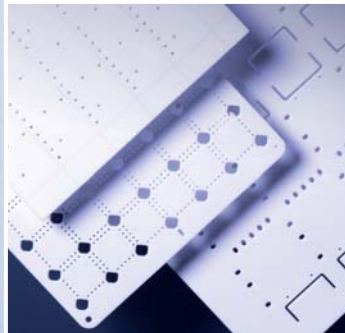
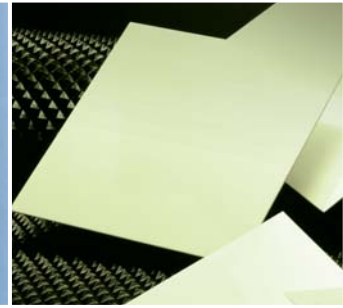


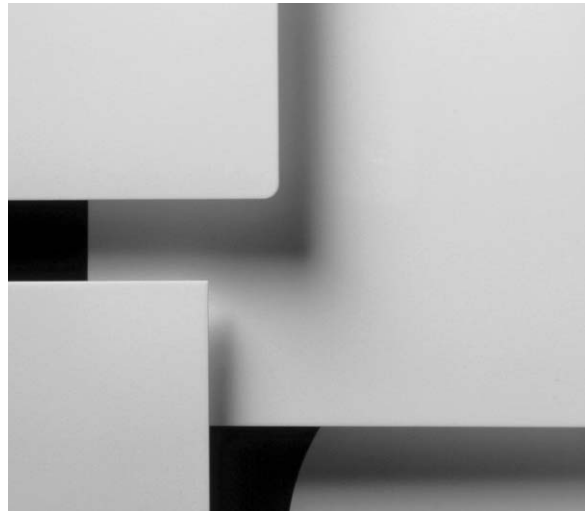
**COORSTEK**  
*Amazing Solutions.®*



**THIN-FILM** CERAMIC  
**SUBSTRATES** DESIGN GUIDE

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*CoorsTek manufactures critical components and complete assemblies for semiconductor, automotive, electronics, medical, telecommunications, military, and other industrial applications. Using advanced technical ceramics and high-performance plastics, our solutions enable customers' products to overcome technological barriers and improve performance, especially in demanding or severe service environments.*

*CoorsTek has a highly qualified staff to assist with material selection and product design. Please contact us today at 303-277-4802 for more information.*

*For general information about CoorsTek, please visit our website at [www.coorstek.com](http://www.coorstek.com).*

# I. Scope and Intent

Alumina, an ideal material for thin-film ceramic substrates, offers a smooth surface finish, high flexural strength, and controlled electrical properties. CoorsTek offers three alumina substrate materials: Superstrate® 996, ADS-996, and ADS-995. These products cover a range of grain sizes and surface finishes. Superstrate® 996, an extremely fine-grained material with superior surface finish characteristics, remains the industry standard.

This technical specification is designed to provide engineers with design guidelines, material property information, inspection methods, and quality standards for CoorsTek thin-film alumina substrates. These guidelines will aid in optimizing substrate design and material selection in order to meet your technical requirements cost effectively.

**NOTE: This document is provided as a general guide for MOST thin-film substrate applications. If your design exceeds defined limits or requires special properties, our substrate specialists may be able to accommodate your requirements. Please contact your CoorsTek Sales Representative or call 303-277-4802 for more information.**

# II. Design Guidelines

The following design standards represent factors that should be considered to ensure optimal substrate design and material selection. Material samples are available on request so that the design or process engineer can determine, by proof test, the product specifications best suited for the process requirements.

## A. Materials

Fine-line resolution, spacing, and process yields are directly influenced by surface finish (reference Table I, below), grain size (reference Figure 2, below), and surface imperfections (reference Table V, page 6). For optimum fine-line definition, Superstrate® 996 and ADS-996 are the preferred material choices. Our ADS-995 is an economical alternative for less demanding applications.

Polished Superstrate® 996 is available in standard sizes from 1.0" to 4.5" (25.4 mm to 114.3 mm) squares. While polished Superstrate® 996 is the industry standard, a full range of CoorsTek substrate materials are available in as-fired resistor, as-fired conductor, lapped, and polished finishes. (Note: Please see section VII, page 13, for High Dielectric and Specialty Materials)

Table I - Typical Surface Finish Centerline Average (CLA)*			
Material	"A" Side	"B" Side	Polished
Superstrate® 996	2 μin (50 nm)	3 μin (76 nm)	1 μin (25 nm)
ADS-996	3 μin (76 nm)	4 μin (101 nm)	1 μin (25 nm)
ADS-995	5 μin (127 nm)	7 μin (178 nm)	2 μin (50 nm)

\* See p.11, Inspection Methods section B for details on Surface Finish measurements.

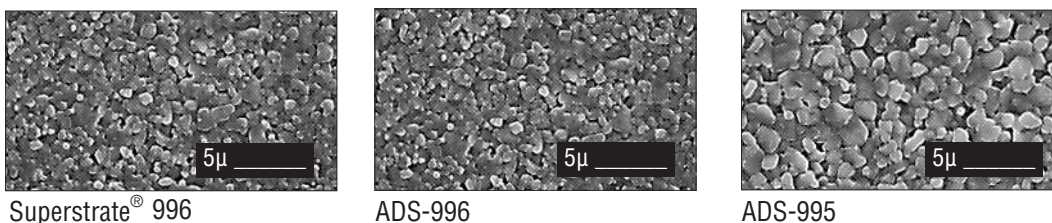


Fig. 2. Scanning Electron Photomicrographs of "A" side (2,000x and 0° tilt).

## B. Standard Thickness and Common Sizes

CoorsTek offers a wide range of sizes and thicknesses. The table below represents our standard sizes and common thickness. If your requirements are outside those listed below, we can customize our products to meet your needs.

Table II - Standard Thicknesses and Common Sizes			
As-Fired	Polished	Common Sizes	Material
0.005" (0.127 mm)	0.005" (0.127 mm)	1"x 1" (25.4 mm x 25.4 mm) 2"x 2" (50.8 mm x 50.8 mm) 2.25"x 2.25" (57.15 mm x 57.15 mm) 2.5"x 2.5" (63.5 mm x 63.5 mm) 3"x 3" (76.2 mm x 76.2 mm)	Superstrate® 996 ADS-996
0.010" (0.254 mm) 0.015" (0.381 mm) 0.020" (0.508 mm) 0.025" (0.635 mm) 0.040" (1.016 mm)	0.010" (0.254 mm) 0.015" (0.381 mm) 0.025" (0.635 mm) 0.030" (0.762 mm)	1"x 1" (25.4 mm x 25.4 mm) 2"x 2" (50.8 mm x 50.8 mm) 2.25"x 2.25" (57.15 mm x 57.15 mm) 2.5"x 2.5" (63.5 mm x 63.5 mm) 3"x 3" (76.2 mm x 76.2 mm) 4.5"x 3.75" (114.3mm x 92.25 mm) 4"x 4" (101.6 mm x 101.6 mm) 4.5"x 4.5" (114.3 mm x 114.3 mm)	Superstrate® 996 ADS-996 ADS-995
0.060" (1.524 mm)	0.035" (0.889 mm) 0.040" (1.016 mm)	1"x 1" (25.4 mm x 25.4 mm) 2"x 2" (50.8 mm x 50.8 mm) 2.25"x 2.25" (57.15 mm x 57.15 mm) 2.5"x 2.5" (63.5 mm x 63.5 mm) 3"x 3" (76.2 mm x 76.2 mm) 4.5"x 3.75" (114.3mm x 92.25 mm) 4"x 4" (101.6 mm x 101.6 mm) 4.5"x 4.5" (114.3 mm x 114.3 mm)	ADS-996 ADS-995

\* For complex sizes and geometries other than listed above, please contact your Coorstek sales representative.

## C. Dimensional Criteria

Our standard length and width tolerance is  $\pm 1\%$ , while standard thickness tolerance is  $\pm 10\%$ . Please see below for a list of our premium tolerances and camber.

Table III - Standard Thicknesses and Tolerances			
Thickness	Thickness Tolerance		
	Standard As-Fired	Premium As-Fired	Polished
0.005" (1.27 mm)	$\pm 0.0005"$ (0.0127 mm)	$\pm 0.0005"$ (0.0127 mm)	$\pm 0.0005"$ (0.0127 mm)
0.010" (0.254 mm)	$\pm 0.001"$ (0.0254 mm)	$\pm 0.0005"$ (0.0127 mm)	$\pm 0.0005"$ (0.0127 mm)
0.015" (0.381 mm)	$\pm 0.0015"$ (0.0381 mm)	$\pm 0.00075"$ (0.01905 mm)	$\pm 0.0005"$ (0.0127 mm)
0.020" (0.508 mm)	$\pm 0.002"$ (0.0508 mm)	$\pm 0.001"$ (0.0254 mm)	$\pm 0.0005"$ (0.0127 mm)
0.025" (0.635 mm)	$\pm 0.0025"$ (0.0635 mm)	$\pm 0.00125"$ (0.03175 mm)	$\pm 0.0005"$ (0.0127 mm)
0.030" (0.762 mm)	$\pm 0.003"$ (0.0762 mm)	$\pm 0.0015"$ (0.0381 mm)	$\pm 0.0005"$ (0.0127 mm)
0.035" (0.889 mm)	$\pm 0.0035"$ (0.0889 mm)	$\pm 0.00175"$ (0.04445 mm)	$\pm 0.0005"$ (0.0127 mm)
0.040" (1.016 mm)	$\pm 0.004"$ (0.1016 mm)	N/A	$\pm 0.0005"$ (0.0127 mm)
0.050" (1.27 mm)	$\pm 0.005"$ (0.127 mm)	N/A	N/A
0.060" (1.52 mm)	$\pm 0.006"$ (0.1524 mm)	N/A	N/A

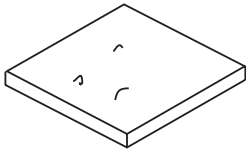
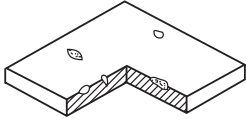
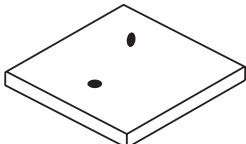
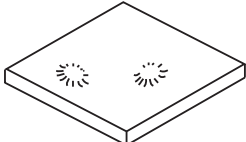
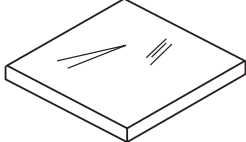
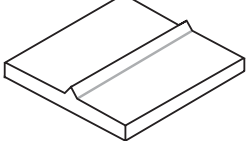
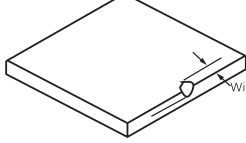
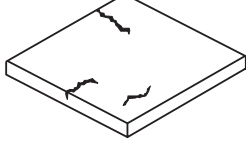
Standard tolerances for polished substrates  $\geq 4.5" \times 4.5"$  (114.3 mm x 114.3 mm) are  $\pm .0007"$  (0.01778 mm).

Table IV - Camber Tolerances			
Camber	Visual Quality Grades		
	Resistor	Conductor	Polished*
Standard	0.002"/"	0.003"/"	0.001" (0.0254 mm)
Premium	0.002"/"	0.002"/"	0.0005" (0.0127 mm)

\*Polished material measured for flatness in restrained state.  
For Substrate  $< 0.010"$  (0.254 mm), please call for camber specifications.

### D. Visual Criteria for Surface Imperfections

The CoorsTek standard visual criteria follows in Table V. Inspection applies to the “A” face only. Substrates measuring 3.5" (88.90 mm) x 3.5" (88.90 mm) or greater have a 0.25" (6.35 mm) border around the perimeter for which only chips and cracks are inspected and rejectable.

Table V - Alumina Surface Imperfections for “A” Side				
Visual Attribute		Resistor Grade (Precision Resistor, Hi-Rel, Micro-Rel)	Standard Grade (Conductor, Hybrid)	Polished
<b>Burrs</b> Fragments of excess material or foreign particle adhering to the surface		> 0.0005" (0.127 mm) high > 0.005" (0.127 mm) diameter	> 0.001" (0.0254 mm) high > 0.010" (0.254 mm) diameter	none allowed
<b>Pits, Holes, and Pocks</b> A deep depression or void		> 0.005" (0.127 mm) diameter	> 0.010" (0.254 mm) diameter	none allowed
<b>Stains, Spots Contamination</b>		none allowed	none allowed	none allowed
<b>Blisters</b> Bubbles or gaseous inclusion at the surface which, if broken, could form a pit, pock, or hole		none allowed	none allowed	none allowed
<b>Scratches</b> Relatively long, narrow, shallow groove or cut in the surface		> 0.0002" (0.00508 mm) deep x 0.25" (6.35 mm) length	> 0.0007" (0.01778 mm) deep x 0.25" (6.35 mm) length	none allowed
<b>Bumps, Fins, Ridges</b>		none allowed	none allowed	none allowed
<b>Chips</b> <i>Open</i> - Material broken off along an edge or corner <i>Closed</i> - Material has not broken off or separated		> 0.75% substrate length unlimited length X unlimited depth	> 1% substrate length unlimited length X unlimited depth	> 0.75% substrate length unlimited length X unlimited depth
<b>Cracks</b> Line of fracture without complete separation		none allowed	none allowed	none allowed

**NOTE:** The criteria in the table does not apply to substrates with surface areas greater than 20 square inches. Please specify acceptance criteria for large area substrates when requesting quotation.

Parts  $\geq 3.5" \times 3.5"$  (88.9 mm x 88.9 mm) have a 0.25" (6.35 mm) free zone or border.  
 Parts  $< 1"$  (25.4 mm) square chip specification  
 Resistor – none over 0.0075" (0.1905 mm)  
 Conductor – none over 0.010" (0.254 mm)

## E . Hard Tooled and Numerically Controlled Punched Substrates

For large volume requirements, you may want to design substrates produced with a punch (hard) tool. We can utilize our NC punch for fast turns on prototypes. Please review the following guidelines to determine if this is a solution to meet your needs, or call us at 303-277-4802 for technical assistance:

### 1. Tooled Corner Radius

Minimum 0.125" (3.175 mm) radius

### 2. Minimum Hole Diameters

<u>Substrate Thickness:</u>	<u>Minimum Hole Diameter:</u>
≤ 0.025" (0.635 mm)	0.010" (0.254 mm)
> 0.025" (0.635 mm) - 0.040" (1.016 mm)	0.020" (0.508 mm)

### 3. Hole Diameter Tolerances

<u>Hole Diameter:</u>	<u>Tolerance:</u>
0.010" (0.254 mm) - 0.029" (0.737 mm)	± 0.002" (0.051 mm)
0.030" (0.762 mm) - 0.099" (2.515 mm)	± 0.003" (0.076 mm)
0.100" (2.540 mm)	± 0.005" (0.127 mm) or ± 0.5%, whichever is greater

Tighter tolerances may be available upon request.

### 4. Hole Spacing

- Hole-to-hole distances (measured from hole center to hole center) should be a minimum of 2 times the diameter of the largest adjacent hole. The resulting wall between two holes should not be less than the thickness of the substrate.
- Hole-to-edge distance (measured from the hole center) should be a minimum of 1.5 times the hole diameter. The resulting wall should not be less than 1.5 times the thickness of the substrate.

### 5. Hole Positional Tolerances

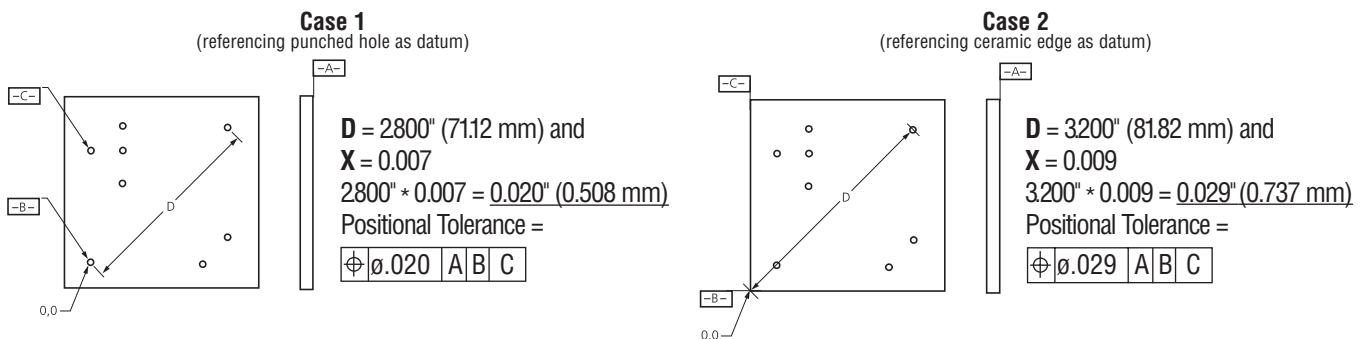
Hole positional tolerance is defined as a cylindrical tolerance zone circumscribing the theoretical true position centerline of a hole, in which the actual measured centerline will fall. The hole positional tolerance is expressed as the diameter of this cylindrical tolerance zone (Reference ANSI Y14.5M).

CoorsTek hole positional tolerancing formula is:

Hole Positional Tolerance = **D**\***X**, where:

**D** = Distance from 0,0 datum to the hole farthest from 0,0.

**X** = Empirically measured constant, determined by CoorsTek process capability studies. The **X** value is 0.007 in cases where the 0,0 datum is referenced from a punched hole, and **X** = 0.009 when referencing from a ceramic edge. Cases 1 and 2 (below) illustrate both referencing methods.



### 6. Numerically Controlled Punch Process

The NC Punch process makes precise holes in "green" ceramic tape without costly hard tooling charges. This process enables our customers to cost-effectively prototype complex substrate designs.

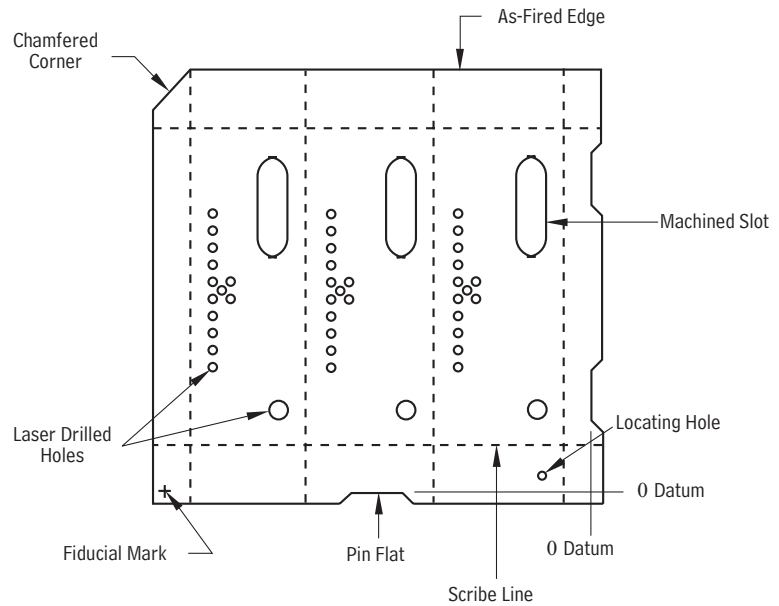
### III. Laser Services

The following are designed to provide engineers with design guidelines, inspection methods, and quality standards for laser machining/profiling, drilling, and scribing of CoorsTek thin-film alumina substrates. These guidelines will aid in optimizing lasered substrate design in order to meet your technical requirements cost effectively. Figure 3 depicts some of our laser capabilities.

If a lasered substrate design does not comply with these guidelines, we may still be able to offer options to your specific design requirements. CoorsTek will indicate exceptions to customer drawings and specifications, should they differ from these guidelines, for the purpose of offering alternatives and possible cost reduction.

We provide the following services:

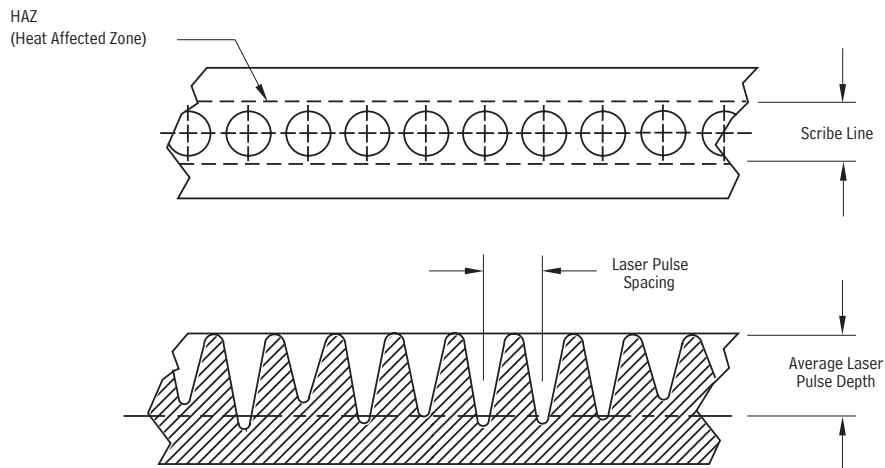
- Design Consultation
- Rapid Prototyping
- Scribing
- Machining
- Annealing



**Fig. 3. Typical Lasered Ceramic Substrate**

#### A. Laser Scribing

CoorsTek offers special differential scribing to enhance preferential singulation. By varying the laser pulse spacing and depth in the (x) and (y) scribe directions, the sequence of singulation may be controlled precisely. Enhanced laser scribing helps to prevent hooking, chipping, and premature breakage – which improves customer process yields. The following figures and tables show typical scribe line configurations and tolerances.



**Fig. 4. Typical Laser Scribed Line: (a) Top View of Laser Scribed Line; (b) Cross Section of Laser Scribed Line**

Table VI - Laser Scribed Tolerances		
Nominal Substrate Thickness	Resultant Segment From Two Broken Edges	Laser Scribed Edge to First Scribe Line
0.010" (0.254 mm)	+ 0.006" (0.152 mm) - 0.002" (0.051 mm)	+ 0.004" (0.102 mm) - 0.002" (0.051 mm)
0.015" (0.381 mm)	+ 0.006" (0.152 mm) - 0.002" (0.051 mm)	+ 0.004" (0.102 mm) - 0.002" (0.051 mm)
0.020" (0.508 mm)	+ 0.006" (0.152 mm) - 0.002" (0.051 mm)	+ 0.005" (0.127 mm) - 0.002" (0.051 mm)
0.025" (0.635 mm)	+ 0.006" (0.152 mm) - 0.002" (0.051 mm)	+ 0.005" (0.127 mm) - 0.002" (0.051 mm)
0.030" (0.762 mm)	+ 0.008" (0.203 mm) - 0.002" (0.051 mm)	+ 0.006" (0.152 mm) - 0.002" (0.051 mm)
0.035" (0.889 mm)	+ 0.008" (0.203 mm) - 0.002" (0.051 mm)	+ 0.007" (0.178 mm) - 0.002" (0.051 mm)
0.040" (1.016 mm)	+ 0.008" (0.203 mm) - 0.002" (0.051 mm)	+ 0.007" (0.178 mm) - 0.002" (0.051 mm)
0.050" (1.270 mm)	+ 0.008" (0.203 mm) - 0.002" (0.051 mm)	+ 0.007" (0.178 mm) - 0.002" (0.051 mm)
0.060" (1.524 mm)	+ 0.014" (0.356 mm) - 0.002" (0.051 mm)	+ 0.010" (0.254 mm) - 0.002" (0.051 mm)

Notes:

1. Laser machined edges to first scribe line tolerance is  $\pm 0.002"$  ( $\pm 0.051$  mm) for all substrate thicknesses.
2. Scribe line to scribe line tolerance prior to breaking is  $\pm 0.002"$  ( $\pm 0.051$  mm).
3. Perpendicularity and parallelism of scribe lines and/or scribed and broken edges will not exceed  $0.0005"/"$  (0.013mm/mm) when measured at laser pulse centers.

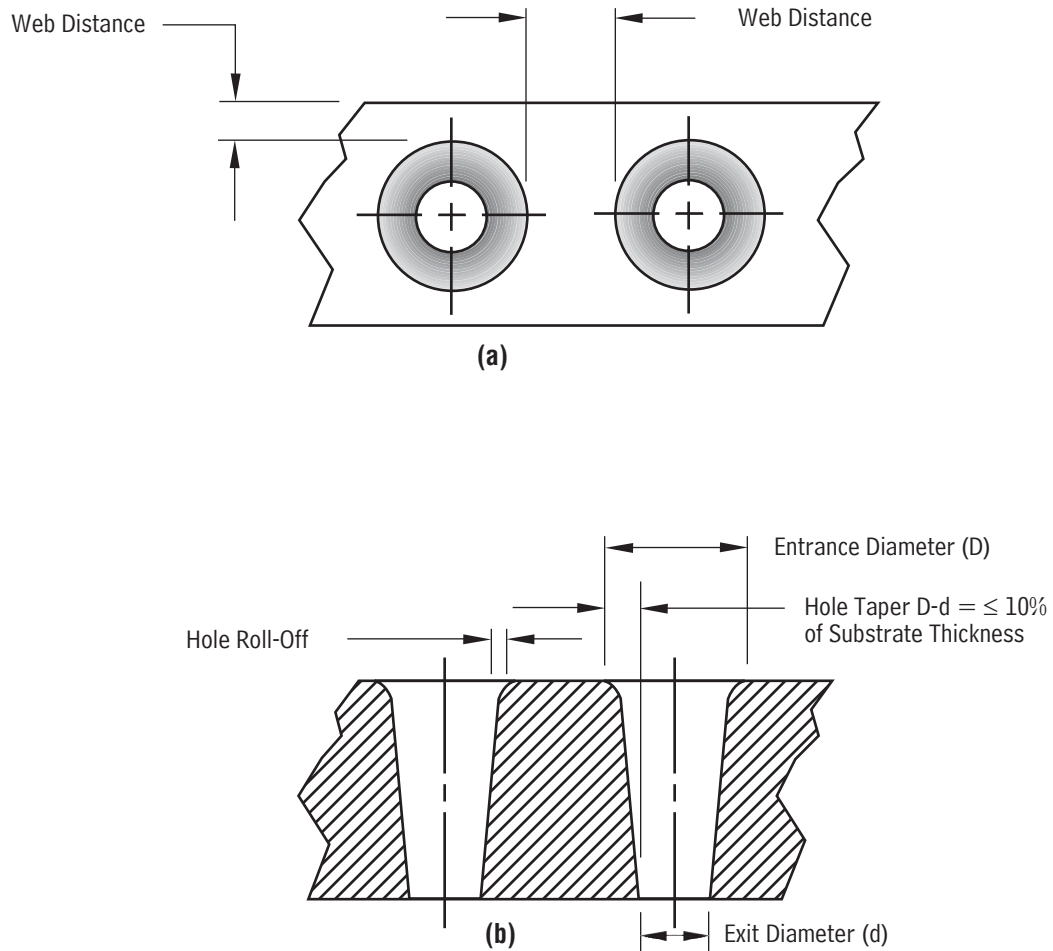
Table VII - Recommended Laser Scribed Pulse Depth And Spacing		
Nominal Substrate Thickness	Laser Pulse Depth	Laser Pulse Spacing: Centerline to Centerline
0.010" (0.254 mm)	0.004" (0.102 mm)	0.005" (0.127 mm)
0.015" (0.381 mm)	0.006" (0.152 mm)	0.006" (0.152 mm)
0.020" (0.508 mm)	0.008" (0.203 mm)	0.006" (0.152 mm)
0.025" (0.635 mm)	0.012" (0.305 mm)	0.006" (0.152 mm)
0.035" (0.889 mm)	0.015" (0.381 mm)	0.006" (0.152 mm)
0.040" (1.016 mm)	0.018" (0.457 mm)	0.006" (0.152 mm)
0.060" (1.524 mm)	0.029" (0.737 mm)	0.007" (0.178 mm)

Notes:

1. Laser pulse depth and laser pulse spacing are reference dimensions.
2. Laser pulse depth and laser pulse spacing can be adjusted to individual customer specifications.

## B. Laser Machining

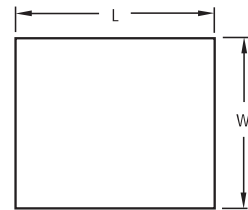
CoorsTek offers machining services for precise hole location, edge definition, and to produce custom shapes and sizes. The following figures show typical hole configurations, design guidelines, and tolerances.



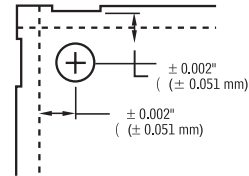
**Fig. 5. Typical Laser Drilled Holes: (a) Top View of Laser Drilled Holes; (b) Cross Section of Laser Drilled Holes**

\*Substrates  $\leq 0.015"$  (0.381 mm) will experience taper  $>10\%$ .

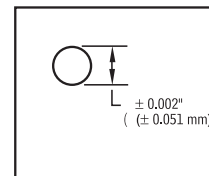
1. Length and Width
- $\pm 0.002"$  ( $\pm 0.051$  mm)



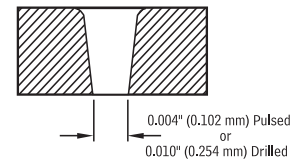
2. Hole Location
- $\pm 0.002"$  ( $\pm 0.051$  mm) from any machined area to hole centerline
  - $\pm 0.002"$  ( $\pm 0.051$  mm) from center of scribe lines to hole centerline
  - $\pm 0.001"$  ( $\pm 0.026$  mm) available upon request



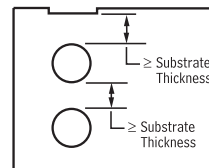
3. Hole Diameter
- $\pm 0.002"$  ( $\pm 0.051$  mm)
  - $\pm 0.001"$  ( $\pm 0.026$  mm) available upon request



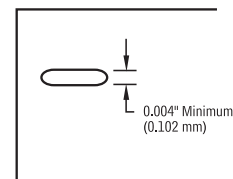
4. Minimum Hole Diameter
- pulsing 0.004" (0.102 mm)
  - drilling 0.010" (0.254 mm)



5. Minimum Web Thickness
- hole edge to another edge substrate thickness
  - between adjacent holes substrate thickness
- Note:** Thinner Materials are more forgiving in this area

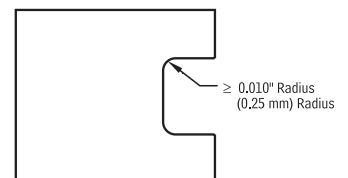


6. Cut Slot
- 0.004" (0.102 mm) minimum



7. Corner Radius
- 0.010" (0.254 mm) Radius

Note: Specify internal corner radii rather than sharp corners ( $90^\circ$ ) to avoid microcracking and chipping.



### C. Annealing

Annealing treatments are also available. For thin-film materials, the customer defines the annealing parameters necessary to achieve specific circuit manufacturing requirements. This can improve surface quality by removing residual contaminants that may remain on the surface.

### D. Tolerances

These specifications are based on the application of statistical process control methods to determine multibeam equipment capability to a Cpk 1.33. Dimensional tolerances should be specified as close as necessary to facilitate customer process requirements and minimize cost.

Tighter tolerances are available upon request. For more information on tighter tolerances, please contact your CoorsTek sales representative or call 303-277-4802 for technical assistance.

## IV. Inspection

### A. Requirement

CoorsTek uses ANSI standards for our in-process and final inspection. The following is a list of our standard requirements. If a customized inspection is required, please submit your requirements when requesting quotation.

Sampling Plan: ANSI Z1.4 Single Sampling Plan for Normal Inspection		
	Inspection Level	Measurement Device
External Sizes	General Inspection Level 1 AQL 1.0	Calipers, Micrometers
Internal Feature Location and Size	Special Inspection Level S-2 AQL 1.5	Optical Measurement
Dye Check	Special Inspection Level S-2 AQL 1.5	Dye Penetrant
Surface Finish	3 parts per lot	Profilometer
Camber, Final Inspection	General Inspection Level 1 AQL 0.65	See methods section
Camber, In-Process	100%	
Visual, Final Inspection	General Inspection Level 1 AQL 1.5	See methods section
Visual, In-Process	100%	
All Other Specifications	General Inspection Level 1 AQL 1.5	—

### B. Methods

**Visual Inspection Procedures:** Reference Table V (page 6)

As-Fired: Visual A face only using pancake light with unaided eye

Lapped: Visual A and B face using pancake light with unaided eye

Polished: Visual A and B face using fluorescent lighting with unaided eye  
Use gloss meter for micro-voids on Superstrate with an Ra less than 2.0  
Use polarized microscope for contamination and cleanliness

#### Length/Width:

Length and width dimensions are inspected using digital calipers or as dictated by tolerances.

#### Thickness:

Thickness is measured using an 0.080" (2.032 mm) diameter anvil micrometer.

#### Surface Finish:

Surface finish is measured with a 0.0004" (0.0102 mm) radius stylus profilometer using a 0.030" (0.762 mm) cutoff, as specified in ANSI/ASME B46.1. The theoretical accuracy of this measurement is  $\pm 1$  microinch ( $\pm 25.4$  micromillimeters). Therefore, measurements from profilometer to profilometer may vary. Published values represent the substrate's typical or average surface finish. CLA (Centerline Average), Ra (Roughness average) and AA (Arithmetic Average) are equivalent terms.

**Surface Porosity:**

Dye penetrant is used to check surface porosity.

**Camber Test Method:**

CoorsTek substrates are 100% inspected for camber using two ground, parallel plates spaced at a fixed distance by the following formula:

$$D = T + (C \times L), \text{ where:}$$

- D** = camber distance setting
- T** = substrate mode of thickness, where the mode is defined as the value most frequently measured
- C** = camber value
- L** = substrate length or longest outside dimension

Substrate mode of thickness, **T**, is established using an 0.080" (2.032 mm) diameter anvil micrometer. The thickness of each sample piece is measured to the nearest 0.0005" (0.013 mm) at any point away from the edge. The measured values are plotted until a mode of thickness value is determined.

**Example:** For a nominal 4.0" (101.2 mm) x 3.5" (88.90 mm) x 0.025" (0.635 mm) substrate:

Measured mode of thickness, **T** = 0.0255" (0.648 mm)

Camber value, **C** = 0.003"/" (0.076 mm/mm)

Maximum outside dimension, **L** = 4.0" (101.2 mm)

Maximum camber allowed,

$$D = 0.0255" (0.648 \text{ mm}) + [0.003"/" (0.076 \text{ mm/mm}) \times 4.0" (101.2 \text{ mm})] = \underline{0.038" (0.952 \text{ mm})}$$

To inspect for camber, parallel plates are set at a 45% angle with a gap equal to the **D** value determined in the formula. Substrates that pass through the gap under their own weight are acceptable.

**Hole Sizes and Shapes:**

Hole diameters and shapes are verified using computer-enhanced optical measuring with top or back light equipment or pin gauges (the CoorsTek preferred method), depending on the customer's preference.

**Hole Locations:**

Hole locations are inspected with computer-enhanced optical measuring equipment on the entry side (standard procedure) using top light.

**Scribe Lines:**

1. Before Break: Scribe line locations are inspected using computer-enhanced optical measuring equipment.
2. After Break: The part segments are inspected with digital calipers.

**Chips:**

Inspection for chips is done under a high-intensity, low-angle light using the unaided eye. If observed, verification of chip size is done with computer-enhanced optical measuring equipment at a magnification of 30x.

**Part Features:**

Location and size of part features are inspected with computer-enhanced optical measuring equipment.

**Pulse Depth:**

Average laser pulse depth is inspected on a substrate cross section using enhanced optical methods at a magnification of 30x. The average is determined over a minimum of 20 adjacent pulses (reference Figure 2).

**Pulse Spacing:**

Average laser pulse spacing is inspected using enhanced optical methods at a magnification of 30x. The average is determined over a minimum of 10 adjacent pulses.

## V. Additional Materials – Microwave Dielectrics and Yttria Partially Stabilized Zirconia (YTZP)

### Capabilities

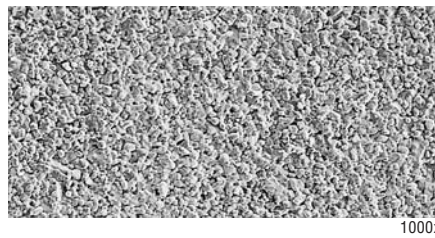
CoorsTek has developed the capability to manufacture substrates from a set of dielectric materials and zirconia that are compatible with commercially available thick-film gold and silver metalization systems. All materials are tape cast and offered in as-fired, lapped, or polished conditions.

Microwave dielectric substrates are available with nominal dielectric constants of 20, 36, and 82. There are a wide variety of uses including microwave stripline circuits and filters. All compositions display near-zero temperature coefficient of frequency. They are available up to 4" (101.6mm) square from 0.010" (0.254mm) to 0.050" (1.27mm) thick.

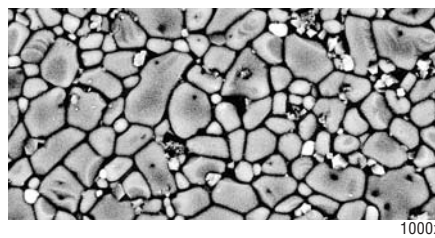
YTZP ceramics are used when high strength is required. They are available up to 4" (101.6mm) square from 0.005" (0.127mm) to 0.00" (1.016mm) thick.

Please see microstructure comparisons with Superstrate® below. Material properties are available upon request.

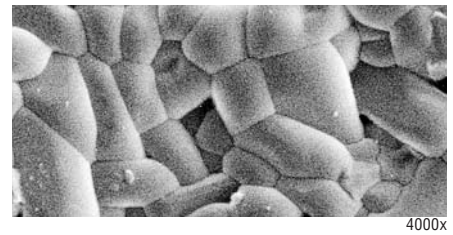
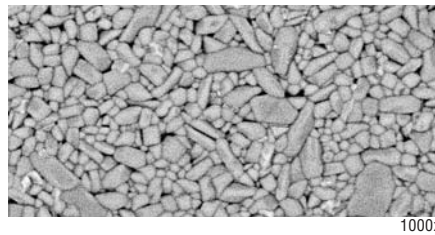
### Superstrate® 996



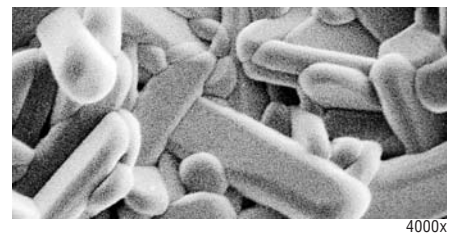
### TD-20 Magnesium Titanate



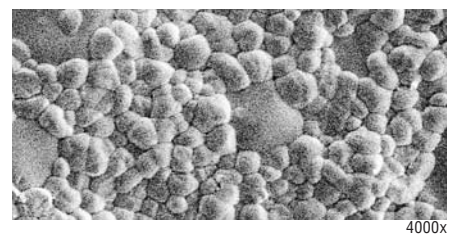
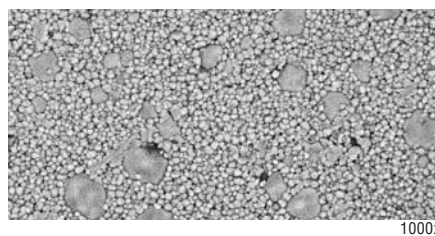
### TD-36 Zirconium Tin Titanate



### TD-82 Barium Neodymium Titanate



### YTZP Yttria Partially Stabilized Zirconia

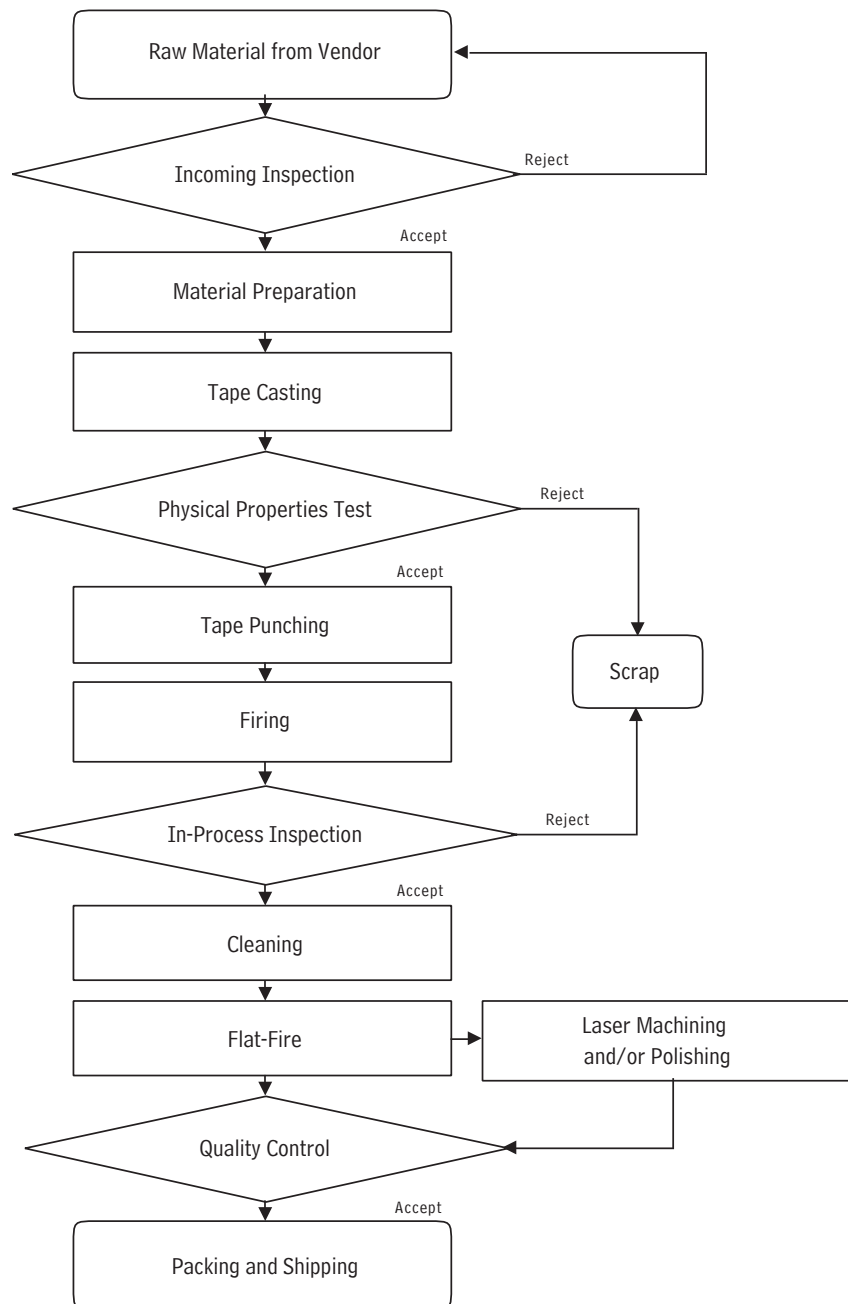


**Fig. 6. Microstructural Comparisons of YTZP and High Dielectric Constant Substrate Materials**  
Material properties available upon request.

## VI. Quality Assurance

### Quality System

Our quality system is built around Total Quality Commitment. It is a philosophy that embraces continuous improvement. Quality is achieved by using our customer's expectations to select target values and minimize variation around those values. The CoorsTek quality system is certified to ISO-9000 and QS-9000, which encompasses every aspect of design, manufacturing, process control, and inspection processes.



## VII. Glossary

The following are definitions of terms used throughout this design guide.

**Annealing** – Heat treatment of thick and thin-film ceramic substrates to thermally modify the heat-affected zone (HAZ) allowing for improved via metal adhesion or, in some cases, to relieve residual stresses.

**As-Fired Edge** – The edge of a substrate produced by mechanical punching of unfired (green) ceramic tape.

**Buffed Edge** – The edge of a substrate produced by a mechanical abrasion process on a laser scribed or as-fired edge.

**Chamfered Corner** – A unique reference used to locate the datum point and/or the working surface (“A” side) for thin-film substrates (reference Figure 3, page 7).

**Coating** – Used to protect substrate surface during laser processing.

**Cut Slot** – Laser machined feature through thickness of substrate with length greater than width (reference Figure 3, page 7).

**Datum** – Reference point (0,0) from which all other ceramic substrate features are measured.

**Drilling** – Laser machining of round holes through the substrate thickness.

**Fiducial** – A marking used as a standard reference for substrate orientation and alignment (reference Figure 3, page 7).

**HAZ** – Acronym for **Heat Affected Zone**. Region of material adjacent to the laser scribe or cut.

**Hole Roll-Off** – In a cross-sectional view of a laser drilled hole, the radius at the intersection of the hole wall (tangent point) and the face of the substrate, on the beam entry side only (reference Figure 5b, page 9).

**Hooking** – A small protrusion left along the edge after breaking. Hooks are considered acceptable if within overall specification limits.

**LASER** – Acronym for **Light Amplification by Stimulated Emission of Radiation**.

**Laser Tick** – An identifying reference mark typically found on the “B” face (non-working surface) of a thin-film substrate, and “A” face of thick-film substrates.

**Locating Hole** – Customer-specified optical and/or mechanical feature (reference Figure 3, page 7).

**Machining/Profiling** – Cutting through a ceramic substrate with a laser beam to produce a desired shape.

**Multi-Up Design** – A single substrate containing multiple laser scribed parts to allow for batch processing in the customer’s process (reference Figure 3, page 7).

**Pin Flat** – Machined indentation, located on substrate edges, used for precise mechanical alignment of the substrate in the customer’s process (reference Figure 3, page 7).

**Pulse Depth** – Average penetration distance of a laser pulse measured from the entrance side of the substrate (reference Figure 4b, page 7).

**Pulse Spacing** – Separation distance between two adjacent laser pulses measured from centerline to centerline (reference Figure 4, page 7).

**Scribing** – To laser machine a line by perforating the material’s surface. Separation of the material may then be done along the perforated line, thus achieving the desired part dimensions (reference Figure 4, page 7).

**Singulation** – Act of separating segments of the scribed substrate into the final part dimensions.

**Slag** – Resolidified ceramic material on the substrate’s surface resulting from laser processing.

**Tab** – Ceramic material left inside a laser cut feature as the result of the start/stop point of the laser beam. Alternatives are available should this cause a problem to the function of the part.

**Taper** – Slope of the wall resulting from laser drilling and machining through the substrate thickness (reference Figure 5b, page 9).

**Web** – Distance separating a hole from another substrate feature. This distance is measured from the hole entrance side (reference Figure 5a, page 9).

## VIII. Properties

The chart is intended to illustrate typical properties. Engineering data is representative. Property values vary somewhat with method of manufacture, size, and shape of part. This data is not to be construed as absolute and does not constitute a warranty for which we assume legal responsibility.

Table VIII. Typical Material Characteristics

Characteristics	Unit	Test Methods	ADS-995	ADS-996	SuperStrate® 996	SuperStrate® TPS
Alumina Content (nominal)	Weight %	ASTM-D2442	99.5	99.6	99.6	99.6
Color		–	White	White	White	White
Nominal Density	g/cc	ASTM-C373	3.88	3.88	3.88	3.95
Hardness		ASTM-E18, R45N	87	87	87	87
Surface Finish	Mircoinches	Profilometer				
As-Fired	(Nanometers)	0.0004" Radius Stylus	5 (127)	3 (77)	2 (51)	n/a
Lapped		0.030" Cutoff	< 30 (762)	< 12 (305)	< 10 (254)	< 10 (254)
Polished		ANSI/ASME B46.1	< 2 (51)	< 1 (26)	< 1 (26)	< 1 (26)
Grain Size	Microns		< 2.2	< 1.2	< 1.0	< 1.0
Water Absorption	%	ASTM373	nil	nil	nil	nil
Gas Permeability	–	**	nil	nil	nil	nil
Flexural Strength	Kpsi (MPa)	ASTM-F394	83 (572)	86 (592)	90 (620)	99 (682)
Elastic Modulus	10e6 psi (GPa)	ASTM-C848	54 (372)	54 (372)	54 (372)	54 (372)
Poisson's Ratio		ASTM-C848	0.2	0.2	0.2	0.2
Coefficient of Linear Thermal Expansion						
	10 <sup>-6</sup> /°C	ASTM-C372				
25°- 300° C			7.0	7.0	7.0	6.3
25°- 600° C			7.5	7.5	7.2	7.2
25°- 800° C			8.0	8.0	7.9	7.9
25°- 1000° C			8.3	8.3	8.2	8.2
Thermal Conductivity		ASTM-C408				
100° C			25.5	26.6	26.9	27
Dielectric Strength	AC Volts/mil	ASTM-D116				
0.025"			575	575	600	640
0.040"			450	450	450	500
Dielectric Constant @ 1 MHz		ASTM-D150	9.8	9.9	9.9	9.9
Loss Tangent @ 1 MHz		ASTM-D150	0.0001	0.0001	0.0001	0.0001
Volume Resistivity	ohm-cm	ASTM-D257				
25° C			> 1.0E+14	> 1.0E+14	> 1.0E+14	> 1.0E+15
100° C			> 1.0E+14	> 1.0E+14	> 1.0E+14	> 1.0E+15
300° C			> 1.0E+12	> 1.0E+12	> 1.0E+13	> 1.0E+15
500° C			> 1.0E+9	> 1.0E+9	> 1.0E+10	> 1.0E+12
700° C			> 1.0E+8	> 1.0E+8	> 1.0E+9	> 1.0E+10

Note: Information in this bulletin illustrates the general laser services of CoorsTek. Users are responsible for selection of laser services suitable for specific applications.

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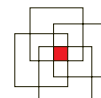
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