

# TECHNICAL NOTE



SPI Supplies  
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## SPI Single Crystal Sapphire Products

### Why choose Single Crystal Sapphire products?

Single crystal sapphire possesses excellent optical, physical and chemical properties. It is the hardest oxide crystals, and remains high strength and chemical resistance at high temperatures. It also features a wide transmission wavelength range, great electrical insulation, and good thermal conductivity at low temperatures.

### Physical Properties of Sapphire

Chemical formula	Al <sub>2</sub> O <sub>3</sub> (99.999%)
Crystal class	Hexagonal system, rhomboidal class 3m
Lattice constants, A	a=4.785, c=12.991
Density, g/cm <sup>3</sup>	3.98
Hardness	2000 with 2000 g identer (Knoop) 9 (Mohs)
Optical transmission range, μm	0.17 - 5.5
Refractive index at 0.532 μm	n <sub>o</sub> =1.7717, n <sub>e</sub> =1.76355
Water absorption	nil
Young Modulus, GPa	345
Shear Modulus, GPa	145
Bulk Modulus, GPa	240
Bending Modulus (Modulus of Rupture), MPa	420 at 20 °C 280 at 500 °C
Elastic coefficient	C11=496, C12=164, C13=115, C33=498, C44=148
Poisson ratio	0.25-0.30
Friction coefficient	0.15 on steel 0.10 on sapphire

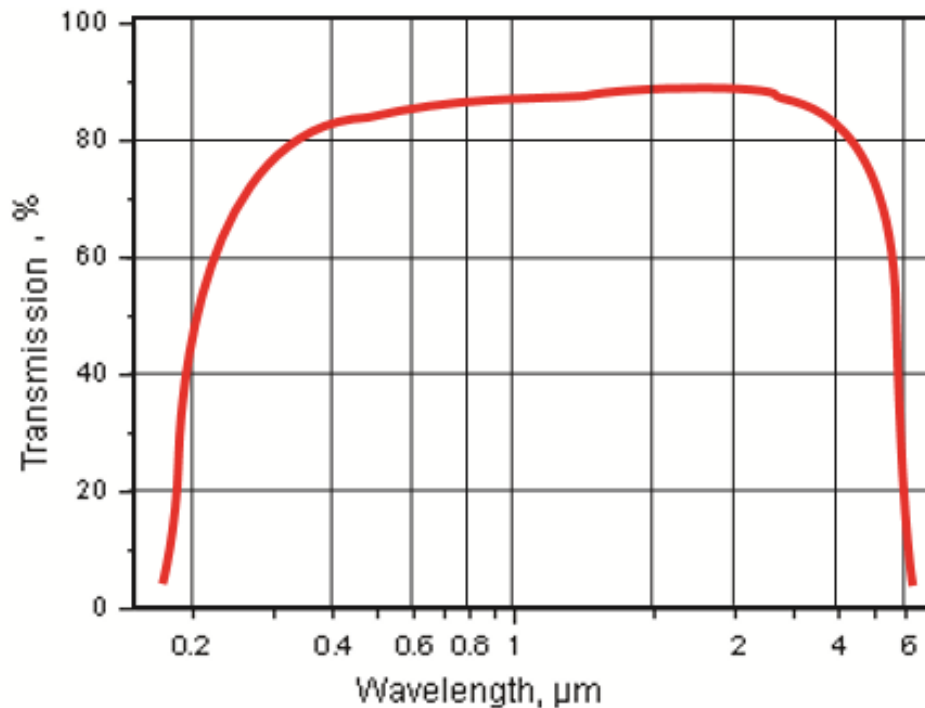
## Thermal Properties of Sapphire

Melting point, K	2303
Specific heat, J/(kg x K)	105 at 91K 761 at 291K
Thermal coefficient of linear expansion, K <sup>-1</sup> , at 323K	6.66 x 10 <sup>-6</sup> parallel to optical axis 5 x 10 <sup>-6</sup> perpendicular to optical axis
Thermal conductivity, W/(m x K) at 300K	23.1 parallel to optical axis 25.2 perpendicular to optical axis

## Electrical Properties of Sapphire

Resistivity, Ohm x cm at 200-500 °C	10 <sup>11</sup> - 10 <sup>16</sup>
Dielectric constant	10.0
Dielectric strength, V/cm	4 x 10 <sup>5</sup>
Loss tangent	1 x 10 <sup>-4</sup>

## Transmission Spectrum of 2 mm-thick Sapphire Window



## Sapphire Refractive Index vs Wavelength

$\lambda, \mu\text{m}$	$N_o$	$N_e$
0.193	1.92879	1.91743
0.213	1.88903	1.87839
0.222	1.87540	1.86504
0.226	1.87017	1.85991
0.244	1.85059	1.84075
0.248	1.84696	1.83719
0.257	1.83932	1.82972
0.266	1.83304	1.82358
0.280	1.82437	1.81509
0.308	1.81096	1.80198
0.325	1.80467	1.79582
0.337	1.80082	1.79206
0.351	1.79693	1.78825
0.355	1.79598	1.78732
0.442	1.78038	1.77206
0.458	1.77843	1.77015
0.488	1.77530	1.76711
0.515	1.77304	1.76486
0.532	1.77170	1.76355
0.590	1.76804	1.75996
0.633	1.76590	1.75787
0.670	1.76433	1.75632
0.694	1.76341	1.75542
0.755	1.76141	1.75346
0.780	1.76068	1.75274
0.800	1.76013	1.7522
0.820	1.75961	1.75168
0.980	1.75607	1.74819
1.064	1.75449	1.74663
1.320	1.75009	1.74227
1.550	1.74618	1.73838
2.010	1.73748	1.72973
2.249	1.73232	1.72432
2.703	1.719	1.711
2.941	1.712	1.704
3.333	1.701	1.693
3.704	1.687	1.679
4.000	1.674	1.666
4.348	1.658	1.65
4.762	1.636	1.628
5.000	1.623	1.615
5.263	1.607	1.599