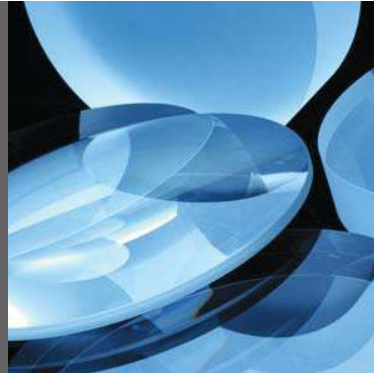


HPFS® Fused Silica ArF Grade



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			
Class	Total inclusion ¹ cross section [mm ²]	Maximum ² size [mm]	Grade			
			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 mm² of inclusions per 100 cm³ 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

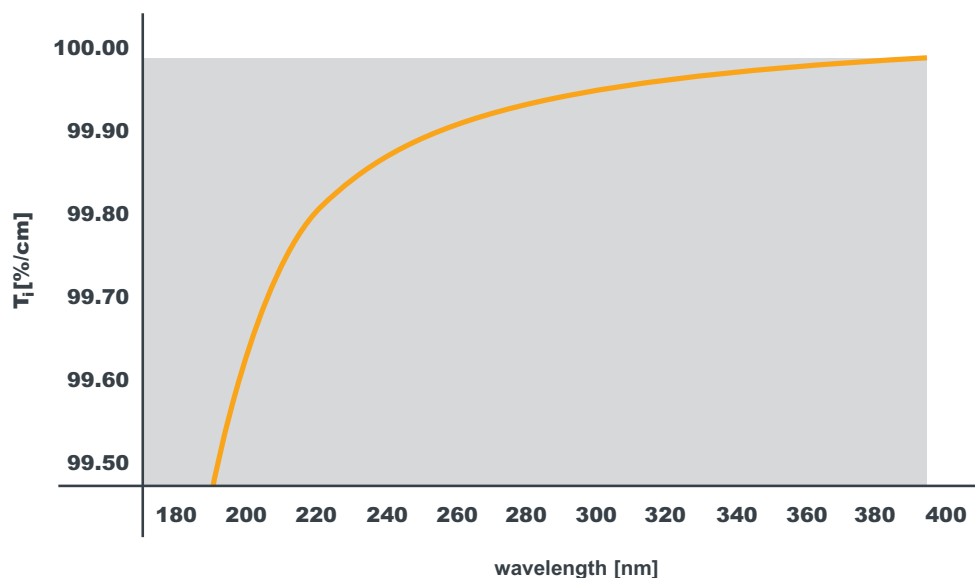
Unless otherwise stated, all values @25 °C

Elastic (Young's) Modulus	72.7 GPa	Softening Point	1585 °C (10 ^{7.6} poises)	
Shear Modulus	31.4 GPa	Annealing Point	1042 °C (10 ¹³ poises)	
Average Modulus of Rupture, abraded	52.4 MPa	Strain Point	893 °C (10 ^{14.5} poises)	
Bulk Modulus	35.4 GPa	Thermal Conductivity	1.30 W/m K	
Poisson's Ratio	0.16	Thermal Diffusivity	0.0075 cm ² /s	
Density	2.201 g/cm ³	Average C.T.E.	0.52 ppm/K	5 °C-35 °C
Knoop Hardness (100 g load)	522 kg/mm ²		0.57 ppm/K	0 °C-200 °C
			0.48 ppm/K	-100 °C-200 °C

Chemical durability and Impurities

Solution		Time	Weight Loss [mg/cm ²]	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 ₂ CO ₃	@95 °C	6 h	0.065	
0.02N H ₂ SO ₄	@95 °C	24 h	< 0.010	
Deionized H ₂ O	@95 °C	24 h	0.015	
10% HF by weight	@25 °C	20 m	0.230	
10% NH ₄ 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] λ [nm]	Refractive Index ^{*2} n	Thermal Coefficient $\Delta n/\Delta T$ ^{*3} (ppm/K)	Polynomial Dispersion Equation Constants ^{*1}	
			A ₀	A ₁
1128.64	1.448870	9.6	2.104025406	-1.456000330 x 10 ⁻⁴
1064.00	1.449633	9.6	-9.049135390 x 10 ⁻³	8.801830992 x 10 ⁻³
1060.00	1.449681	9.6	8.435237228 x 10 ⁻⁵	1.681656789 x 10 ⁻⁶
1013.98 n _t	1.450245	9.6	1.681656789 x 10 ⁻⁶	-1.675425449 x 10 ⁻⁸
852.11 n _s	1.452469	9.7	-1.675425449 x 10 ⁻⁸	8.326602461 x 10 ⁻¹⁰
706.52 n _r	1.455149	9.9	8.326602461 x 10 ⁻¹⁰	
656.27 n _c	1.456370	9.9		
643.85 n _{c'}	1.456707	10.0	Sellmeier Dispersion Equation Constants ^{*2}	
632.80 n _{He-Ne}	1.457021	10.0	B ₁	0.68374049400
589.29 n _D	1.458406	10.1	B ₂	0.42032361300
587.56 n _d	1.458467	10.1	B ₃	0.58502748000
546.07 n _e	1.460082	10.2	C ₁	0.00460352869
486.13 n _F	1.463132	10.4	C ₂	0.01339688560
479.99 n _{F'}	1.463509	10.4	C ₃	64.49327320000
435.83 n _g	1.466701	10.6	$\Delta n/\Delta T$ Dispersion Equation Constants ^{*3}	
404.66 n _h	1.469628	10.8	C ₀	9.390590
365.01 n _i	1.474555	11.2	C ₁	0.235290
334.15	1.479785	11.6	C ₂	-1.318560 x 10 ⁻³
312.57	1.484514	12.0	C ₃	3.028870 x 10 ⁻⁴
308.00	1.485663	12.1	Other Optical Properties	
248.30	1.508433	14.2	v _d	67.79
248.00	1.508601	14.2	v _e	67.64
214.44	1.533789	17.0	n _F - n _C	0.006763
206.20	1.542741	18.1	n _F - n _{C'}	0.006802
194.17	1.559012	20.4	Stress Coefficient	35.0 nm/cm MPa
193.40	1.560208	20.5	Striae	ISO 10110-4 Class 5/Thickness Direction
193.00	1.560841	20.6	Birefringence	≤ 1nm/cm, lower specifications available
184.89	1.575131	22.7		

*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 $\Delta n/\Delta T$ Equation (20–25°C) = $C_0 + C_1 \lambda^{-2} + C_2 \lambda^{-4} + C_3 \lambda^{-6}$ 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.