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Reliability of metallized ceramic substrates

tech note

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.

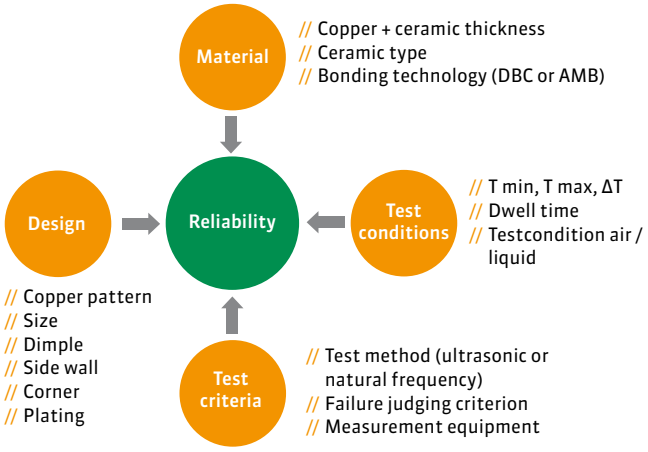
Influencing factors:

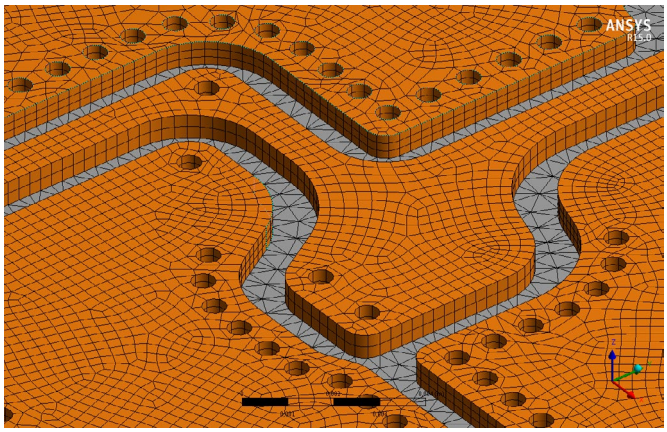
// Raw material properties (copper & ceramic)
// Substrate design
// Test conditions
// Test criteria

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





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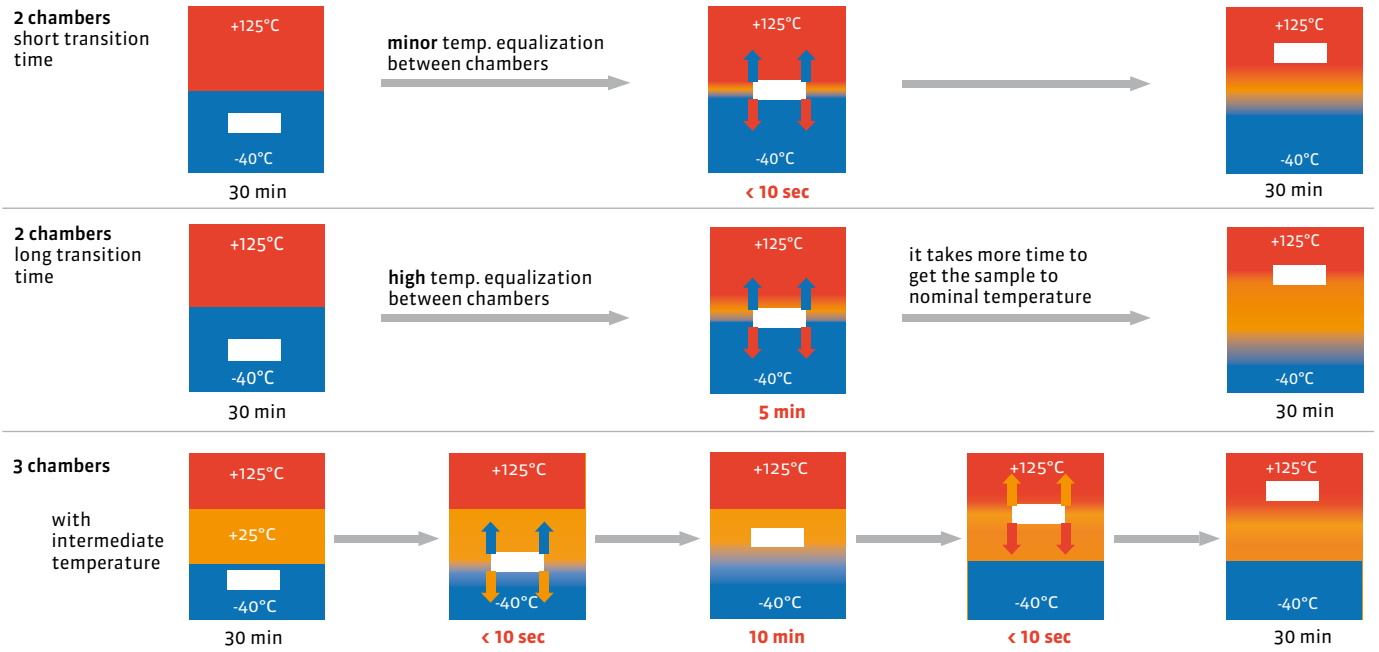
Thermal test profile:

// 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



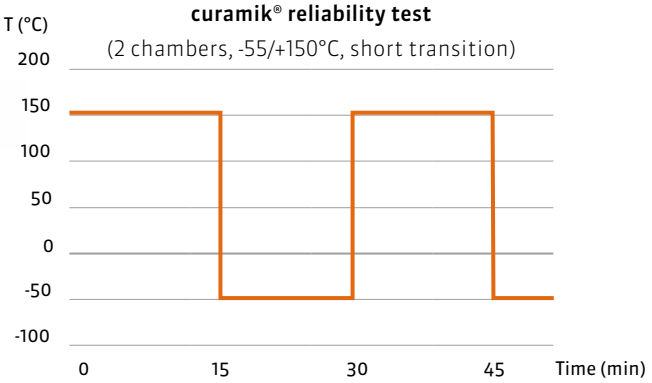
curamik® Solution

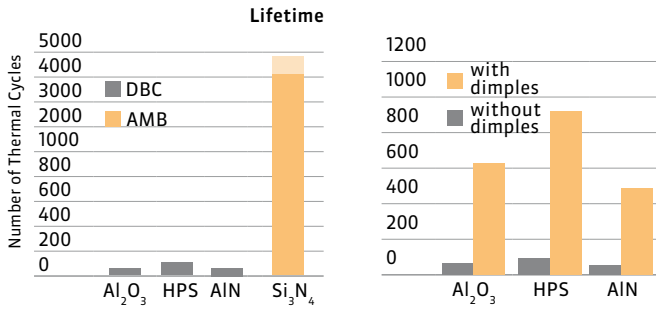
// curamik® Thermal (AlN-DBC) has the best thermal conductivity but limited reliability.

// curamik® Power (Al_2O_3-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 Al_2O_3) is the substrate of choice for applications with longer lifetime requirements and for molded power modules.

// curamik® Performance (Si_3N_4-AMB) enables new packaging concepts thanks to its superior mechanical properties and longer lifetime.





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