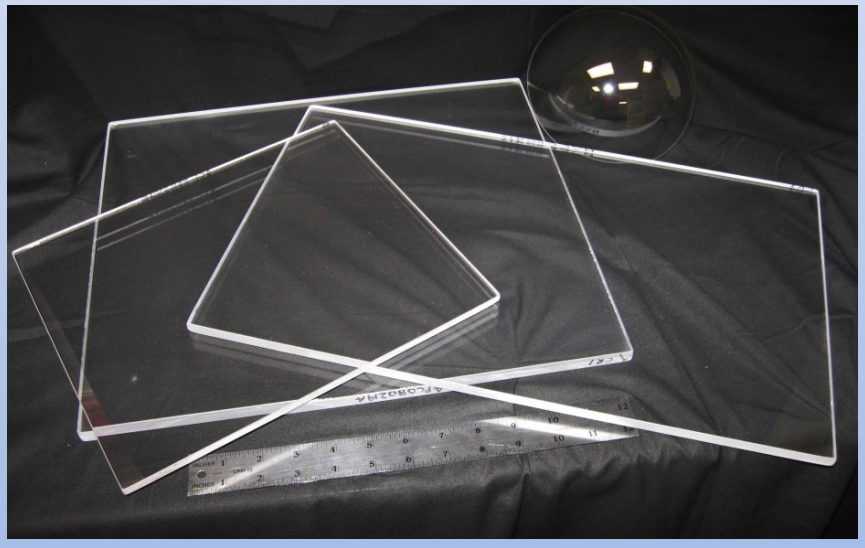
Technology Assessment & Transfer, Inc.
Transparent Spinel



Bridging the Gap Between Research and the Marketplace

Technical Data

Transparent Spinel Ceramics

Spinel ($MgAl_2O_4$) Optical Ceramic is a transparent polycrystalline ceramic whose combination of high hardness, light weight and broadband optical properties make it an ideal material for stringent optical applications and transparent armor. Its transmission window spans the range from 0.19 um to 6.0 um and exceeds that of single crystal sapphire and ALON™. Additional advantages versus sapphire and ALON include optical isotropy and high temperature stability, respectively.

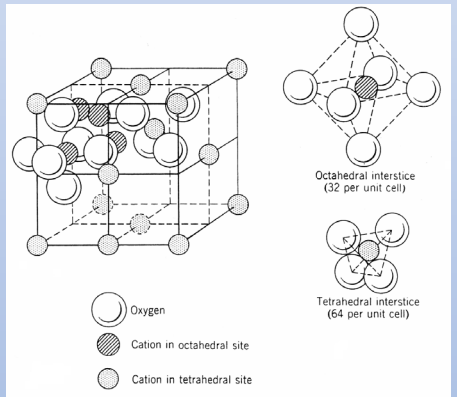
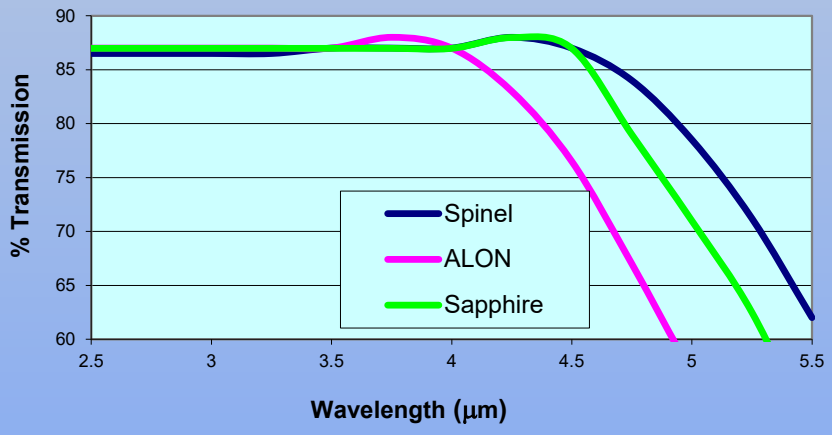
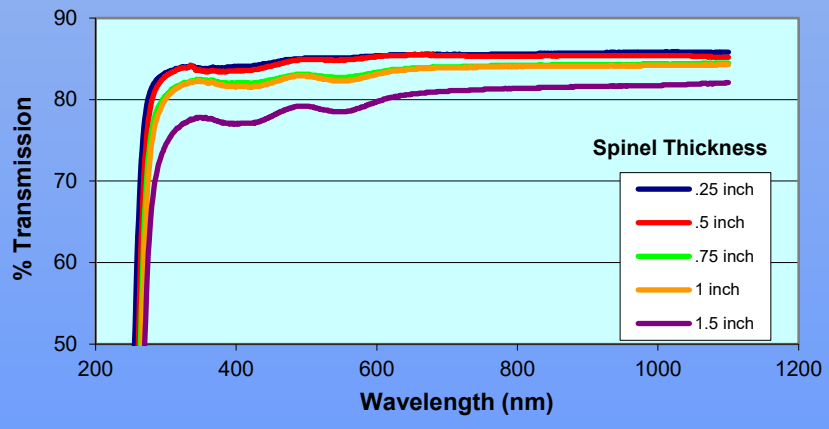


Fig. 1 Atomic layers parallel to the (001) plane in spinel.

Crystal Structure

The crystal structure of the spinel is based on an FCC close-packed oxygen sub-lattice in which a fraction of the octahedral and tetrahedral sites are filled. The polycrystalline structure of the magnesia spinel is optically isotropic. Magnesia spinel undergoes no polymorphic transformations and hence is devoid of any thermally induced phase changes.



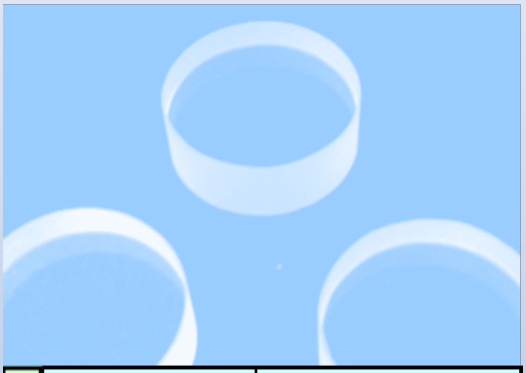


Absorption coefficient (cm^{-1}) at 5 μm

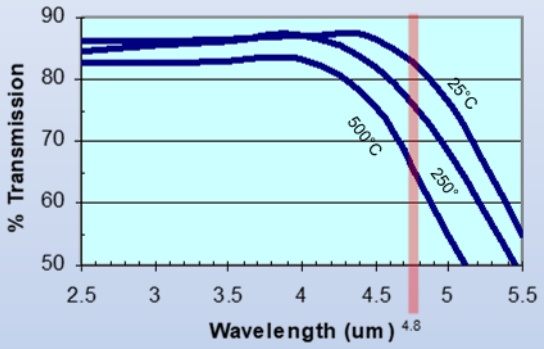
Material	25°C	250°C	500°C
Spinel	0.4	0.7	1.3
Sapphire	0.8	1.3	2.4
ALON	1.6	2.4	3.7

Optical Ceramics Division

Characterization of Polycrystalline Transparent Spinel

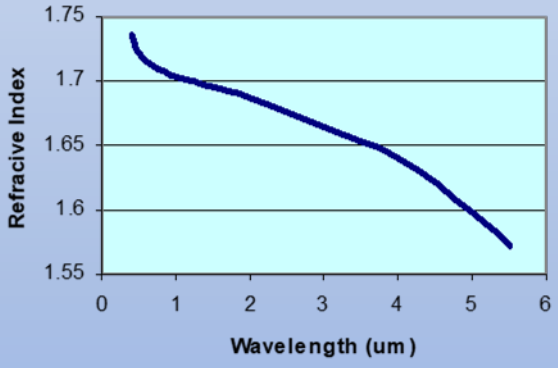


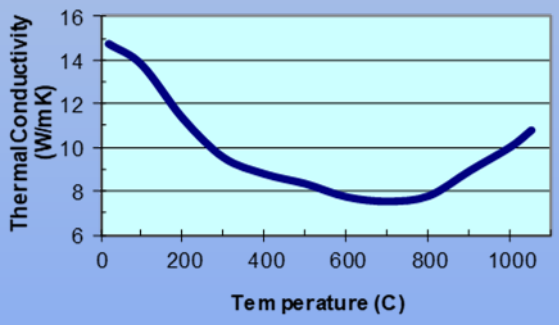
Polycrystalline Transparent Spinel Characterization	
Composition	$MgAl_2O_4$
Grain Size	150-500μm
Crystal Structure	Cubic, spinel, isotropic
Density	3.58g/cc
Form	polycrystalline
Melting Point	2135°C
Young's Modulus	277 GPa
Shear Modulus	192 GPa
Poisson's Ratio	0.26
Hardness (Knoop, 200g)	1645 Kg/mm
Fracture Toughness	1.5-2.0 Mpa-m1/2
Flexure Strength	185-250 MPa
Specific Heat	0.21 cal/g-°C
Thermal Conductivity, RT	14.7 W/m-°K
Coefficient of Thermal Expansion	25-100°C = 6.09×10^{-6}/°C
	25-500°C = 7.30×10^{-6}/°C
	25-1000°C = 7.90×10^{-6}/°C
Refractive Index	1.7108



% Transmission Superiority over sapphire and ALON at 4.8μm

°C	Sapphire	ALON
25	4%	8%
250	5%	9%
500	5%	13%





Spinel Dielectric Properties

	1KHz	1MHz	9.3GHz
Constant	8.2	8.2	8.3
Loss Index	0.00025	0.0002	0.0001

Erosion Resistant Material

No Rain Erosion at
470 mph for 20 min
1.0"/min rate with 2mm avg. drop size

No Sand Erosion at
75 m/s with 149-177 μm at 3 mg/cm2 loading
210 m/s with 38-44 μm at 12 mg/cm2 loading

Corrosion Resistance Performance

	% Transmission Loss at 0.4μm		% Transmission Loss at 4.0μm	
Environment	30 hrs	100 hrs	30 hrs	100 hrs
50% HF at 20 C	2%	2%	<1%	<1%
50% H_2SO_4 at 20 C	<1%	<1%	<1%	<1%
50% H_2SO_4 AT 100 C	2%	10%	<1%	<1%
50% HNO_3 at 20 C	<1%	<1%	None	None
50% NaOH at 20 C	None	None	None	None
Sea Water at 20 C	None	None	None	None
Jet Fuel at 20 C	None	None	None	None

Bridging the Gap Between Research and the Marketplace

Optical Ceramics Division

Equipment and Processing Capabilities

Vacuum Hot Pressing

Technology Assessment & Transfer operates and maintains a wide variety of furnaces to develop and produce its transparent spinel ceramics. Currently, 30-ton, 250-ton and 600-ton vacuum hot presses are used to manufacture the majority of spinel components. TA&T hot presses are capable of fabricating spinel windows over 400 in^2.

Pressureless Sintering

Pressureless sintering offers the potential for lower cost, large economies of scale production for both military and commercial products. A variety of forming methods are available for hemispherical, ogive and aspherical shaped components which can also lead to lower cost processing methods depending on the size and shape of the component.

Other Processing and Characterization Capabilities

Lamination	Calcining
Particle Size Distribution	Polishing
Surface Area	White light Haze testing
UV-vis and FTIR Transmission Spectra	Coatings

For more information, please visit our website, www.techassess.com

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