



Optical Material

The most important material properties to consider for an optical element are transmission versus wavelength, index of refraction, thermal characteristics, mechanical and chemical characteristics and cost.

General optical glass: Schott glass, Ohara glass

Special glass: Fused Silica, Dynasil fused silica, color glass, float glass,...

Optical crystal: α -BBO, Calcite, CaF_2 , MgF_2 , Quartz, Sapphire, BaF_2 , MgO , Silicon, Ge, ZnSe, ZnS, , YVO_4 , LiNbO_3 , YAG...

Materials	Refractive Index	Transmission Range (μm)	Thermal Expansion Coefficient ($10^{-6}/\text{K}$)
BK7	1.5164 (588 nm)	0.330 - 2.1	7.5
SF11	1.78472(588nm)	0.370 - 2.5	6.8
SF14	1.76182(588 nm)	0.420 - 2.0	8.1
UVFS	1.4858 (308 nm)	0.185 - 2.5	0.54
CaF_2	1.399 (5.0 μm)	0.170 - 7.8	18.85
Sapphire	1.755 (1.0 μm)	0.180 - 4.5	8.4
Silicon	3.4179 (10 μm)	1.200 - 7.0	4.15
Ge	4.003 (10 μm)	1.900 - 16.	6.1
ZnSe	2.40 (10 μm)	0.630 - 18.	7.8
ZnS	2.2 (10 μm)	0.380 - 14.	6.5
MgF_2	$n_o=1.3836$ $n_e=1.3957$ (405nm)	0.130 - 7.0	a:13.7 b: 8.48
YVO_4	$n_o=1.9500$ $n_e=2.1554$ (1.3 μm)	0.400 - 5.0	a:4.46 b:11.37
Calcite	$n_o=1.6557$ $n_e=1.4852$ (633 nm)	0.210 - 2.3	a:24.39 b:5.68
Quartz	$n_o=1.5427$ $n_e=1.5518$ (633 nm)	0.200 - 2.3	7.07
α -BBO	$n_o=1.6749$ $n_e=1.5555$ (532 nm)	0.190 - 3.5	a:4.0 c: 36
LiNbO_3	$n_o=2.2863$ $n_e=2.2027$ (633 nm)	0.370 - 4.5	a:16.7 c: 2.0

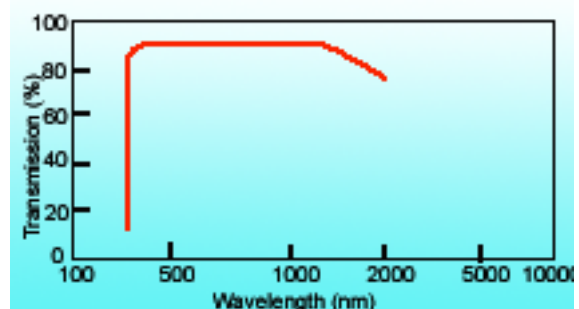
BK7

BK7 is a borosilicate crown optical glass with high homogeneity and low bubble and inclusion content. Its good physical and chemical properties make it widely used in visible NIR windows, lenses and prisms.

Transmission range: 330nm-2100nm

Thermal Expansion Coefficient: $7.5 \times 10^{-6}/\text{K}$

Density: $2.51 \text{g}/\text{cm}^3$





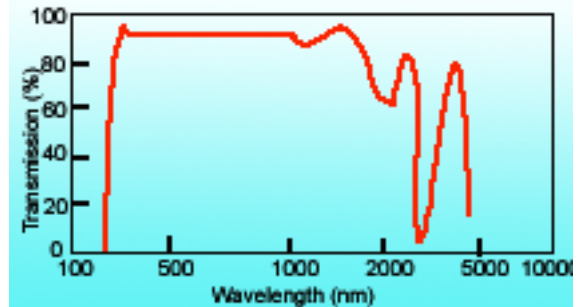
Fused Silica

Fused silica is formed by chemical combination of silica material include good UV and IR transmission, low coefficient of thermal expansion, providing stability and resistance to thermal operating range and high laser damage threshold. Used for windows, lenses, prisms and mirror substrates.

Transmission range: 185nm-2500nm

Thermal Expansion Coefficient: $0.54 \times 10^{-6}/K$

Density: 2.20g/cm^3



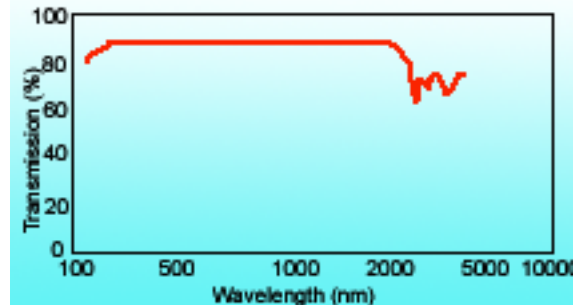
Crystal Quartz

Crystal quartz is a positive uniaxial birefringent single crystal. Crystal quartz is most commonly used for high damage threshold waveplates

Transmission range: 200nm-2300nm

Thermal Expansion Coefficient: $7.07 \times 10^{-6}/K$

Density: 2.65g/cm^3



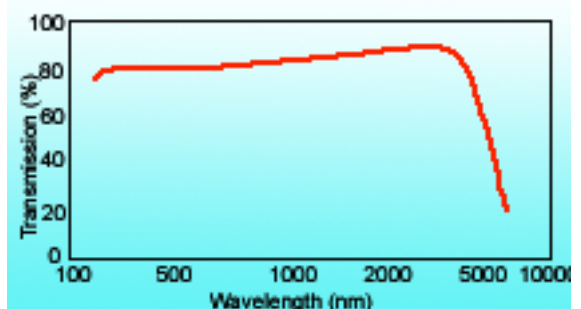
Sapphire

Sapphire is a single crystal aluminum oxide or Al_2O_3 and is one of the hardest materials, which have good transmission characteristics over the visible, and near IR spectrum. Sapphire exhibits high mechanical strength, chemical resistance and thermal stability. It is often used in environment where scratch resistance is importance.

Transmission range: 180nm-4500nm

Thermal Expansion Coefficient: $8.4 \times 10^{-6}/K$

Density: 3.98g/cm^3





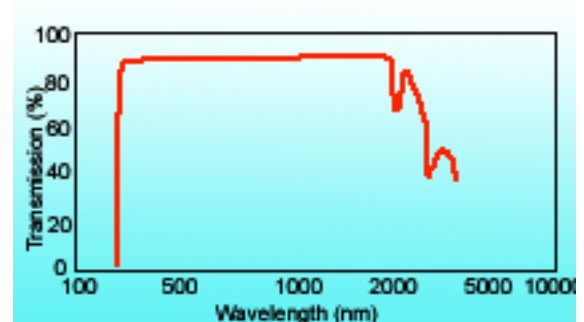
α-BBO crystal

α-BBO is an excellent crystal to replace Calcite in Glan-Taylor and Glan-Laser polarizers as well as walk-off beam splitters, especially for high power and UV polarizer, due to its unique UV transparency, good mechanical properties and high damage threshold. The physical, chemical, thermal and optical properties of α-BBO crystal are similar to those of β-BBO.

Transmission range:190nm-3500nm

Walk off angle @45° :5.3° (351nm),
5.0°(633nm)

Density:2.51g/cm³



Calcite

Calcite is a negative uniaxial crystal that has high birefringence, wide spectral transmission and availability in reasonably sized rhombs. Although it is a fairly soft crystal and easily scratched, it is an ideal material for visible and near IR polarizers, such as Glan Taylor, Glan Thompson and Glan laser.

Transparency Range: 350nm - 2300nm	<p>Transparency Curve of Calcite</p>
Particle Shape: Crystalline Rhombihedral	
Density: 2.7 g/cm ³	
Hygroscopic Susceptibility: low susceptibility to moisture	
Mohs Hardness: 3	
Thermal Expansion Coefficient: $\alpha_a = 24.39 \times 10^{-6}/K$; $\alpha_c = 5.68 \times 10^{-6}/K$	
Crystal Class: negative uniaxial with $n_o = n_a = n_b$, $n_e = n_c$	
Refractive Indices, Birefringence ($\Delta n = n_e - n_o$) and Walk-off Angle at 45° (ρ): $n_o = 1.6557$, $n_e = 1.4852$, $\Delta n = -0.1705$, $\rho = 6.20''$ at 0.63 μm $n_o = 1.6629$, $n_e = 1.4885$, $\Delta n = -0.1744$, $\rho = 6.32''$ at 1.30 μm	
Sellmeier Equation (λ in μm): $n_o^2 = 2.69705 + 0.0192064/(\lambda^2 - 0.01820) - 0.0151624\lambda^2$ $n_e^2 = 2.18438 + 0.0087309/(\lambda^2 - 0.01018) - 0.0024411\lambda^2$	

**CaF₂**

The CaF₂ is an excellent material in laser optics field. It has very wide transmission range from 130nm to 9500 nm, especially, has the high transmission in IR range. CaF₂ is widely used in Laser, IR and UV optics. It is slightly soluble in water and is susceptible to thermal shock.



Formula	CaF ₂					
Max. sizes	Ø180 mm					
Transmission range,	0.15 - 9.0 µm					
Density	3.18 g/cm ³					
Melting point	1418°C					
Hardness	4 Mohs					
Thermal expansion coef.	16.2-19.4 x10 ⁻⁶ /K					
Thermal conductivity	9.17 W m ⁻¹ K ⁻¹					
Specific heat capacity	888 J kg ⁻¹ K ⁻¹					
Solubility in water	0.0016 g/100 cm ³					
Wavelength (µm)	0.2	0.5	1.0	5.0	10.0	12.0
Refractive index	1.4951	1.4365	1.4289	1.3990	1.3002	1.2299
Absorption coefficient	0.10 at 0.2 µm;0.01 at 0.4 µm;0.03 at 2.7 µm(cm ⁻¹)					

Transparency Curve of CaF₂

MgF₂

Magnesium transmits well into the VUV region at the hydrogen Lyman-alpha line (121nm) and beyond. It is used for most UV optics and is excellent for excimer laser use.

Formula	MgF ₂						
Max. sizes	Ø80 mm						
Transmission range,	0.13 - 7.0µm						
Density	3.18 g/cm ³						
Melting point	1255°C						
Hardness	6 Mohs						
Specific heat	920 J kg ⁻¹ K ⁻¹						
Solubility in water	0.0076g/100 cm ³						
Thermal expansion Coefficient (10 ⁻⁶ /K)	parallel c-axis: 10.86 - 14.54 vertical c-axis: 6.23 - 9.25						
Wavelength (µm)	0.2	0.5	1.0	3.0	5.0	7.0	
Refractive index	n _o	1.4231	1.3797	1.3736	1.3618	1.3400	1.3044
	n _e	1.4367	1.3916	1.3852	1.3724	1.3487	1.3101
Absorption coef.	0.07 at 0.2 µm;0.02 at 5.0 µm(cm ⁻¹)						

Transparency Curve of MgF₂