Sapphire : Physical & Mechanical Properties

Sapphire has a rhombohedral type structure and is a highly anisotropic material, with properties that are largely dependent on crystallographic orientation. The properties shown in the table below are average values for different orientations, for more detailed property information please contact us.

The melting point of sapphire is 2040 °C, and it has extremely high chemical stability even at high temperatures. Sapphire's energy gap of 9.1 eV is one of the largest for oxide crystals, which permits excellent optical transmission with very little absorption from about 0.250 to 5.0 microns.

Sapphire is the material of choice for stringent optical applications involving exposure to high stresses and harsh environments. Sapphire is one of the strongest and hardest materials available; it has excellent abrasion resistance and exceptional thermal shock properties. The hardness of sapphire on the Mohs scale is 9, compared to 10 for diamond.

The strength of sapphire largely depends on the surface finish quality and subsurface damage caused by manufacturing processes. The selection of appropriate polishing techniques and heat treatments significantly improves the strength of sapphire. For design criteria, a tensile strength of 400 mpa (58,000 psi) is often chosen.

PROPERTIES OF SAPPHIRE

PHYSICAL		THERMAL	
Chemical formula	Al_2O_3	Thermal conductivity	0.065 cal cm^{-1} s^{-1} $°C^{-1}$
Crystal structure	Hexagonal system (rhombohedral)	(60° to c-axis) at 25 °C	
Unit cell dimension	a = 4.758 Å , c = 12.991 Å	Thermal expansion	8.40 x 10^{-6} $°C^{-1}$
Density	3.98 g cm^{-3}	coefficient	
Hardness	9 mohs, 1525-2000 Knoop	(60° to c-axis) 25 - 800 °C	
Melting point	2040 °C	Specific heat at 25 °C	0.10 cal g^{-1}
Boiling point	2980 °C	Heat capacity at 25 °C	18.6 cal $°C^{-1}$ mol^{-1}
MECHANICAL*		**ELECTRICAL**	
Tensile strength	40,000-60,000 psi (design criterion)	Volume resistivity	10^{14} Ohm-cm
Flexural strength	70,000-130,000 psi (design criterion)	Dielectric strength	480,000 V cm^{-1}
Young's modulus	50 x 10^6 psi	Dielectric constant	
Compressive modulus	55 x 10^6 psi	E perpendicular to c-axis	9.4
Flexural modulus	52 x 10^6 psi	E parallel to c-axis	11.5
Rigidity modulus	21.5 x 10^6 psi	Dissipation factor, *tan delta*	10^{-4}
Volumetric modulus of elasticity (bulk modulus)	35 x 10^6 psi		
Poisson's ratio	0.29		

* psi = 6.9 kPa