Design- Guideline

Alumina

Aluminum nitride

This Design-Guideline prior describes the general conditions for laser machining alumina substrates and aluminum nitride substrates with regard to the specific challenge of complex production for individual customers in the engineer-to-order-process. Our standards-based but customer-centered approaches of engineering are flexibly scalable to react to changing degrees of complexity and customized orders in a quick, precise and efficient way.

diversity of materials and applications

T +49 (0) 36601 9327-54 | F +49 (0) 36601 9327-71 | vertrieb@lcpgmbh.de | www.lcpgmbh.de

General

The LCP Laser-Cut-Processing GmbH is one of the specialists in laser machining of fine and micro components. Our technological core competences are listed below:

- Laser precision cutting
- Laser drilling
- Laser scribing
- Laser marking
- Laser patterning/ ablation
- Wafer sawing (DICING)
- Contract measurements
- Laser fine welding
- Precision bending
- Mechanics
- Vibratory finishing

On the basis of our highly developed technologies and long lasting experience we are able to process the following special materials precisely according to the customer requirements:

- Ceramics like Al_2O_3 up to 3,0 mm
  AlN, Si_3N_4, SiC up to 4,0 mm
- mono- or polycrystalline silicon up to 4,0 mm

Ceramics with special surfaces, such as thin-film substrates, are always handled with gloves.

Further information to the different types and properties of ceramics you can find in the category „ceramics, glass, silicon" at www.lcpgmbh.de

This design guideline can also be used as an indication for working with other ceramic materials such as SiC, Si3N4, ZrO2 or porous ceramics. An adjustment-free transmission is not possible.

diversity of materials and applications
T +49 (0) 36601 9327-54 | F +49 (0) 36601 9327-71 | vertrieb@lcpgmbh.de | www.lcpgmbh.de
LCP LASER CUT PROCESSING

General Layout Description

1. Standard blank ceramic substrates

The following table shows the dimensions of 96% alumina substrates that we have in stock. Those and different dimensions, which gladly can be requested, are purchased by suppliers like Ceramtec, CoorsTek and Kyocera and Maruwa. Different dimensions can be requested.

	Standard thickness substrate [mm]	Standard Dimensios [mm] (Tolerance limits: ±1,5%) und camber (CB) [%]
96% Al_2O_3	0,25 ±0,03	115x165 CB 0,7
	0,38 ±0,05	115x165 CB 0,6 / 138x190,5 camber 0,6
	0,5 ±0,05	115x115 CB 0,3 / 165x138 CB 0,3
	0,63 ±0,06	115x115 CB 0,2 or CB 0,3 / 115x165 CB 0,3
	0,76 ±0,08	115x115 CB 0,3 / 115x165 CB 0,3
	1,0 ±0,10	115x115 CB 0,2 / 115x165 CB 0,2 or CB 0,3 / 170x205 CB 0,3
	1,27 ±0,12	115x165 CB 0,3
99% Al_2O_3	0,25 ±0,03	115x115 CB 0,8
	0,38 ±0,05	115x115 CB 0,3
	0,5 ±0,05	115x115 CB 0,3 / 133 x 190,5 CB 0,2
	0,63 ±0,06	115x115 CB 0,2
	1,0 ±0,10	115x165 CB 0,2

Design Guideline Ceramic AL_2O_3- and ALN-applications

	Standard thickness substrate [mm]	Standard Dimensios [mm] (Tolerance limits: ±1,5%) und camber (CB) [%]
AlN	0,38 ±0,05	114x114 CB 0,6
	0,5 ±0,05 oder ±0,03	114x114 CB 0,3
	0,63 ±0,06	110x127 CB 0,3 / 140x150 CB 0,3
	1,0 ±0,10	114x114 CB 0,3 / 127x178 CB 0,6
	1,5 ±0,035	114x114 CB 0,3
	2,0 ±0,05	113,5x113,5 / 140x150 CB 0,3

Additional the supplier indicates an edge camber of ≤0,15 mm in an area of 4 mm from the edge. A consistent quality of the substrate is guaranteed by subducting this area.

Typically, AlN ceramics with substrate thicknesses ≤ 1.5 mm are produced by tape casting.
Other substrate thicknesses can be produced by uniaxial dry pressing and cold isostatic pressing.
After sintering in both cases, the "as fired" surface is brushed and cleaned or reworked by lapping / grinding / polishing to obtain flat surfaces with individual substrate thickness and less thickness variation (up to ± 0.0127 mm).

diversity of materials and applications
T +49 (0) 36601 9327-54 | F +49 (0) 36601 9327-71 | vertrieb@lcpgmbh.de | www.lcpgmbh.de
LCP LASER CUT PROCESSING

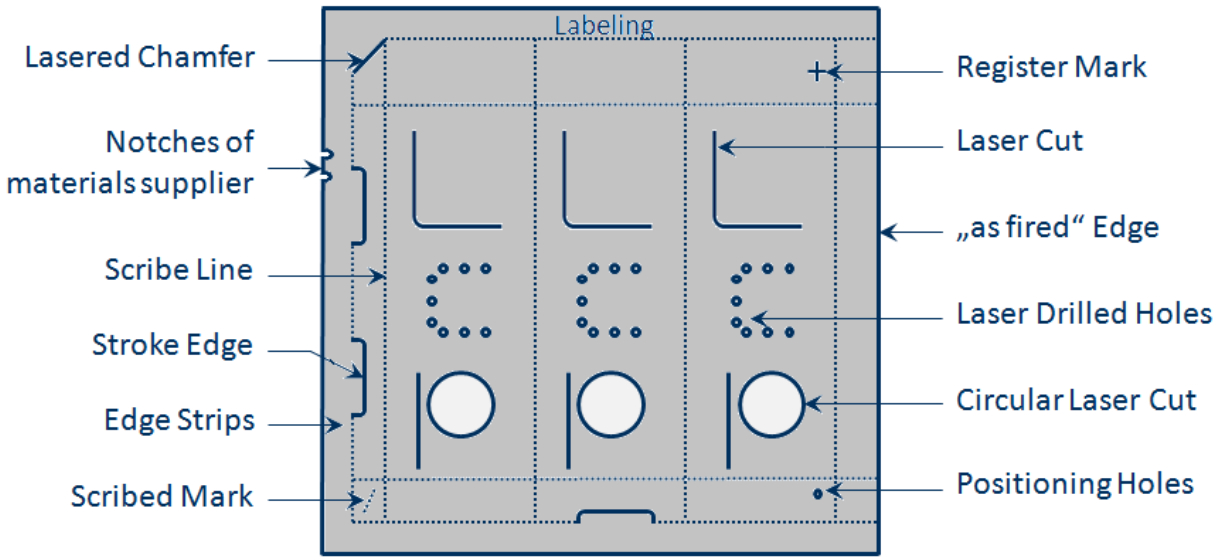
Design Guideline Ceramic AL_2O_3- and ALN-applications

2. Laser Processing (Scribing, Drilling, Cutting, Ablation)

Below you will find an overview of the design guidelines, quality standards and test methods used in the processing of Al2O3 benefit substrates or in the processing of aluminum nitride.

In addition to our standard raw substrates, we also process Al_2O_3 ceramics with thicknesses between 0.09 and 3.0 mm and aluminum nitride with thicknesses between 0.25 and 4.0 mm and maximum dimensions of 350x350 mm². By default, CO_2 laser sources are used, whereby various solid-state laser sources, especially for AlN ceramics, are used. The laser processing is independent of the shaping process of the substrates.

The following illustration shows an overview to the different possibilities of laser processing in thick-film alumina substrates. Moreover the layout can be aligned with camera systems by using the edges of the blank material, register/ print marks or similar objects. More information to the particular laser technologies are given hereafter.*



* no standard

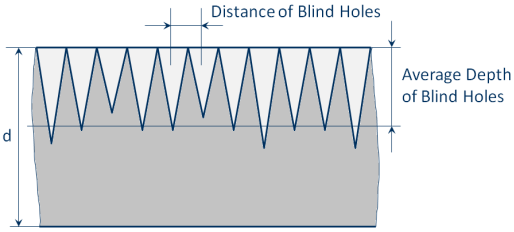
diversity of materials and applications
T +49 (0) 36601 9327-54 | F +49 (0) 36601 9327-71 | vertrieb@lcpgmbh.de | www.lcpgmbh.de
LCP LASER CUT PROCESSING

Design Guideline Ceramic AL_2O_3- and ALN-applications

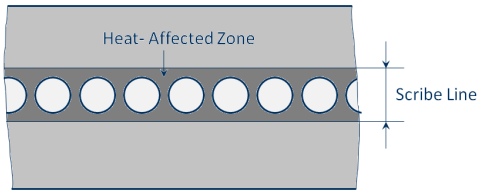
Laser Scribing

Among other things the LCP Laser-Cut-Processing GmbH offers the laser scribing in ceramics. With this process closely in a row positioned blind holes were generated in the surface of the material to originate a perforation line which is used as predetermined breaking point by separating the ceramic parts. The depth and distance of the blind holes are also realizable by the customer's specification.*

Scribe line - cross section



Scribe line – top view



a. Position accuracy of scribe lines (unseparated condition)

Nominal dimension ±0,050 mm (±0,015 mm*)

The tolerance is valid for the distance between scribe lines among one another as well as the distance between scribe lines and scribed external contours (unseparated condition) in case of generating them in the same process. If external contours are already present, the position accuracy refers to the declared attachment points or position marks.

b. Distance between scribe lines

To separate scribed contours neat it is recommended to have a distance of three to five times of the substrate thickness between the scribe lines among each other and between first scribe line and external contour. The edge between the customer's component and the external contour is usually removed by the LCP Laser-Cut-Processing GmbH. The behavior during separating along the scribe lines is affected by the substrates quality and the chosen parameters for depth and distance of the blind holes.

* no standard

diversity of materials and applications
T +49 (0) 36601 9327-54 | F +49 (0) 36601 9327-71 | vertrieb@lcpgmbh.de | www.lcpgmbh.de
LCP LASER CUT PROCESSING

Design Guideline Ceramic AL_2O_3- and ALN-applications

c. Tolerances of length/ width between scribed external contours depending on substrate thickness (separated condition)

Substrate thickness d [mm]	Tolerance limits [mm]	
≤ 0,63	- 0,050	0,150
≤ 1,00	- 0,050	0,200
≤ 1,50	- 0,050	0,350
≤ 2,00	- 0,050	0,500

d. Distance and depth of blind holes depending on substrate thickness (from break edge to break edge)

	Substrate thickness d [mm]	distance [mm]	depth [mm]
96% Al_2O_3	0,25	0,140 ± 0,020	0,140 ± 0,040
	0,38	0,140 ± 0,020	0,170 ± 0,050
	0,50	0,150 ± 0,020	0,200 ± 0,050
	0,63	0,150 ± 0,020	0,250 ± 0,050
	0,76	0,150 ± 0,020	0,300 ± 0,050
	1,00	0,160 ± 0,020	0,400 ± 0,050
	1,27	0,180 ± 0,020	0,500 ± 0,050
99% Al_2O_3	0,25 - 1,00	0,100 ± 0,020	(see 96% AL_2O_3)
AlN	0,38	0,150 ± 0,020	0,150 ± 0,050
	0,50	0,150 ± 0,020	0,180 ± 0,050
	0,63 (CO_2)	0,150 ± 0,020	0,180 ± 0,050
	0,63 (FKL)	0,120 ± 0,020	0,25 +0,2 - 0
	1,00	0,120 ± 0,020	0,40 + 0,2 - 0
	1,50	0,140 ± 0,020	0,60 + 0,2/-0,15
	2,00	0,160 ± 0,020	0,80 + 0,2/-0,15
	2,50	0,160 ± 0,020	1,000 ± 0,20
	3,00	0,160 ± 0,020	1,300 ± 0,20

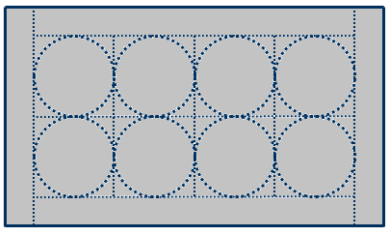
diversity of materials and applications
T +49 (0) 36601 9327-54 | F +49 (0) 36601 9327-71 | vertrieb@lcpgmbh.de | www.lcpgmbh.de
LCP LASER CUT PROCESSING

Design Guideline Ceramic AL_2O_3- and ALN-applications

The tolerances are valid for at least 90% of the blind holes. The named distance is an average value of not less than 10 blind holes. Other specifications according to the blind holes of scribe lines are realizable, too.

Circles and interrupted scribe lines

In addition to straight and continuous scribe lines it is also possible to generate circular forms and interrupt scribe lines precisely.



Laser Drilling and Cutting

The drilling and cutting process is a combination of laser beam fusion and sublimation cutting where a high percentage of vaporization is strived. Nevertheless the resulting molten mass is cast out by the laser beam accompanied process gas at the same time.

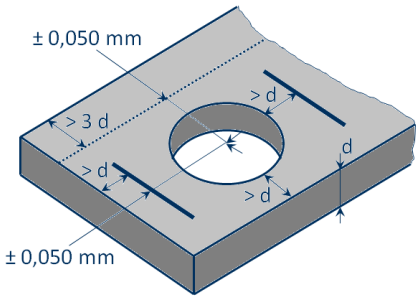
Laser drilling is a typical process to produce vias for bonding the front and back of the substrate whereas laser cutting is applied to produce stroke edges, low toleranced dimensions and edges for future mechanical applications.

The standard width of the cutting kerf is 0,100 mm but this could be customized within a small range on dependence of the substrate thickness.

a. Contour distance and web width

Both issues depend on the thickness of the material.

The web width between contours within the same component should be greater than the thickness of the utilized material.



Position accuracy:
nominal dimension ±0,050 mm (±0.025 mm*).

The tolerance is valid for the distance between drilled holes among one another as well as the distance between drilled holes and scribe lines/ cutting edges in case of generating them in the same process. If external contours are already present, the position accuracy refers to the declared attachment points or position marks.

* no standard

diversity of materials and applications
T +49 (0) 36601 9327-54 | F +49 (0) 36601 9327-71 | vertrieb@lcpgmbh.de | www.lcpgmbh.de
LCP LASER CUT PROCESSING

Design Guideline Ceramic AL_2O_3- and ALN-applications

b. Diameter of the drilled holes

Nominal dimension ±0,050 mm (±0.025 mm*)

The inspection of the diameter takes place on the materials outlet side of the laser beam where the smallest diameter of the hole is detectable.
For example the smallest diameter of a drilled hole is assumed to be 0,100 mm (0,075 mm*) in a 0,630 mm thick substrate.

c. Form tolerance FT und conicity of drilled holes

FT = < 0,05 d + 0,01

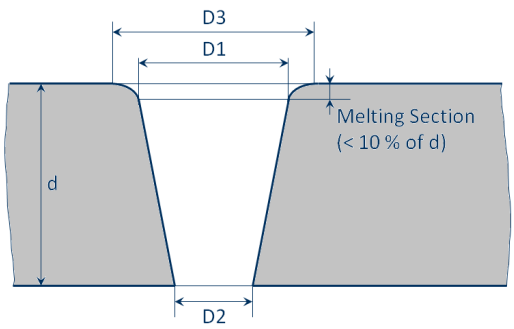
The measurement of the form tolerance on the materials outlet side of the laser beam is based on the principle of the index circle of Gauss.

Substrate thickness d [mm]	Form tolerance
≤ 0,25	≤ 0.03
≤ 0,38	≤ 0.04
≤ 0,50	≤ 0.04
≤ 0,63	≤ 0.05
≤ 0,76	≤ 0.06
≤ 1,02	≤ 0.07
≤ 1,27	≤ 0.08

The tapering of holes (conicity) between the materials inlet side D1 and outlet side D2 of the laser beam is lower than 7% of the substrate thickness d.

D1 – D2 ≤ 7% of d

D3 – D1 = melting section



The caustic of the laser beam is one reason for the leaning of the cutting edge. Normally the single-edge leaning is smaller than 3,5% of the substrate thickness.

* no standard

diversity of materials and applications
T +49 (0) 36601 9327-54 | F +49 (0) 36601 9327-71 | vertrieb@lcpgmbh.de | www.lcpgmbh.de
LCP LASER CUT PROCESSING

Design Guideline Ceramic AL_2O_3- and ALN-applications

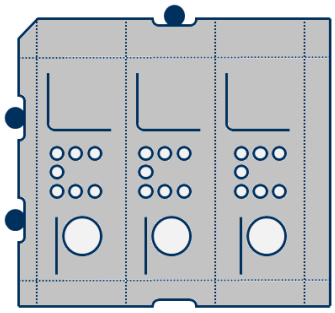
d. Radien in corners

R ≥ ½ of substrate thickness (R ≥ 0,050 mm*)

Because of the hazard of micro cracks it is necessary to avoid small radii in corners. It is recommended that the radius is greater than the half of the substrate thickness.

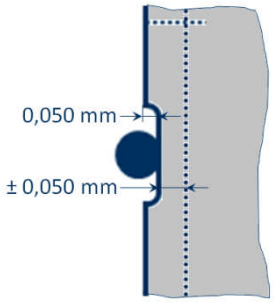
e. Stroke edges or cut external edges for precise positioning

It is possible to generate cuts along scribe lines that function as stroke edges. This brings the advantage of positioning more precisely and also a lower risk of spalling in the later printing process.



Furthermore it is possible to generate stroke edges directly in the external edges of the substrate.

If the external edge of a raw substrate is used for the customer's component we recommend a cut extension of about 0,5 mm related to external edge. Generating a stroke edge in scribed external contours is also possible by locating the laser cut within the scribe line.



It is typical to generate 3 to 4 laser cuts with a length of 10 to 20 mm.

* no standard

diversity of materials and applications
T +49 (0) 36601 9327-54 | F +49 (0) 36601 9327-71 | vertrieb@lcpgmbh.de | www.lcpgmbh.de
LCP LASER CUT PROCESSING

Design Guideline Ceramic AL_2O_3- and ALN-applications

Laser Patterning (Ablation)

By laser patterning or labeling letter as well as complex structures in form of depressions are realizable in different materials with a high (repeating) accuracy. Often this process is applied for labeling and for patterning coated and metalized components.

a. Position accuracy — nominal dimension ±0,100 mm (±0,050 mm*)
Within machining area of 100 x 100 mm²

By previous measuring* of components and structures a higher position accuracy is obtainable and if needed an aligned double-sided processing is also possible.

b. General tolerances — nominal dimension ±0,050 mm

c. Edge leaning — ≤ 10° (depends on material)

d. Depth of ablation — nominal dimension ±0,050 mm (±0,025 mm*)

e. Contour fidelity — better than 0,020 mm

* no standard

diversity of materials and applications
T +49 (0) 36601 9327-54 | F +49 (0) 36601 9327-71 | vertrieb@lcpgmbh.de | www.lcpgmbh.de
LCP LASER CUT PROCESSING

3. Dicing

Besides the diverse possibilities of laser processing the LCP Laser-Cut-Processing GmbH also offers severing alumina substrates by wafer dicing as well as a combined processing.

With the integrated optical kerf control and automatic controlling of the blade abrasion we can achieve high edge quality.

a.	typical blade thickness	0,100 - 0,400 mm (others possible on request*)
b.	typical cutting depth	up to 3,0 mm (deeper possible on request*)
c.	position accuracy	0,003 mm in y- axis 0,001 mm in z- axis
d.	measuring accuracy	0,0013 mm
e.	wafer sizes	up to Ø 203 mm (8“) (max. 250 x 250 mm² without processing frame*)
f.	refrigerant	piped water

* no standard

diversity of materials and applications
T +49 (0) 36601 9327-54 | F +49 (0) 36601 9327-71 | vertrieb@lcpgmbh.de | www.lcpgmbh.de
LCP LASER CUT PROCESSING

4. Finishing Process

96% Al_2O_3-ceramic

a. Removing edge strips and separate substrate

By removing the edge strips manually along the generated scribe lines the customer's component is fabricated. Upon customer request also the separation of the substrates can take place.

b. Brushing and washing

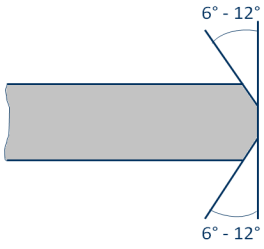
While processing ceramics with laser radiation unavoidable burrs of glazed ceramic occurs in the environment of the processed lines.

These burrs on the materials inlet side of the laser beam are minimized to a height of less than 0,010 mm typically by mechanical deburring and brushing. The glazed ceramic on the other side of the substrate is also deburred manually/ mechanically. At the end a washing process takes place to remove loose particles from the substrate's surface. The whole process has no influence on the specific roughness given by the blank ceramic manufactures.

c. Facetting (edge grinding)*

Another finishing process offered by the LCP Laser-Cut-Processing GmbH is the edge grinding of straight scribed external contours. This is a suitable method to lower the risk of spallings by working with strokes in following processes.

By facetting the external contour of the substrate material from both sides of the edge is removed in an angle of 6° to 12°. This remains a relative straight stroke edge as shown exemplary in the picture below.



(not drawn to scale)

d. Surface protection (Scribing Solution)*

In a limited scale it is also possible to use a special polymer as surface protection which is applied before the laser processing. Especially for already printed substrates this method can be beneficial.

99% Al_2O_3-ceramic

By default, thin-film substrates do not require post-processing to maintain surface finish.

* no standard

diversity of materials and applications
T +49 (0) 36601 9327-54 | F +49 (0) 36601 9327-71 | vertrieb@lcpgmbh.de | www.lcpgmbh.de
LCP LASER CUT PROCESSING

Design Guideline Ceramic AL_2O_3- and ALN-applications

AlN-ceramic

a. Removing edge strips

By removing the edge strips manually along the generated scribe lines the customer's component is fabricated.

b. Brushing and washing

While processing ceramics with laser radiation unavoidable burrs of glazed ceramic occurs in the environment of the processed lines. as well as in the edge areas around the laser contours in the form of splashes of material.

As standard, the ceramic substrates on the laser entrance side are aftertreated by mechanical deburring and brushing. In connection with the possible subsequent chemical cleaning, the throw-off in the range <0.05 mm around the contour is minimized down to a height of less than 0.025 mm.

c. Chemical cleaning (acidic / basic)

Since in the laser processing of aluminum nitride takes place partly a reduction process of the material, is formed in the metallic aluminum and deposited on the cutting edge, then offers a dry cleaning of the components*. Depending on the specification, the burning skin of the AlN can be preserved (acidic environment) or destroyed (alkaline environment). The chemical cleaning can cause dimensional changes in the contour and surface texture.

d. Vibratory grinding

About the selection of suitable grinding (Compound-water mixture or dry granules) and a variety of machine parameters, this machining process, the best ways different workpieces and materials for deburring and cleaning.

e. Radiate

Another option for deburring and cleaning of aluminum nitride ceramics is the glass bead blasting are available. Here, the workpiece surface is bombarded by compressed air with the smallest solids of different materials and different sizes.

* no standard

diversity of materials and applications
T +49 (0) 36601 9327-54 | F +49 (0) 36601 9327-71 | vertrieb@lcpgmbh.de | www.lcpgmbh.de
LCP LASER CUT PROCESSING

5. Quality assurance

The LCP Laser-Cut-Processing GmbH has a quality management certified according to ISO 9001. We have a integrated management system in combination ISO9001 and ISO14001.

The current valid certificates can be downloaded at **www.lcpgmbh.de/en**.

Initial sample test reports EMPB/PPAP (acc. VDA Band 2)* especially for automotive components can be issued.

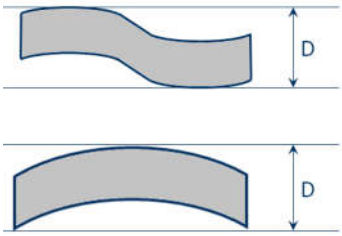
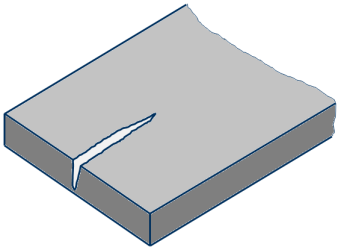
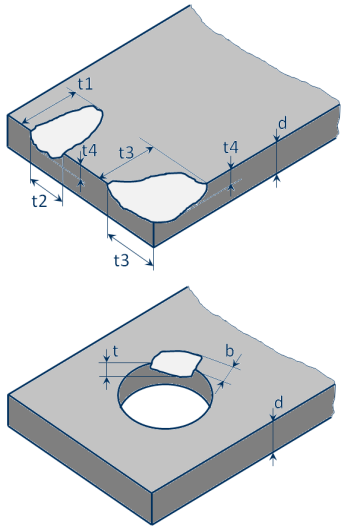
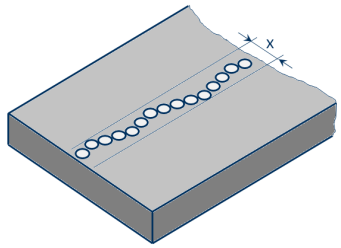
Defaults:

1. Inspection acc. Att.
2. Incoming inspection acc. Checking plan
3. Visual and dimension Inspection during production
4. Capability (cpk value)
5. Final inspection acc. Checking plan

The standard requirements for quality control apply if the customer has no special requirements.

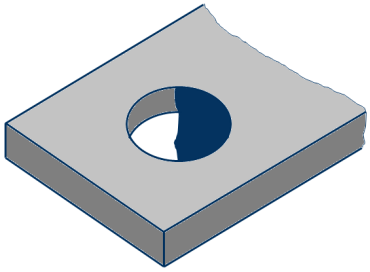
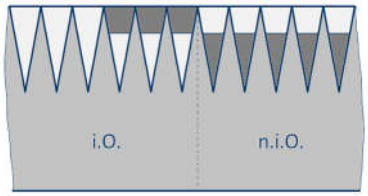
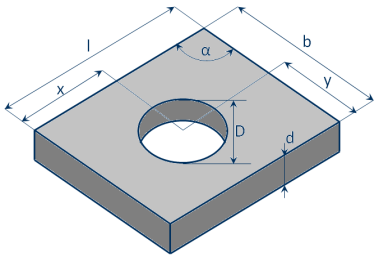
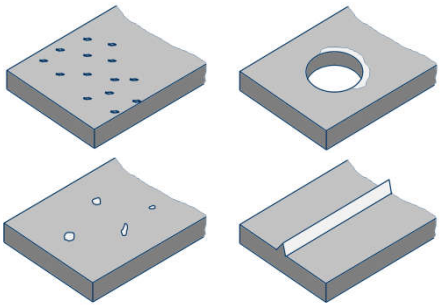
* no standard

Design Guideline Ceramic AL_2O_3- and ALN-applications

Characteristic	Failure criterion	Test method
Camber 	D > permitted difference according to longest outside dimension of the substrate	Visual Unaided eye Contol gauge as perDIN 41850 T1 Computer-enhanced optical measurement equipment / optical surface measuring system
Cracks 	Visible crack	Microscope (at least magnification of 16x + low angle light Dye penetrant
Spallings 	Edge t1 > 0,150 mm t2 > 0,500 mm t4 > 0,5 x d Corner t3 > 0,500 mm t4 > 0,5 x d Drilled hole t > 0,1 x d b > 0,150 mm	Visual Microscope (at least magnification of 16x + low angle light Computer-enhanced optical measurement equipment
Track Width, Line Deviation 	X > 0,200 mm	Visual Microscope (at least magnification of 16x + low angle light Computer-enhanced optical measurement equipment

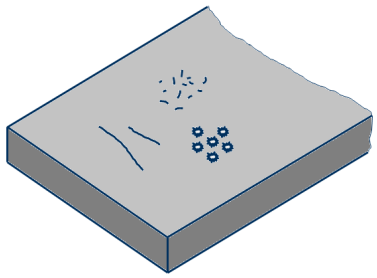
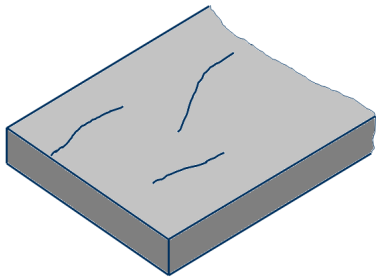
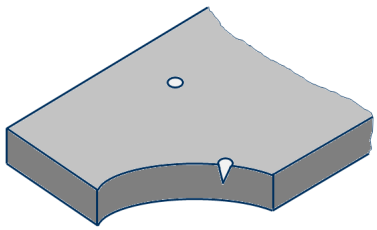
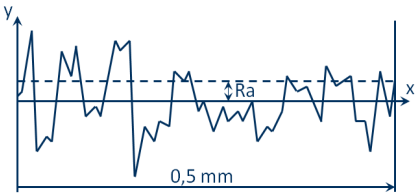
diversity of materials and applications
T +49 (0) 36601 9327-54 | F +49 (0) 36601 9327-71 | vertrieb@lcpgmbh.de | www.lcpgmbh.de
LCP LASER CUT PROCESSING

Design Guideline Ceramic AL_2O_3- and ALN-applications

Characteristic	Failure criterion	Test method
Blocked Drilled Holes 	Adhered glazed ceramic Loose particles	Microscope (at least magnification of 16x + low angle light or Measuring projector
Glazed Scribe Lines 	> 50% per hole	Visual Computer-enhanced optical measurement equipment
Dimensions 	Outside drawing tolerances	Computer-enhanced optical measurement equipment or Caliper gauge
Burrs, Glazed Ceramic, Bumbs, Fins, Ridges,… 	Height > 0,015 mm	Microscope (at least magnification of 16x + low angle light Computer-enhanced optical measurement equipment / optical surface measuring system

diversity of materials and applications
T +49 (0) 36601 9327-54 | F +49 (0) 36601 9327-71 | vertrieb@lcpgmbh.de | www.lcpgmbh.de
LCP LASER CUT PROCESSING

Design Guideline Ceramic AL_2O_3- and ALN-applications

Contaminations 	Visible discoloration Adhesion of particles	Visual Unaides eye
Scratches 	Depth > 0,02 mm	Microscope (at least magnification of 16x + low angle light Optical surface measuring system
Open Pores 	Ø > 0,2 mm	Microscope (at least magnification of 16x + low angle light Computer-enhanced optical measurement equipment
Mean Roughness Ra 	Ra < 0,2 µm Ra > 0,8 µm	surface roughness measurement equipment

diversity of materials and applications
T +49 (0) 36601 9327-54 | F +49 (0) 36601 9327-71 | vertrieb@lcpgmbh.de | www.lcpgmbh.de
LCP LASER CUT PROCESSING