CaF_2
Calcium Fluoride

Calcium fluoride is used for optical purposes as windows, prisms and lenses transmitting from the vacuum ultraviolet into the infrared.

CaF_2 is useful in both the ultraviolet and infrared. Due to its composition CaF_2 has a much longer usable lifetime than most materials operating in a fluorine environment.

Properties

Solubility[1]: 1.6 x 10^{-3}g/100g H_20 at 18°C. 1.7 x $l0^{-3}$g/100g H_20 at 26°C.

Refractive Index: Data in vacuum ultraviolet region from 0.131 to To 0.182μ obtained by Handke[2] on natural crystals at 18°C. The data vary from 1.6921 at 0.1311μ to 1.5152 at 0.1810μ. The new data[3] on natural and synthetic materials starts at 0.2288μ and covers the spectral region up to 9.724μ. The refractive index varies from 1.47635 at 0.2298μ to 1.30756 at 9.724μ for 19°C. For this region a dispersion (after Sellmeier[12]):

$$n^2 - 1 = \frac{0.5675888\lambda^2}{\lambda^2 - 0.050263605^2} + \frac{0.4710914\lambda^2}{\lambda^2 - 0.100390^2} + \frac{3.8484723\lambda^2}{\lambda^2 - 34.649040^2}$$

is valid to the fifth significant figure. For the intermediate region from 0.1819μ to 0.2286μ, the data by Harting[4] can be used. The data for natural and synthetic CaF_2 crystals agree perfectly.

Temperature Coefficient *(dn/dT)*: According to Mailtson[3] this varies from – 6.2x10^{-6}/°C at 0.2288μ to – 5.6x10^{-6}/°C. at 9.724μ with a minimum of – 10.6x10^{-6}/°C at 0.852μ. Refractive indices from 0.546 μ to 1.85μ have also been measured at – 18O°C[5].

Dispersion *(dn/dλ)*: Given by Malitson[3], decreases from 0.5819 at 022μ to a minimum of 0.0046 at 1.6μ and then increases to 0.0264 at 9.8μ.

Transmission Range: Ultraviolet sharp cutoff: 0.125μ[6,7], 1.22mm sample. Temperature influence on ultraviolet cutoff between 27°C and 128°C[8]. Infrared sharp cutoff: 12μ[8] 1.19mm sample.

Reflection Loss: For n_D = 1.434 of a plane parallel plate and $\theta = 0°$

Without multiple reflection	6.3%
With multiple reflection	6.2%

Infrared Absorption Maxima[9]: 38.9μ and 30.5μ

Renstrahl Frequencies[9]: 35μ and 25μ. The reflection is a minimum at 16μ between 21μ and 41μ the reflection is over 50%. Influence of temperature[10].

References

1. Handbook of Chemistry and Physics 59th Ed., 1979.
2. Handke. Ph.D. Thesis, University of Berlin, 1898.
3. I. H. Malitson, Appl. Optics, *2*, 1103(1963).
4. H. Harting, Ber, deutsch. Akad. Wiss. No. *4*, 1948.
5. T. W. Houston, L. F. Johnson, P Kisliuk, and D. P. Wash, J. Opt. Soc. Am., *53*, 1286 (1963).
6. E. G. Schneider, Phys. Rev., *45*, 152 (1934).
7. A. H. Laufer, J. A. Pirog and J. R. McNesby, J. Opt. Soc. Am., *55*, 64 (1965).
8. J. E. Stewart, Appl. Optics, *1, 75* (1962).
9. W Kaiser. W. G. Spitzer; R. H. Kaiser, and L. E. Howarth, Phys. Rev, *127*, 1960 (1962).
10. J. Krevitsky, "Report of NRL Progress" February 1960, pp. 36-39.
11. M. H. Greenblat, Rev. Sci. Inst. *29*, 738 (1958).
12. Born and Wolf, Principals of Optics, p.96, New York, 1964.

SAINT-GOBAIN
CRYSTALS

CaF_2
Calcium Fluoride

Properties (cont'd)

Quality: Vacuum ultraviolet quality calcium fluoride is grown from highly purified salt. This material is guaranteed to transmit 50% @ 1257Å for a 2mm thick path length.

For the study of spectra in the ultraviolet region, vacuum ultraviolet quality calcium fluoride is recommended.

Optical quality calcium fluoride is recommended for windows, prisms and lenses for use in the infrared. Calcium fluoride is used as a host lattice for laser crystals. We have extensive experience in doping calcium fluoride with uranium and the rare earths.

Europium-activated calcium fluoride is a standard product for use as a scintillation detector.

Some Practical Limitations

Moisture: Calcium fluoride can be used as polished optical elements for several years in the laboratory or in direct contact with the open atmosphere. There is no visible change on exposure to 100% relative humidity for one month at 72-85°F.

Acids: Nitric acid attacks calcium fluoride.

Temperature: The reaction with atmospheric moisture will take place above 600°C in a normal atmosphere. Calcium fluoride begins to soften appreciably at 600°C. Taking this into consideration, calcium fluoride can be operated in a dry atmosphere up to 900°C.

Pressure: It is possible to calculate minimum thickness pressure windows from the elastic data. See the section, "Design of Pressure Windows."

Irradiation: The irradiation of calcium fluoride does cause some loss in ultraviolet transmission. This loss is not as serious as with lithium fluoride, but serious enough so that we would not recommend this material as an ultraviolet window for space applications if it is directly exposed to space-environment for a long period of time.

Handling–Orientation: Calcium fluoride crystals can be oriented by using the (111) cleavage faces as a reference or by using x-ray techniques.

Cleavage: Calcium fluoride cleaves along the (111) plane.

Cutting and Polishing: Calcium fluoride is a relatively hard optical crystal and is best cut or shaped with diamond tools. Polishing may be accomplished with aluminum oxide powder or with standard polishing powders. Best results are obtained when the polishing vehicle does not contain water. Calcium fluoride is sensitive to thermal shock, so that care should be taken during grinding and polishing operations.

CaF_2
Calcium Fluoride

Some Practical Limitations (cont'd)

Sealing: Vacuum seals with calcium fluoride can be made with either silver chloride[10, 11] or a suitable epoxy. We have experience in designing and building mounted calcium fluoride windows.

Transmission Spectrum