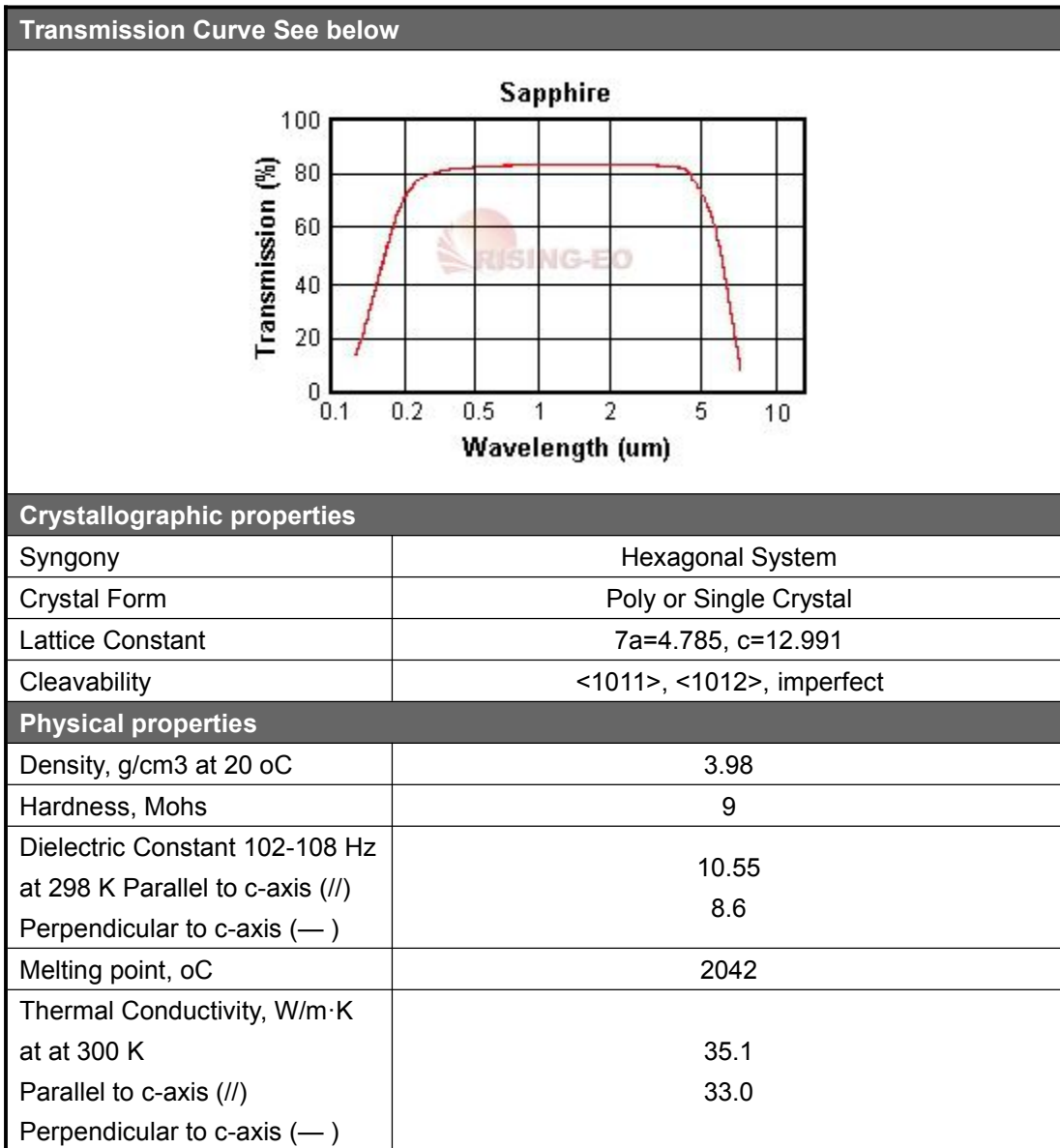


Sapphire Single crystal Sapphire possesses a unique combination of excellent optical, physical and chemical properties, the most useful is that it is the hardest of the oxide crystals. Sapphire maintains its strength even at high temperatures. It has good thermal properties, excellent electrical and dielectric properties, and is chemically resistant to common acids and alkali at temperatures up to 1000°C as well as to HF below 300°C.

Sapphire is anisotropic hexagonal crystal. Its properties depend on crystallographic direction (relative to the optical C-axis). Large sized sapphire crystals up to 4 inches in diameter are available in Rising EO. Rising EO's sapphire crystals are produced by two method——TGT and Czochraski for the highest optical and substrate quality.



Thermal Expansion, 1/K at 298 K	5.6 × 10 ⁻⁶
Parallel to c-axis (//)	5.0 × 10 ⁻⁶
Perpendicular to c-axis (—)	
Specific Heat Capacity, W×s/g/k	0.418
Bandgap, eV	9.9
Knoop Hardness, kg/mm ²	1370
Young's Modulus, Gpa	335
Shear Modulus, GPa	148
Bulk Modulus, Gpa at 273 K	240
Poisson's Ratio	0.25
Elastic Coefficient	C11=496, C12=164, C13=115, C33=498, C44=148
Apparent Elastic Limit	275 MPa (13000psi)

Crystal properties					
Crystal Growth Method			Czochralski or TGT		
Maximum Size			<Φ100mm		
Optical properties					
Transmission Range			0.15~5.5um		
Reflection Loss, for two surfaces at 5 μm			14%		
dn/dt (@633nm), /K			13'10 ⁻⁶		
Refractive Index			See below		
Wavelength (um)	No	Ne	Wavelength (um)	No	Ne
0.185	/	/	0.800	1.76013	1.7522
0.193	1.92879	1.91743	1.064	1.75449	1.74663
0.213	1.88903	1.87839	1.320	1.75009	1.74227
0.226	1.87017	1.85991	1.550	1.74618	1.73838
0.248	1.84696	1.83719	2.010	1.73748	1.72973
0.266	1.83304	1.82358	2.703	1.71900	1.71100
0.280	1.82437	1.81509	3.333	1.70100	1.69300
0.308	1.81096	1.80198	3.704	1.68700	1.67900
0.355	1.79598	1.78732	4.000	1.67400	1.66600
0.488	1.7753	1.76711	4.348	1.65800	1.65000
0.532	1.7717	1.76355	4.762	1.63600	1.62800
0.633	1.7659	1.75787	5.000	1.62300	1.61500
0.780	1.76068	1.75274	5.263	1.60700	1.59900

Chemical properties	
Solubility in water at 20 oC, g/100cm ³	98×10 ⁻⁶
Solubility in acids	Soluble
Molecular Weight	101.94

Main Applications

These properties encourage the use of Sapphire in aggressive environments where reliability, optical transmission or strength is required. It has the following wide applications in the range from the vacuum ultraviolet to the near infrared:

Optical applications:

- Illumination windows
- Sapphire light guides
- LCD projector windows
- Optical components, such as lenses, prisms, other laser and infrared optics

Medical applications:

- Surgical tips
- Endoscope lenses

Analytical applications:

Used in very high-pressure applications in replacement of glass or quartz tubes in NMR. Sapphire replaces quartz to improve durability and reduce contamination in mass spectroscopy.

Aerospace applications:

- Windows for sensors
- Infrared Countermeasure lamps

Electronic applications: Sapphire substrate with different orientation has different applications:

1 (0001) Basal Plane Sapphire Substrate:

- Epitaxial Gallium Nitride chip for blue LED
- IR detector

2 (-1 1 0 2) R-Plane Sapphire Substrate:

- GaAs wafer carriers
- Microwave IC
- SOS (Silicon on Sapphire)- High Speed IC
- Pressure Transducer

3 (1 -1 2 0) A Plane Sapphire Substrate:

- The growth of high Te superconductors

General Specifications

Optical Sapphire Windows		
Chemical properties		
Parameters	Commercial grade	Precision grade
Orientation	C-axis $\pm 1^\circ$, C-axis $\pm 0.5^\circ$, or any orientation as customers' request	
Diameter Tolerance	+0/-0.10mm	
Thickness Tolerance	± 0.10 mm	
Clear Aperture	>Central 90% of diameter	
Surface Quality	60-40 S/D	40-20 S/D
Parallelism	3~5 arc min	1 arc min
Surface Flatness	1 λ per 25mm	$\lambda/4$
Chamfer	0.15~0.35mm $\times 45^\circ$ face width $\times 45^\circ \pm 15^\circ$	
Coating	Coatings are available upon request	
Epi-ready Sapphire Substrates		
Parameters	Value	
Diameter	50.8 ± 0.05 mm	76.2 ± 0.05 mm
Thickness	330-430 $\pm 50\mu$	380-480 $\pm 50\mu$
Orientation	C (0001) $\pm 0.2^\circ$ A (1120) $\pm 0.2^\circ$ R (1102) $\pm 0.2^\circ$	C (0001) $\pm 0.2^\circ$ A (1120) $\pm 0.2^\circ$ R (1102) $\pm 0.2^\circ$
TTV and Bow	<20 μ m	<25 μ m
Front Surface	Epi polished	Epi polished
Back Side	Lapped or polished	Lapped or polished
Flatness	<5 μ m	<5 μ m
Roughness (Ra)	<0.5 μ m	<0.8 μ m