

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 is developed to work with 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. The 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 three criteria: grade, inclusions and homogeneity

Inclusion Class <sup>1,2</sup>			Homogeneity <sup>3,4</sup>			
Class	Total Inclusion Cross Section	Maximum Size [mm]	Grade AA ≤ 0.5	Grade A ≤ 1	Grade C ≤ 2	Grade 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<sup>2</sup> of inclusions per 100 cm<sup>3</sup> 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 will be analysed over the full aperture. Larger parts will be analysed using multiple overlapping apertures. The minimum thickness for index homogeneity verification is 20.3 mm. For thinner parts, the parent piece is certified.

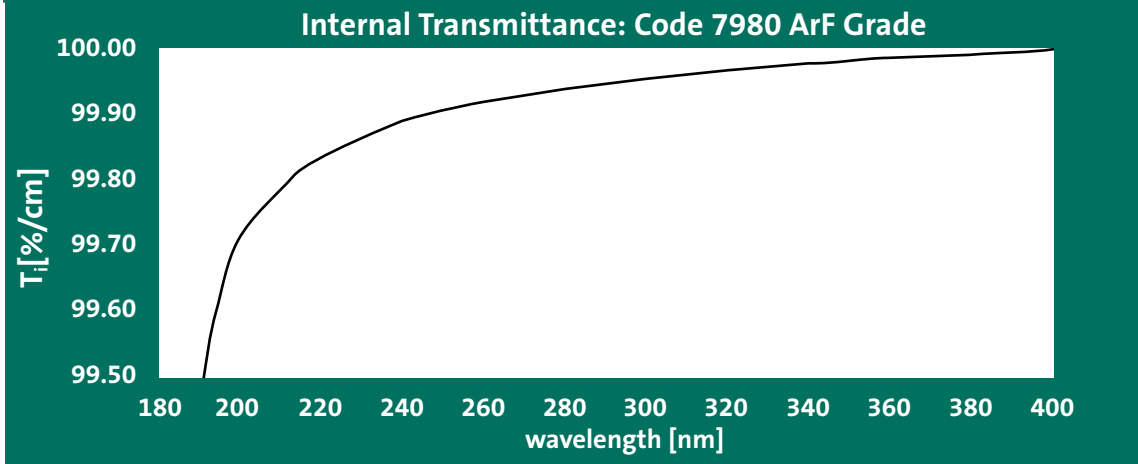
## Mechanical and Thermal Properties: Unless otherwise stated, all values @ 25°C

Elastic (Young's) Modulus	72.7 GPa	Softening Point	1585°C (10 <sup>7.6</sup> poises)
Shear Modulus	31.4 GPa	Annealing Point	1042°C (10 <sup>13</sup> poises)
Average Modulus of Rupture, abraded	52.4 MPa	Strain Point	893°C (10 <sup>14.5</sup> poises)
Bulk Modulus	35.4 GPa	Specific Heat	0.770 J/g K
Poisson's Ratio	0.16	Thermal Conductivity	1.30 W/m K
Density	2.201 g/cm <sup>3</sup>	Thermal Diffusivity	0.0075 cm <sup>2</sup> /s
Knoop Hardness (100 g load)	522 kg/mm <sup>2</sup>	Average C.T.E.O.	52 ppm/K      5°C-35°C
Compressive Strength	1.14 GPa		0.57 ppm/K      0°C-200°C
Tensile Strength	54 MPa		0.48 ppm/K      -100°C-200°C

## Chemical Durability and Impurities

Solution		Time	Weight Loss [mg/cm <sup>2</sup> ]	Impurities
5% HCl by weight	@95°C	24 h	< 0.010	OH content (by weight): 800-1000 ppm Impurities other than OH: <100 ppb
5% NaOH	@95°C	6 h	0.453	
0.02N Na <sub>2</sub> CO <sub>3</sub>	@95°C	6 h	0.065	
0.02N H <sub>2</sub> SO <sub>4</sub>	@95°C	24 h	< 0.010	
Deionized H <sub>2</sub> O	@95°C	24 h	0.015	
10% HF by weight	@25°C	20 m	0.230	
10% NH <sub>4</sub> F*HF by weight	@25°C	20 m	0.220	

# 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°C in 760mm Hg Dry Nitrogen Gas

Wavelength [air] $\lambda$ [nm]	Refractive Index $n$ *	Thermal Coefficient $\Delta n/\Delta T$ *3 (ppm/K)	Polynomial Dispersion Equation Constants *1	
1128.64	1.448870	9.6	$A_0$	2.104025406
1064.00	1.449633	9.6	$A_1$	$-1.456000330 \times 10^{-4}$
1060.00	1.449681	9.6	$A_2$	$-9.049135390 \times 10^{-3}$
1013.98 $n_t$	1.450245	9.6	$A_3$	$8.801830992 \times 10^{-3}$
852.11 $n_s$	1.452469	9.7	$A_4$	$8.435237228 \times 10^{-5}$
706.52 $n_r$	1.455149	9.9	$A_5$	$1.681656789 \times 10^{-6}$
656.27 $n_c$	1.456370	9.9	$A_6$	$-1.675425449 \times 10^{-8}$
643.85 $n_{c'}$	1.456707	10.0	$A_7$	$8.326602461 \times 10^{-10}$
632.80 $n_{He-Ne}$	1.457021	10.0	Sellmeier Dispersion Equation Constants *2	
589.29 $n_D$	1.458406	10.1	$B_1$	0.68374049400
587.56 $n_d$	1.458467	10.1	$B_2$	0.42032361300
546.07 $n_e$	1.460082	10.2	$B_3$	0.58502748000
486.13 $n_F$	1.463132	10.4	$C_1$	0.00460352869
479.99 $n_{F'}$	1.463509	10.4	$C_2$	0.01339688560
435.83 $n_g$	1.466701	10.6	$C_3$	64.49327320000
404.66 $n_h$	1.469628	10.8	$\Delta n/\Delta T$ Dispersion Equation Constants *3	
365.01 $n_i$	1.474555	11.2	$C_0$	9.390590
334.15	1.479785	11.6	$C_1$	0.235290
312.57	1.484514	12.0	$C_2$	$-1.318560 \times 10^{-3}$
308.00	1.485663	12.1	$C_3$	$3.028870 \times 10^{-4}$
248.30	1.508433	14.2	Other Optical Properties	
248.00	1.508601	14.2	$\nu_d$	67.79
214.44	1.533789	17.0	$\nu_e$	67.64
206.20	1.542741	18.1	$n_F - n_C$	0.006763
194.17	1.559012	20.4	$n_{F'} - n_{C'}$	0.006802
193.40	1.560208	20.5	Stress Coefficient	35.0 nm/cm MPa
193.00	1.560841	20.6	*Striae	ISO 101 10-4 Class 5/Thickness Direction
184.89	1.575131	22.7	Birefringence	$\leq 1nm/cm$ , lower specifications available

\*1 Polynomial Equation:

$$n^2 = A_0 + A_1 \lambda^4 + A_2 \lambda^2 + A_3 \lambda^{-2} + A_4 \lambda^{-4} + A_5 \lambda^{-6} + A_6 \lambda^{-8} + A_7 \lambda^{-10} \text{ with } \lambda \text{ in } \mu m$$

\*2 Sellmeier Equation:

$$n^2 - 1 = B_1 \lambda^2 / (\lambda^2 - C_1) + B_2 \lambda^2 / (\lambda^2 - C_2) + B_3 \lambda^2 / (\lambda^2 - C_3) \text{ with } \lambda \text{ in } \mu m$$

\*3 dn/dT Equation:

$$dn/dT = C_0 + C_1 \lambda^{-2} + C_2 \lambda^{-4} + C_3 \lambda^{-6} \text{ with } \lambda \text{ in } \mu m$$

# 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.