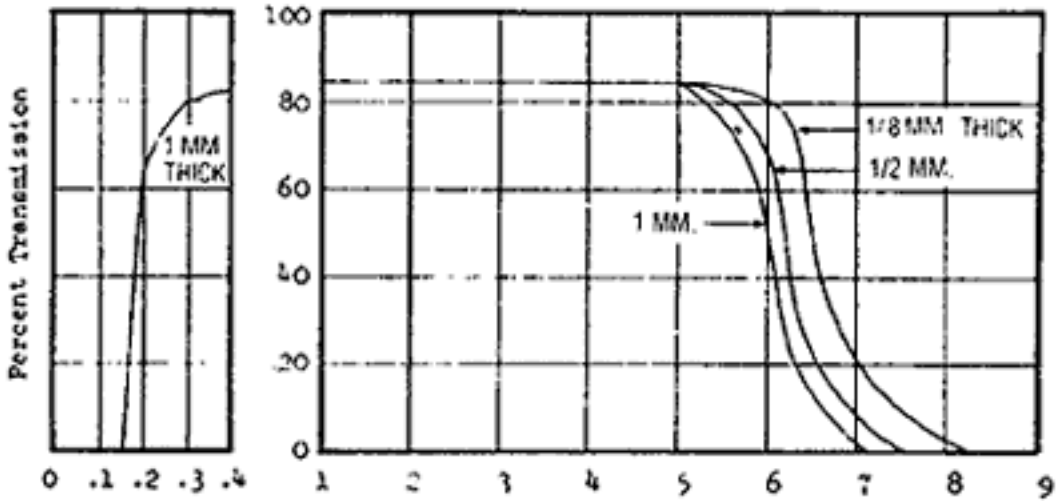
# Sapphire

Sapphire is an anistrophic crystal, hexagonal system, composed of unicrystalline alpha aluminum oxide, essentially 100% pure. Various properties are a function of crystallographic direction (related to the optic axis of the crystal). In the tables below, if no orientation is shown, this indicates that the property listed does not vary appreciably in relation to orientation or the variation is less than the experimental error of measurement.

**Transmission:**

Transmission of synthetic sapphire is shown in the following curve. Data in UV region is approximate, as transmission depends on surface finish, internal quality and purity of individual specimen. The following curve shows transmission of sapphire uncorrected for Fresnel losses.




**Melting Point:**

2040 C

**Wavelength:**

Microns

**Refractive Index:**

20C

| | |
|---|---|
| 0.3 Micron | 1.814 |
| 0.4 | 1.785 |
| 0.7 | 1.763 |
| 1.0 | 1.757 |
| 2 Micron | 1.740 |
| 3 | 1.713 |
| 4 | 1.677 |
| 5 | 1.623 |

**Young's Modulus:**

50 to 55,000,000 PSI

**Bending Modulus (Minimum):**

20C 60,000 PSI

500C 40,000 PSI

1000C 60,000 PSI

**Thermal Conductivity:**

12K (-261C) = 8.0 cal/cm$^2$/sec/C/cm
300K (23C) = .09 cal/cm$^2$/sec/C/cm
50C = .07 cal/cm$^2$/sec/C/cm

**Coefficient of Expansion:**

(Mean between 20C and T) per C

| | Perpendicular to C-axis | Parallel to C-axis |
|---|---|---|
| 50C | .0000050 | .0000067 |
| 500C | .0000077 | .0000083 |
| 1000C | .0000083 | .0000090 |

**Electrical Resistivity:**

20C $10^{19}$ ohm-cm
500C $10^{12}$ ohm-cm
1000C $10^{9}$ ohm-cm

**Dielectric constant:**

11.0 at $10^{10}$ cycles (parallel to C-axis)

**Loss Tangent:**

.0002 at $10^{10}$ cycles

**Density:**

3.98

**Hardness:**

Moh 9, Knoop 1525 to 2000

**Chemical Resistance:**

Inert to virtually all reagents at room temperatures and many at high temperatures. Essentially inert to all acids including HF, and resistant to alkalis but becoming soluble at higher temperatures.

**Coefficient of Friction:**

0.15 with highly polished high carbon steels (with or without lubricants)

**Sealing Characteristics:**

Sapphire can be wetted by glass, titanium, zirconium or moly-manganese mixtures. It can be matched to titanium, molybdenium, the high nickel-iron allows such as Carpenter 49, Kovar and the Corning glass 7520. With the good technique, bonds can be made directly to Corning 7052.

As can be seen from the list of properties, sapphire is unique when compared to optical materials useful within its transmission range in that it is by far the strongest, toughest, thermal shock and chemically resistant material available, and it can be used at far higher temperatures than most optical materials. Also, its thermal conductivity is relatively high despite its extreme electrical non-conductivity. Moderate refractive index, transparency in visible region, good transmission and relatively low emission at high temperatures plus unusual stability combine to make it valuable as a component on military optics.