 V</td>
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</tr>
<tr>
<td>100 V</td>
<td></td>
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</tr>
</tbody>
</table>

QPL since 2012
Smaller capacitors with lower rated voltages

• Roadmap for next years:
  ✓ Small sizes: from 0402 to 1210
  ✓ 10V rated parts or less
  ✓ Maximum capacitance multiplied by 5 to 10

• Necessary to have:
  ✓ New equipments
  ✓ Printing / stacking in clean environment

Work in progress
Alternative components with reduced losses
Alternative components with reduced losses

• Goals and constraints:
  ➔ To keep the CV product
  ➔ To be able to be used in a power / high voltage environment
  ➔ To reduce losses
  ➔ NPO have low dielectric constant
  ➔ BX / X7R have a high DF

• Decision: To use a **N2200 material** which allows to manufacture capacitors which have the same capacitance values left than X7R under voltage but very reduced power dissipation
Alternative components with reduced losses

• C48X main characteristics:

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dissipation factor at 1kHz, $1V_{\text{eff}}$</td>
<td>$\leq 10 \cdot 10^{-4}$</td>
</tr>
<tr>
<td>Typical DF at 400Hz, $1V_{\text{eff}}$</td>
<td>$\leq 5 \cdot 10^{-4}$</td>
</tr>
<tr>
<td>Insulation resistance at 20°C under $500V_{\text{cc}}$</td>
<td>$\geq 20000\Omega$ or $500\Omega \cdot \mu F$</td>
</tr>
<tr>
<td>Dielectric withstanding voltage</td>
<td>$&gt;1.4 U_{\text{RC}}$</td>
</tr>
<tr>
<td>Temperature coefficient</td>
<td>$-2200 \pm 500 \text{ ppm/}^\circ C$</td>
</tr>
</tbody>
</table>

• Power dissipation
Alternative components with reduced losses

• 2 main driving directions: high voltage and medium voltage
• Evaluation on high voltage (500V to 5kV) parts
  ✔ Families
    ● Chips with flexible termination
    ● SMD parts (chips with DIL connections)
    ● Through hole mounting molded parts
  ✔ Tests based on ESCC 2 263 000 + additional tests
    ● 500 thermal shocks -55°C / +125°C
    ● 100 thermal shocks -55°C / +125°C - 85/85 damp heat 1000h
    ● Partial discharge evaluation
    ● Power dissipation measurements
    ● Vibrations ....

Positive results
Alternative components with reduced losses

• Extension to medium voltage
  ✓ To increase type 1 ranges (factor 3 to 4 expected)
    • Sizes: 0603 to 1210
    • Voltage: 100V to 1000V
    • SMD chips with Ag/Ni/Sn-Pb terminals
  ✓ Evaluation based on ESCC 2 263 000 + thermal shocks and 85/85 damp heat test

Positive results
Alternative components with reduced losses

• Administrative roadmap for next years
  ✓ Introduction of C48X high voltage ranges in EPPL
  ✓ Qualification C48X high voltage ranges
  ✓ Qualify 0603 to 1210 medium voltage ranges

• New development: Evaluate and qualify high voltage SMD capacitors
  ✓ Single chip components
  ✓ Stacks

Work in progress
Thanks for your attention.
Any question?

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