

S & D MATERIALS

OPTICAL PARTS AND SEMICONDUCTOR SOLUTIONS

SINGLE-CRYSTAL SAPPHIRE PROPERTIES and ATTRIBUTES

High Strength ▪ Excellent Optical Transmission ▪ Extreme Hardness

Single Crystal sapphire (Al_2O_3) is unique among optical materials in that, due to its extraordinary strength, hardness and thermal properties, it is used extensively in non-optical applications. Sapphire's rhombohedral crystal structure makes the material anisotropic, so some optical and mechanical property values vary along different crystal axes. While sapphire's chemical composition is the same regardless of growth method, material produced using different technologies can exhibit variances in attributes like color, defect density, optical transmission and brittleness.

For Pro Tips on designing parts in sapphire, please see our [Design Notes](#) section.



GENERAL	Chemical Formula:	Al_2O_3	OPTICAL	Index of Refraction	Ordinary ray (C axis), $N_o = 1.768$ Extraordinary ray, $N_e = 1.760$
	Category:	Oxide mineral, crystalline		Birefringence:	0.008
	Names:	Corundum, Sapphire, Alpha-Alumina		Transmission Range:	0.17 to 5.5 μm
	Crystal Shape:	Trigonal		Temperature Coefficient of Refractive Index:	$13 \times 10^{-6} \text{ } ^\circ\text{C}^{-1}$ (Visible Range)
THERMAL	Melting Point:	2053 $^\circ\text{C}$	ELECTRICAL	Volume Resistivity:	10^{16} ohm-cm (25 $^\circ\text{C}$) 10^{11} ohm-cm (500 $^\circ\text{C}$) 10^6 ohm-cm (1000 $^\circ\text{C}$)
	Max Useful Temp:	$\sim 2000^\circ\text{C}$		Dielectric Strength:	480,000 Volts/cm (1200v/mil)
	Specific Heat:	0.181 cal/gm $^\circ\text{K}$ (25 $^\circ\text{C}$) 0.300 cal/gm $^\circ\text{K}$ (1000 $^\circ\text{C}$)		Dielectric Constant:	11.5 (103 - 109 Hz, 25 $^\circ\text{C}$) parallel to C-axis 9.3 (103 - 109 Hz, 25 $^\circ\text{C}$) perpendicular to C-axis
	Thermal Conductivity:	0.4 watts/cm $^\circ\text{K}$ (25 $^\circ\text{C}$) 0.1 watts/cm $^\circ\text{K}$ (1000 $^\circ\text{C}$)		Loss Tangent:	8.6×10^{-5} (@1010Hz, 25 $^\circ\text{C}$) parallel to C-axis 3.0×10^{-5} (@1010Hz, 25 $^\circ\text{C}$) perpendicular to C-axis
PHYSICAL / MECHANICAL	Thermal Expansion Coefficient	(25 $^\circ\text{C}$ > 1000 $^\circ\text{C}$) 8.8×10^{-6} , parallel to C axis 7.9×10^{-6} , perp. to C axis	CHEMICAL	Magnetic Susceptibility:	-0.21×10^6 parallel to C axis -0.25×10^6 perpendicular to C axis
	Density:	3.97 gm/cm 3 (25 $^\circ\text{C}$)		Weather Resistance:	Unaffected by atmospheric exposure
	Young's Modulus:	435 Gpa (63×10^6 psi) parallel to C axis (25 $^\circ\text{C}$) 386 Gpa (56×10^6 psi) parallel to C axis (1000 $^\circ\text{C}$)		Salt Water Resistance:	Unaffected by marine exposure
	Shear Modulus:	175 Gpa (26×10^6 psi)		Biological Resistance:	Unaffected by in-vivo exposure Non-thombogenic Non-reactive with bodily fluids
	Poisson's Ratio:	0.27 - 0.30 Orientation-dependent			
	Flexural Strength:	1035 Mpa (150kpsi) parallel to C axis (25 $^\circ\text{C}$) 760 Mpa (110kpsi) perpendicular to C axis (25 $^\circ\text{C}$)			
	Compressive Strength:	$\sim 2\text{GPa}$ (300 kpsi) (25 $^\circ\text{C}$)			
	Tensile Strength:	40 - 60 kpsi			
Hardness:	9 Mohs 1900 Knoop parallel to C axis 2200 Knoop perp. To C axis				