Reliability is a key factor when engineers have to design a new power module and select the corresponding substrate material. Depending on the mission profile and packaging concept, customers very often have to make a trade off between electrical, thermal, and mechanical performance of the metallized ceramic substrate. The reliability of a metallized ceramic substrate can be defined as its thermo mechanical behavior or resistance under stress conditions and is typically best characterized by thermal cycling or thermal shock tests.

The purpose of this document is to provide some basic information about the factors that influence the lifetime of metallized ceramic substrates, test conditions, test criteria as well as typical failure mechanisms and workarounds.

**Mechanical stress analysis:**
- Ceramic is a brittle material and fatigue cracks are likely to occur under stress conditions
- Inner stress is caused by CTE mismatch between copper and ceramic
- Inner stress is mainly concentrated at the copper edge and on the interface with ceramic
- Round corner is more critical than sharp corner
- Dimples act as thermal stress relief and enhance the substrate reliability by factor 10

### Reliability of metallized ceramic substrates

**Influencing factors:**
- Raw material properties (copper & ceramic)
- Substrate design
- Test conditions
- Test criteria

<table>
<thead>
<tr>
<th>Material Design</th>
<th>Test conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper + ceramic thickness</td>
<td>T min, T max, ∆T</td>
</tr>
<tr>
<td>Ceramic type</td>
<td>Dwell time</td>
</tr>
<tr>
<td>Bonding technology (DBC or AMB)</td>
<td>Testcondition air / liquid</td>
</tr>
</tbody>
</table>

**Reliability**
- Copper pattern
- Size
- Dimple
- Side wall
- Corner
- Plating

**Test criteria**
- Test method (ultrasonic or natural frequency)
- Failure judging criterion
- Measurement equipment
Thermal test profile:
// Pay attention to ΔT and transition time
// curamik® reference: -55°C ~ 150°C, thermal shock
// Thermal shock is generally more critical than thermal cycle test
// Liquid test is generally more critical than air test

Temperature cycling test in different oven

2 chambers short transition time
- 40°C
- +125°C
- 40°C
- +125°C
30 min
< 10 sec

2 chambers long transition time
- 40°C
- +125°C
- 40°C
- +125°C
30 min
5 min
it takes more time to get the sample to nominal temperature

3 chambers
- 40°C
- +125°C
- +25°C
- +125°C
- 40°C
- 40°C
- 40°C
30 min
< 10 sec
10 min
< 10 sec

curamik® Solution
// curamik® Thermal (AlN-DBC) has the best thermal conductivity but limited reliability.

// curamik® Power (Al₂O₃-DBC) offers the best price / performance ratio and is the preferred and most popular substrate for industrial applications in conventional power modules.

// curamik® Power Plus (HPS-DBC with Zirconium toughed Al₂O₃) is the substrate of choice for applications with longer lifetime requirements and for molded power modules.

// curamik® Performance (Si₃N₄-AMB) enables new packaging concepts thanks to its superior mechanical properties and longer lifetime.