

## Materials Properties Chart

Specifications are offered as assistance to Engineers and Purchasing professionals in the design and procurement of thin and thick film circuit substrates.

Centerline Technologies makes no certification as to the suitability of materials for any application. (Basis for specifications available upon request.)

Properties	Units	Polished High Density 996 Alum. Oxide	As-fired High Density 996 Alum. Oxide Hi-rel Grade	Beryllium Oxide	Aluminum Nitride	Fused Silica Quartz	Sapphire (Crystalline)	Polished Titanates	Ferrites and Garnets
Chemical Composition		Al <sub>2</sub> O <sub>3</sub>	Al <sub>2</sub> O <sub>3</sub>	BeO	AlN	SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	—	—
Purity	%	99.6	99.6	99.5	98	100	100	—	—
Color		White	White	White	Tan	Transparent	Transparent	Cream	Gray
Nominal Density	g/cm <sup>3</sup>	3.87	3.87	2.85	3.28	2.2	3.97	—	—
Surface Finish (Polished)	μ-inches	<1.0	n/a	2.0-4.0	<2.0	60/40 Optical	<1.0μ-inch CLA	<3.0	<16.0
Surface Finish (As fired)	μ-inches	n/a	2-3	n/a	n/a	n/a	n/a	n/a	n/a
Camber	inch/inch	.0003/.0005	.002	.0003/.0005	.0003/.0005	.0003/.0005	.0003/.0005	—	—
Thickness	inches	0.004-.040*	0.005-0.025*	0.005-0.100*	0.004-0.100*	0.004-0.080*	0.004-0.050*	0.005-0.025*	0.010-0.025*
Thickness Tolerance	inches	±0.0005	±0.001*	±0.0005	±0.0005	±0.0005	±0.0005	±0.0005	±0.0005
Process Sizes	inches								
(L/W)		1.0/4.5	1.0/2.25	1.0/4.5	1.0/2.25	1.0/2.25	1.0/2.25	1.0/2.25	
Coefficient of Thermal Expansion (CTE)	10-6	7.0-8.3 (25-1000°C)	7.0-8.3 (25-1000°C)	9.0 (25-1000°C)	4.6 (25-300°C)	0.55 (20-320°C)	A plane @ 25°C-5.3	—	—
Thermal Conductivity	Watts/m <sup>2</sup> K	26.9	26.9	270	170	n/a	n/a	—	—
Dielectric Constant	@1 MHz	9.9±0.1	9.9±0.1	6.5	8.6	3.826	11.5/9.3†	36-180	14.5-17.6
Dielectric Constant	@4 MHz	9.9	9.9	—	—	—	—	—	—
Dielectric Constant	@10 MHz	9.7	9.7	—	—	—	—	—	—
Dissipation Factor (Loss Tangent)	@1 MHz	0.0001	0.0001	0.0004	0.001	0.000015	.00086/.0003†	—	—
Dissipation Factor (Loss Tangent)	@10 MHz	0.0002	0.0002	—	—	—	—	—	—
Q	@1 GHz	5000	5000	—	5000	—	—	—	—
Hardness	Rockwell	87	87	45	n/a	7 Mohs	1800/2200A Knoop	—	—
Flexural Strength	K(10-3) lbs/sq.in.	90	90	35 (3 pt. bend)	59 (4 pt. bend)	25	60	—	—
Compressive Strength	M(10-3) lbs/sq.in.	54	54	n/a	n/a	161	350	—	—
Grain Size	um (microns)	<1.0	<1.0	9-16	5-7	Amorphous	Single Crystal	—	—

• Additional thicknesses and tolerances available upon request

† Value varies with orientation (“A” plane / “C” plane)

## 99.6% Alumina Specification Chart

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Properties	Units	Polished High Density 996 Alum. Oxide	As-fired High Density 996 Alum. Oxide Hi-rel Grade
Chemical Composition		Al <sub>2</sub> O <sub>3</sub>	Al <sub>2</sub> O <sub>3</sub>
Purity	%	99.6	99.6
Color		White	White
Nominal Density	g/cm <sup>3</sup>	3.87	3.87
Surface Finish (Polished)	μ-inches	<1.0	n/a
Surface Finish (Lapped)	μ-inches	8-15*	n/a
Surface Finish (As fired)	μ-inches	n/a	2-3
Camber	inch/inch	.0003/.0005	.002
Thickness	inches	0.004-.040*	0.005-0.025*
Thickness Tolerance	inches	±0.0005	±0.001*
Process Sizes	inches		
(L/W)	1.0/6.0	1.0/6.0	
Coefficient of Thermal Expansion (CTE)	10-6	7.0-8.3 (25-1000°C)	7.0-8.3 (25-1000°C)
Thermal Conductivity	Watts/m <sup>2</sup> K	26.9	26.9
Dielectric Constant	@1 MHz	9.9±0.1	9.9±0.1
Dielectric Constant	@4 MHz	9.9	9.9
Dielectric Constant	@10 MHz	9.7	9.7
Dissipation Factor (Loss Tangent)	@1 MHz	0.0001	0.0001
Dissipation Factor (Loss Tangent)	@10 MHz	0.0002	0.0002
Q	@1 GHz	5000	5000
Hardness	Rockwell	87	87
Flexural Strength	K(10-3) lbs/sq.in.	90	90
Compressive Strength	M(10-3) lbs/sq.in.	54	54

## BeO / AlN Specification Chart

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Properties	Units	Beryllium Oxide	Aluminum Nitride
Chemical Composition		BeO	AlN
Purity	%	99.5	98
Color		White	Tan
Nominal Density	g/cm <sup>3</sup>	2.85	3.28
Surface Finish (Polished)	μ-inches	2.0-4.0	<2.0*
Surface Finish (Lapped)	μ-inches	20-30*	15-25*
Surface Finish (As fired)	μ-inches	n/a	n/a
Camber	inch/inch	.0003/.0005	.0003/.0005
Thickness	inches	0.005-0.100*	0.004-0.100*
Thickness Tolerance	inches	±0.0005	±0.0005
Process Sizes	inches		
(L/W)	1.0/2.25	1.0/4.5	
Coefficient of Thermal Expansion (CTE)	10-6	9.0 (25-1000°C)	4.6 (25-300°C)
Thermal Conductivity	Watts/m <sup>2</sup> K	270	170
Dielectric Constant	@1 MHz	6.5	8.6
Dielectric Constant	@4 MHz	—	—
Dielectric Constant	@10 MHz	—	—
Dissipation Factor (Loss Tangent)	@1 MHz	0.0004	0.001
Dissipation Factor (Loss Tangent)	@10 MHz	—	—
Q	@1 GHz	—	5000
Hardness	Rockwell	45	n/a
Flexural Strength	K(10-3) lbs/sq.in.	35 (3 pt. bend)	59 (4 pt. bend)
Compressive Strength	M(10-3) lbs/sq.in.	n/a	n/a
Grain Size	um (microns)	9-16	5-7

• Additional thicknesses and tolerances available upon request

• Additional surface finishes available upon request

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## Optical Materials Specification Chart

Specifications are offered as assistance to Engineers and Purchasing professionals in the design and procurement of thin and thick film circuit substrates.

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Properties	Units	Fused Silica Quartz	Sapphire (Crystalline)
Chemical Composition		SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>
Purity	%	100	100
Color		Transparent	Transparent
Nominal Density	g/cm <sup>3</sup>	2.2	3.97
Surface Finish (Polished)	μ-inches	60/40 Optical	<1.0μ-inch CLA
Surface Finish (Lapped)	μ-inches	7-12*	10-20*
Surface Finish (As fired)	μ-inches	n/a	n/a
Camber	inch/inch	.0003/.0005	.0003/.0005
Thickness	inches	0.004-0.080*	0.004-0.050*
Thickness Tolerance	inches	±0.0005	±0.0005
Process Sizes	inches		
(L/W)	1.0/2.25	1.0/2.25	
Coefficient of Thermal Expansion (CTE)	10-6	0.55 (20-320°C)	A plane @ 25°C-5.3
Thermal Conductivity	Watts/m°K	n/a	n/a
Dielectric Constant	@1 MHz	3.826	11.5/9.3†
Dielectric Constant	@4 MHz	—	—
Dielectric Constant	@10 MHz	—	—
Dissipation Factor (Loss Tangent)	@1 MHz	0.000015	.00086/.0003†
Dissipation Factor (Loss Tangent)	@10 MHz	—	—
Q	@1 GHz	—	—
Hardness	Rockwell	7 Mohs	1800/2200A Knoop
Flexural Strength	K(10-3) lbs/sq.in.	25	60
Compressive Strength	M(10-3) lbs/sq.in.	161	350
Grain Size	um (microns)	Amorphous	Single Crystal

• Additional thicknesses and tolerances available upon request

• Additional surface finishes available upon request

† Value varies with orientation (“A” plane / “C” plane)