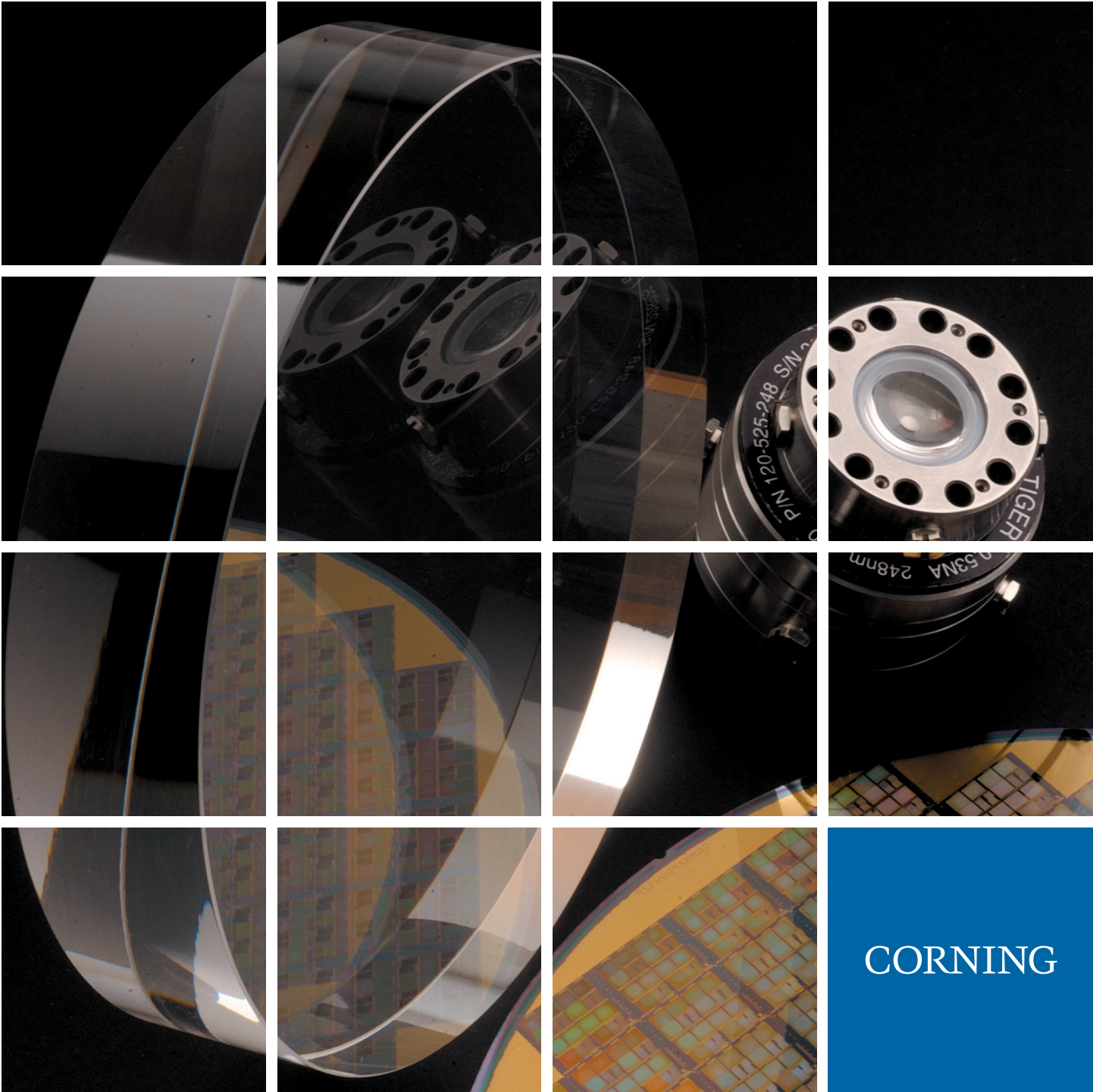


# Corning® HPFS® 7979, 7980, 8655 Fused Silica

Optical Materials Product Information  
Specialty Materials Division



CORNING

## HPFS® 7979, 7980 and 8655 Fused Silica

Dedication to technology leadership and world-class metrology capabilities play a major role in Corning's ability to produce leading edge materials. Corning is committed to ensuring that its customers are provided qualified, authentic products.

Corning has a minimum of 25 years of measurement experience and provides a certificate of compliance for each sale of product to verify the authenticity of our HPFS® Fused Silica Materials.

Fused Silica is offered in many different grades to support various product applications. Glass codes 7980, 7979, and 8655 are high purity non-crystalline silica glasses with excellent optical qualities.

Product characteristics include extraordinary low refractive index variations leading to state-of-the-art homogeneity values, lowest birefringence values, large size capabilities, exceptional transmittance from the deep ultraviolet through the infrared region, and an ultra-low thermal expansion coefficient; all of which are critical to our customers' demanding needs.

## HPFS® Summary of Key Attributes

| Attribute  | Fused Silica        |                |                |                   |                       |               |                |
|--|---------------------|----------------|----------------|-------------------|-----------------------|---------------|----------------|
|  | 7980 Standard Grade | 7980 Krf Grade | 7980 ArF Grade | 7980 Mirror Grade | 7980 Industrial Grade | 7979 IR Grade | 8655 ArF Grade |
| Visible Transmittance  | ■                   | ■              | ■              | ■                 | ■                     | ■             | ■              |
| UV Transmittance   | ■                   | ■              | ■              |                   |                       |               | ■              |
| Infrared Transmittance   |                     |                |                |                   |                       | ■             | ■              |
| Homogeneity Certified in Use-Axis AA, A, C, F (By Size)  | ■                   | ■              | ■              |                   |                       | ■             | ■              |
| Inclusion Class Certified 0, 1, 2, 5   | ■                   | ■              | ■              | ■                 |                       | ■             | ■              |
| Striae Certified ISO 10110-4 Class 5 (None)  | ■                   | ■              | ■              | ■                 |                       | ■             | ■              |
| Homogeneity Certified in Off-Axis AA, A, C, F (By Size)  | ■                   | ■              | ■              |                   |                       | ■             | ■              |
| Low Birefringence  | ■                   | ■              | ■              | ■                 |                       | ■             | ■              |
| UV Laser Resistant (Data available upon request)   |                     | ■              | ■              |                   |                       |               | ■              |
| Economical (No certification of any properties except visible transmission. Tooling applications.) |                     |                |                |                   |                       | ■             |                |

## Quality Grade Selection Chart

For Mirror Grade - see chart on next page

| Inclusion Class |   |                                | Homogeneity <sup>3,4</sup> [ppm] |          |            |          |          |          |          |                      |
|-----------------|---|--------------------------------|----------------------------------|----------|------------|----------|----------|----------|----------|----------------------|
|                 |   |                                | Grade                            |          |            |          |          |          |          |                      |
| Class           | Total Inclusion Cross Section <sup>1</sup> [mm <sup>2</sup> ] | Maximum Size <sup>2</sup> [mm] | AA<br>≤ 0.5                      | A<br>≤ 1 | B<br>≤ 1.5 | C<br>≤ 2 | D<br>≤ 3 | E<br>≤ 4 | F<br>≤ 5 | G<br>NS <sup>5</sup> |
| 0               | ≤0.03   | 0.10                           | ■                                | ■        | ■          | ■        | ■        | ■        | ■        | ■                    |
| 1               | ≤0.10   | 0.28                           |                                  | ■        | ■          | ■        | ■        | ■        | ■        | ■                    |
| 2               | ≤0.25   | 0.50                           |                                  |          | ■          | ■        | ■        | ■        | ■        | ■                    |
| 3               | ≤0.50   | 0.76                           |                                  |          |            | ■        | ■        | ■        | ■        | ■                    |
| 4               | ≤1.00   | 1.00                           |                                  |          |            | ■        | ■        | ■        | ■        | ■                    |
| 5               | ≤2.00   | 1.27                           |                                  |          |            | ■        | ■        | ■        | ■        | ■                    |

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 a 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.
5. NS (Not Specified)

## HPFS® Data and Properties

|                       | Inclusion Class | Homogeneity Grade | Birefringence<br>Lower specifications<br>available upon request<br>[nm/cm] | Striae<br>ISO 10110-4<br>Class | Metallic<br>Impurities<br>[ppb] | OH Content<br>[ppm] |
|-----------------------|-----------------|-------------------|--|--------------------------------|---------------------------------|---------------------|
| 7979 IR Grade         | 0, 1, 2         | AA, A, C, F       | ≤ 5  | 5                              | < 100                           | < 1                 |
| 7980 Standard Grade** | 0 - 5           | AA - F            | ≤ 5  | 5                              | < 1000                          | 800 - 1000          |
| 7980 KrF Grade*       | 0, 1, 2         | AA, A, C, F       | ≤ 1  | 5                              | < 500                           | 800 - 1000          |
| 7980 ArF Grade*       | 0, 1, 2         | AA, A, C, F       | ≤ 1  | 5                              | < 100                           | 800 - 1000          |
| 7980 Mirror Grade     | See below       | NS                | ≤ 5  | 1                              | NS                              | 800 - 1000          |
| 7980 Industrial Grade | NS              | NS                | ≤ 5  | 1                              | NS                              | 800 - 1000          |
| 8655 ArF Grade*       | 0, 1, 2         | AA, A, C, F       | ≤ 1  | 5                              | < 10                            | < 1                 |

\* No visible fluorescence when exposed to deuterium source from 215 nm - 400 nm. Material contains hydrogen to minimize absorption under UV exposures.

\*\* HPFS® 7980 Standard Fluorescence-Free Grade available upon request.

## Mechanical Properties

| Unless otherwise stated, all values @ 25 °C |                        |
|---|------------------------|
| Elastic (Young's) Modulus                   | 73 GPa                 |
| Shear Modulus                               | 31 GPa                 |
| Modulus of Rupture, abraded                 | 52.4 MPa               |
| Bulk Modulus                                | 35.9 GPa               |
| Poisson's Ratio                             | 0.16                   |
| Density                                     | 2.20 g/cm <sup>3</sup> |
| Knoop Hardness (100g load)                  | 522 kg/mm <sup>2</sup> |
| Tensile Strength                            | 54 MPa                 |
| Compressive Strength                        | 1.14 GPa               |

## Thermal Properties

| Glass Code:                       | 7980                      | 7979    | 8655                    | Viscosity                 |
|-----------------------------------|---------------------------|---------|-------------------------|---------------------------|
| Softening Point*                  | 1585 °C                   | 1627 °C | 1627 °C                 | 10 <sup>7.6</sup> poises  |
| Annealing Point*                  | 1042 °C                   | 1180 °C | 1180 °C                 | 10 <sup>13</sup> poises   |
| Strain Point*                     | 893 °C                    | 1068 °C | 1068 °C                 | 10 <sup>14.5</sup> poises |
| Specific Heat                     | 0.770 J/(g K)             |         |                         |                           |
| Thermal Conductivity              | 1.38 W/(m K)              |         |                         |                           |
| Thermal Diffusivity               | 0.0075 cm <sup>2</sup> /s |         |                         |                           |
| Thermal Expansion** (ppm/C):      |                           |         |                         |                           |
|                                   | 5 °C to 35 °C             |         | 0.52 x 10 <sup>-6</sup> |                           |
|                                   | 0 °C to 200 °C            |         | 0.57 x 10 <sup>-6</sup> |                           |
|                                   | -100 °C to +200 °C        |         | 0.48 x 10 <sup>-6</sup> |                           |
| ASTM Procedures - *C-598, **E-228 |                           |         |                         |                           |

## Mirror Quality Grade Selection Chart

| Mirror Grade: Inclusion Classes                     |   |                             |                              |
|---|---|-----------------------------|------------------------------|
| Critical Zone:                                      | Blank Dimensions (Diameter or Diagonal) |                             |                              |
|   | < 508 mm<br>(20")                       | 508 - 1143 mm<br>(20 - 45") | 1143 - 2286 mm<br>(45 - 90") |
| Max. Mean Diameter                                  | 0.254 mm<br>(0.010")                    | 0.762 mm<br>(0.030")        | 1.524 mm<br>(0.060")         |
| Max. Avg. #/mm <sup>3</sup><br>(#/in <sup>3</sup> ) | 2 ppm<br>(0.04)                         | 3 ppm<br>(0.05)             | 5 ppm<br>(0.08)              |
| Non-Critical Zone:                                  | Blank Dimensions (Diameter or Diagonal) |                             |                              |
|   | < 508 mm<br>(20")                       | 508 - 1143 mm<br>(20 - 45") | 1143 - 2286 mm<br>(45 - 90") |
| Max. Mean Diameter                                  | 1.016 mm<br>(0.040")                    | 1.524 mm<br>(0.060")        | 3.81 mm<br>(0.150")          |
| Max. Avg. #/mm <sup>3</sup><br>(#/in <sup>3</sup> ) | 3 ppm<br>(0.05)                         | 3 ppm<br>(0.05)             | 9 ppm<br>(0.15)              |

# Refractive Index and Dispersion: HPFS® 7980

| Conditions: 22 °C, 760 mm Hg, N <sub>2</sub> |                                       |  |   |                  |                |               |
|--|---------------------------------------|--|---|------------------|----------------|---------------|
| Wavelength<br>[Vacuum]<br>[nm]               | Refractive<br>Index <sup>2</sup><br>n | Thermal<br>Coefficient<br>$\Delta n/\Delta T^3$<br>[ppm/C] | Polynomial Dispersion Equation Constants <sup>1</sup> , 22 °C             |                  |                |               |
| 1128.950                                     | 1.448866                              | 9.6  | A <sub>0</sub>  | 2.104025406E+00  |                |               |
| 1014.260 n <sub>t</sub>                      | 1.450241                              | 9.6  | A <sub>1</sub>  | -1.456000330E-04 |                |               |
| 852.344 n <sub>s</sub>                       | 1.452463                              | 9.7  | A <sub>2</sub>  | -9.049135390E-03 |                |               |
| 706.714 n <sub>r</sub>                       | 1.455144                              | 9.9  | A <sub>3</sub>  | 8.801830992E-03  |                |               |
| 656.454 n <sub>c</sub>                       | 1.456364                              | 9.9  | A <sub>4</sub>  | 8.435237228E-05  |                |               |
| 632.990                                      | 1.457016                              | 10.0   | A <sub>5</sub>  | 1.681656789E-06  |                |               |
| 587.725 n <sub>d</sub>                       | 1.458461                              | 10.1   | A <sub>6</sub>  | -1.675425449E-08 |                |               |
| 546.227 n <sub>e</sub>                       | 1.460076                              | 10.2   | A <sub>7</sub>  | 8.326602461E-10  |                |               |
| 486.269 n <sub>F</sub>                       | 1.463123                              | 10.4   | Sellmeier Dispersion Equation Constants <sup>2</sup> , 22 °C              |                  |                |               |
| 435.957 n <sub>g</sub>                       | 1.466691                              | 10.6   |   |                  |                |               |
| 404.770 n <sub>h</sub>                       | 1.469615                              | 10.8   | A <sub>1</sub>  | 0.68374049400    |                |               |
| 365.119 n <sub>i</sub>                       | 1.474539                              | 11.2   | A <sub>2</sub>  | 0.42032361300    |                |               |
| 334.244                                      | 1.479764                              | 11.6   | A <sub>3</sub>  | 0.58502748000    |                |               |
| 312.657                                      | 1.484493                              | 12.0   | $\Delta n/\Delta T$ Dispersion Equation Constants <sup>3</sup> , 20-25 °C |                  |                |               |
| 253.728                                      | 1.505522                              | 13.9   |   |                  | B <sub>1</sub> | 0.00460352869 |
| 228.872                                      | 1.521154                              | 15.5   |   |                  | B <sub>2</sub> | 0.01339688560 |
| 214.506                                      | 1.533722                              | 17.0   | B <sub>3</sub>  | 64.49327320000   |                |               |
| 206.266                                      | 1.542665                              | 18.1   | Other Optical Properties  |                  |                |               |
| 194.227                                      | 1.558918                              | 20.3   |   |                  | C <sub>0</sub> | 9.390590      |
| 184.950                                      | 1.575017                              | 22.7   |   |                  | C <sub>1</sub> | 0.235290      |
|  |                                       |  |   |                  | C <sub>2</sub> | -1.318560E-03 |
|  |                                       |  | C <sub>3</sub>  | 3.028870E-04     |                |               |
|  |                                       |  | nF'-nC'   |                  | 0.006797       |               |
|  |                                       |  | Stress Coefficient  |                  | 35.0 nm/cm MPa |               |
|  |                                       |  | Abbe Constants:   |                  |                |               |
|  |                                       |  | V <sub>e</sub>  | 67.6             |                |               |
|  |                                       |  | V <sub>d</sub>  | 67.8             |                |               |

\*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  $\lambda$  in  $\mu m$

\*2 Sellmeier Equation:  $n^2 - 1 = A_1 \lambda^2 / (\lambda^2 - B_1) + A_2 \lambda^2 / (\lambda^2 - B_2) + A_3 \lambda^2 / (\lambda^2 - B_3)$  with  $\lambda$  in  $\mu m$

\*3  $\Delta n/\Delta T$  Equation:  $\Delta n/\Delta T$  [ppm/C] =  $C_0 + C_1 \lambda^{-2} + C_2 \lambda^{-4} + C_3 \lambda^{-6}$  with  $\lambda$  in  $\mu m$

The above dispersion equations were fit to the refractive indices of 20 wavelengths from 1129 nm to 185 nm.

# Refractive Index and Dispersion: HPFS® 8655 and 7979

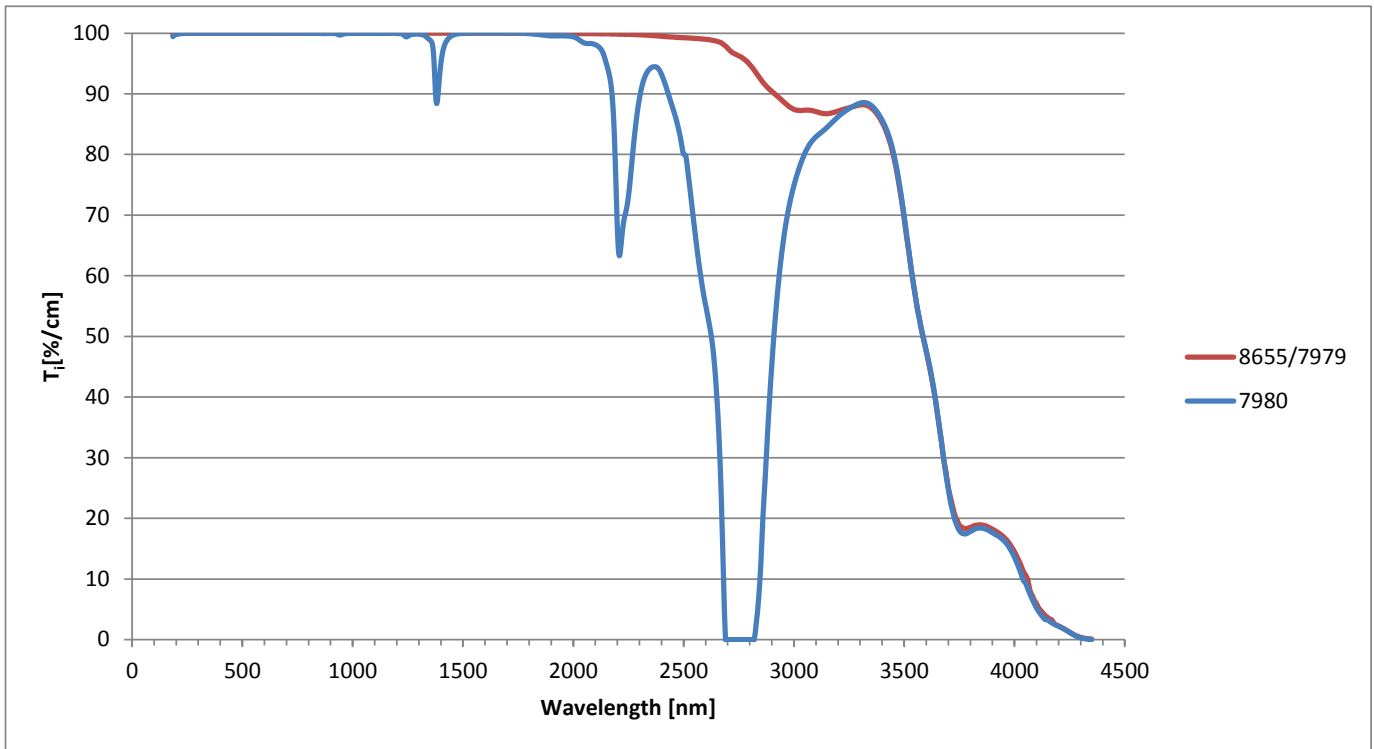
| Conditions: 22 °C, 760 mm Hg, N <sub>2</sub> |                                 |   |  |                  |                |
|--|---------------------------------|---|--|------------------|----------------|
| Wavelength [Vacuum] [nm]                     | Refractive Index <sup>1</sup> n | Thermal Coefficient <sup>2</sup> Δn/ΔT [ppm/°C] | Sellmeier Dispersion Equation Constants <sup>1</sup> , 20 °C |                  |                |
| 2326.050                                     | 1.433027                        | 8.7   | A <sub>1</sub>   | 7.033574317E-02  |                |
| 2058.650                                     | 1.437307                        | 9.3   | A <sub>2</sub>   | 7.241205497E-01  |                |
| 1970.630                                     | 1.438601                        | 9.6   | A <sub>3</sub>   | 3.097807778E-01  |                |
| 1813.570                                     | 1.440776                        | 9.1   | A <sub>4</sub>   | 9.309957497E-01  |                |
| 1530.000                                     | 1.444337                        | 9.7   | B <sub>1</sub>   | -2.301552288E-03 |                |
| 1128.950                                     | 1.448930                        | 9.7   | B <sub>2</sub>   | 6.272886117E-03  |                |
| 1014.26 n <sub>t</sub>                       | 1.450304                        | 9.6   | B <sub>3</sub>   | 1.415449740E-02  |                |
| 852.344 n <sub>s</sub>                       | 1.452526                        | 9.5   | B <sub>4</sub>   | 1.016434845E+02  |                |
| 780.237                                      | 1.453731                        | 9.5   | Sellmeier Dispersion Equation Constants <sup>1</sup> , 22 °C |                  |                |
| 706.714 n <sub>r</sub>                       | 1.455205                        | 9.9   |  |                  |                |
| 656.454 n <sub>c</sub>                       | 1.456425                        | 10.1  | A <sub>1</sub>   | 3.550277875E-02  |                |
| 644.025 n <sub>c</sub>                       | 1.456763                        | 10.1  | A <sub>2</sub>   | 7.353314507E-01  |                |
| 632.990                                      | 1.457077                        | 9.9   | A <sub>3</sub>   | 3.334560303E-01  |                |
| 587.725 n <sub>d</sub>                       | 1.458522                        | 10.2  | A <sub>4</sub>   | 9.269506614E-01  |                |
| 546.227 n <sub>e</sub>                       | 1.460135                        | 10.5  | B <sub>1</sub>   | -4.826183477E-03 |                |
| 486.269 n <sub>f</sub>                       | 1.463183                        | 10.4  | B <sub>2</sub>   | 5.808687673E-03  |                |
| 480.126 n <sub>f'</sub>                      | 1.463561                        | 10.4  | B <sub>3</sub>   | 1.399572492E-02  |                |
| 435.957 n <sub>g</sub>                       | 1.466751                        | 10.7  | B <sub>4</sub>   | 1.012182926E+02  |                |
| 404.770 n <sub>h</sub>                       | 1.469674                        | 10.9  | Sellmeier Dispersion Equation Constants <sup>1</sup> , 25 °C |                  |                |
| 388.975                                      | 1.471446                        | 10.9  |  |                  |                |
| 365.119 n <sub>i</sub>                       | 1.474599                        | 11.3  | A <sub>1</sub>   | 2.623483282E-02  |                |
| 340.463                                      | 1.478646                        | 11.6  | A <sub>2</sub>   | 7.306029048E-01  |                |
| 334.244                                      | 1.479824                        | 11.7  | A <sub>3</sub>   | 3.475321572E-01  |                |
| 312.657                                      | 1.484554                        | 12.0  | A <sub>4</sub>   | 9.216052441E-01  |                |
| 296.814                                      | 1.488798                        | 12.5  | B <sub>1</sub>   | -5.783959035E-03 |                |
| 289.444                                      | 1.491056                        | 12.5  | B <sub>2</sub>   | 5.600103210E-03  |                |
| 253.728                                      | 1.505585                        | 14.0  | B <sub>3</sub>   | 1.389808930E-02  |                |
| 228.872                                      | 1.521218                        | 15.3  | B <sub>4</sub>   | 1.006578079E+02  |                |
| 226.572                                      | 1.523018                        | 15.9  | Δn/ΔT Dispersion Equation Constants <sup>2</sup> , 20-25 °C  |                  |                |
| 214.506                                      | 1.533786                        | 16.8  |  |                  |                |
| 213.923                                      | 1.534371                        | 17.0  | D <sub>0</sub>   | 9.545124E+00     |                |
| 206.266                                      | 1.542731                        | 18.2  | D <sub>1</sub>   | -9.835579E-02    |                |
| 202.613                                      | 1.547213                        | 18.3  | D <sub>2</sub>   | 2.003170E-01     |                |
| 194.227                                      | 1.558985                        | 20.4  | D <sub>3</sub>   | 2.209816E-03     |                |
| 184.950                                      | 1.575091                        | 22.1  | D <sub>4</sub>   | 1.980644E-04     |                |
|  |                                 |   | Other Optical Properties                                     |                  |                |
|  |                                 |   | nF'-nC'  |                  | 0.006797       |
|  |                                 |   | Stress Coefficient   |                  | 35.0 nm/cm MPa |
|  |                                 |   | Abbe Constants:  |                  |                |
|  |                                 |   | V <sub>e</sub>   | 67.6             |                |
| V <sub>d</sub>                               | 67.8                            |   |  |                  |                |

\*1 Sellmeier Equation:  $n^2-1 = A_1 \lambda^2/(\lambda^2 - B_1) + A_2 \lambda^2/(\lambda^2 - B_2) + A_3 \lambda^2/(\lambda^2 - B_3) + A_4 \lambda^2/(\lambda^2 - B_4)$  with  $\lambda$  in  $\mu\text{m}$

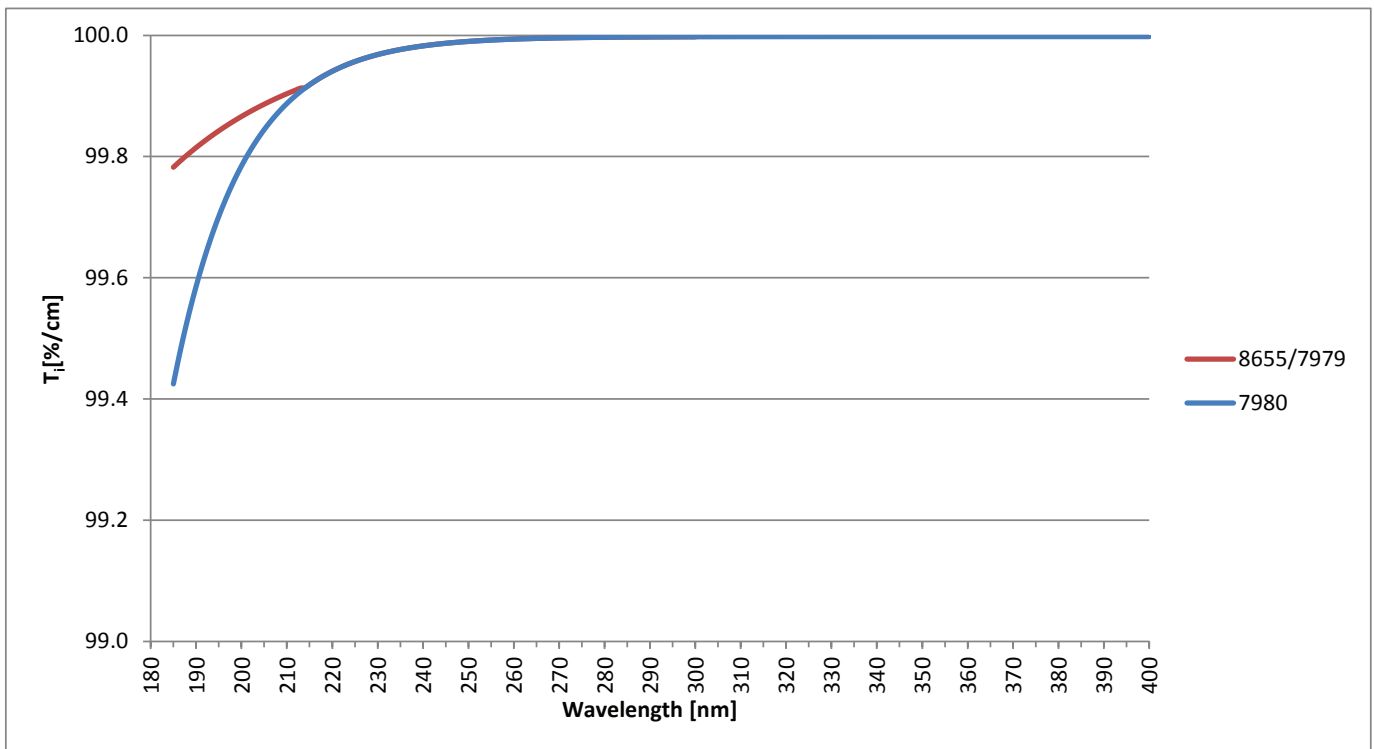
\*2 Δn/ΔT Equation:  $\Delta n/\Delta T$  [ppm/°C] =  $D_0 + D_1 \lambda^2 + D_2 \lambda^{-2} + D_3 \lambda^{-4} + D_4 \lambda^{-6}$  with  $\lambda$  in  $\mu\text{m}$

The above Sellmeier dispersion equation was used to fit the refractive indices of 35 wavelengths from 2326 nm to 185 nm.

## Broad Spectrum Internal Transmittance



## UV Internal Transmittance



HPFS<sup>®</sup> 7980 Standard Grade meets high  $T_i \geq 88.00$  %/cm @185 nm. (Equivalent to  $T_e \geq 80.00$  %/cm @185 nm)

HPFS<sup>®</sup> 7980 KrF Grade meets high  $T_i \geq 99.90$  %/cm @248 nm.

HPFS<sup>®</sup> 7980 ArF Grade meets high  $T_i \geq 99.50$  %/cm @193 nm.

HPFS<sup>®</sup> 8655 Grade meets high  $T_i \geq 99.75$  %/mm @193 nm.

HPFS<sup>®</sup> 8655 Grade Typical initial absorption  $k: \leq 0.0001$ /cm at 193 nm.

Higher transmittance is available upon request.

## Worldwide Accessibility

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

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For additional product or technical information, please visit: <http://www.corning.com/worldwide/en/products/advanced-optics/product-materials/semiconductor-laser-optic-components/high-purity-fused-silica.html>.

To place an order, obtain additional technical information or specific requirements, please contact us at [specialtymaterials@corning.com](mailto:specialtymaterials@corning.com)

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