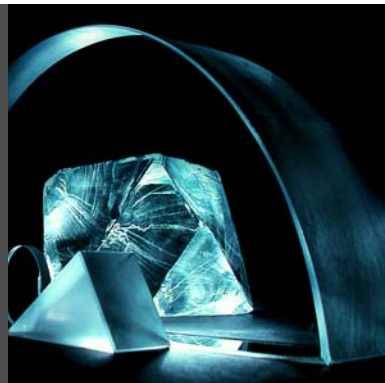


# Calcium Fluoride CaF<sub>2</sub>

## Physical and Chemical Properties



**CORNING**  
Discovering Beyond Imagination



Semiconductor  
Optics

### Calcium Fluoride (CaF<sub>2</sub>) Physical & Chemical Properties

#### Environmental Effects:

Exposure to 100% relative humidity at room temperature does not fog polished surfaces even after one month. In normal working conditions, polished surfaces will not degrade. For temperatures exceeding 600°C, calcium fluoride surfaces will degrade in the presence of moisture. In dry environments, calcium fluoride can be used up to 1000°C, but it does not begin to soften at 800°C. Calcium fluoride is inert to organic chemicals and many acids, including HF. It will slowly dissolve in nitric acid.

#### Fabrication:

Calcium fluoride can be machined with standard diamond tools and water-based coolants. The material takes a good polish using either aluminum oxide, chromic oxide or diamond-based polishing powders using either pitch or cloth laps.

#### Size:

Corning Semiconductor Optics grows a range of diameters up to 14.5" [368 mm] from which optical components are custom fabricated.

**Molecular Weight:** 78.06

**Structure:** Cubic, fluorite type, space group Fm3m,  $a_0 = 5.462$  Angstroms,  $z = 4$ .

**Density:** 3.18 g. cc<sup>-1</sup> at 25°C.

**Melting Point:** 1423°C

**Boiling Point:** 2500°C

**Solubility:** 0.015 g. per 100g H<sub>2</sub>O at room temperature.

#### Mechanical & Elastic Properties:

**Young's Modulus:** 75.8 GPa

#### Fracture Strength:

Measurements by Raytheon on Corning Semiconductor Optics single crystals and Raytheon fusion cast material show that fracture strength is very dependent on surface finish. Fracture strengths varied from 34.1 +/- 15.1 MPa for rough finish pieces to 157.2 +/- 13.7 MPa for well-annealed, optically polished material.

**Rupture Modulus:**

Hughes Aircraft observed that the mean modulus of rupture for 900°C forgings was 74.2 MPa for a 77% reduction. Rupture always occurred with no evidence of yield, indicating that the ultimate strength is still higher.

**Elastic Constants:**

Elastic compliance x 10 <sup>-2</sup> /GPa	Elastic stiffness x 10 <sup>2</sup> GPa
S <sub>11</sub> = 0.6867	C <sub>11</sub> = 1.6420
S <sub>12</sub> = 0.1451	C <sub>12</sub> = 0.4398
S <sub>44</sub> = 2.9764	C <sub>44</sub> = 0.3370

**Dielectric Constant:** E<sub>0</sub> = 6.81 at 27°C.

**Poisson Ratio:** 0.26

**Hardness:** 158.3 Knoop for both (100) and (110) directions.

**Thermal Properties****Heat capacity:**

T K	C <sub>p</sub> J/g K
85.32	0.280
104.51	0.577
186.00	0.699
216.40	0.757
276.00	0.837
296.50	0.853

**Thermal Conductivity:**

T °C	watt/m K
88	61.0
200	16.5
320	11.7

**Linear Thermal Expansion Coefficient:**

T °C	T K	Coefficient x 10 <sup>-6</sup> K <sup>-1</sup>
-180	93	6.7
-160	113	9.1
-140	133	11.1
-120	153	12.8
-100	173	14.1
-80	193	15.2
-60	213	16.2
-40	233	17.0
-20	253	17.7
0	273	18.3
20	293	18.7
40	313	19.1
60	333	19.4
80	353	19.7
100	373	20.0
120	393	20.4
140	413	20.8
160	433	21.3
180	453	21.7
200	473	22.2

**Debye Temperature:** 513 +/- 2 K

**Optical Properties****Transmission Range:**

0.12 microns to beyond 7.5 microns, depending on thickness.

**Energy Gap:**

10eV

**Restrahl Frequency:**

35 micron and 25 micron maxima.

**Reciprocal Dispersive Power:**

94

**Photoelasticity**

in the visible region, the piezo-optic coefficients are: 10<sup>-12</sup> Pa

q<sub>11</sub> = -0.038

q<sub>12</sub> = 1.08

(q<sub>11</sub>-q<sub>12</sub>) = -1.46

q<sub>44</sub> = 0.71

At 10.6 microns (q<sub>11</sub>-q<sub>12</sub>) = -0.513

**Optic modes:**

Transverse: 257 cm<sup>-1</sup> at 300 K and 267 cm<sup>-1</sup> at 80 K

Longitudinal: 463 cm<sup>-1</sup> 300 K and 472 cm<sup>-1</sup> at 80 K

**Absorption Coefficients:**

Wavelength microns	Absorption coefficient cm <sup>-1</sup>
1.06	2 x 10 <sup>-5</sup>
2.7	1 x 10 <sup>-3</sup>
3.8	2 x 10 <sup>-4</sup>
5.25	5 x 10 <sup>-4</sup>
6.25	0.0035
7.69	0.11
8.69	0.48
9.09	0.65
10.6	3.5

Typical surface absorption coefficient at 5.25 microns is 3 x 10<sup>5</sup>cm<sup>-1</sup>.

**Index of Refraction dispersion formula**

(Valid over the range 263nm to 153nm)

$$n^2 = A_0 + A_1\lambda^2 + A_2\lambda^4 + A_3\lambda^6 + A_4\lambda^8 + A_5\lambda^{10} + A_6\lambda^{12} \quad (1)$$

where n is the refractive index, λ is the vacuum wavelength in micrometer (μm) and A<sub>0</sub>, A<sub>1</sub>, A<sub>2</sub>, A<sub>3</sub>, A<sub>4</sub>, A<sub>5</sub>, A<sub>6</sub> are the constants of the dispersion formula. Table on next page shows the constants of the formula (1) .

**Thermal dispersion of index of refraction formula**

(Valid over the range 20 °C to 25°C)

$$dn/dt = (B_0 + B_1\lambda^2 + B_2\lambda^4 + B_3\lambda^6 + B_4\lambda^8) \times 10^{-6} \quad (2)$$

B<sub>0</sub>, B<sub>1</sub>, B<sub>2</sub>, B<sub>3</sub> and B<sub>4</sub> are the constants of the formula (2) and λ is the vacuum wavelength in micrometer (μm). Table on next page shows the constants of the formula (2) .

**Refractive Index: between 0.25 and 8 microns**

Wavelength microns	n	Wavelength microns	n	Wavelength microns	n
0.25	1.4673	0.75	1.43112	3.50	1.41402
0.30	1.45399	0.80	1.43055	4.00	1.40961
0.35	1.44652	0.85	1.43006	4.50	1.40458
0.40	1.44185	0.90	1.42963	5.00	1.39891
0.45	1.43872	0.95	1.42925	5.50	1.39258
0.50	1.43649	1.00	1.4289	6.00	1.38556
0.55	1.43485	1.50	1.42627	6.50	1.37782
0.60	1.43358	2.00	1.42386	7.00	1.36933
0.65	1.43259	2.50	1.4211	7.50	1.36005
0.70	1.43178	3.00	1.41784	8.00	1.34995

**Temperature Variation of Refractive Index dn/dT of CaF<sub>2</sub> {x 10<sup>-5</sup>°C}**

Temperature °C	0.46 microns	0.63 microns	1.15 microns	3.39 microns
-180.00	-0.39	-0.40	-0.41	-0.40
-160.00	-0.53	-0.54	-0.56	-0.52
-140.00	-0.64	-0.66	-0.68	-0.63
-120.00	-0.74	-0.77	-0.78	-0.73
-100.00	-0.83	-0.85	-0.87	-0.82
-80.00	-0.90	-0.93	-0.95	-0.89
-60.00	-0.95	-0.99	-1.01	-0.95
-40.00	-1.00	-1.03	-1.06	-1.00
-20.00	-1.04	-1.07	-1.10	-1.05
0.00	-1.07	-1.10	-1.13	-1.09
20.0	-1.10	-1.13	-1.15	-1.12
40.00	-1.12	-1.15	-1.18	-1.14
60.00	-1.14	-1.17	-1.20	-1.17
80.00	-1.16	-1.19	-1.22	-1.19
100.00	-1.18	-1.21	-1.24	-1.21
120.00	-1.20	-1.23	-1.26	-1.23
140.00	-1.22	-1.26	-1.29	-1.25
160.00	-1.26	-1.30	-1.32	-1.27
180.00	-1.29	-1.34	-1.36	-1.30
200.00	-1.34	-1.40	-1.41	-1.34

**DUV Refractive Index and dn/dT Between 153 and 253 nm**

Wavelength (nm)	Refractive Index n	Thermal Coefficient (dn/dt) (ppm/K)	Polynomial Dispersion Equation constants 20.0 deg. C at 1013.25 hPa N2	
248.3	1.467945	-7.5	A0	2.010676482
248	1.468057	-7.5	A1	0.09792014958
214.44	1.484616	-5.7	A2	0.009375701135
206.2	1.490376	-5.0	A3	-0.0001423385867
194.17	1.500662	-3.7	A4	0.000007129779833
193	1.501808	-3.6	A5	-0.0000001168313575
184.89	1.510638	-2.4	A6	0.000000001055628646
180.3	1.516437	-1.6	dn/dT Dispersion Equation Constants	
174.44	1.524890	-0.4	B0	-57.18332811
157.63	1.558722	5.8	B1	268.2922914
153	1.571830	8.7	B2	3.102836946
			B3	-0.08060676782
			B4	0.0009506519835

## Worldwide Accessibility

### United States/Canada sales office

Corning Incorporated  
Fluoride Crystals Business  
24 E. Brookfield Road  
PO Box 189  
Brookfield, MA 01535  
t 508 867 8200  
f 508 867 8349  
crystals@corning.com

### European sales office

Corning GmbH  
Corning International  
Abraham-Lincoln-Strasse 30  
D-65189 Wiesbaden, Germany  
t 49 611 7366 100  
f 49 611 7366 143  
CIgermany@corning.com

### Asia sales offices

Corning International K.K.  
No. 35 Kowa Building, 3F  
14-14, Akasaka 1-chome  
Minato-Ku, Tokyo 107-0052  
Japan

t 81 3 3586 1052  
f 81 3 3567 0906

Corning International  
1 Kim Seng Promenade  
#12-12  
Great World City  
West Tower  
Singapore 237994  
Republic of Singapore

t 65 733 6511  
f 65 861 7310

Corning Korea Company Ltd.  
10th Floor, Kukje Center Bldg.  
191, Hangangro 2-Ka  
Yongsan-Ku  
Seoul, Korea 140-702

t 82 2 796 9500  
f 82 2 796 9300

Corning Glass Taiwan Co. Ltd.  
Room# 1023, 12F  
No. 205  
Tun Hua North Road  
Taipei, Taiwan  
t 886 2 2716 0338  
f 886 2 2716 0339

### Australia sales office

Corning International Australia  
Suite 18  
12 Tryon Road  
Lindfield, NSW 2070  
Australia

t 61 2 9416 0492  
f 61 2 9416 0493

### World headquarters

Corning Incorporated  
One Riverfront Plaza  
Corning, New York 14831-0001  
t 607 974 9000

*The information contained herein is based upon data considered to be accurate. However, no warranty is expressed or implied regarding the performance of this product. The only applicable warranties are those that are set out in a contract or purchase.*

*We are here to help you specify the best product for your application. For further information, please contact:*

## Corning Incorporated

One Riverfront Plaza  
Corning, NY 14831

607 974 9000

HPFS® is a registered trademark of  
Corning Incorporated

© Corning Incorporated 2003

October 13, 2003