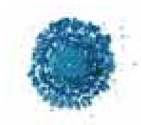
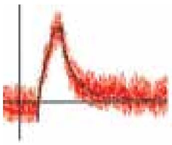
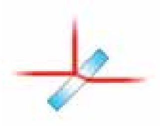
SOLUTIONS & SERVICES

We do following Quality Control Tests of various Optical components to guaranty the best performance of elements and constant repeatability

Laser Induced Damage Threshold (LIDT) Tests for wide range of laser wavelengths	**Total Scattering Measurements**	**Optical Absorption Tests** according to ISO 11551 standard	**Reflection/Transmission Tests** for wide range of laser wave-lengths
			

Laser Engraving

We provide laser-engraving services to our customer who buys our products and want to engrave initials of their own company or organization.

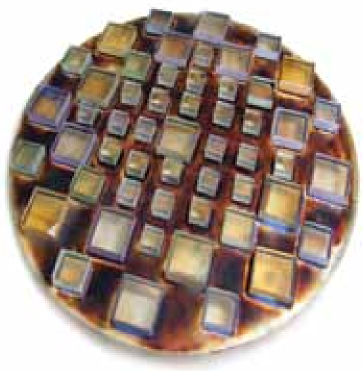
We engrave on optomechanics, plexiglass, crystal, leather, rubber, marble, ceramics and glass, among others. It is most suitable and the preferred choice of equipments in industries such as advertisement, gifts etc.

Please contact us for further information **info@altechna.com**

Repolishing and recoating

(recovers the damaged components)

Crystals after polishing



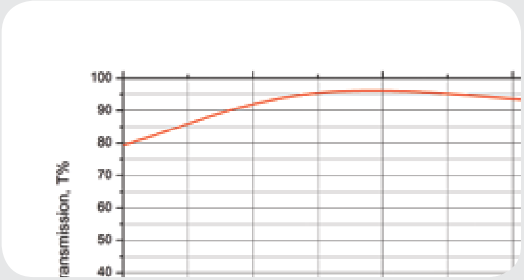
Polishing of the crystals

Altechna offer high quality **Repolishing** and **Recoatings** of damaged nonlinear and laser crystals, optical windows, laser mirrors or other optical components.

More about **Recoating** you can find at the **Coatings Section.**

APPENDIXES

Optical Materials



Description

Altechna offers a broad range of materials for variuos optical applications, suited for a wide range of customer goods as well as for industrial and scientific applications. Our range of optical glasses includes such popular materials as BK7, CaF_2, Sapphire , Fused Silica, MgF_2, Zinc Selenide Laser Grade, Calcite, Crystal Quartz and other infrared and ultraviolet materials. These are only examples and a small fragment of our capabilities. There are two instances in which you might need to know more about optical materials. First, you may need to determine the performance of a catalog component in a particular application. Second, you may need specific information when selecting the material for a custom component. The data in the following is intended to assist in these situations.

BK7 Optical Glass

Description

BK7 is a material used in a large fraction of "Altechna" products.

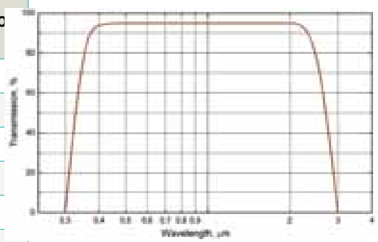
BK7 is a borosilicate crown optical glass with high homogeneity and low bubble and inclusion content. Its good physical and chemical properties (described below), inexpensiveness make it widely used in visible and NIR large variety optical components: windows, lenses or prisms.

Standard Specifications

Transmission Range	350 nm to 2.5 µm
Density	2.51 g/cm3
Thermal Expansion	7.1×10^{-6} /°K @ -30° + 70°C, & 8.3×10^{-6} /°K @ 20°C to 300°
Surface Finish	BK-7 polishes extremely well & polishes of 10-5, or 20-10 scratch-dig are achieved at extra costs respectively, mainly for UV & visible applications.
Surface Figure	Surface figure of 1/10 wave to 1/4 wave @ 0.6328µm are specified mostly on lenses for ultraviolet & visible use.
AR Coating Options	AR @ 0.8-2.5µm, AR @ 1.064, AR @ visible wavelength.
Products Manufactured	Lenses, Windows, Wedges, Prism, Beamsplitters, Filters.

BK7 Refractive Index

Wave-length (µm)	Index of Refractio (n)
0.4047	1.530
0.4800	1.523
0.5461	1.519
0.6328	1.515
0.8521	1.510
1.0600	1.507
1.5300	1.501
1.9700	1.495
2.3250	1.489



BK7 Transmission curve

Fused Silica (UV and IR Grade SiO_2)

Description

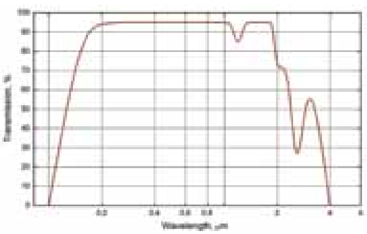
Fused silica is formed by chemical combination of silicon and oxygen. Advantages of fused silica material includes good UV and IR transmission, low thermal expansion, providing stability and resistance to thermal shock over large temperature excursions, wider thermal operating range and high laser damage threshold. UV grade fused silica offers both highest transmission (especially in deep-UV) and very low fluorescence levels. The material has high homogeneity and good transmission in the visible and near infrared spectral regions. Fused silica (FS) is an ideal optical material for many applications and is one of the base materials for windows, lenses, prisms and mirror substrates.

Standard Specifications

Transmission Range	0.18 µm to 2.5 µm (UV Grade), 0.25 µm to 3.5 µm (IR Grade)
Density	2.202 g/cm3
Thermal Expansion	5.5 x 10^{-7} /°C @ 20 to 320°C
Surface Finish	Fused Silica polishes extremely well & polishes of 10-5, or 20-10 scratch-dig are achieved at extra costs respectively, mainly for UV & visible applications.
Surface Figure	In the infrared, typical surface figure ranges from 1/4 wave to 2 waves @ 0.6328 µm & are specified depending on the system performance requirements. Surface figure of 1/10 wave to 1/4 wave @ 0.6328 µm are specified mostly on lenses for ultraviolet & visible use.
AR Coating Options	Typical available infrared coatings are a BBAR from 0.8 - 2.5 µm & an AR coating for 1.064 µm wavelength.
Products Manufactured	Lenses, Windows, Wedges, Optical Beamsplitters, Optical Filters, Prism.

FS Refractive Index

Wavelength (µm)	Index of Refraction (n)
0.1850	1.575
0.1700	1.615
0.2144	1.5337
0.3021	1.4872
0.4046	1.4696
0.4358	1.4666
0.5461	1.4601
0.6438	1.4567
0,8621	1.4525
1.0830	1.4494
1.3950	1.4458
1.7091	1.4421
2.0581	1.4372
3.2439	1.4131



UVFS Transmission curve

Calcium Fluoride (CaF_2)

Description

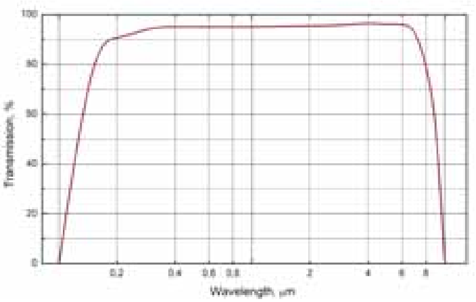
Calcium Fluoride can be used in the ultraviolet, visible and infrared spectral regions. Calcium Fluoride has a transmission above 90% between 0.25 and 7μm. Calcium Fluoride is twice as hard as Barium Fluoride and also less susceptible to thermal shock. However, it is commonly used in cryogenically cooled thermal imaging systems. It is less expensive than Barium Fluoride. CaF_2 is diamond turnable. It has good transmission from 170 nm to 7800nm. It is slightly soluble in water and is susceptible to thermal shock. Common uses of CaF_2 include IR components such as windows, lenses and prisms.

Standard Specifications

Transmission Range	0.13 μm to 7.0 μm
Density	3.18 g/cm3
Thermal Expansion	18.85×10^{-6} /°C
Surface Finish	Polishes of 20-10 scratch-dig are mostly specified for use in UV & visible applications. Typical specifications for surface quality in the infrared are a 40-20 scratch dig in the 0.75 to 3 μm spectral region & 60-40 scratch-dig for the 3-7 μm area.
Surface Figure	In the UV & Visible spectral regions, surface figure ranges from 1/10 wave to 1/4 wave @ 0.6328 μm. In the infrared, typical required surface figure ranges from 1/4 wave to 2 waves @ 0.6328 μm & are specified depending on the system performance requirements.
AR Coating Options	Available coatings for CaF2 include BBAR for 0.8 to 2.5 μm, 3 to 5μm or the 1 to 5 μm spectral regions.
Products Manufactured	Lenses, Aspheric lenses, windows, Optical Beamsplitters, Optical Filters, Wedges, Prisms.

CaF_2 Refractive Index

Wavelength (μm)	Index of Refraction (n)
0.2	1.4951
0.5	1.4365
1.0	1.4289
2.0	1.4239
3.0	1.4179
4.0	1.4096
5.0	1.3990
6.0	1.3856
7.0	1.3693
8.0	1.3498
9.0	1.3268
10.0	1.3002
11.0	1.2676



CaF_2 Transmission curve

Magnesium Fluoride (MgF_2)

Description

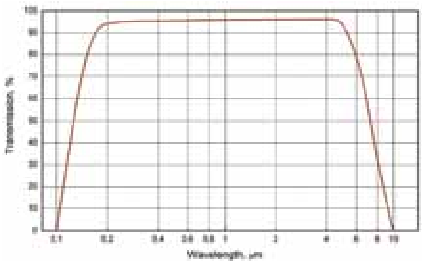
Magnesium Fluoride is used for optical elements in both the infrared and ultraviolet. Its useful transmission range is from 0.19µm; to 6.5µm. The refractive index varies from about 1.48 to 1.3. Magnesium Fluoride is a bi-refringence material and this aspect should be taken into consideration before selection of this material in an optical design. Magnesium Fluoride is one of the lowest index infrared materials, second only to Lithium Fluoride. It is resistant to thermal and mechanical shock. The material is twice as hard as Calcium Fluoride but only half as hard as Germanium. Magnesium Fluoride is significantly more expensive than Calcium Fluoride and Barium Fluoride, but usually not more expensive than Lithium Fluoride. Magnesium Fluoride is similar to Calcium Fluoride in its resistance to water.

Standard Specifications

Transmission Range	0.121 µm to 7.0 µm
Density	3.177 g/cm3
Thermal Expansion	13.7 x 10^{-6} /°C Parallel to C-axis
Surface Finish	Polishes of 10-5, or 20-10 scratch-dig are achieved at extra costs respectively mainly for UV applications. Typical specifications for surface quality in the visible & near infrared regions are a 40-20 & 60-40 scratch dig in the 3 to 7 µm range. MgF2 is diamond turnable.
Surface Figure	In the UV & Visible spectral regions, surface figure ranges from 1/10 wave to 1/2 wave @ 0.6328 µm. In the infrared, typical required surface figure ranges from 1/2 wave to 2 waves @ 0.6328 µm & are specified depending on the system performance requirements.
AR Coating Options	Magnesium Fluoride can be AR coated for use in the infrared but generally without much improvement in transmission due to its low index of refraction & already high transmission.
Products Manufactured	Lenses, Aspheric lenses, Windows, Optical Beamsplitters, Optical Filters, Wedges, Prisms.
Products Manufactured	Lenses, Windows, Wedges, Optical Beamsplitters, Optical Filters, Prism.

MgF2 Refractive Index

Wavelength (µm)	Index of Refraction	
	n_o	n_e
0.2	1,4231	1,4367
0.5	1,3797	1,3916
1.0	1,3736	1,3852
2.0	1,3686	1,3797
3.0	1,3618	1,3724
4.0	1,3525	1,3622
5.0	1,3400	1,3487
6.0	1,3242	1,3315



MgF2 Transmission curve

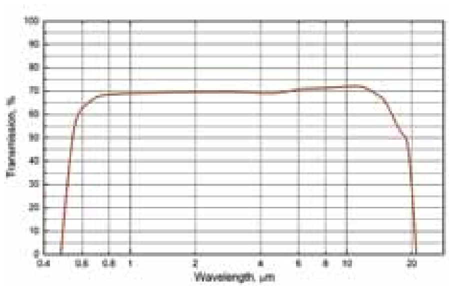
Zinc Selenide (ZnSe)

Description

Zinc Selenide is used for infrared windows, lenses, and prisms where transmission in the range 0.63µm to 18µm is desired. Zinc Selenide has a very low absorption co-efficient and is used extensively for high power infrared laser optics. It is non-hygroscopic. Zinc Selenide is a relatively soft material and scratches rather easily. The low absorption of the material avoids the thermal runaway problems of Germanium. Zinc Selenide requires an anti-reflection coating due to its high refractive index if high transmission is required. ZnSe has a fairly low dispersion across its useful transmission range. Zinc Selenide, a chemically vapor deposited material, is the material of choice for optics used in high power CO2 laser systems due to its low absorption at 10.6µm. However it is also a popular choice in systems operating at various bands within its wide transmission range. ZnSe has a high resistance to thermal shock making it the prime material for high power CO2 laser systems.

Standard Specifications

Transmission Range	0.6 µm to 16 µm
Density	5.27 g/cm3
Thermal Expansion	7.1 x 10^{-6} /°K @ 273°K, 7.8 x 10^{-6} /°K @ 373°K, 8.3 x 10^{-6} /°K @ 473°K
Surface Finish	Typical specifications for surface quality in the infrared are 40-20 or 60-40 scratch-dig in the 0.8 to 7µm spectral region & 60-40, 80-50 or 120-80 scratch-dig for the 7 to 16µm area, depending upon system performance requirements. Diamond Turned surface finishes of 150 Å rms or better are typical.
Surface Figure	In the infrared, typical required surface figures range from 1/2 wave to 2 waves @ 0.6328 µm depending on the system performance requirements.
AR Coating Options	Typical available coatings for ZnSe include BBAR for 0.8 to 2.5 µm, 3 to 5 µm, 1 to 5 µm, 8 to 12 µm, & the 3 to 12 µm spectral regions & single wavelength coating AR at 10.6 µm. Many other specialized wavelength bands are possible within the 0.6 to 16 µm range.
Products Manufactured	Lenses, Aspheric Lenses, Binary (diffractive) Lenses, Windows, Optical Beamsplitters, Optical Filters, Prism.



ZnSe Transmission curve

ZnSe Refractive Index

Wavelength (µm)	Index of Refraction (n)
0,58	2,6754
1	2,4892
3	2,4376
5	2,4295
7	2,4218
9	2,4122
10,6	2,4028
11	2,4001
13	2,3850
15	2,3623
17	2,3448

Germanium (Ge)

Description

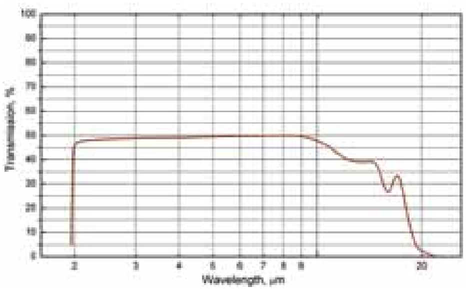
Germanium has the highest index of refraction of any commonly used infrared transmitting materials. Its refractive index is such that Germanium makes an effective natural 50% beamsplitter without the need for coatings. Germanium is also used extensively as a substrate for production of optical filters. Germanium is a high index material that is used to manufacture Attenuated Total Reflection (ATR) prisms for spectroscopy. It is a very popular material for systems operating in the 3-5 or 8-12µm spectral regions. Germanium blocks UV and visible light and in the infrared up to about 2µm. Its high index is desirable for the design of lenses that might not otherwise be possible. Germanium has nearly the highest density of the infrared transmitting materials and this should be taken into consideration when designing for weight restricted systems. Germanium is subject to thermal runaway, meaning that the hotter it gets, the more the absorption increases. Pronounced transmission degradation starts at about 100°C and begins rapidly degrading between 200°C and 300°C, resulting in possible catastrophic failure of the optic. Germanium can be AR coated with Diamond producing an extremely tough front optic.

Standard Specifications

Transmission Range	2 µm to 14 µm
Density	5.33 g/cm3
Thermal Expansion	2.3 x 10^{-6} /°K @ 100°K, 5.0 x 10^{-6}/°K @ 200°K, 6.0 x 10^{-6}/°K @ 300°K
Surface Finish	Typical specifications for surface quality in the infrared are 40-20 or 60-40 scratch-dig in the 2 to 7 µm spectral region & 60-40, 80-50 or 120-80 scratch- dig for the 7-14 µm area, depending upon system performance requirements. Diamond turned surface finishes of 120 Å rms or better are typical.
Surface Figure	In the infrared, typical surface figure ranges from 1/2 wave to 2 waves @ 0.6328 µm depending on the system performance requirements.
AR Coating Options	Typical available coatings for Germanium include BBAR for 3 to 5 µm, 8 to 12 µm, & the 3 to 12 µm spectral regions. Many application specialized bands are possible between the 2 & 14 µm.
Products Manufactured	Lenses, Aspheric Lenses, Binary (Diffractive) Lenses, Windows, Optical Beamsplitters, Optical Filters, Wedges, Prisms.
Products Manufactured	Lenses, Windows, Wedges, Optical Beamsplitters, Optical Filters, Prism.

Ge Refractive Index

Wavelength (µm)	Index of Refraction (n)
2	4,1079
3	4,0446
4	4,0242
6	4,0106
8	4,0053
10	4,0040
12	4,0029
15	4,0017



Ge Transmission curve

Sapphire (Al_2O_3)

Description

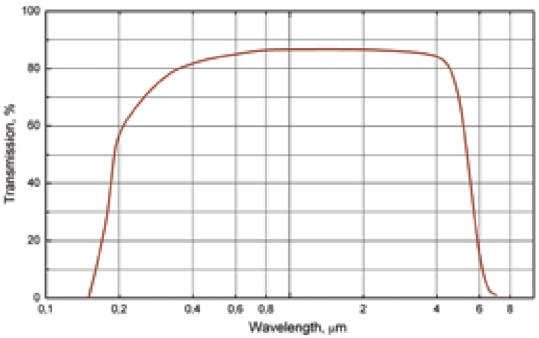
Sapphire is grown by a variety of methods. Verneuil and Czochralski methods are usual for standard grade Sapphire material. Higher quality Sapphire, particularly for electronic substrates is manufactured by Kyropulos growth and this can be very pure with excellent UV transmission. Large thin sheets of Sapphire can be made by ribbon growth. Sapphire is slightly birefringent, general purpose IR windows are usually cut in a random way from crystal but for specific applications where the birefringence is an issue, an orientation is selected. Usually this is with the optic axis at 90 degrees to the surface plane and is known as “zero degree” material. Synthetic optical sapphire has no colouration. Sapphire is used for its extreme toughness and strength because it is one of the hardest materials. Sapphire is a very useful optical window material for use in the UV, visible, and near infra-red. It has 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 important.

Standard Specifications

Transmission Range	0.17 µm to 5.5 µm
Density	3.97g/cm3
Thermal Expansion	6.66 x 10^{-6} @ 323K, 5 x 10^{-6} 10^{-6} @ 323K
AR Coating Options	Typical available coatings for Sapphire include BBAR for various spectral regions. Many application specialized bands are possible between the 0.2 & 5.5 µm.
Products Manufactured	Lenses, prisms and other laser and infrared optics are fabricated from high optical quality sapphire.

Sapphire Refractive Index

Wave-length (µm)	Index of Refraction	
	no	ne
1,0	1,7545	1,7460
2,0	1,7374	1,7299
3,0	1,7015	1,6920
4,0	1,6748	1,6679



Sapphire Transmission curve

Useful formulas & constants

Material (transmission range, µm)	**Refraction index @ 355 nm, 20 °C**	**Refraction index @ 532 nm, 20 °C**	**Refraction index @ 800 nm, 20 °C**	**Refraction index @ 1064 nm, 20 °C**	**Refraction index @ 2000 nm, 20 °C**
ZnSe (0.50-20.00)	---------	n = 2.696	n = 2.524	n = 2.485	n = 2.447
Silicon (1.200 – 7.0)	n = 5.63 and k = 3.15	n = 4.20 and k = 0.01	n = 3.71 and k = 0.01	n = 3.60 and k = 0.00	n = 3.49 and k = 0.00
Sapphire (0.180 – 4.5)	n_o = 1.7960, n_e = 1.7873 at 24 °C	n_o = 1.7718, n_e = 1.7636 at 24 °C	n_o = 1.7603, n_e = 1.7524 at 24 °C	n_o = 1.7546, n_e = 1.7469 at 24 °C	n_o = 1.7375, n_e = 1.7299 at 24 °C
MgF2 (0.130 – 7.0)	no = 1.3870, ne = 1.3992	n_o = 1.3789, n_e = 1.3908	n_o = 1.3751, n_e = 1.3867	n_o = 1.3732, n_e = 1.3848	n_o = 1.3678, n_e = 1.3791
BK7 (0.36 – 2.3)	---------	n = 1.51947	n = 1.51078	n = 1.50663	n = 1.4945
Fused silica (0.185 – 2.5)	n = 1.47607	n = 1.46071	n = 1.45332	n = 1.44963	n = 1.43809
Quartz (0.200 – 2.3)	n_o = 1.5646, n_e = 1.5744	n_o = 1.5469, n_e = 1.5561	n_o = 1.5383, n_e = 1.5472	n_o = 1.5341, n_e = 1.5428	n_o = 1.5209, n_e = 1.5291
SF11 (0.370 – 2.5)	---------	n = 1.79479	n = 1.76475	n = 1.75434	n = 1.73799
CaF2 (0.170 – 7.8)	n = 1.44597 at 24 °C	n = 1.43537 at 24 °C	n = 1.43053 at 24 °C	n = 1.42848 at 24 °C	n = 1.42386 at 24 °C
Crystals (transmission range, µm)	**Refraction index @ 355 nm, 20 °C**	**Refraction index @ 532 nm, 20 °C**	**Refraction index @ 800 nm, 20 °C**	**Refraction index @ 1064 nm, 20 °C**	**Damage thresh-old (10 ns, 1064 nm)**
LiNbO3 (0.4 – 4.0)	---------	n_o = 2.32505, n_e = 2.23278	n_o = 2.25722, n_e = 2.17507	n_o = 2.23402, n_e = 2.15519	100 MW/cm²
KTP (0.35 – 4.5)	n_x = 1.86702 n_y = 1.8893 n_z = 2.03425	n_x = 1.77846 n_y = 1.78917 n_z = 1.88935	n_x = 1.74896 n_y = 1.75719 n_z = 1.84546	n_x = 1.7809 n_y = 1.74579 n_z = 2.83018	1 GW/cm²
KDP (0.2 – 1.5)	n_o = 1.52228, n_e = 1.48624 at 24.8 °C	n_o = 1.50511, n_e = 1.47089 at 24.8 °C	n_o = 1.49801, n_e = 1.46371 at 24.8 °C	n_o = 1.49564, n_e = 1.46027 at 24.8 °C	5 GW/cm²
BBO (0.186 – 3.3)	n_o = 1.70550, n_e = 1.57745	n_o = 1.67497, n_e = 1.55551	n_o = 1.66137, n_e = 1.54618	n_o = 1.65513, n_e = 1.54256	4.5 GW/cm²
Nd:YAG (0.19 – 3.8)	---------	n = 1.8417	n = 1.8245	n = 1.8180	750 MW/cm²

Index of refraction: Materials of greater density have a higher index of refraction

$$n \equiv \frac{c}{v} \qquad n = \frac{\lambda_0}{\lambda_n}$$

n = index of refraction
c = speed of light in a vacuum - 3×10^8 m/s
v = speed of light in the material [m/s]
λ_0 = wavelenght of the light in a vacuum [m]
λ_n = its wavelenght in the material [m]

Law of Refraction: **Snell's Law**

$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

travelling to a region of lesser density $\theta_2 > \theta_1$

n = index of refraction
θ = angle of incidence travelling to a region of greater density: $\theta_2 < \theta_1$

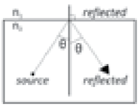
Lensmaker's Equation for a thin lens in air

$$\frac{1}{f} = \frac{1}{p} + \frac{1}{i} = (n-1)\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$$

f = focal length [m]
i = image distance [m]
p = object distance [m]
n = index of refraction [m]
r_1 = radius of surface nearest to the object [m]
r_2 = radius of surface nearest to the image[m]

Critical angle: The maximum angle of incidence for which light can move from n_1 to n_2

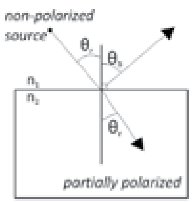
$$\sin\theta_c = \frac{n_2}{n_2} \quad \text{for } n_1 > n_2$$



Brewster angle:

$$\tan\theta_B = \frac{n_2}{n_1} \qquad \theta_r + \theta_B = 90°$$

n = index of refraction
θ_B = angle of incidence producing a 90° angle between reflected and refracted rays
θ_r = angle of incidence of the refracted ray



Fresnel's laws can besummarized in the following two equations which give the reflectance of the s- and p-polarized components

$$r_s = \left[\frac{\sin(\theta_1 - \theta_2)}{\sin(\theta_1 + \theta_2)}\right]^2 \qquad r_p = \left[\frac{\tan(\theta_1 - \theta_2)}{\tan(\theta_1 + \theta_2)}\right]^2$$

In the limit of normal incidence in air, we got

$$r = \left(\frac{n-1}{n+1}\right)^2$$