Bending strength of ceramics for curamik substrates

tech note

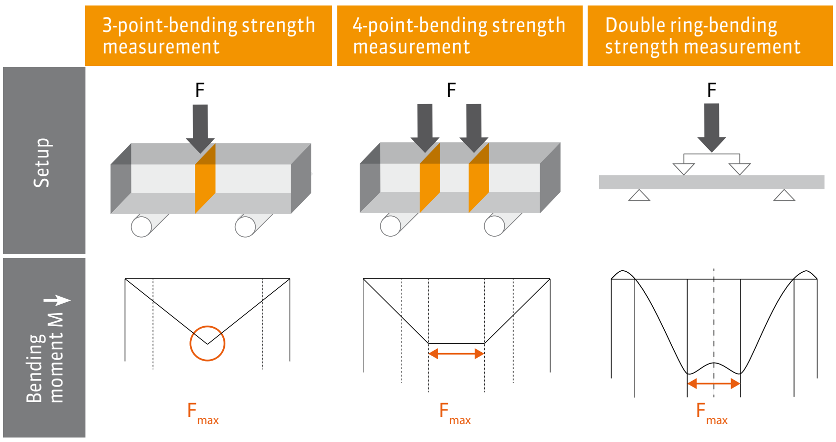
Mechanical stability of substrates is gaining more focus as new packaging technologies like US welding and silver sintering bring high mechanical forces to metallized substrates. The mechanical stability of metallized substrates is mainly dependent on the type of ceramic material used. Bending strength is one of the main physical properties for mechanical stability and a key factor of the indication of reliability and processability of a metallized ceramic substrate.

The strength of ceramic materials is typically characterized by the material‘s resistance to tensile stress. Breaking triggering factors are excessive stresses at defects in the ceramics. The resistance of the ceramic against tensile strength depends on the type, frequency and distribution of even the smallest of defects in the material. The spread of resistance is due to the scattering of the defect size and is best described by the Weibull distribution. There are no general guidelines for the measurement of the bending strength of thin ceramic substrates (h=0.25-1.0 mm). The measurement can be calculated using DIN EN 843-1 which describes a minimum thickness h for the samples of 2.5 + 0.2 mm.

Measurement methods:

// 3-point-bending
// 4-point-bending
// Double ring bending

All methods are destructive measurements



	3-point-bending strength measurement	4-point-bending strength measurement	Double ring-bending strength measurement
Formula	$\sigma_{Bb} = \frac{3Fl}{2bh^2}$	$\sigma_{Bb} = \frac{3Fd}{bh^2}$	$\sigma_{Bb} = K \frac{F}{h^2}$

σ_{Bb}	Bending strength [N/mm²]
F	Maximum force [N]
l	Distance between the center of each supporting roll [mm] (3 point-bending)
d	Distance between the axis of inner and outer supporting roll [mm] (4 point-bending)
b	width of specimen [mm]
h	thickness of specimen [mm]
K	constant, for square specimens = 1.04

Weibull distribution:
The value B indicates the probability that a component of volume V breaks under a load of σ. The Weibull m describes the slope of the distribution (the larger m, the lower the distribution).

$$B(\sigma) = 1 - \exp\left(-\left(\frac{\sigma}{\sigma_0}\right)^m \cdot \frac{V}{V_0}\right)$$

B = fracture probability
σ = external stress
V = component volume
V_0 = reference volume
σ_0 = reference tension
m = Weibull modulus

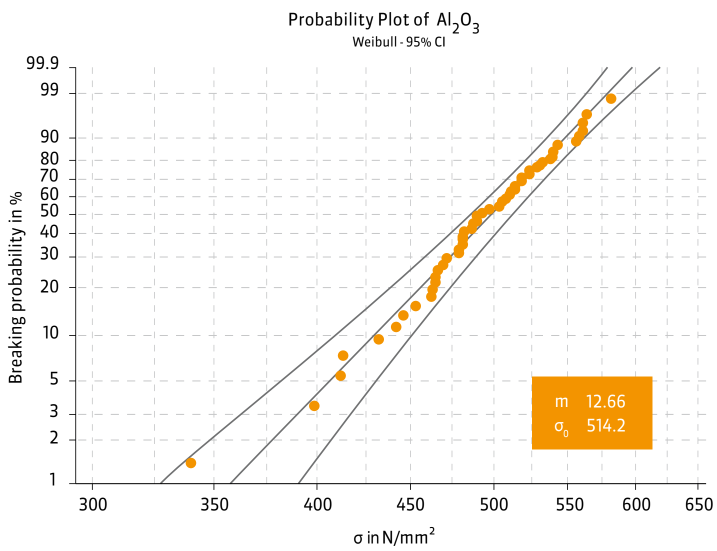


Diagram 1: Graphical description of a Weibull distribution with scale = σ_0 for bending strength

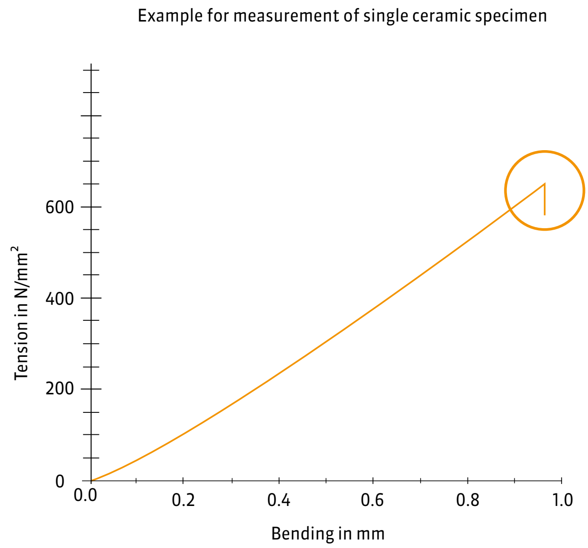


Diagram 2: tension vs. bending until break of sample

curamik® Solution

// curamik® Thermal substrates using AlN ceramic bring lowest bending strength with highest thermal performance.

// curamik® Power substrates using Al_2O_3 ceramic have the best cost advantage with general bending strength.

// curamik® Power Plus substrates using HPS (ZTA) ceramic bring high mechanical performance due to high bending strength for a valuable price.

// curamik® Performance substrates using Si_3N_4 ceramic show the best mechanical performance with the highest bending strength combined with very good thermal performance.

Measurement method at Rogers Germany:

// 3-point bending test on 40 x 24 mm specimens
// The sample lies on supporting pins with a distance of 30 mm and a diameter of 2 mm
// Force is applied from top side in the middle between the supporting pins until the specimen breaks
// Maximum force before break occurs is being recorded
// Measurement speed 5 mm / min

Bending strength of ceramics for curamik® substrates

Ceramic Material	Bending strength
Al_2O_3	>450 N/mm²
HPS (ZTA9%)	>600 N/mm²
AlN	>350 N/mm²
Si_3N_4	>700 N/mm²

Rogers Corporation
www.rogerscorp.com/pes
www.curamik.com