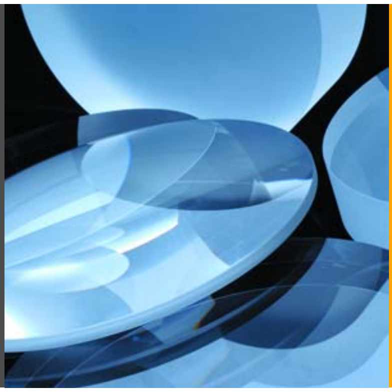
HPFS® Fused Silica ArF Grade

CORNING
Discovering Beyond Imagination



Semiconductor Optics

HPFS® ArF Grade, Corning code 7980, is a high purity synthetic amorphous silicon dioxide manufactured by flame hydrolysis. The noncrystalline, colorless, silica glass combines a very low thermal expansion coefficient with excellent optical qualities and exceptional transmittance in the deep ultraviolet. ArF Grade was developed for 193 nm lithography systems.

In order to satisfy the challenging quality requirements of our customers in leading edge applications such as microlithography, Corning is dedicated to continuous improvement. Our investments in research and development, combined with Corning's quality systems, support our technology leadership position and ensure that we meet our customer's requirements on time, every time.

Quality Grade Selection Chart—HPFS® ArF Grade

Corning defines and certifies the quality of HPFS® glass using two criteria: inclusions and homogeneity grade.

Inclusion Class			Homogeneity[3,4] ppm			
			Grade			
Class	Total inclusion[1] cross section [mm^2]	Maximum[2] size [mm]	AA ≤ 0.5	A ≤ 1	C ≤ 2	F ≤ 5
0	≤ 0.03	0.10	■	■	■	■
1	≤ 0.10	0.28		■	■	■
2	≤ 0.25	0.50			■	■

NOTES:

1. Defines the sum of the cross section in mm^2 of inclusions per 100 cm^3 of glass. Inclusions with a diameter ≤ 0.10 mm are disregarded.
2. Refers to the diameter of the largest single inclusion.
3. Index homogeneity: the maximum index variation (relative), measured over the clear aperture of the blank.
4. Index homogeneity is certified using an interferometer at 632.8 nm. The numerical homogeneity is reported as the average through the piece thickness. Blanks with diameter up to 450 mm can be analyzed over the full aperture. Larger parts can be analyzed using multiple overlapping apertures. The minimum thickness for index homogeneity verification is 20 mm. For thinner parts, the parent piece is certified.

Mechanical & Thermal Properties

Unless otherwise stated, all values @25 ºC

Elastic (Young's) Modulus	72.7 GPa
Shear Modulus	31.4 GPa
Average Modulus of Rupture, abraded	52.4 MPa
Bulk Modulus	35.4 GPa
Poisson's Ratio	0.16
Density	2.201 g/cm^3
Knoop Hardness (100 g load)	522 kg/mm^2

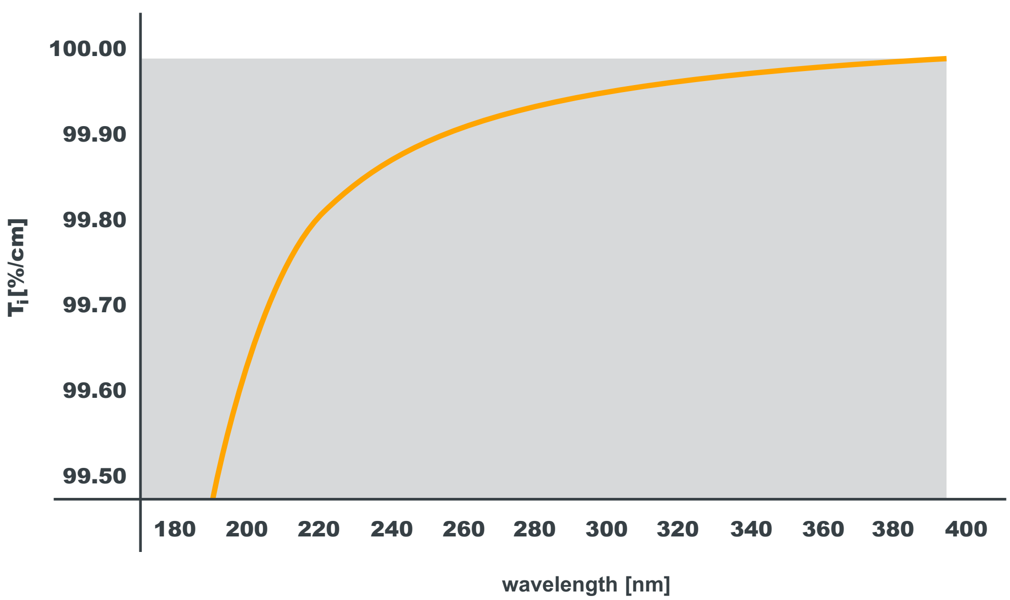
Softening Point		1585 ºC ($10^{7.6}$ poises)
Annealing Point		1042 ºC (10^{13} poises)
Strain Point		893 ºC ($10^{14.5}$ poises)
Thermal Conductivity		1.30 W/m K
Thermal Diffusivity		0.0075 cm^2/s
Average C.T.E.	0.52 ppm/K	5 ºC-35 ºC
	0.57 ppm/K	0 ºC-200 ºC
	0.48 ppm/K	-100 ºC-200 ºC

Chemical durability and Impurities

Solution		Time	Weight Loss [mg/cm^2]
5% HCL by weight	@95 ºC	24 h	< 0.010
5% NaOH	@95 ºC	6 h	0.453
0.02N NA_2CO_3	@95 ºC	6 h	0.065
0.02N H_2SO_4	@95 ºC	24 h	< 0.010
Deionized H_2O	@95 ºC	24 h	0.015
10% HF by weight	@25 ºC	20 m	0.230
10% NH_4F*HF by weight	@25 ºC	20 m	0.220

Impurities	
OH content (by weight):	800 – 1000 ppm
Impurities other than OH:	<100 ppb

Internal transmittance



HPFS® ArF Grade is certified to meet $T_i \geq 99.5\%$/cm@193nm.Higher transmittance is available upon request. A typical internal transmittance curve for HPFS® ArF Grade fused silica is shown here.

Refractive index and dispersion

Data in 22 ºC in 760mm Hg dry nitrogen gas

Wavelength [air] λ [nm]	Refractive Index *2 n	Thermal Coefficient Δn/ΔT*3 (ppm/K)
1128.64	1.448870	9.6
1064.00	1.449633	9.6
1060.00	1.449681	9.6
1013.98 n_t	1.450245	9.6
852.11 n_s	1.452469	9.7
706.52 n_r	1.455149	9.9
656.27 n_C	1.456370	9.9
643.85 $n_{C'}$	1.456707	10.0
632.80 $n_{He\text{-}Ne}$	1.457021	10.0
589.29 n_D	1.458406	10.1
587.56 n_d	1.458467	10.1
546.07 n_e	1.460082	10.2
486.13 n_F	1.463132	10.4
479.99 $n_{F'}$	1.463509	10.4
435.83 n_g	1.466701	10.6
404.66 n_h	1.469628	10.8
365.01 n_i	1.474555	11.2
334.15	1.479785	11.6
312.57	1.484514	12.0
308.00	1.485663	12.1
248.30	1.508433	14.2
248.00	1.508601	14.2
214.44	1.533789	17.0
206.20	1.542741	18.1
194.17	1.559012	20.4
193.40	1.560208	20.5
193.00	1.560841	20.6
184.89	1.575131	22.7

Polynomial Dispersion Equation Constants *1	
A_0	2.104025406
A_1	$-1.456000330 \times 10^{-4}$
A_2	$-9.049135390 \times 10^{-3}$
A_3	$8.801830992 \times 10^{-3}$
A_4	$8.435237228 \times 10^{-5}$
A_5	$1.681656789 \times 10^{-6}$
A_6	$-1.675425449 \times 10^{-8}$
A_7	$8.326602461 \times 10^{-10}$

Sellmeier Dispersion Equation Constants *2	
B_1	0.68374049400
B_2	0.42032361300
B_3	0.58502748000
C_1	0.00460352869
C_2	0.01339688560
C_3	64.49327320000

Δn/ΔT Dispersion Equation Constants *3	
C_0	9.390590
C_1	0.235290
C_2	-1.318560×10^{-3}
C_3	3.028870×10^{-4}

Other Optical Properties	
ν_d	67.79
ν_e	67.64
$n_F - n_C$	0.006763
$n_{F'} - n_{C'}$	0.006802
Stress Coefficient	35.0 nm/cm MPa
Striae	ISO 10110-4 Class 5/Thickness Direction
Birefringence	≤ 1nm/cm, lower specifications available

*1 Polynomial Equation: $n^2 = A_0 + A_1 \lambda^4 + A_2 \lambda^2 + A_3 \lambda^{-2} + A_4 \lambda^{-4} + A_5 \lambda^{-6} + A_6 \lambda^{-8} + A_7 \lambda^{-10}$ with λ in µm

*2 Sellmeier Equation: $n^2-1 = B_1 \lambda^2/(\lambda^2-C_1) + B_2 \lambda^2/(\lambda^2-C_2) + B_3 \lambda^2/(\lambda^2-C_3)$ with λ in µm

*3 Δn/ΔT Equation (20–25ºC) = $C_0 + C_1 \lambda^{-2} + C_2 \lambda^{-4} + C_3 \lambda^{-6}$ with λ in µm

Resistance to laser damage

Samples of HPFS® ArF Grade are regularly tested at Corning's Metrology Laboratory, Sullivan Park Research Center, to maintain the high standards to which Corning is committed.