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TECHNICAL DATA — ALON™ OPTICAL CERAMIC

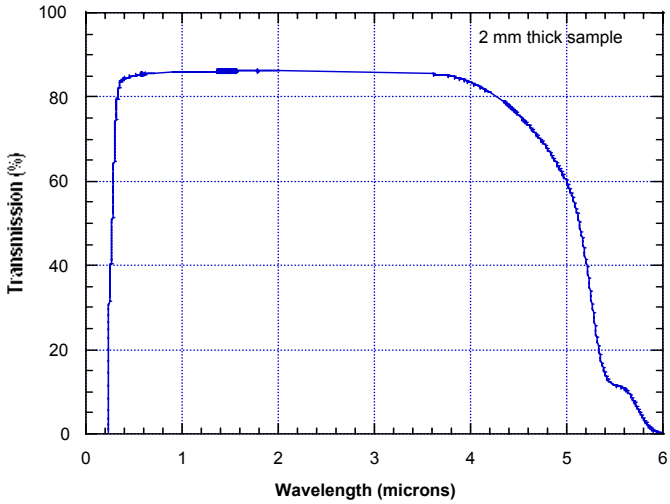
ALON™ Optical Ceramic is an extremely durable crystalline material with excellent optical transparency in the near ultraviolet, visible and infrared up to approximately 5 µm wavelength.

ALON™ Optical Ceramic is fabricated using a proprietary powder processing technique. The material combines mechanical and optical properties similar to sapphire with the advantages of an isotropic cubic crystal structure. It has an approximate composition of $Al_{23}O_{27}N_5$.

ALON™ Optical Ceramic can be made to order as windows, domes, plates, rods and tubes in a wide range of sizes and thicknesses by a variety of conventional ceramic forming methods such as injection molding, isostatic pressing and slipcasting.

TYPICAL PROPERTIES OF ALON™ OPTICAL CERAMIC

Composition……	$Al_{23-1/3X}O_{27+X}N_{5-X}$ (0.429<X<2)
Grain Size (typical)….....	150-250 microns
Structure……..	Cubic, Spinel
Lattice Constant……..	7.956A – 7.936A
Density……	3.696 – 3.691 g/cc
Form……	Polycrystalline
Melting Point…….	2150°C
Young's Modulus……..	46.9×10^6 psi
Shear Modulus…….	18.9×10^6 psi
Poisson's Ratio…….	0.24
Hardness……	1850 Kg/mm² (Knoop Indentation, 200g load)
Fracture Toughness……..	2.0 MPa-$m^{1/2}$
Flexure Strength……	55,000 psi
Specific Heat…….	0.22 cal/g-°C
Thermal Conductivity	(cal/cm-s-°C)
75°C…….	0.023
270°C……	0.017
540°C…….	0.015
830°C…….	0.017
Transmission Limits	0.22 to 6 microns



Thermal Expansion Coeff.

30-200°C	5.65×10^{-6}
30-400°C	6.40×10^{-6}
30-600°C	6.93×10^{-6}
30-900°C	7.50×10^{-6}

Dielectric Properties

Freq. (GHz)	k	tan δ ($x10^{-5}$)
35-45	9.190	31
55-60	90181	67
90-110	9.175	96

Index of Refraction

λ(µm)	n
0.48	1.803
0.50	1.801
0.64	1.790
0.68	1.788
0.70	1.787
1.00	1.779
2.00	1.761
3.00	1.737
4.00	1.702
5.00	1.653

Infrared Absorption Coefficient

λ(µm)	α (cm^{-1})
3.8	0.080
4.000	0.159
4.230	0.288
4.380	0.409
4.545	0.598
4.717	0.849
4.902	1.230
5.000	1.598
5.102	2.000
5.319	5.230
5.550	8.060
5.814	11.030

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ALON™ Optical Ceramic

Comparison To Window Materials

Property	ALON™ Optical Ceramic	Fused Silica	Sapphire	Spinel	Magnesia	Zinc Sulfide	Yttria
Composition	$Al_{23}O_{27}N_5$	SiO_2	Al_2O_3	$MgAl_2O_4$	MgO	ZnS	Y_2O_3
Density (Grams/cm^3)	3.7	2.5	3.98	3.59	3.58	4.08	5.03
Areal Density 1" thickness (lb/ft^2)	19.23	11.44	20.68	18.61	18.55	21.20	26.14
Young's Modulus (Msi)	46.0	10.6	60.9	38.9	35.5	10.7	26.0
Poisson's Ratio	0.24	0.17	0.22	0.26	0.18	0.3	0.23
Flexural Strength (Ksi)	55	16.0	100	26.7	19.1	14.9	21.8
Hardness (kg/mm^2)	1850	460	2200	1520	640	250	720

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Comparison To Ceramics for Semiconductor Processing

PROPERTIES	Conditions	UNITS	ALON™	Coors Alumina AD 99.5	Coors Alumina AD99.8	Sapphire	Quartz (fused silica)
Density		g/cc	3.69	3.9	3.92	3.97	2.21
Grain Size		Micrometers	150-250	6	6	single crystal	amorphous
Color			Transparent	ivory	ivory	Transparent	Transparent
Flexural Strength		MPa (ksi)	379 (55)	379 (55)	552 (80)	742 (107.7)	48 (7)
Fracture Toughness		MPa-m^1/2	2 (indentation method)	3 to 4	3 to 4	2	0.8
Compressive Strength	25°C	MPa (ksi)	2677 (388) (see note 1)	2600 (377)	3792 (550)		650 - 1100
Hardness	Knoop,200 g load, 25°C)	(kg/mm^2)	1850	2000	2000	2000	460
Elastic Modulus		GPa (psi x $10^{6)}$	334 (48.4)	370 (53.6)	386 (55.9)	344 (49.8)	70 (10.1)
Shear Modulus		psi x 10^6	135 (19.6)				
Poisson's Ratio			0.239	0.23	0.23	0.27	0.16
Thermal Conductivity		W/m-K (cal/cm-sec-oC)	9.5 (0.023)	37 (0.09)	33 (0.08)	36	1.6
TCE (30-900°C)		10^{-6}/°C	7.5	8.2	8.4		0.45
Specific Heat		(J/g-K) (Cal/g -°C))	0.77 (0.22)	0.67 (0.19)	0.67 (0.19)	0.75 (0.21)	0.22
Thermal Shock ΔT (oC)		°C	N/A	200	N/A	200	>1400
Transmission range (microns)			0.22-6	N/A	N/A	0.2-6	0.2-4.5
Dielectric Constant	1 kHz @25ºC						
	1 MHz			9.6		9.3-11.4	3.8
	3.044 GHz		9.1				
	1GHz		9.19				
Dissipation Factor (x10-5)	1 kHz @25ºC						
	1 MHz						
	3.044 GHz		31.4				
	1GHz		31				20
Note:1	ASTM C773-88						