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Optical Materials

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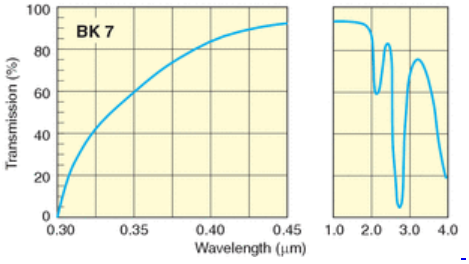
Product Detail

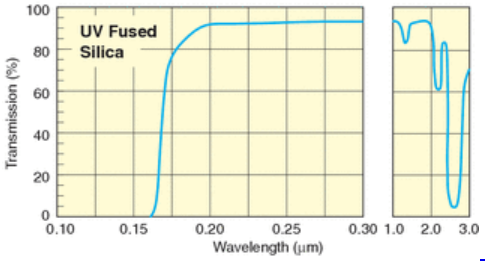
BK 7

BK 7 is one of the most common borosilicate crown glasses used for visible and near infrared optics. Its high homogeneity, low bubble content, and straightforward manufacturability make it a good choice for transmissive optics. The transmission range for BK 7 is 380–2100 nm. It is not recommended for temperature sensitive applications, such as precision mirrors.



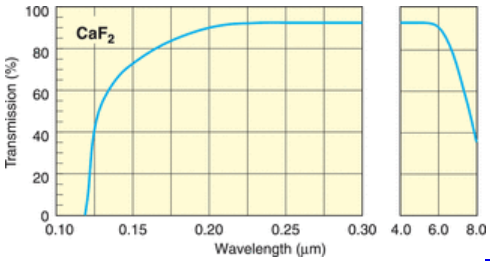
UV Grade Fused Silica

UV Grade Fused Silica is synthetic amorphous silicon dioxide of extremely high purity. This non-crystalline, colorless silica glass combines a very low thermal expansion coefficient with good optical qualities, and excellent transmittance in the ultraviolet. Transmission and homogeneity exceed those of crystalline quartz without the problems of orientation and temperature instability inherent in the crystalline form. Fused silica is used for both transmissive and reflective optics, especially where high laser damage threshold is required.



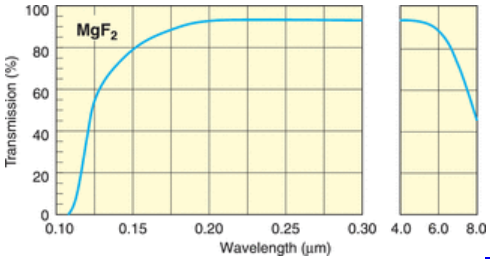
CaF_2

Calcium Fluoride is a cubic single crystal material grown using the vacuum Stockbarger Technique with good vacuum UV to infrared transmission. CaF_2 has excellent UV transmission, down to 170 nm, and its non-birefringent properties make it ideal for deep UV transmissive optics. Material for IR use is grown using naturally mined fluorite, at much lower cost. CaF_2 is sensitive to thermal shock, so care must be taken during handling.



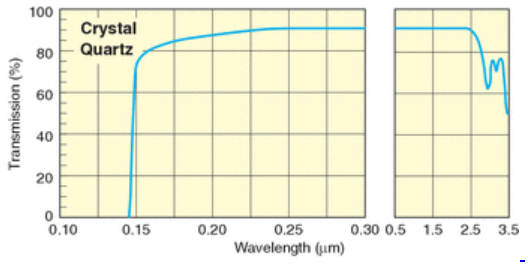
MgF_2

Magnesium Fluoride is a positive birefringent crystal grown using the vacuum Stockbarger Technique with good vacuum UV to infrared transmission. It is typically oriented with the c axis parallel to the optical axis to reduce birefringent effects. High vacuum UV transmission, down to 150 nm, and its proven use in fluorine environments make it ideal for lenses, windows, and polarizers for Excimer lasers. MgF_2 is resistant to thermal and mechanical shock.



Crystal Quartz

Crystal Quartz is a positive uniaxial birefringent single crystal grown using a hydrothermal process. It has good transmission from the vacuum UV to the near infrared. Due to its birefringent nature, crystal quartz is commonly used for wave plates.



Pyrex®

Pyrex® is a borosilicate glass with a low coefficient of thermal expansion. It is mainly used for non-transmissive optics, such as mirrors, due to its low homogeneity and high bubble content.

Zerodur®

Zerodur® is a glass ceramic material that has a coefficient of thermal expansion approaching zero, as well as excellent homogeneity of this coefficient throughout the entire piece. This makes Zerodur ideal for mirror substrates where extreme thermal stability is required. Zerodur should not be used for transmissive optics due to inclusions in the material.

Properties of Optical Materials

	Abbe Number Vd	Coefficient of Thermal Expansion (10^{-6}/°C)	Conductivity (W/m°C)	Heat Capacity (J/gm°C)	Density at 25°C (gm/cm^3)	Knoop Hardness (kg/mm^2)	Young's Modulus (GPa)
BK 7	64.17	7.1	1.114	0.858	2.51	610	81.5
SF 2	33.85	8.4	0.735	0.498	3.86	410	55
UV Fused Silica	67.8	0.52	1.38	0.75	2.202	600	73
CaF_2	94.96	18.85	9.71	0.85	3.18	158	75.8
MgF_2	106.18	13.7 ‖ to c axis 8.48 ⊥ to c axis	21 ‖ to c axis 30 to ⊥ c axis	1.024	3.177	415	138.5
Crystal Quartz	69.87	7.1 to ‖ c axis 13.2 ⊥ to c axis	10.4 ‖ to c axis 6.2 ⊥ to c axis	0.74	2.649	740	97 ‖ to c axis 76.5 ⊥ to c axis
Pyrex®	66	3.25	1.13	0.75	2.23	418	65.5
Zerodur®	56.09	0 ± 0.1	1.46	0.80	2.53	620	90.3

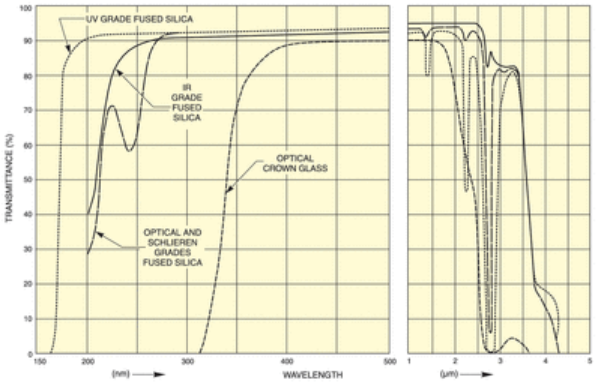
Index of Refraction

Wavelength (nm)	Source	BK 7	SF 2	UV Fused Silica	CaF_2	MgF_2 n_o	MgF_2 n_e	Crystal Quartz n_o	Crystal Quartz n_e
193	ArF excimer laser	1.65528	1.52127	1.56077	1.50153	1.42767	1.44127	1.66091	1.67455
244	Ar-Ion laser	1.58265	1.98102	1.51086	1.46957	1.40447	1.41735	1.60439	1.61562
248	KrF excimer	1.57957	1.93639	1.50855	1.46803	1.40334	1.41618	1.60175	1.61289
257	Ar-Ion laser	1.57336	1.86967	1.50383	1.46488	1.40102	1.41377	1.59637	1.60731
266	Nd:YAG laser	1.56796	1.82737	1.49968	1.46209	1.39896	1.41164	1.59164	1.60242
308	XeCl excimer laser	1.55006	1.73604	1.48564	1.45255	1.39188	1.40429	1.57556	1.58577
325	HeCd laser	1.54505	1.71771	1.48164	1.44981	1.38983	1.40216	1.57097	1.58102
337.1	N_2 laser	1.54202	1.70749	1.47919	1.44813	1.38858	1.40085	1.56817	1.57812
351	XeF excimer laser	1.53896	1.69778	1.47672	1.44642	1.38730	1.39952	1.56533	1.57518
351.1	Ar-Ion laser	1.53894	1.69771	1.47671	1.44641	1.38729	1.39951	1.56531	1.57516
354.7	Nd:YAG laser	1.53821	1.69548	1.47612	1.44601	1.38699	1.39920	1.56463	1.57446
363.8	Ar-Ion laser	1.53649	1.69029	1.47472	1.44504	1.38626	1.39844	1.56302	1.57279
404.7	Mercury arc, h line	1.53023	1.67263	1.46961	1.44151	1.38360	1.39567	1.55714	1.56670
416	Kr-Ion laser	1.52885	1.66893	1.46847	1.44072	1.38301	1.39505	1.55583	1.56535
435.8	Mercury arc,g line	1.52669	1.66331	1.46670	1.43949	1.38207	1.39408	1.55379	1.56323
441.6	HeCd laser	1.52611	1.66184	1.46622	1.43916	1.38183	1.39382	1.55324	1.56266
457.9	Ar-Ion laser	1.52461	1.65807	1.46498	1.43830	1.38118	1.39314	1.55181	1.56119
465.8	Ar-Ion laser	1.52395	1.65641	1.46443	1.43792	1.38088	1.39284	1.55118	1.56053
472.7	Ar-Ion laser	1.52339	1.65505	1.46397	1.43760	1.38064	1.39258	1.55065	1.55998
476.5	Ar-Ion laser	1.52309	1.65432	1.46372	1.43744	1.38051	1.39245	1.55036	1.55969
480	Cadmium arc, F' line	1.52283	1.65367	1.46350	1.43728	1.38040	1.39233	1.55011	1.55943
486.1	Hydrogen arc, F line	1.52238	1.65258	1.46313	1.43703	1.38020	1.39212	1.54968	1.55898
488	Ar-Ion laser	1.52224	1.65225	1.46301	1.43695	1.38014	1.39206	1.54955	1.55885
496.5	Ar-Ion laser	1.52165	1.65083	1.46252	1.43661	1.37988	1.39179	1.54898	1.55826
501.7	Ar-Ion laser	1.52130	1.65000	1.46223	1.43641	1.37973	1.39163	1.54865	1.55792
510.6	Cu vapor laser	1.52073	1.64865	1.46176	1.43609	1.37948	1.39137	1.54810	1.55735
514.5	Ar-Ion laser	1.52049	1.64808	1.46156	1.43595	1.37937	1.39126	1.54787	1.55711
532	Nd:YAG laser	1.51947	1.64570	1.46071	1.43537	1.37892	1.39079	1.54689	1.55610
543.5	HeNe laser	1.51886	1.64427	1.46019	1.43502	1.37865	1.39051	1.54630	1.55549
546.1	Mercury arc, e line	1.51872	1.64397	1.46008	1.43494	1.37859	1.39044	1.54617	1.55535
578.2	Cu vaport laser	1.51720	1.64053	1.45880	1.43408	1.37792	1.38974	1.54470	1.55383
587.6	Helium arc, d line	1.51680	1.63963	1.45846	1.43385	1.37774	1.38956	1.54431	1.55343
589.3	Sodium arc, D line	1.51673	1.63947	1.45840	1.43381	1.37771	1.38952	1.54424	1.55336
594.1	HeNe laser	1.51653	1.63904	1.45824	1.43370	1.37762	1.38943	1.54405	1.55316
611.9	HeNe laser	1.51584	1.63752	1.45765	1.43331	1.37732	1.38911	1.54337	1.55247
628	Ruby laser	1.51526	1.63626	1.45716	1.43298	1.37706	1.38884	1.54281	1.55188
632.8	HeNe laser	1.51509	1.63590	1.45702	1.43289	1.37698	1.38876	1.54264	1.55171
635	Laser diode	1.51501	1.63574	1.45695	1.43284	1.37695	1.38873	1.54257	1.55164
643.8	Cadmium arc, C' line	1.51472	1.63512	1.45671	1.43268	1.37682	1.38859	1.54228	1.55134
647.1	Kr-Ion laser	1.51461	1.63489	1.45661	1.43262	1.37677	1.38854	1.54218	1.55123
650	Laser diode	1.51452	1.63469	1.45653	1.43257	1.37673	1.38850	1.54209	1.55114
656.3	Hydrogen arc, C line	1.51432	1.63427	1.45637	1.43246	1.37664	1.38840	1.54189	1.55093
670	Laser diode	1.51391	1.63340	1.45601	1.43223	1.37646	1.38821	1.54148	1.55051
676.4	Kr-Ion laser	1.51372	1.63301	1.45585	1.43212	1.37637	1.38812	1.54130	1.55032
694.3	Ruby laser	1.51322	1.63198	1.45542	1.43185	1.37615	1.38789	1.54080	1.54981
750	Laser diode	1.51184	1.62922	1.45424	1.43109	1.37553	1.38724	1.53943	1.54839
780	Laser diode	1.51118	1.62796	1.45367	1.43074	1.37524	1.38693	1.53878	1.54771
830	Laser diode	1.51020	1.62613	1.45282	1.43023	1.37480	1.38647	1.53779	1.54668
850	Laser diode	1.50984	1.62548	1.45250	1.43004	1.37464	1.38630	1.53742	1.54630

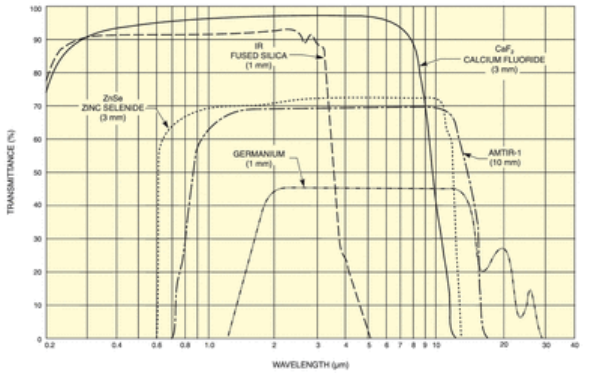
852.1	Cesium arc, s line	1.50980	1.62541	1.45247	1.43002	1.37462	1.38628	1.53739	1.54626
905	Laser diode	1.50892	1.62387	1.45168	1.42957	1.37422	1.38586	1.53648	1.54532
980	Laser diode	1.50779	1.62202	1.45067	1.42902	1.37371	1.38533	1.53531	1.54409
1014	Mercury arc, t line	1.50731	1.62128	1.45024	1.42879	1.37350	1.38510	1.53481	1.54357
1053	Nd:YLF laser	1.50678	1.62049	1.44976	1.42854	1.37326	1.38485	1.53425	1.54299
1060	Nd:Glass laser	1.50669	1.62035	1.44968	1.42850	1.37322	1.38480	1.53415	1.54288
1064	Nd:YAG laser	1.50663	1.62028	1.44963	1.42848	1.37319	1.38478	1.53410	1.54282
1300	Laser diode	1.50370	1.61644	1.44692	1.42721	1.37188	1.38338	1.53094	1.53950
1320	Nd:YAG laser	1.50346	1.61616	1.44669	1.42711	1.37177	1.38327	1.53068	1.53922
1550	Laser diode	1.50065	1.61312	1.44402	1.42602	1.37052	1.38194	1.52761	1.53596
1970.1	Mercury arc	1.49495	1.60780	1.43852	1.42401	1.36803	1.37928	1.52138	1.52932
2100	Ho:YAG laser	1.49296	1.60608	1.43659	1.42334	1.36718	1.37837	1.51924	1.52703
2325.4	Mercury arc	1.48921	1.60291	1.43293	1.42212	1.36559	1.37667	1.51524	1.52277
2940	Er:YAG laser	1.47670	1.59273	1.42065	1.41827	1.36051	1.37123	1.50246	1.50908

Transmittance of Optical Materials

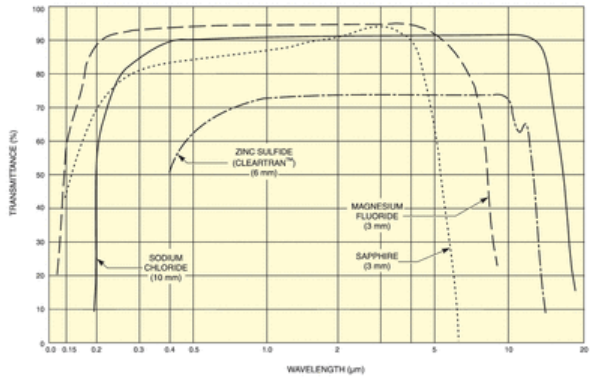
These graphs compare the transmission of standard optical materials. The transmission values listed here are equivalent to "external transmittance" and takes into consideration the reflectances you get from uncoated optical elements.



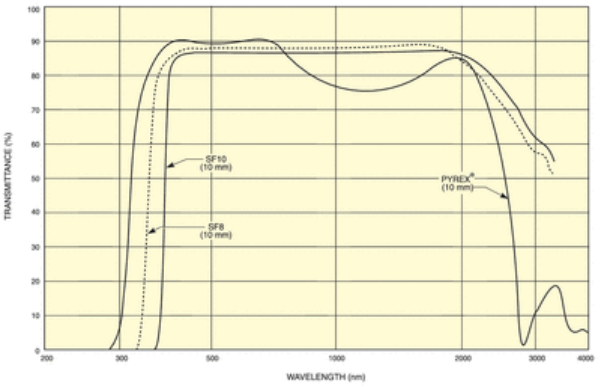
Transmission of 10 mm thick fused silica, BK7, and crown glass windows.



Transmittance of IR optical materials.



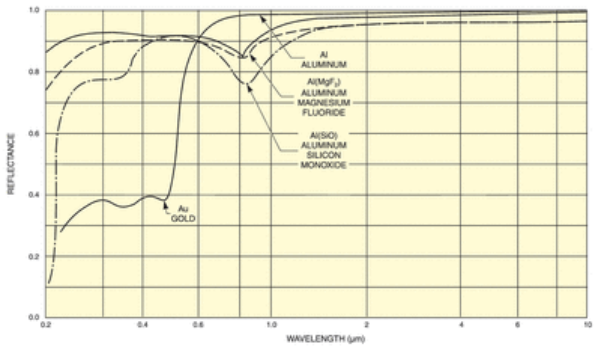
Transmittance of UV-IR materials.



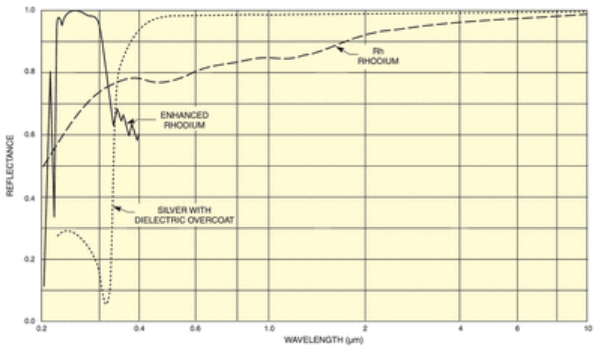
Transmittance of VIS-NIR materials.

Reflectance of Optical Materials

All metal reflectors deteriorate slowly in polluted atmosphere. Cumulative exposure to intense ultraviolet radiation also affects performance; overheating of the reflective surface will destroy the reflector.



Typical near normal incidence reflectance of freshly deposited Al, $AlMgF_2$, AlSiO, and Au.



Typical near normal incidence reflectance of Rhodium, enhanced Rhodium, and Silver with Dielectric orvercoat.

The enhanced rhodium coating has been optimized for high performance in the ultraviolet, a wide range of angles of incidence and longevity. It is the most efficient and durable coating available for ellipsoidal reflectors. The $AlMgF_2$ coating has been optimized for performance in the near UV.

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