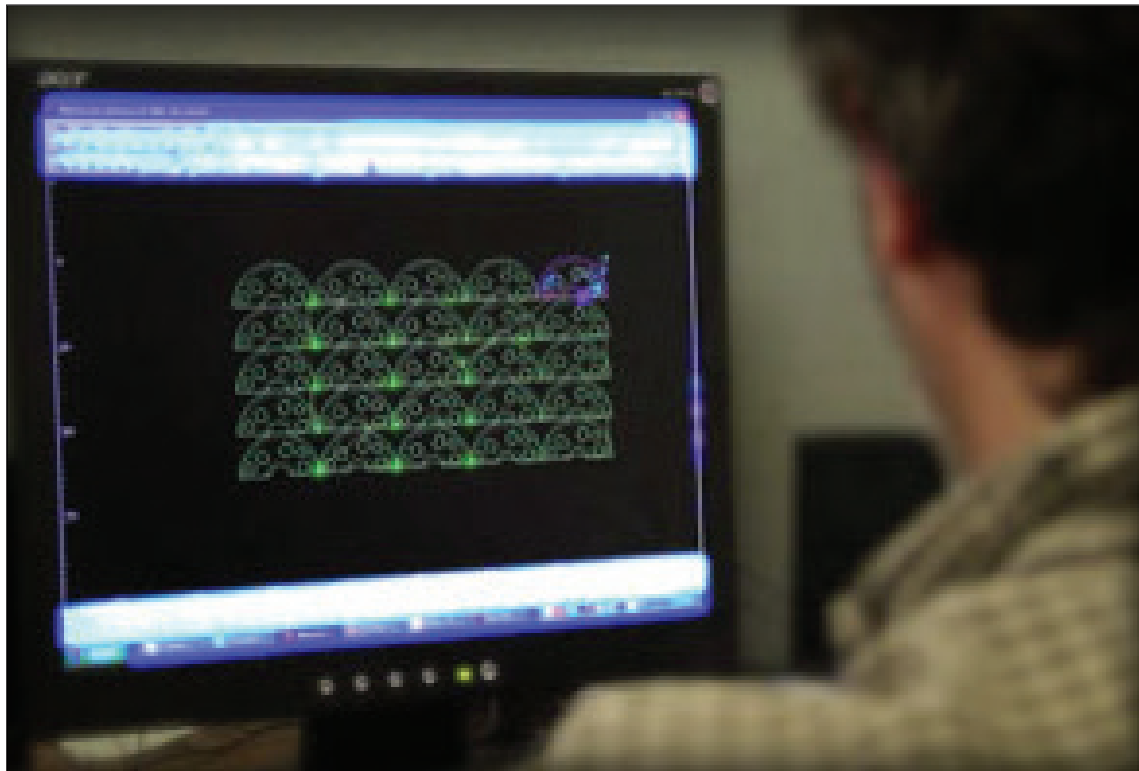
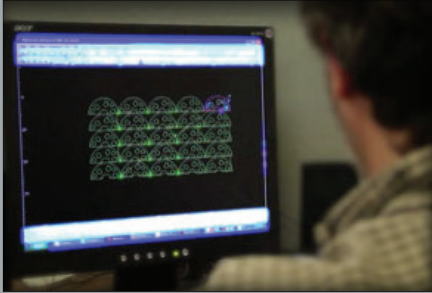


DESIGN GUIDELINE OPTIMAL TOLERANCES AND LAYOUTS FOR LASER PROCESSING CERAMIC SUBSTRATES

How to Properly Orient Ceramic Substrate Cutting and Drilling Layouts in CAD





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Efficient layouts produce optimal yields

Use the tolerances and specifications listed below as general engineering guidelines. But please note: we have the capability to yield significantly tighter tolerances based upon your requirements and/or the demands of specific applications. Our coordinate measuring system has resolution capability to within 1 micron repeatability and to within 6 microns X-Y linear accuracy. Unless otherwise noted on your specifications, our standard tolerances (shown below) will be applied.

Minimum distance between laser machined features or singulated edges:

Greater than or equal to ceramic thickness when measured from the most narrow distance between features.

Average scribe depth and laser pulse spacing: per table below

Substrate Thickness	Ref. Pulse Depth, External Scribe	Avg. Pulse Depth, Internal Scribe	Avg. Pulse Spacing, Internal Scribe
0.010"	40-70%	35-65%	0.003-0.005"
0.015"	40-65%	35-65%	0.004-0.006"
0.020"	40-65%	35-65%	0.004-0.006"
0.025"	45-65%	35-65%	0.005-0.007"
0.030"	45-65%	40-65%	0.005-0.007"
0.040"	45-70%	45-70%	0.006-0.008"
> 0.040"	50-70%	50-70%	0.006-0.008"

Internal machined or scribed feature to internal feature: tolerance $\pm 0.001"$, non-cumulative.

Overall length and width tolerance for cut edges: $\pm 0.002"$

Length and width tolerance for singulated edges: per table below

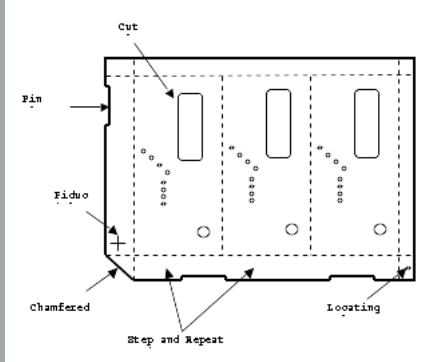
Substrate Thickness	Tolerance
< 0.016"	+0.003/-0.002"
0.017-0.030	+0.004/-0.003"
0.031-0.040"	+0.005/-0.003"
0.041-0.060"	+0.006/-0.004"
< 0.016"	+0.007/-0.005"

Accumet Design Guideline:

Optimal Tolerances and Layouts for Laser Processing Ceramic Substrates

Figure 1. Lasered ceramic substrate:

(a) Typical view



(b) Singulated edge and feature tolerance

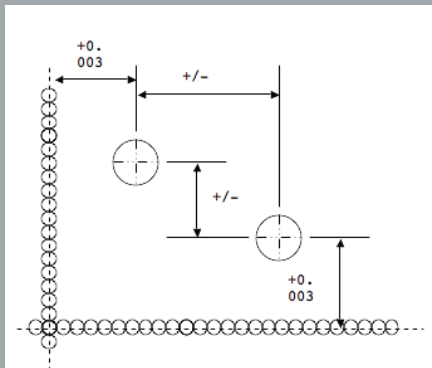
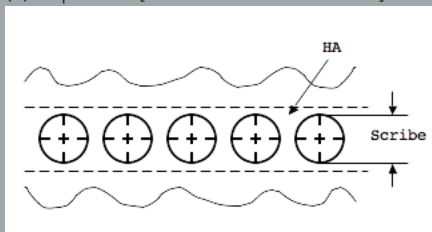
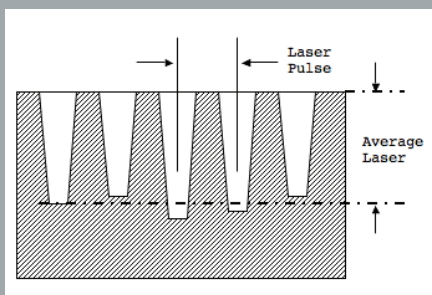


Figure 2. Typical laser scribed line:

(a) Top View ["A" Face of Substrate]



(b) Cross Section



Singulated edge to internal feature: tolerance $+0.003/-0.002$ " (Figure 1)

Hole diameter: ± 0.002 " for Exit Diameter (Figure 3)

Hole taper: tolerance 10% of substrate thickness, 0.005" maximum (Figure 3)

As-fired edge to internal feature, mechanically aligned: tolerance ± 0.010 "

As-fired edge to internal feature, optically aligned: tolerance ± 0.005 "

Optically determined feature to internal feature, optically aligned: tolerance ± 0.002 "

Slag height: 0.001" maximum above ceramic surface when measured with a micrometer.

Thickness, non-lapped: $\pm 10\%$ of standard manufacturer's thicknesses.

Thickness, lapped: per lapping purchase order specifications.

Surface finish, non-polished: per table below

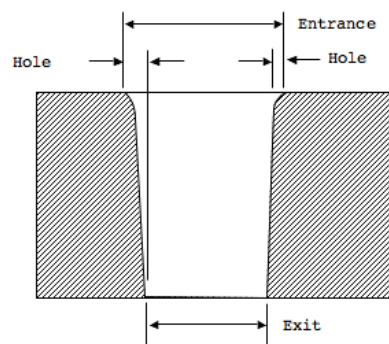
Substrate Type	Finish
96% Alumina	15-35 microinches
99.6% Alumina	3-5 microinches
Aluminum Nitride, Thick Film	15-35 microinches

Surface finish, polished: per polishing purchase order specifications.

Camber, as fired: per table below

Substrate Thickness	Camber
≤ 0.010 "	$+0.004$ "/inch
0.011-0.030"	$+0.003$ "/inch
0.031-0.040"	$+0.002$ "/inch
> 0.041 "	$+0.003$ "/inch

Figure 3. Typical laser drilled features (cross section)



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